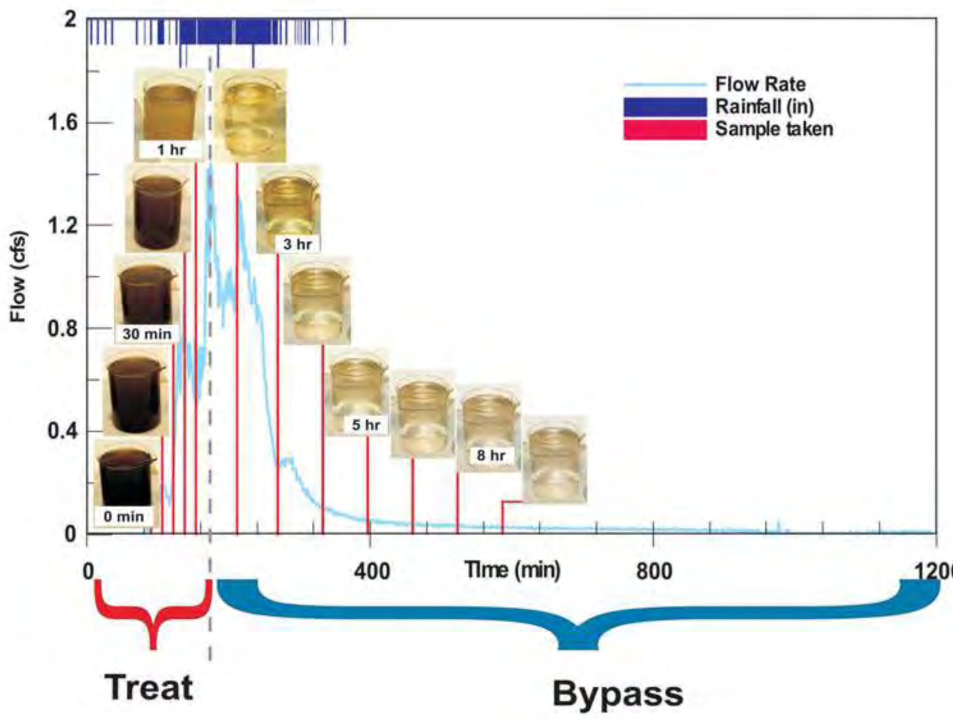
First Flush Phenomenon Characterization



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GLOSSARY

ADD	Antecedent Dry Days
ADT	Average Daily Traffic
AADT	Annual Average Daily Traffic
ASCE	American Society of Civil Engineers
BMP	Best Management Practice
COD	Chemical Oxygen Demand
Department	California Department of Transportation
DOC	Dissolved Organic Carbon (see also Total Organic Carbon)
DOT	Department of Transportation
EMC	Event Mean Concentration
EPA	US Environmental Protection Agency
FF	"First Flush" refers to pollutant concentration or mass that is associated with initial portion of the runoff (usually, less than 50 percent of the total runoff volume) within a storm event. First flush can be applied to a single constituent such as DOC, particle, or litter, and is referred to as "first flush of DOC", "first flush of particles" or "first flush of litter". First flush can also be used for group of constituents such as PAHs that will be referred as "first flush of PAHs". Also see the term seasonal first flush
GC	Gas Chromatography
ICP	Inductively Coupled Plasma
LARWQCB	Los Angeles Regional Water Quality Control Board
LACDPW	Los Angeles County Department of Public Works
MFF	Mass First Flush Ratio
MFF_n	Ratio of the discharged pollutant mass to the runoff volume in the first n% of the runoff. For instance, $MFF_{10} = 3$ means 30 percent of the discharged mass occurs over the first 10 percent of the initial runoff volume.
MPN	Most Probable Number

NPDES	National Pollutant Discharge Elimination System
O & G	Oil and Grease
PAHs	Polynuclear Aromatic Hydrocarbons
PEMC	Partial Event Mean Concentration
PFF	Particle First Flush Ratio
PNFF	Particle Number First Flush Ratio
$PNFF_n$	Ratio of the number of discharged particle to the runoff volume in the first n% of the runoff. For instance, $PNFF_{20}$ = 2.5 means 50 percent of the discharged particles is associated with 20 percent of the initial runoff volume.
PSD	Particle Size Distribution
RMS Error	Root Mean Square Error
Seasonal FF	First flush of pollutant concentration of mass that is associated with the first storm of the season compared with the pollutant concentration or mass in the remaining storm events
TEF	Treatment Effectiveness Factor
TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon
TSS	Total Suspended Solids
VSS	Volatile Suspended Solids
US EPA	United States Environmental Protection Agency
USWS	United States Weather Service

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EXECUTIVE SUMMARY

"First flush" is a phenomenon that is associated with the occurrence or belief that the first portion of stormwater runoff in a storm event is the most contaminated. While most researchers believe that the first portion of runoff does have higher contaminant concentrations, opinions vary as to the importance of the increased concentrations, and whether the actual mass of the first flush is a significant portion of the total runoff mass. Lay people generally believe there is a first flush, and associate hazardous driving conditions with the onset of rainfall. There is also a general believe that the first rainfall of a new rainy season is the most contaminated (seasonal first flush), and washes out several months of contaminant buildup. The concept of seasonal first flush is applicable to climates such as California, which have distinct wet and dry seasons.

This study has identified several types of first flushes, but all, with the exception of "seasonal first flush" indicate the discharge of greater concentrations or mass in the early part of a storm event. The term first flush can be used to describe the discharge of any contaminant. For example, a first flush that is associated with particles or litter will be reported as "particle first flush" or "litter first flush," respectively.

The first flush study was jointly performed by the University of California at Los Angeles (UCLA) and the University of California at Davis (UCD). Most of the data presented in this report were collected by UCLA from three representative highway sites in west Los Angeles, California. Much effort went into developing a quantitative way of defining the mass first flush. Various other aspects of first flush were also investigated such as: water quality during storm events, litter characteristics, correlations among contaminants, first flush of organics, litter and particles, models for the build up and washoff of pollutants, new methods for measuring oil and grease, grab and composite sampling strategies.

The existence of a first flush may present alternative opportunities for stormwater pollutant reduction strategies. First, the cost of treatment, such as a stormwater BMP, is more dependent on the volume of water to be treated than the contaminant concentrations. Second, removal efficiency is greater at higher concentrations and zero at lower concentrations. These phenomena have been demonstrated using catch basin inserts, sorbers and sedimentation devices. The emerging American Society of Civil Engineers database on stormwater treatment BMP trials has also shown this effect.

1. INTRODUCTION

1.1 Overview of the First Flush Phenomenon

The "**first flush**" phenomenon is generally assumed for rainfall events, and can be described as a concentration first flush or a mass first flush. A concentration first flush occurs when the first runoff has high concentration relative to runoff later in the storm event. A mass first (concentration times flow rate) is flow dependent and it will occurs when both concentration and the initial runoff is high relative to mass emission rate in the later runoff. Concentration first flushes have been frequently reported, but mass first flushes have rarely been quantified. For example, most of the parameters monitored for all the events in this study had higher concentrations at the beginning of the runoff than later in the runoff. Mass first flushes were less frequently observed and with lower magnitudes. This is due to the nature of the runoff, which generally has lower flow rate at the beginning of the storm than in the middle of the storm. Therefore, the mass emission rate in the middle of the storm event may be greater than at the beginning of the storm event, in spite of lower concentrations in the middle of the storm. The concept can be applied to any particular constituent or water quality parameter. Therefore, a first flush in total organic carbon (TOC), for example, can be called a TOC first flush.

The concept of first flush can also be applied to a rainfall season. In California and many other areas of the world, rainfall occurs over distinct periods. For example, the bulk of the rainfall in Los Angeles occurs from approximately November to March, with the months of January and February usually having the greatest rainfall. The long dry period from April or May to October allows contaminants to build up. The first large rainfall of the season, occurring any time from October to January, generally mobilizes the built-up contaminants, creating a larger discharge. This phenomenon is called a "**seasonal first flush**."

In this report the term first flush will be used as follows:

First flush	The discharge of a larger mass or higher concentration in the early part of a storm relative to the later part of the storm. The term can be applied to any contaminant. The magnitude of the first flush will depend on site specific conditions, but the term first flush is applicable.
Seasonal first flush	The discharge of a larger mass or higher concentration of the first storm or first few storms of a rainy season, relative to storms later in the season.

Both terms can be applied to any water quality parameter and constituents such as metals, litter, particles, toxicity, turbidity, etc. and both terms can be used to describe a mass first flush or a concentration first flush. The modifiers of the terms indicate if it is a mass or a concentration.

Various ways have been previously proposed to quantify mass first flush, and absolute quantitative definitions have been offered. An early definition offered by Bertrand-Krajewski *et al.* (1998) is typical and suggested the existence of a first flush if 80% of the pollutant mass is emitted in the first 30% of the runoff. Other definitions and observations have been offered, and will be discussed in greater detail later (Thornton and Saul, 1987; Geiger, 1987; Vorreiter and Hickey, 1994; Saget *et al*, 1995; Gupta and Saul, 1996; Sansalone and Buchberger, 1997; Larsen *et al*., 1998; Sansalone *et al*., 1998; Deletic, 1998). They all in some way suggest a higher pollutant mass emission rate in the early part of the storm than in the later part, and the early part is generally considered the first 20 to 40% of the runoff volume. In this report and in earlier papers (see Bibliography at the end of this report, which lists our previously submitted or published reports and papers), we have proposed a mass first flush ratio or MFF, which quantitatively describes the mass first flush and is sufficiently broad to apply to any initial portion of the storm.

It is possible to have a concentration seasonal first flush as well as a mass seasonal first flush. The techniques used to describe a mass first flush can also be used to describe a mass seasonal first flush. Occasionally, when investigators are describing both the first flush of a single storm and an entire season, they may use the term "**storm first flush**" to emphasize that the first flush is for a single storm event. In this study, he term "storm first flush" is not used. The term first flush always refers to a single storm event and seasonal first flush will always be used for an entire season.

Evidence collected in this study, combined with other datasets from Southern California, have provided the first quantitative demonstration of a seasonal first flush. The existence of a seasonal first flush presents opportunities and challenges stormwater management.

The presence of a mass first flush depends on a number of factors, which will be discussed in greater detail throughout the report. Often one sees or reads of an investigator describing a very large watershed, and noting that a first flush was not observed. Such conclusions are naïve, because in a large watershed, stormwater must be transported a great distance to a single discharge point, or mouth of the watershed. Therefore, the time of travel of the runoff from various places in the watershed to the monitoring point is different (time of travel is the elapsed time for a quantity of stormwater to flow from the point of generation to the monitoring point). In this case, the first flush from each small area in the watershed arrives at the mouth of the watershed at different times, which mixes the smaller first flushes of each area into a broad discharge pattern. Therefore, the first flush from one area is mixed with runoff from other areas that occurred much later in the storm.

The definition of large watershed for this context is a function of the time of travel. The first flush of pollutants observed in this study was generally within the first few minutes to the first hour after detecting observable runoff. First flushes are much less likely to occur in large watersheds.

The imperviousness of the watershed or catchment area also affects the first flush. Highly impervious surfaces create high velocities that easily transport solids or scour contaminants from surfaces, and runoff occurs almost immediately at the beginning of rainfall. Previous work performed in our laboratory (Lau *et al*, 1998), evaluated Ballona Creek and Malibu Creek during rainfall events. Flow appeared in the Ballona Creek watershed (~70% impervious) 10 to 15 minutes after the beginning of measurable rainfall. The same rainfall did not produce additional runoff in Malibu Creek until 10 to 12 hours after the beginning of measurable rainfall. The quickly occurring runoff, or short time of travel provided by highly impervious watersheds, provides more opportunity for first flushes.

The bulk of our efforts have been devoted to estimating the mass first flush of highway emissions, with the objective of proposing methods to improve the effectiveness of best management practices (BMPs) that take advantage of the first flush. Highways catchments are landuses that are likely to have a first flush. They are generally impervious and small. Our three sites, which were picked in 1998 as "typical" of for the Department's sites, are 0.6 to 1.6 hectares and are more than 95% impervious. Runoff appears only a few minutes after measurable rainfall. The nature of the Department's sites, and by implication many sites for other state departments of transportation (DOT), may provide an excellent opportunity for improved stormwater management at reduced cost because of the likelihood of first flushes.

A BMP that takes advantage of the first flush is sometimes called "first flush friendly" and an example of such a BMP is an infiltration/sedimentation basin. An infiltration/sedimentation basin could be operated in one of two ways: it could be operated as a flow through device, which would remove some portion of the contaminants such as suspended solids, throughout a storm event. For large storms, over the design frequency of the basin, some portion of the flow rate would be bypassed, or the basin would operate at high flow rate and reduced efficiency. An alternative way of operating the basin is to fill the basin with the first runoff, and bypass the remaining runoff. The second strategy provides greater opportunity the small particles to settle, and will be a superior strategy if there is a significant mass first flush. The definition of "significant" will depend on site-specific issues, which we will address later in the report.

Our findings suggest that for most pollutants, the second strategy is preferable. Generally, 30 to 50% of the pollutants in highway runoff from a single storm event are contained in the first 10 to 20% of the runoff volume. This can mean that treating the first 20% of the flow can treat 50% of the pollutants. Conversely, uniformly treating 20% of the flow during the entire storm would treat only 20% of the mass. The ratio of mass treated to volume treated in the first case is 2.5 and in the second case is 1.0. Generally, the cost of managing stormwater is more related to the volume than the concentration, which means that the first strategy will be much more cost effective than the second strategy. Also, emerging information collected by others (Strecker et al. 2001) and our laboratory (Lau and Stenstrom, 2002) shows that BMPs are generally more effective in treating higher concentrations than lower concentrations (i.e., the removal efficiency of a catch basin insert or a sedimentation basin may be close to zero at low concentrations, and as high as 70% or more at high concentrations). Therefore, applying BMPs to the first runoff, when the concentrations are higher, will be a more effective strategy for two reasons: 1) the most contaminated runoff is being treated, and if there is bypassing it will be less contaminated runoff that occurs later in the storm, and 2) the BMPs are likely to have higher removal efficiencies treating the more contaminated runoff.

The first flush or seasonal first flush can represent an opportunity to achieve higher pollutant reductions at lower cost or effort. For example, the Department has been required to remove litter from highway catch basins at the end of the summer. The seasonal first flush presents an opportunity to remove six to nine months of litter buildup in a single cleaning. If a seasonal first flush did not exist, the monthly cleanings might be needed to remove the same mass of litter.

1.2 Focus of the Report

This report describes the results of an extensive study to characterize and quantify the first flush of highway pollutants from three sites near UCLA, and to report on data collected by two consultants funded by the Department at other sites in District 7. The study was conducted over four years and includes storms monitored from 1999 to 2003, or four wet seasons.

1.3 Report Organization

This report is organized to be brief yet comprehensive. It is complemented by a CD that includes all data and graphical representations in PDF format.

The report is organized in chapters. The introduction chapter summaries the important concepts to be realized by taking advantage of the first flush in highway stormwater management, focus of the report and the report organization. Chapter 2 describes methodology and summarizes analytical methods and sampling strategies. Chapter 3 summaries the water quality results, providing summaries, such as the event mean concentrations (EMCs), for the various parameters. Chapter 4 presents the first flush results and discussion in the following order: meaningful definition of first flush for practical implication, organic (PAH) first flush, litter first flush, particle first flush and seasonal first flush. Chapter 5 presents additional topics related to first flush that include: preliminary treatment evaluation strategy with respect to first flush pollutant loads, a new method to monitor oil and grease, and sampling issue-composite versus grab sampling. Chapter 6 summarizes the information presented in chapter 4 and 5. Full results are compiled in a CD as summary tables and graphs and presented in Appendices A through K.

A series of technical memorandums are also included in the appendix. The technical memorandums were issued to the Department much earlier than the final report and were designed to provide early availability of the results. A bibliography of the papers presented at conferences and submitted or published in journals is listed at the end of this report. The technical memorandums along with technical papers provide greater detail or more explanation than contained in the final report, which allows a more readable, compact final report. The main report includes only the most important parts of the technical memorandums and technical papers.

2. METHODOLOGIES

2.1 Description of Monitoring Sites

Three monitoring stations were used for the UCLA-sampled first flush studies. They were selected by the Department in 1999, based on five major criteria: clearly defined runoff area, personnel safety, proximity to UCLA, representativeness and access to the flow stream. Table 2.1 summarizes the site characteristics. Initially the sites were labeled by the Department as UCLA 1, 2 and 3. Later the Department assigned numbers to the sites as 7-201, 7-202, and 7-203. Some of the early reports and publications use the "UCLA-n" designation, and later reports and publications use the "7-20n" designation.

Figure 1 shows the location of the sites. The sub-watersheds are delineated by bold blue lines. Red lines show major freeways. The light blue object north of Site 1 is the Sepulveda Dam flood protection area. It is close to Site 1, but is hydraulically separated from the site. The travel time travel by automobile to the sites from ULCA via freeways is usually less than 15 minutes, but can be more during high traffic conditions. Additionally, the sites can be reached in about the same time via surface streets. Easy and quick site access was important in order to reach the sites quickly to catch the first flush

Monitoring site 7-201 was located near the intersection of the US 101 and IS 405 Freeways, on the south side of US 101. The site was accessible from a service road, which was reached from the Haskell exit of the northbound US 101 Freeway. The Department's right-of-way was protected by a chain link fence, and a gate was ideally located for entry. This site has several 20-inch diameter corrugated drainage pipes and they all have lengthy straight sections to facilitate flow measurement. The freeway is elevated at this point with sound walls. No other drainage can enter the site. There is a free waterfall as the stormwater exits the pipe to facilitate sampling.

Monitoring site 7-202 was located near the IS 405 Freeway and the Getty Center exit, on the east side of the freeway. The site was accessible from a public park and the Department's right-of-way was unobstructed. Drainage was through a 24-inch diameter corrugated drainage pipe. The site has a single stormwater inlet with several grates, along the east shoulder. There are no sound walls, and a hill exists on the east side of the shoulder. In heavy rainfall events, it is possible for runoff from the hill to reach the shoulder and the Department's inlet. Analysis of runoff rates suggests that this rarely happened. Sampling was also possible at a free waterfall.

Monitoring site 7-203 was located on the east side of the IS 405 Freeway just south of the point where it passes over Santa Monica Boulevard. This site was constructed as a monitoring site previously by the Department. It has a 24-inch diameter plastic corrugated pipe (smooth on the inside, corrugated on the outside) which collects runoff from the northbound, east side of the freeway. The curb was opened to collect runoff from the shoulder, and no runoff can enter the site in any other way, including the freeway and shoulder south of the site. It has no sound walls. It has AC power and a small house (approximately 2.5 square with a pitched roof approximately 3 ft high in the center) to hold an automatic sampler. The small house was reused to contain the composite sampler after the first year of our study. As the runoff exits the pipe there is a gap of 20 cm, which creates a free waterfall for sampling.

Table 2.1 Summary description of UCLA monitoring stations

Site characteristics/ parameter	**Monitoring Site**		
	7-201	**7-202**	**7-203**
Freeway/postmile	US 101 PM 17	IS 405 PM 34.8	IS 405 PM 30.8
Location	Eastbound US 101	IS 405 Freeway and Sepulveda	North Bound IS 405 and Santa Monica Blvd.
Drainage area (m^2)	12802	16918	3917
Freeway type	Grade	Fill	Cut
Annual average daily traffic	328,000	260,000	322,000
Longitude	34.16	34.10	34.05
Latitude	-118.48	-118.48	-118.44

All three sites were virtually 100 percent impervious, and the runoff coefficient was usually 0.9 to 0.95. Each site was equipped in the first year with an American Sigma rain gage and flow meter. The flow meter recorded flow and rainfall in one-minute intervals. In the second year a composite sampler was added to each site and it was also an American Sigma device. Data from each site was downloaded into a laptop, Windows-based computer after the end of each storm.

The three sites were also used for litter collection during the second and third years of the study. Litter bags, with 6 mm octagonal openings were attached to the corrugated pipes. An aluminum collar fabricated in the UCLA shops was used for Sites 1 and 2. The collar clamped to the outside of the corrugated pipes, and had an opening at the top that allowed the sampling team access to the free waterfall with a scope. Figures 2.2, 2.3 and 2.4 show several pictures of the sites.

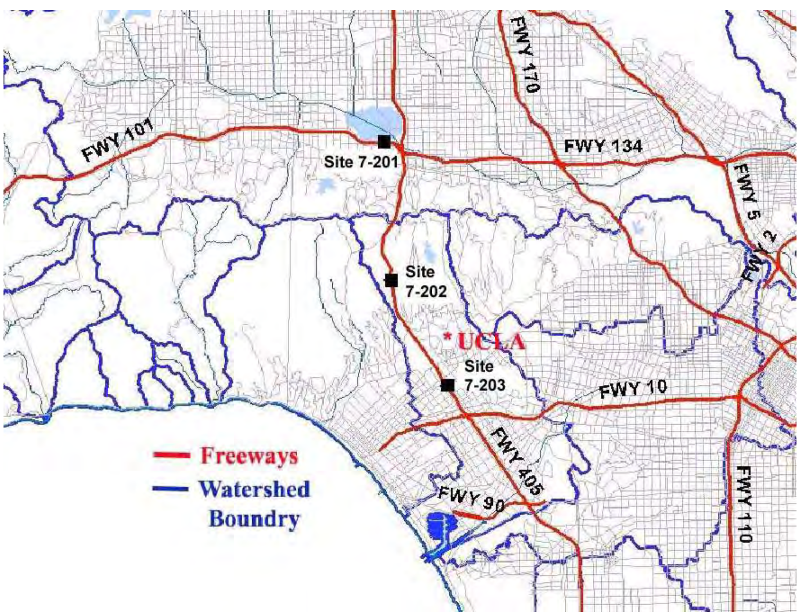


Figure 2.1 Locations of UCLA Sites 1 to 3 (Department's designation 7-201, 7-202, 7-203)

Figure 2.2 Pictures of Site 1, clockwise from the top: **1)** site from a distance of 30 meters; **2)** drainage pipe showing free waterfall and cables for level and velocity sensors, and **3)** rain gage above the sound wall.

Figure 2.3 Pictures of Site 2, clockwise from the top: **1)** site from a distance of 15 meters, showing rain gage, rain protection enclosure, PVC pipe for cables. The discharge is obscured by the brush; **2)** drainage pipe showing free waterfall and PVC pipe for cables for level and velocity sensors, and **3)** freeway looking north showing the four inlet grates.

Figure 2.4 Pictures of Site 3, clockwise from the top: 1) site from a distance of 50 meters, looking north, showing drainage pipe (an early picture, taken before our study) 2) drainage pipe showing rain gage and dry/wet collection containers from an earlier study. The free water fall is at the end of the black pipe, and 3) site entrance from shoulder, looking south.

The sites were maintained by the Department during the study. Maintenance was coordinated with District 7 personnel and occasionally the UCLA team had to perform brush removal. Site 3 shows additional equipment for dry and wet deposition sampling, but was not part of our study. It was especially important at Site 3 to contain the overhead growth, to prevent interference with the rain gage.

2.2 Sampling Strategies

Weather forecasting was an important aspect of the sampling. It was necessary to obtain the most reliable forecast in order to avoid time consuming and frustrating mobilizations for storms that did not occur, as well as making sure that the teams were prepared for the real events. A variety of forecasting methods were used. The long term (3 to 5 day) forecasts by the US Weather Service (USWS) were useful to prepare the teams for upcoming events, in order to check the equipment and replace batteries. UCLA's Department of Atmospheric Sciences also provided useful forecasts. When USWS forecast suggested that a storm probability was greater than 50%, the sampling teams were mobilized to each sampling site, to within 5 to 10 minutes travel time to each site. After some practice, USWS Doppler radar was useful in predicting the beginning of rainfall. Approximately 80% of the storms approached the sampling sites from the north west (i.e., Santa Barbara) and active rainfall could be observed as it traveled to the sites. Storms that came from a southerly direction (i.e., Santa Catalina Island) were less predictable.

Detecting the first flush required grab samples to be collected throughout the storm but especially in the early runoff period. Grab samples can be collected manually or can be collected with automated samplers having multiple bottles. Multi-bottle samplers were not available and manual sampling was used. The manual sampling also provided greater flexibility, allowing larger sample volumes to be collected as well as special samples using different bottles. The sampling strategy was perfected in the first year and a consistent protocol was used in the second and later years. Automatic flow-weighted composite samplers were also added in the second year.

In the first year (1999-2000), five grab samples were collected in the first hour of runoff followed by two or three grab samples collected in the following two to three hours, which were combined to create a composite sample. This strategy adequately characterized the initial runoff but was inadequate to characterize later runoff, and especially for long storms with a lengthy period of light rainfall. The mass contribution of the runoff late in the storm was significant compared to the mass in the early runoff.

In the second year, five grab samples were again collected in the first hour, followed by one grab sample per hour for the next 7 hours, providing a total of 12 grab samples. For storms lasting less than 8 hours, fewer grab samples were collected. For storms lasting longer than 8 hours, an additional one or two grab samples were collected in the period from 8 hours to the end of the storm. In the first year, all samples were analyzed. In later years, storms that were sampled but were too short to produce a sufficient number of samples to create pollutographs were not analyzed.

The highly impervious nature of the sites created runoff soon after the beginning of rainfall. Even though the time of travel from UCLA to the sites was short, it was still necessary to mobilize the sampling teams before the beginning of rainfall in order to collect the first runoff. Three teams of two people each were used in the early part of the storm when more frequent sampling occurred. After the first few hours of the storm event, the sample team was reduced to one or two teams and the other team members worked in the laboratory on analytical methods.

The sampling teams generally arrived at the sampling site prior to the start of the storm event. Sampling began as soon as the flow was observed at the collection point, or if runoff had already begun, as soon the teams arrived.

Runoff samples were collected from the storm drain outfall (or drain pipe) using a polypropylene scoop, and then transferred to 4-L amber glass bottles. In all cases samples were collected from a free waterfall. The bottles were then transported to the laboratory at UCLA immediately after collection and refrigerated at 4°C until analyzed. Generally the first five bottles were transported to the laboratory after the first hour, and one or two more trips were made as the storm progressed. Returning samples to the laboratory at frequent intervals was not particularly burdensome, because of its close proximity and because the team wanted to get out of the rain and warm up in the hour between samples. The time between the sample collection and receipt of samples at UCLA laboratory was less than 4 hours. This became important in the last year of the study, when particle size distribution (PSD) was being measured. Changes in the PSD were observable after 10 to 12 hours of storage. Therefore a holding time of 6 hours was established for particle size distribution analysis.

Samples were collected in 4-L amber glass bottles. The bottles were prewashed and kept in the laboratory cold room prior to the storm. As soon as samples arrived at the laboratory they were mixed and divided into sub samples for different analysis. In the first three years of the study, the most time-critical analysis was filtration for metals analysis, which must be completed within 24-hours of sample collection. Later the particle size distribution became the most time-critical analysis, which needed to be preformed within six hours of sample collection. Additional sample were collected for particle size analysis, depending on the types of analysis being performed, which is described in more detail later in the report.

In the second and third year of the study, litter samples were collected, using a large, reusable bag with 6-mm openings. The draw-string bag was placed over discharge of each pipe to capture the entire flow, but still allowed the grab samples to be collected from a free water fall. Three bags were collected for each site for each storm. The first bag was installed before the beginning of the storm, and removed after 1 hour of runoff. A second bag was then installed and was removed after 8 hours or the cessation of grab sample collection. The third bag was installed and was left in place until the next day, well after the end of the storm. It was retrieved and all bags for all sites were transported to an outside lab under contract with the Department for performing the litter analysis. The bags were cleaned and reused.

Autosamplers (Sigma 900MAX, American Sigma) were installed at all three monitoring locations prior to the second storm season (2000-2001) begins. Flow-weighted composite samples was collected and analyzed for the same suite of contaminants, except oil and grease.

2.3 Constituents and Analytical Methods

The water quality parameters were selected based on the Department's Storm Water Monitoring Protocols (California Department of Transportation, 2000a), in compliance with the NPDES permits. Table 2.2 shows the selected water quality parameters and their corresponding analytical methods. All analyses were performed as soon as the samples were collected, and within the recommended holding time. All analyses were performed in the UCLA Water Quality Laboratory, except for metals analysis. The metal samples were filtered and digested at UCLA, but the final analysis was done using an ICP/AE instrument at the Castaic Water Laboratory (a State certified laboratory).

Polynuclear aromatic hydrocarbons (PAHs) were also monitored, but not as routinely as the other constituents. Both dissolved and particulate bounded PAHs were analyzed according to US EPA Methods (SW-846, 1999): Method 3535 was used for dissolved PAHs and Method 3546 was used for particulate-bound PAHs. Both fractions were analyzed using a Finnigan 4000 Quadrapole mass-spectrometer with a Varian 3400 gas chromatograph. A splitless injector (at 290^{o}C) was used for sample injection onto a 30 m x 0.25 mm i.d. DB-5ms capillary column (J&W Scientific). The GC temperature was programmed at 30^{o}C for 4 min., 30^{o} - 300^{o} at 6^{o}C/min and 300^{o}C for 30 min. Mass spectral data were collected by using a scan range of 35 - 500 amu and a scan rate of 1 scan/s. A total of 41 PAHs were analyzed using this method.

2.4 Rainfall and Monitored Events

The number of monitored events was impacted distribution of rainfall. Figure 2.5 shows the rainfall that occurred during the four years and compares the total for each year. The vertical bars show the monthly rainfall. It is clear that the majority of the rainfall usually occurs in January and February, and almost no rainfall occurs between May and October. This rainfall pattern is associated with Mediterranean climates, and will be important in analyzing the seasonal first flush noted earlier. Based upon the amounts of rainfall that occurred each year, year 1 (1999-2000) was an average year. Years 2 and 4 (2000-2001 and 2002-2003) were wet years. Year 3 (2001-2002) was an extremely dry year. The study years followed the general monthly trends, although 2002-2003 had no rainfall in January and more than average rainfall in March.

Figure 2.6 shows the rainfall arranged as a probability plot. The 50% probability storm for the UCLA sites was 18 mm. The largest single storm was over 100 mm.

Table 2.2 Constituents monitored

Parameters	Units	Reporting Limits	Analytical Method	Holding Time and Preservation
Conventionals				
Total suspended solids	mg/L	2	EPA[1] 160.2	7 days; refrigerated at 4°C
Turbidity	NTU	1	EPA 150.1	48 hours; refrigerated at 4°C
Conductivity	μmho/cm	1	EPA 180.1	28 days; refrigerated at 4°C
pH	pH	0.01	EPA 120.1	Analyze immediately
Hardness	mg/L as $CaCO_3$	2	EPA 130.2	6 months; acidify with HNO_3 to pH < 2
Chemical oxygen demand	mg/L	2	EPA 410.0	Analyze as soon as possible
Dissolved organic carbon	mg C/L	1	EPA 415.1	7 days; acidify to pH <2 with H_3PO_4
Nutrients				
Ammonia[2]	mg /L	0.01	EPA 350.3	Analyze as soon as possible
Nitrite[2]	mg /L	0.01	EPA 354.1	48 hours; refrigerated at 4°C
Nitrate[2]	mg /L	0.1	EPA 300.0	48 hours; refrigerated at 4°C
Total Kjeldahl Nitrogen[2]	mg /L	0.1	EPA 351.4	7 days; refrigerated at 4°C, acidify to pH <2 with H_2SO_4
Ortho-Phosphate[3]	mg /L	0.1	EPA 300.0	48 hours; refrigerated at 4°C
Phosphorus (Dissolved and Total)[3]	mg /L	0.03	EPA 200.7	48 hours; refrigerated at 4°C
Organics				
Particulate PAHs	μg/L	1–5 x 10^{-3}	EPA 3535	7 days; refrigerated at 4°C
Dissolved PAHs	μg/L	1–5 x 10^{-3}	EPA 3546	7 days; refrigerated at 4°C
Oil and grease	mg/L	1	C18 SPE[4]	28 days; acidify to pH < 2 with HCl
Metals (dissolved and total)			EPA 200.7	Filter immediately, acidity to pH < 2 with HNO_3
Cadmium, chromium, nickel, zinc	μg/L	1		
Copper		3		
Lead		5		
Microbiological				
Total coliform	MPN/100 ml	2	SM[5] B9221	24 hours
Fecal coliform	MPN/100 ml	2	SM C9221	24 hours

EPA Methods and Guidance for Analysis of Water (USEPA, 1999)
[2] Reported as mg nitrogen per liter
[3] Reported as mg phosphorus per liter
[4] Lau and Stenstrom (1997)
[5] Standard Methods (1999)

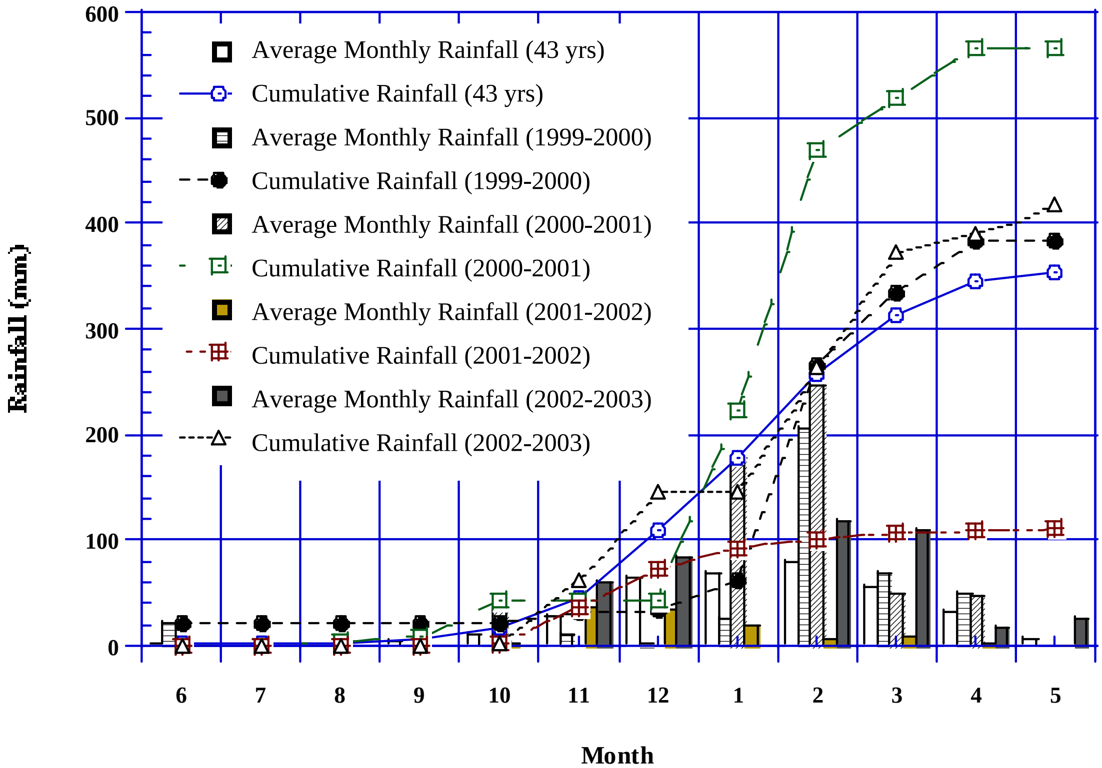


Figure 2.5 Rainfall during the study.

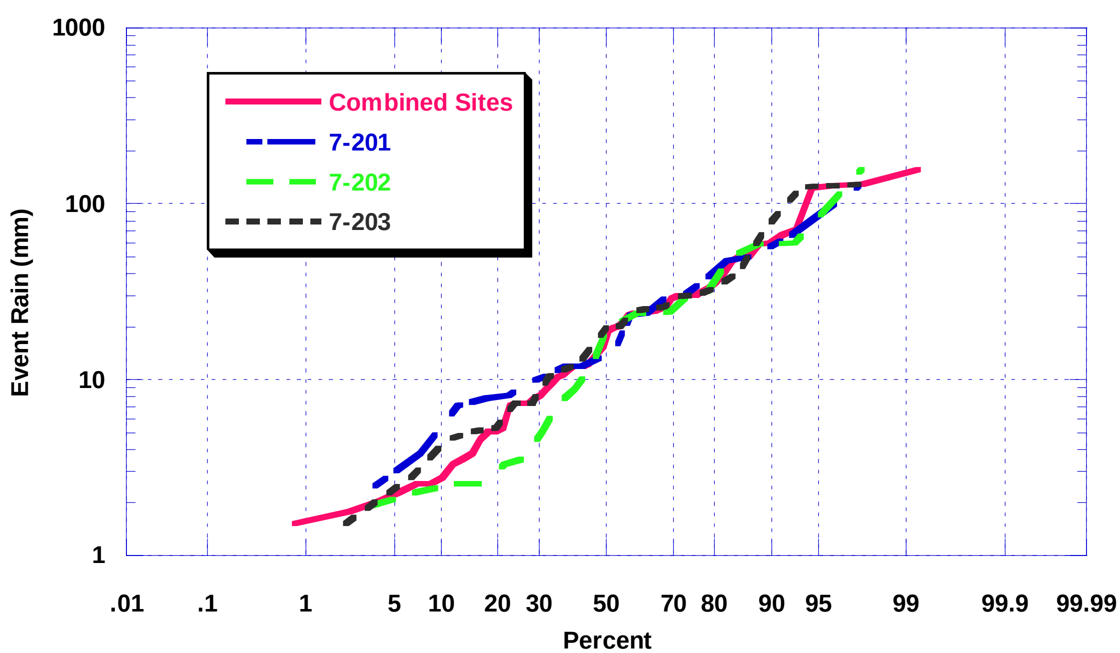


Figure 2.6 Rainfall probabilities for all three sites.

Tables 2.3 to 2.7 show the monitored storm events for each year. Generally, all large storm events were monitored. Storm events that followed an earlier storm within 24 to 36 hours were generally not monitored. A special effort was made to insure that the first storm of each rainy season was monitored. Appendix A shows the sampled event parameters in greater detail and also includes the events sampled by the consultants in years two and three.

Table 2.3 Basic statistics of storm events

Site		Total Rainfall (mm)	Max. Intensity (mm/hr)	Antecedent Dry Day	Storm Duration (hr)	Ave. Rainfall Intensity (mm/hr)
7-201	No. of storm events	30	29	30	30	30
	Min. / Max.	1.3 / 127.0	3.0 / 51.8	1.0 / 69.4	2.0 / 47.5	0.1 / 10.7
	Median / Mean	13.8 / 25.0	12.2 / 18.4	11.7 / 15.6	10.1 /12.1	1.7 / 2.6
	Standard Dev.	28.3	17.0	16.0	11.2	2.6
7-202	No. of storm events	32	32	32	32	32
	Min. / Max.	1.8 / 156.0	3.0 / 61.0	1.0 / 192.2	0.5 / 46.5	0.2 / 11.3
	Median / Mean	20.2 / 26.4	12.2 / 18.9	12.6 / 22.3	8.2 / 10.9	2.1 / 3.0
	Standard Dev.	32.0	18.4	34.8	11.1	2.9
7-203	No. of storm events	35	33	34	35	35
	Min. / Max.	0.5 / 128.5	3.0 / 51.8	0.3 / 192.3	1.4 / 52.2	0.1 / 8.9
	Median / Mean	15.5 / 25.1	21.3 / 21.1	11.7 / 21.9	7.3 / 10.6	2.2 / 2.8
	Standard Dev.	30.3	12.8	34.1	11.1	2.3
Combined sites	No. of storm events	97	94	96	97	97
	Min. / Max.	0.5 / 156.0	3.0 / 82.3	0.3 / 192.3	0.5 / 52.2	0.1 / 11.3
	Median / Mean	15.5 / 25.5	15.2 / 19.5	11.7 / 20.1	8.6 / 11.2	2.0 / 2.8
	Standard Dev.	30.0	16.1	29.8	11.0	2.6

Table 2.4 Events sampled in Year 1 (1999-2000)

Site ID	Date	Event Rain (mm)	Max. Intensity (mm/hr)	Antecedent Dry (days)	Peak Flow (L/s)	Cumulative Precipitation (mm)
7-201	01/17/00	1.27	3.05	17	0.32	1.27
	01/25/00	17.02	6.10	8	16.84	18.29
	01/30/00	2.54	3.05	5	1.14	20.83
	02/10/00	7.37	12.19	10	15.71	28.19
	02/11/00	18.54	15.24	1	46.37	46.74
	02/20/00	90.68	51.82	4	139.49	137.41
	02/27/00	3.30	6.10	4	6.18	140.72
	03/05/00	45.72	-	2	11.89	186.44
	03/08/00	17.78	12.19	2	22.21	204.22
	04/17/00	13.21	12.19	40	16.99	217.42
7-202	11/20/99	1.78	15.24	12	5.86	1.78
	01/17/00	1.78	3.05	17	0.32	3.56
	01/25/00	25.15	6.10	8	16.84	28.70
	01/30/00	12.70	6.10	5	1.14	41.40
	02/10/00	11.68	12.19	10	15.71	53.09
	02/11/00	25.15	24.38	1	46.37	78.23
	02/20/00	92.46	82.30	4	139.49	170.69
	02/27/00	7.37	15.24	4	6.18	178.05
	03/05/00	50.80	36.58	2	15.52	228.85
	03/08/00	23.37	12.19	2	22.21	252.22
	04/17/00	44.45	27.43	40	66.62	296.67
7-203	11/08/99	1.27	-	-	0.28	1.27
	12/31/99	0.51	-	41	0.28	2.54
	01/17/00	1.52	3.05	17	0.85	4.06
	01/25/00	18.29	6.10	8	16.99	22.35
	01/30/00	13.46	6.10	5	14.16	35.81
	02/10/00	14.99	24.38	10	15.57	50.80
	02/12/00	21.08	24.38	2	14.16	71.88
	02/20/00	58.93	45.72	4	24.92	169.67
	02/27/00	10.16	12.19	4	5.66	210.57
	03/04/00	5.84	24.38	6	11.33	216.41
	03/08/00	18.80	12.19	2	2.27	276.10
	04/17/00	56.39	51.82	40	19.82	332.49

Table 2.5 Events sampled in Year 2 (2000-2001)

Site ID	Date	Event Rain (mm)	Max. Intensity (mm/hr)	Antecedent Dry (days)	Peak Flow (L/s)	Cumulative Precipitation (mm)
7-201	10/26/00	23.88	9.14	33.63	27.13	32.51
	01/08/01	3.81	3.05	69.39	12.15	52.83
	01/10/01	127.00	51.82	1.98	63.12	179.83
	02/10/01	13.21	21.34	14.20	22.96	239.27
	02/19/01	7.11	6.10	5.36	8.52	375.16
	02/24/01	14.48	6.10	0.97	5.01	391.67
	03/04/01	11.94	6.10	4.02	10.39	473.20
	04/20/01	8.13	12.19	13.17	9.97	552.45
7-202	10/26/00	23.88	9.14	33.63	11.75	32.51
	01/08/01	5.08	3.05	69.39	4.62	54.10
	01/10/01	155.96	60.96	1.94	36.08	210.06
	02/19/01	23.88	15.24	4.84	17.08	375.41
	02/24/01	19.05	6.10	0.99	9.37	396.49
	03/04/01	8.89	12.19	4.02	18.41	474.98
	04/06/01	30.23	12.19	31.13	38.62	542.80
7-203	10/26/00	25.91	30.48	33.58	7.26	34.54
	01/08/01	5.33	6.10	69.36	5.80	56.39
	01/10/01	128.52	36.58	1.96	21.58	184.91
	02/10/01	15.49	21.34	14.21	11.41	246.63
	02/19/01	30.23	21.34	5.33	20.73	405.64
	02/24/01	11.43	9.14	0.99	3.34	419.10
	03/04/01	5.08	6.10	4.02	3.28	493.78
	04/06/01	25.40	21.34	31.57	9.88	556.77

Table 2.6 Events sampled in Year 3 (2001-2002)

Site ID	Date	Event Rain (mm)	Max. Intensity (mm/hr)	Antecedent Dry (days)	Peak Flow (L/s)	Cumulative Precipitation (mm)
7-201	11/12/01	7.87	3.05	11.90	68.44	9.40
	11/24/01	47.24	51.82	11.64	75.67	56.64
	12/20/01	10.67	21.34	6.26	24.65	68.33
	01/27/02	11.94	6.10	27.13	11.18	80.26
	02/17/02	2.03	3.05	20.38	4.71	82.30
7-202	10/30/01	3.30	6.10	192.20	14.25	3.30
	11/12/01	11.94	33.53	13.10	82.37	15.24
	11/24/01	50.29	51.82	11.69	123.97	65.53
	12/14/01	3.56	12.19	19.77	34.73	69.09
	01/27/02	31.75	15.24	27.13	30.27	123.44
	02/17/02	7.37	6.10	20.27	13.20	130.81
	03/06/02	2.54	3.05	17.61	3.91	133.35
	03/17/02	2.29	6.10	10.66	13.26	135.64
7-203	10/30/01	2.79	6.10	192.30	4.79	2.79
	11/12/01	7.37	27.43	13.10	12.88	10.16
	11/24/01	29.72	39.62	11.69	17.58	39.88
	12/20/01	12.19	33.53	6.31	13.88	54.10
	01/27/02	24.64	24.38	27.14	10.20	78.74
	02/17/02	7.37	9.14	20.31	9.80	86.11
	03/07/02	4.57	12.19	17.39	6.04	90.68
	03/17/02	10.41	24.38	10.60	16.40	101.09

Table 2.7 Events sampled in Year 4 (2002-2003)

Site ID	Date	Event Rain (mm)	Max. Intensity (mm/hr)	Antecedent Dry (days)	Peak Flow (L/s)	Cumulative Precipitation (mm)
7-201	11/07/02	28.96	12.19	40.13	21.10	30.23
	11/29/02	9.65	39.62	20.23	29.36	39.88
	12/16/02	29.72	18.29	16.43	49.41	76.45
	12/19/02	36.07	24.38	3.25	69.69	112.01
	02/11/03	23.37	18.29	44.27	24.95	146.81
	03/15/03	66.55	45.72	11.68	88.09	445.77
	05/02/03	50.29	51.82	18.10	77.84	495.81
7-202	11/07/02	58.67	18.29	41.21	109.44	58.42
	11/29/02	1.78	6.10	19.97	10.79	60.20
	12/15/02	2.54	6.10	16.21	18.86	62.23
	12/16/02	59.94	42.67	1.21	154.61	121.16
	02/11/03	24.38	15.24	44.26	37.99	204.72
	04/14/03	21.34	21.34	27.85	137.79	475.24
7-203	11/07/02	71.37	15.24	40.16	15.80	72.64
	11/29/02	1.52	6.10	19.96	0.93	74.17
	12/16/02	40.64	30.48	0.27	57.57	117.86
	12/19/02	32.51	18.29	3.09	25.06	151.13
	02/10/03	20.07	15.24	44.12	19.44	182.63
	03/15/03	123.19	39.62	11.68	48.32	538.48
	04/12/03	19.81	30.48	27.85	39.79	558.29

3. WATER QUALITY RESULTS

The large body of data collected over the four years to quantify the first flush has utility to describe the various parameters associated with highway runoff. To the best of the authors' knowledge, these three sites may have been more extensively monitored for a larger variety of parameters than any other highway sites. Since many of the site specific parameters for the three sites are similar (e.g., rainfall, average daily traffic, location, etc.) the pooled data represents an even larger data resource.

The parameters were monitored in two ways after the first year of the study: using a series of grab samples, and automatically sampled, flow-weighted composite samples. A flow weighted composite sample can be calculated from a series of grabs if the flow rates were simultaneously measured. The flow weighted composite sample, whether collected by an automated instrument or calculated from a series of grab samples, is called an event mean concentration or EMC. There are several procedures, and in Chapter 4 we describe some of the benefits of the various approaches. Before we present the EMCs of water quality parameters, we will show a proper method to compute the EMC from grab samples.

3.1 Computation of Event Mean Concentrations (EMCs)

Mathematically, EMCs can be defined as total pollutant mass (*M*) discharged during an event divided by total volume (*V*) discharge of the storm event.

$$EMC = \frac{M}{V} = \frac{\int C(t)Q(t)dt}{\int Q(t)dt} \tag{3.1}$$

In equation 3.1, *C(t)* is a smooth real-valued function of time that represents the pollutant concentration curve, and *Q(t)* is also a smooth real-valued function of time that represents the stormwater flow rate curve. However, in practice, the integrals are not by the functions of *Q(t)* and *C(t)* but approximations created by discrete measurements of *Q(t)* and *C(t)*. If we assume we measure the concentration and the flow rate based on equal time-interval in a storm event, the EMC can be estimated as

$$EMC = \frac{\sum_i c_i q_i}{\sum_i q_i} \tag{3.2}$$

where q_i and c_i are the measurements for the discharge rate and pollutant concentration in the i^{th} interval. From the point of view of approximating the continuous functions in equation 3.1, the more measurements we take, the more accurate approximation we can obtain by equation 3.2. When we view the measurements of the flow rate as the weights, equation 3.2 becomes the discharge-weighted average throughout the storm event, as follows:

$$EMC = \sum_i w_i c_i \tag{3.3}$$

$$w_i = \frac{q_i}{\sum_i q_i} \tag{3.4}$$

where w_i is the flow weight, and $\sum_{i=1}^{n} w_i = 1$. In practice, one common situation is the number of concentration measurements does not match the number of flow measurements. Generally there are many fewer concentration measurements, because concentration measurements are much more expensive and time consuming; flow measurements can be easily and automatically obtained by the instrument. For most situations the weights must be adjusted for each concentration measurement in equation 3.3. One of the reasonable ways to adjust the weights is to use the discharge volume. One approach (Charbeneau and Barrett, 1998) splits the discharge volume from the mid-point between two consecutive concentration measurements. Figure 3.1 shows this approach, and the adjusted weight can be written as:

$$w_i = \frac{V_i}{\sum_i V_i} \tag{3.5}$$

where V_i is the corresponding discharge volume for the i^{th} concentration measurement. This mid-discharge splitting method can also be applied for measurements at unequal time-interval bases. Alternatively, if the concentration measurements are based on constant discharge volume, the weighted average of $w_i c_i$ form is reduced to the arithmetic average. Ideally, automated samplers can collect samples in proportion to discharge volume. Additionally there are always slight errors (noise) in sample volume and pace that change the equal weights. Thus, an EMC can be calculated using a series of flow-weighted grab samples.

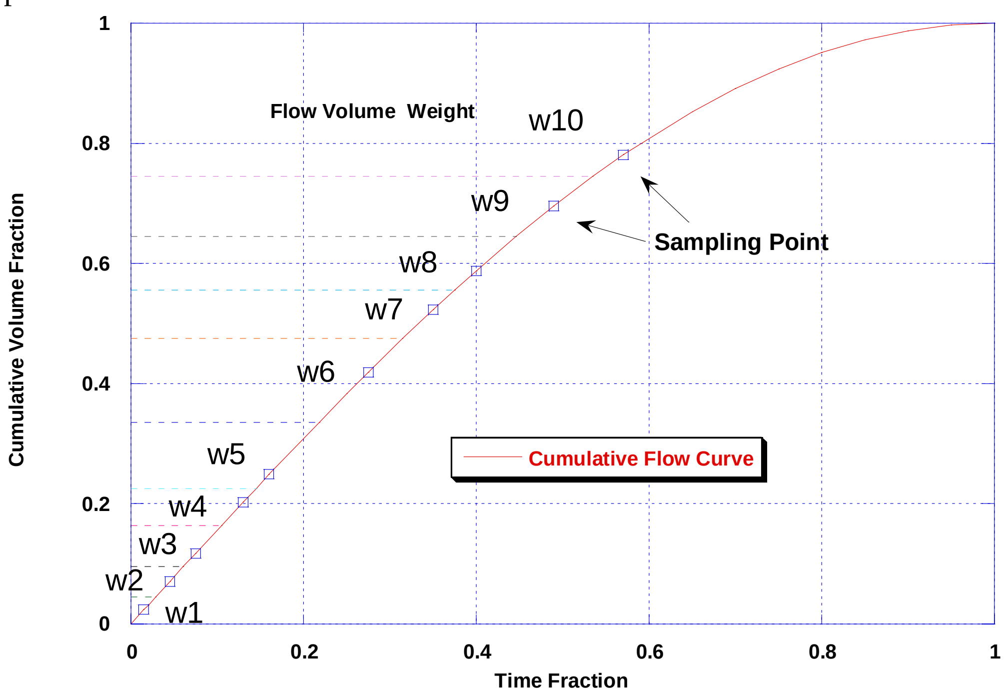


Figure 3.1 Example of flow weighing for EMC calculations.

The EMCs shown in this report were calculated from grab samples, using flow weights as described, unless noted otherwise.

3.2 EMCs of Water Quality Parameters

Table 3.1 shows the mean, median and EMCs for the pollutants measured during the four years of the study. The different estimates of the concentration are provided to show the variability. The maximum values for some values are startlingly high; for example, the maximum value of COD is 2282.8. These high numbers would have been unobserved if only automatic composite samplers had been used.

Table 3.1 Basic statistics of principal EMCs and grab samples for combined sites

Parameters	No. of cases[1]	Mean of EMCs	Median of EMCs	Mean of Grabs	Median of Grabs	Min. of EMCs	Max. of EMCs	Std. Dev. of EMCs
TSS (mg/L)	62 / 569	67.7	57.6	71.3	45.9	8.8	466.4	62.9
Turbidity (NTU)	62 / 569	46.8	33.0	52.0	31.9	10.9	170.5	39.2
Cond. (µmho/cm)	62 / 569	239.0	135.0	315.1	157.0	23.4	1991.7	302.7
Hardness (mg/L)	62 / 569	78.4	50.7	104.9	48.4	6.8	598.0	95.6
COD (mg/L)	62 / 569	252.3	119.8	321.3	138.5	19.3	2282.8	373.0
DOC (mg/L)	62 / 544	67.6	29.4	81.4	29.3	2.9	848.8	126.8
Oil & Grease (mg/L)	62 / 569	14.0	9.3	18.1	10.6	1.5	80.2	14.6
TKN (mg/L)	62 / 569	9.7	4.1	11.6	4.7	0.8	111.3	16.4
NH_3-N (mg/L)	62 / 569	4.6	1.4	5.5	1.3	0.1	65.0	9.7
NO_2-N (mg/L)	62 / 569	0.3	0.2	0.5	0.2	0.0	3.0	0.4
NO_3-N (mg/L)	62 / 552	2.7	1.2	3.2	1.5	0.0	34.7	5.3
Total P (mg/L)	43 / 564	0.9	0.4	895.8	437.1	0.1	8.2	1.6
PO_4-P (mg/L)	45 /138	0.3	0.1	653.2	355.0	0.0	2.7	0.5
Dissolved P (mg/L)	62 / 566	0.7	0.2	740.1	291.0	0.1	7.3	1.3
Total Cd (µg/L)	24 / 361	2.5	1.4	3.0	1.1	0.5	20.2	3.9
Total Cr (µg/L)	58 / 563	10.1	8.8	10.5	8.4	2.4	40.1	6.3
Total Cu (µg/L)	62 / 564	93.1	55.7	113.9	64.7	16.2	920.8	125.2
Total Ni (µg/L)	62 / 563	20.0	11.2	23.3	12.8	2.3	253.7	33.9
Total Pb (µg/L)	47 / 556	33.0	25.0	24.6	19.2	4.6	239.1	38.1
Total Zn (µg/L)	62 / 558	506.4	267.9	564.9	274.0	83.4	8881.3	1137.0
Dissolved Cd (µg/L)	43 / 299	1.3	0.5	2.4	0.8	0.5	17.8	2.7
Dissolved Cr (µg/L)	58 / 495	2.8	2.0	3.5	2.3	0.5	19.3	2.8
Dissolved Cu (µg/L)	62 / 566	65.9	35.4	85.5	39.2	5.3	735.3	103.9
Dissolved Ni (µg/L)	62 / 558	15.7	7.9	18.9	8.7	0.5	229.2	31.3
Dissolved Pb (µg/L)	47 / 392	4.9	3.6	6.0	4.1	0.5	43.5	6.5
Dissolved Zn (µg/L)	62 / 562	415.4	177.7	465.5	184.0	42.4	8150.0	1055.7

[1] Number of events / total number of grab samples

Of particular interest are the particulate forms of the metals, since they have the greatest opportunity for removal through removal of the suspended solids. Soluble metals are much more difficult to remove, requiring ion exchange, precipitation or reverse osmosis.

Table 3.2 shows the percentage of the metals that are sorbed to suspended solids. The percentage sorbed ranges from nearly zero to 100%. In general, Cd, Cr and Pb are particulate-bound and Cu, Ni and Zn are more associated with the dissolved phase.

In future projects the association between metals and particles will be further investigated. There is evidence in our study, mostly anecdotal at present, that the soluble metals are not in equilibrium and that sorption to particles is continuing well after 24 hours. Our protocol required metal samples to be filtered within 24 hours (essentially ending the sorption process), but were generally filtered in less than 12 hours. In a future project, we hope to investigate the rate of sorption and equilibrium of soluble metals during the 24 hours after sample collection. If the metals equilibrium is shifting towards the particulate phase, it is a useful finding for BMP selection, since BMPs can generally remove pollutants sorbed to suspended solids than soluble pollutants.

Table 3.2 Summary statistics for particulate-bound metals (% of total metals sorbed to solids)

		Site 1	**Site 2**	**Site 3**	**Combined**
No. of cases	Cd	130	164	150	444
	Cr	171	192	193	556
	Cu	172	192	200	564
	Ni	172	192	200	564
	Pb	163	192	200	555
	Zn	166	192	200	558
Minimum	Cd	6.9	0.0	5.0	0.0
	Cr	0.2	16.0	30.2	0.2
	Cu	0.2	2.3	2.1	0.2
	Ni	0.3	0.9	1.4	0.3
	Pb	23.2	25.3	7.5	7.5
	Zn	0.8	1.2	0.3	0.3
Median	Cd	57.2	50.0	50.0	50.0
	Cr	71.4	74.8	74.4	73.7
	Cu	26.1	42.4	25.7	31.1
	Ni	22.2	31.9	28.8	27.9
	Pb	90.8	92.5	81.7	87.6
	Zn	21.4	33.6	19.6	24.1

		Site 1	**Site 2**	**Site 3**	**Combined**
Standard Dev	Cd	27.7	33.8	30.9	31.7
	Cr	19.0	15.3	15.4	16.9
	Cu	15.7	20.6	22.8	20.8
	Ni	20.9	22.4	24.6	23.0
	Pb	18.3	15.2	18.7	17.9
	Zn	20.9	26.1	19.1	22.7
Maximum	Cd	100.0	100.0	100.0	100.0
	Cr	100.0	100.0	100.0	100.0
	Cu	91.5	84.0	85.3	91.5
	Ni	100.0	87.5	90.6	100.0
	Pb	100.0	100.0	99.5	100.0
	Zn	92.1	93.4	78.7	93.4
Mean	Cd	69.4	53.7	58.2	59.8
	Cr	66.3	73.8	73.9	71.5
	Cu	29.2	42.0	32.7	34.8
	Ni	28.2	35.4	35.3	33.2
	Pb	84.0	86.5	77.1	82.4
	Zn	27.8	36.5	25.3	29.9

Note: Site 1, 2 and 3 are 7-201, 7-202 and 7-203, respectively.

3.3 Correlation among Water Quality Parameters

The correlation among pollutants and TSS is also interesting and important. Tables 3.3 and 3.4 show the correlations. The numbers above the line are the Pearson correlation coefficient, frequently referred to as "R." Below the line are the probabilities associated with obtaining a random result with the same value of R (lower numbers indicate less likelihood of a random or artifactual finding). Generally, probabilities less than 0.05 are considered significant results.

The organic or oxygen demanding pollutants shown in Table 3.3 are particularly significant. The COD and DOC are highly correlated, suggesting that the COD is primarily composed of organic compounds, and not reduced inorganic, such as nitrite, sulfur compounds and certain metals. This is also an important correlation for an important finding described later between Oil and Grease and COD. The high correlations suggest one of two things: either the two correlated pollutants are measuring the same material, or that the sources of the pollutants are similar or release the pollutants in similar ways.

For the case of COD and DOC, the two parameters are measuring similar properties. The DOC measures the amount of organic carbon, but not its oxidation state. For COD, the tendency to react with oxygen is measured. The two are related depending on the form of the carbon. For example, methane, the most reduced form of organic carbon, has an oxygen demand weight ratio of 5.6 (e.g., 5.6 grams of oxygen are consumed for each gram of methane oxidized). For a highly oxidized form of carbon, such as carbon monoxide, the ratio is only 1.3. The high correlation between COD and DOC suggests that the oxygen-consuming pollutants are organic and have relatively consistent oxidation state.

The high correlations between different metals probably suggest similar sources. For example, metals used in manufacturing are frequently alloys, such as brass, which is an alloy of Cu, Zn and Pb. Brass particles would show all three metals in the analysis.

The poor correlation of particulate Cd and TSS shows that the sorbed Cd varies with TSS concentration. Even though the percentage sorbed is high, as shown in Table 3.2, a treatment system removing particulates would have a varying Cd removal rate. The high variability associated with Cd may be in part related to its low concentration, which is usually near the detection limits of the analytical procedures.

Table 3.3 Correlation analysis results among non-metals and TSS

Water Quality Parameter	TSS	COD	DOC	O & G	TKN	NH_3-N	T-P
TSS	1	0.40	0.34	0.38	0.40	0.39	0.35
COD	0.00	1	0.95	0.83	0.84	0.79	0.74
DOC	0.00	0.00	1	0.98	0.89	0.88	0.60
O & G	0.00	0.00	0.00	1	0.89	0.85	0.84
TKN	0.00	0.00	0.00	0.00	1	0.84	0.87
NH_3-N	0.00	0.00	0.00	0.00	0.00	1	0.81
Tot. P	0.00	0.00	0.00	0.00	0.00	0.00	1

- above the diagonal : Pearson's Coefficient "r"
- below the diagonal : Probability Values (P-Value)

Table 3.4 Correlation analysis results for particulate phase metals and TSS

Parameter	TSS	Part. Cd	Part. Cr	Part. Cu	Part. Ni	Part. Pb	Part. Zn
TSS	1	0.02	0.59	0.58	0.57	0.60	0.60
Part. Cd	0.67	1	0.02	0.30	0.26	0.62	0.75
Part. Cr	0.00	0.60	1	0.75	0.70	0.65	0.70
Part. Cu	0.00	0.00	0.00	1	0.85	0.70	0.83
Part. Ni	0.00	0.00	0.00	0.00	1	0.70	0.75
Part. Pb	0.00	0.00	0.00	0.00	0.00	1	0.74
Part. Zn	0.00	0.00	0.00	0.00	0.00	0.00	1

- above the diagonal : Pearson's Coefficient "r"

- below the diagonal : Probability Values (P-Value)

4. FIRST FLUSH RESULTS AND DISCUSSION

This chapter discusses the measured first flush of the various monitored parameters. The parameters have been ranked according to the magnitude of the first flush. In order to rank the first flush, a new parameter was developed, called the mass first flush ratio (MFF). Other first flush characteristics discussed in this chapter include PAHs, litter, and particles (based upon particle counting methods and not TSS). The results of seasonal first flush have also been discussed in this chapter..

4.1 Meaningful Definition of First Flush for Practical Application

The first flush of the highway runoff sites were characterized with mass first flush ratios. As noted in the introduction, this ratio is a quantitative method of concepts proposed earlier. It quantifies the mass of emitted pollutants as a function of the storm progress, as indicated by the normalized runoff volume (e.g., 0 to 1, with 1 being the total volume). It is defined as follows:

$$MFF_n = \frac{\dfrac{\int_0^{t_1} C(t)Q(t)dt}{M}}{\dfrac{\int_0^{t_1} Q(t)dt}{V}} \tag{4.1}$$

In equation 4.1, MFF is the mass first flush ratio, and is dimensionless; n is the index or point in the storm, and corresponds to the percentage of the runoff, ranging from 0 to 100%. M is the total mass of emitted pollutant, V is the total runoff volume, C(t) and Q(t) are the pollutant concentration and runoff volume as functions of time. The terms have the same meaning as used earlier in equation 3.1 that defined the EMC.

By definition, the MFF is equal to zero at the storm beginning and always equals 1.0 at the end of the storm. Values greater than 1 indicate that normalized mass is being discharged faster than the normalized volume, or a first flush.

The MFF can be defined or visualized graphically, and Figure 4.1 shows the concept for a hypothetical storm. The normalized pollutant mass emission is plotted as a function of the normalized flow volume. This line is sometimes called a “load graph.” The MFF can be calculated at any point on the curve by dividing the Y axis value by the X axis value.

In Figure 4.1, two points were selected at normalized runoff volumes of 0.1 and 0.3, or 10 and 30% of the storm volume (i.e., n = 10 and n = 30). The intersection of the load graph for 10 and 30 are 0.45 and 0.66. This means that 45% of the pollutant mass was discharged in the first 10% of the runoff, and 66% of the mass was discharged in the 20% of the runoff. The MFF ratio is the quotient of the normalized pollutant mass divided by the normalized pollutant volume. Figure 4.1 shows the MFF_{10} = 4.5 and MFF_{30} = 2.2. To calculate the percentage of pollutant discharged at a point in the storm using the MFF ratio, the index is multiplied by the ratio, or 10 x 4.5 =45% or 30 x 2.2 = 66%.

Calculating the first flush requires a series of grab samples, or at least two flow weighed composite samples. The ratio can be conveniently calculated using the series of grab samples as shown in the previous chapter for EMC calculation. Alternatively, a full storm composite sample, as normally collected, can be used for the denominator of the MFF ratio. The numerator can be a second flow-weighted composite sample, which must be collected from the storm beginning to the point in the storm corresponding to n. The MFF ratio or knowledge of the first flush cannot be determined from routine monitoring data, and the data collected in this study are unique among the Department's stormwater monitoring programs.

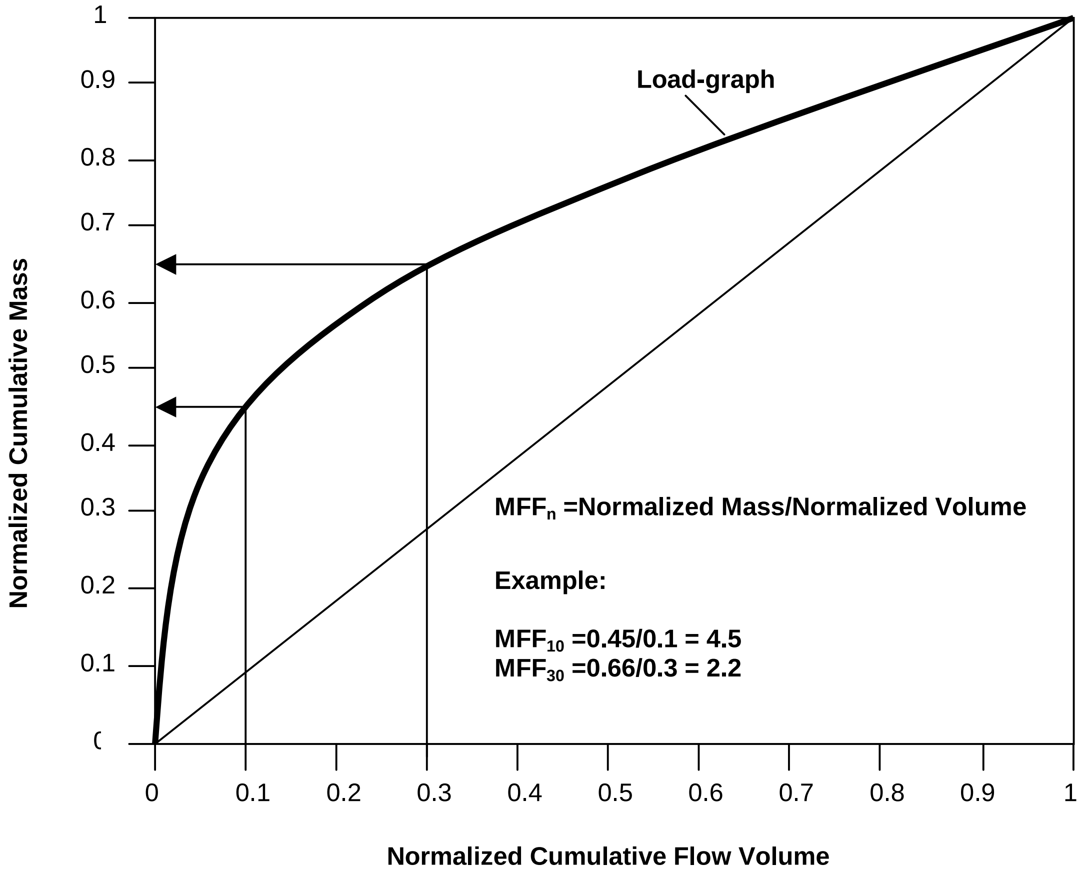


Figure 4.1 Load graph example of MFF calculation.

The MFF ratio can be related to another concept called the partial EMC or PEMC. The PEMC is a flow weighted composite sample, collected from the storm beginning to a point in the storm, as described in the previous paragraph. The MFF ratio can be defined as follows, and is numerically the same as calculated from equation 4.1

$$MFF_n = PEMC_n/EMC \qquad (4.2)$$

MFF ratios have been calculated for the last three years of the study (data from the first year was not suitable, since the tail of the storm was monitored with only a composite sample). The appendix contains the MFF ratios, calculated from 10 to 50% of the storm, for all events and for all parameters.

Table 4.1 shows the MFF_{20} ratios for all three UCLA sites and the pooled data for all three sites, for 26 pollutants. They are ranked by magnitude. Generally the chemical oxygen demanding (COD) or organics indicating pollutants (DOC, O&G, TKN) have the highest MFF ratios. It should be expected that they have similar ratios, since they are highly correlated, as shown in the last chapter. The fact that their values are high suggests that they are washed or scoured from the sites early in the storm.

Table 4.1 Ranked mass first flush ratios for MFF_{20}

Rank	7-201		7-202		7-203		Combined Sites	
	Parameters	**Median**	**Parameters**	**Median**	**Parameters**	**Median**	**Parameters**	**Median**
1	COD	1.740	Dissolved Ni	2.086	DOC	2.511	Dissolved Ni	1.943
2	Total P	1.706	DOC	2.005	Dissolved Ni	2.405	DOC	1.942
3	Dissolved P	1.688	NH_3-N	2.000	COD	2.326	TKN	1.895
4	TKN	1.589	Total Zn	1.999	TKN	2.180	COD	1.883
5	Dissolved Ni	1.577	Dissolved Cu	1.982	Dissolved Cu	2.122	NH_3-N	1.882
6	Oil & Grease	1.567	COD	1.948	NH_3-N	2.099	Dissolved P	1.748
7	TSS	1.559	TKN	1.944	TSS	1.980	TSS	1.718
8	NH_3-N	1.558	Dissolved Zn	1.927	Total Ni	1.864	Total P	1.717
9	DOC	1.522	Dissolved P	1.862	Total Cu	1.792	Oil & Grease	1.699
10	Total Ni	1.489	Total Ni	1.845	Oil & Grease	1.787	Dissolved Cu	1.680
11	Total Zn	1.484	Total Cu	1.714	Dissolved P	1.747	Total Ni	1.680
12	Dissolved Zn	1.428	Oil & Grease	1.709	Total P	1.747	Total Zn	1.666
13	Conductivity	1.416	Total P	1.703	Conductivity	1.741	Dissolved Zn	1.657
14	Dissolved Cu	1.401	NO_3-N	1.486	Dissolved Zn	1.661	Total Cu	1.644
15	Total Cu	1.396	Total Cd	1.459	Total Zn	1.652	Conductivity	1.538
16	NO_2-N	1.392	Turbidity	1.429	Hardness	1.607	Hardness	1.484
17	Total Cr	1.358	TSS	1.416	NO_3-N	1.573	NO_2-N	1.371
18	Turbidity	1.299	Dissolved Pb	1.377	NO_2-N	1.369	NO_3-N	1.345
19	Total Pb	1.225	PO_4-P	1.366	Dissolved Pb	1.339	Turbidity	1.288
20	Hardness	1.200	Dissolved Cr	1.349	Total Cd	1.269	Total Cd	1.264
21	Dissolved Cr	1.152	Total Pb	1.323	Total Cr	1.224	Total Pb	1.230
22	Total Cd	1.074	Dissolved Cd	1.307	Total Pb	1.131	Total Cr	1.223
23	Dissolved Cd	1.001	NO_2-N	1.251	Turbidity	1.093	Dissolved Pb	1.206
24	Dissolved Pb	1.000	Hardness	1.227	Dissolved Cd	1.091	Dissolved Cr	1.172
25	PO_4-P	1.000	Conductivity	1.214	Dissolved Cr	1.040	Dissolved Cd	1.087
26	NO_3-N	0.983	Total Cr	1.200	PO_4-P	1.000	PO_4-P	1.000

The range or statistical variability of the MFF ratios is also important. Table 4.1 shows only the median values. Figures 4.2 and 4.3 show notched box plots of the MFF_{10} to MFF_{50} ratios for combined sites for COD, TSS and the six metals of most interest to the Department (Cd. Cr, Ni, Pb, Cu and Zn). The bar plots show the 25% and 75% percentiles (edges of the bar), the median (notch of the bar), confidence intervals (5%, upper and lower knees), fences and outliers. Different software produces slightly different notch bar plots. Systat 10.2 (Richmond, CA) was used to produce all the notched bar plots in this report. The advantage of notched bar plots over standard bar plots is the ability to observe statistical differences in categories. If the knees of the notches do not overlap, there is a significant difference in the categories.

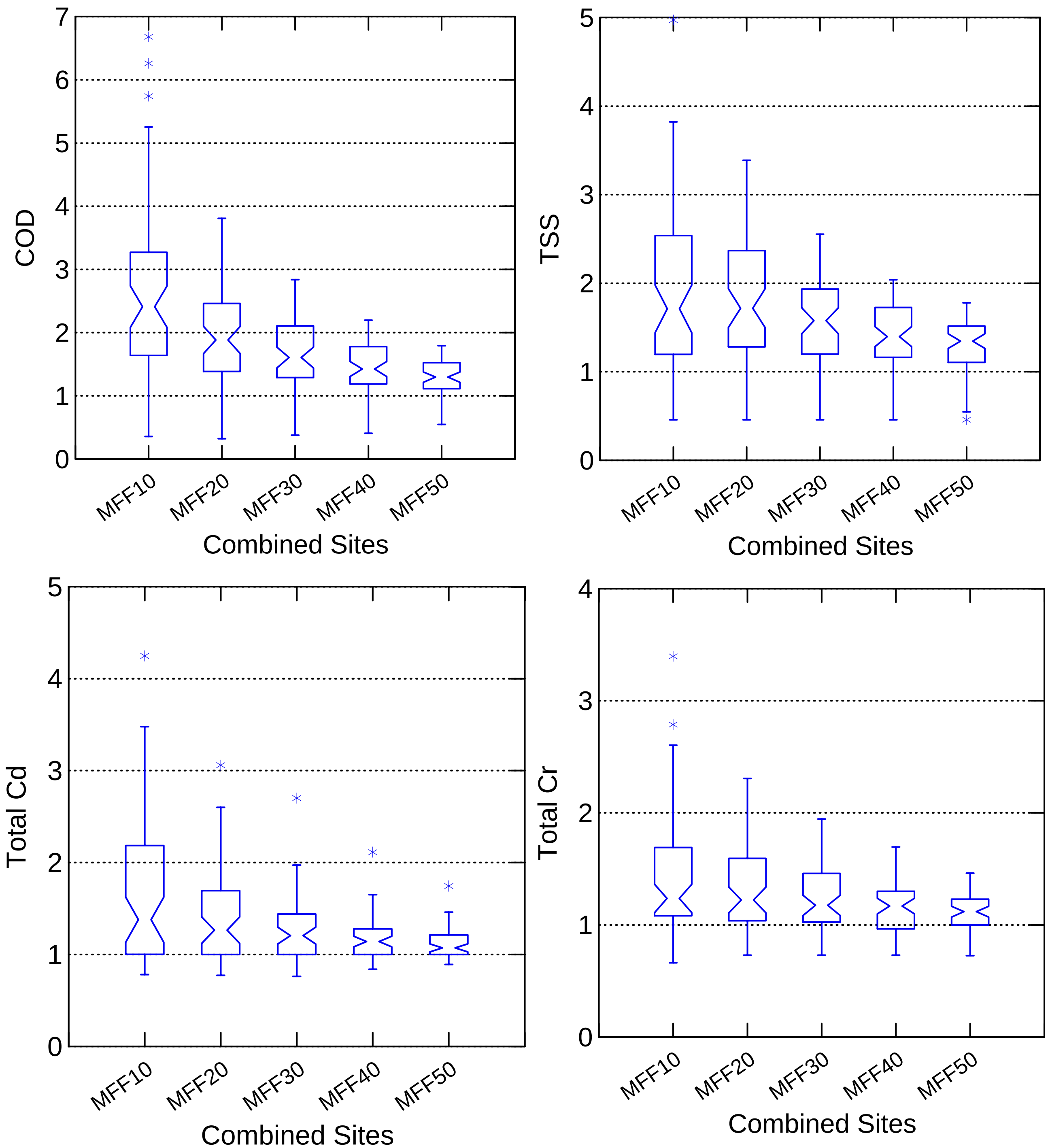


Figure 4.2 Notched bar graphs for MFF ratios (10 to 50%) for COD, TSS, Total Cd and Total Cr for the combined sites (The number of cases is 58 for COD and TSS, and 62 for metals).

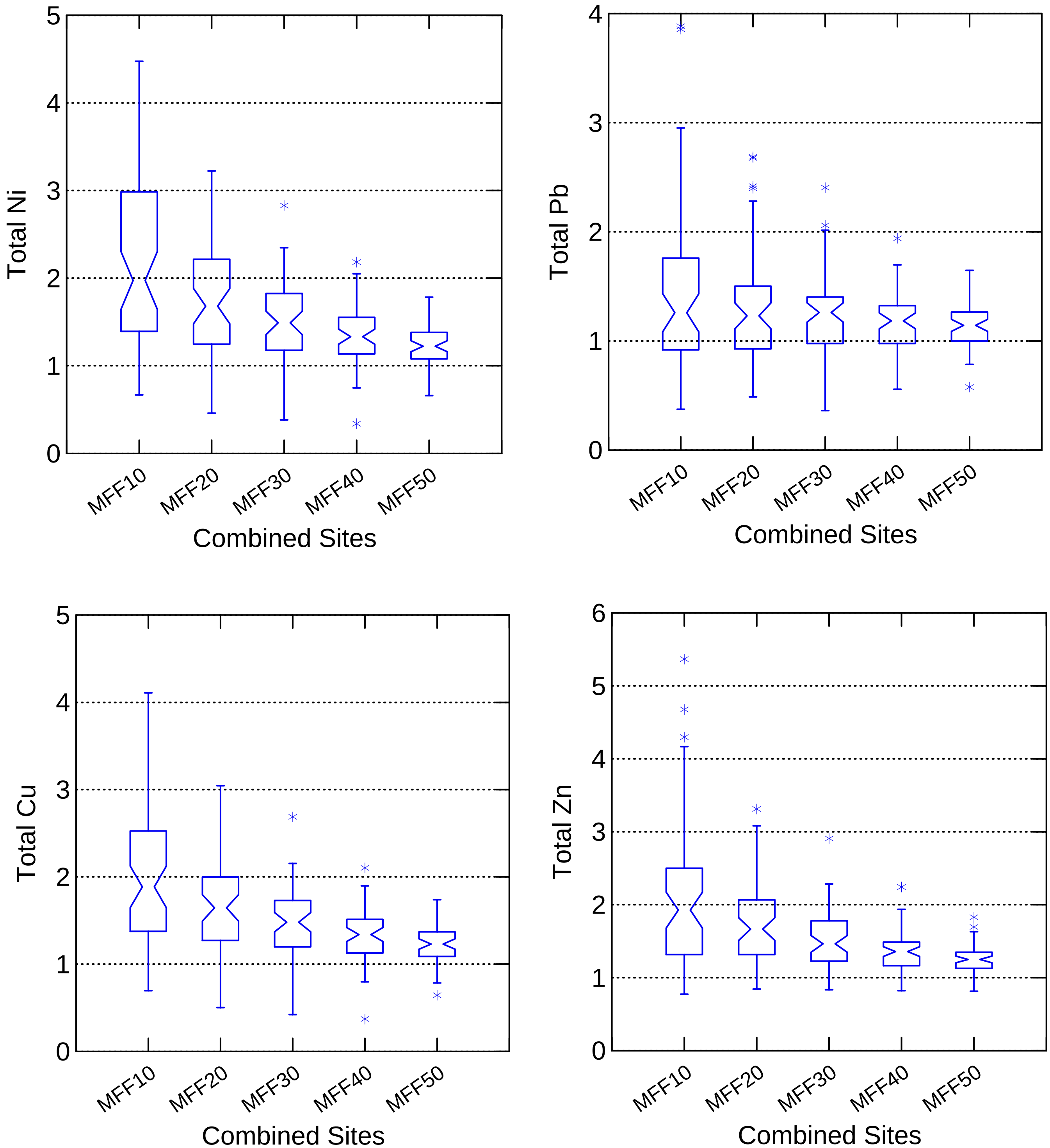


Figure 4.3 Notched bar graphs for MFF ratios (10 to 50%) for Total Ni, Pb, Cu and Zn for the combined sites (The number of cases is 58 for COD and TSS, and 62 for metals).

Ratios for the individual sites, including those monitored by the consultants are shown in the appendix. All the ratios measured in this investigation decline with increasing runoff volume. It is possible that a ratio at a larger flow volume could be larger than a ratio for a smaller volume, but an unusual runoff behavior would have to occur.

As noted earlier the MFF ratios for the different pollutants are in many cases highly correlated, and the correlations are shown in the appendices. Unfortunately, no significant correlations have been found yet between MFF ratios and storm and site parameters, such as ADD, ADT, rainfall intensity, and total rainfall. At present the Pearson-type correlations, which are useful for describing linear relationships, have been investigated. There are other opportunities to detect meaningful relationships. Techniques that will be investigated in our future work will include component analysis, Bayesian analysis and neural networks. These have been successfully applied by our group (Ha, et al, 2003) for determining relationships among water quality parameters and land use. These tools are better in detecting non-linear relationships.

4.2 PAH First Flush

Polynuclear aromatic hydrocarbons (PAHs) are often associated with highway runoff and combustion residuals. PAHs are included in organic measurements such as COD and DOC, but are generally so low in concentration that there first flush behavior cannot be determined from these measurements. In order to measure the first flush of PAHs, 32 different PAHs were measured at three sites over the study. At first, both soluble and particulate phase PAHs were measured. Soluble phase PAHs were rarely above the detection limit of 5 ng/L, and the analysis was abandoned. Particulate phase PAHs were found, and Table 4.2 shows typical results. Figure 4.4 shows the MFF ratios for total PAHs.

Table 4.2 Particulate phase PAHs for Site 1, 2001-2002 season

PAH Compound	EMC (ng/L)							
	10/30	11/12	11/24	12/14	1/27	2/17	3/7	3/17
Napthalene	28	6		17	6	2		11
Acenapthylene								
Acenapthene								
Fluorene								
Phenanthrene	83	24	14	54	21	22	29	42
Anthracene	14			14				
Fluoranthene	226	53	31	277	59	73	98	166
Pyrene	511	128	73	532	134	144	220	356
Benz[a]anthracene	93	24	17	102	24	29	31	50
Chrysene	332	85	51	295	86	108	179	241
Benzo[b]fluoranthene	57	41	22	124	38	38	25	84
Benzo[k]fluoranthene	60	11	9	59	13	20	22	30
Benzo[a]pyrene	147	48	28	124	44	48	71	113
Indeno[1,2,3,cd]pyrene	65	16	9	24	8	7		31
Dibenzo(ah)anthracene				0				
Benz[g,h,i]perylene	296	86	41	229	73	74	100	195
Total PAHs	1882	529	300	1852	511	568	778	1327

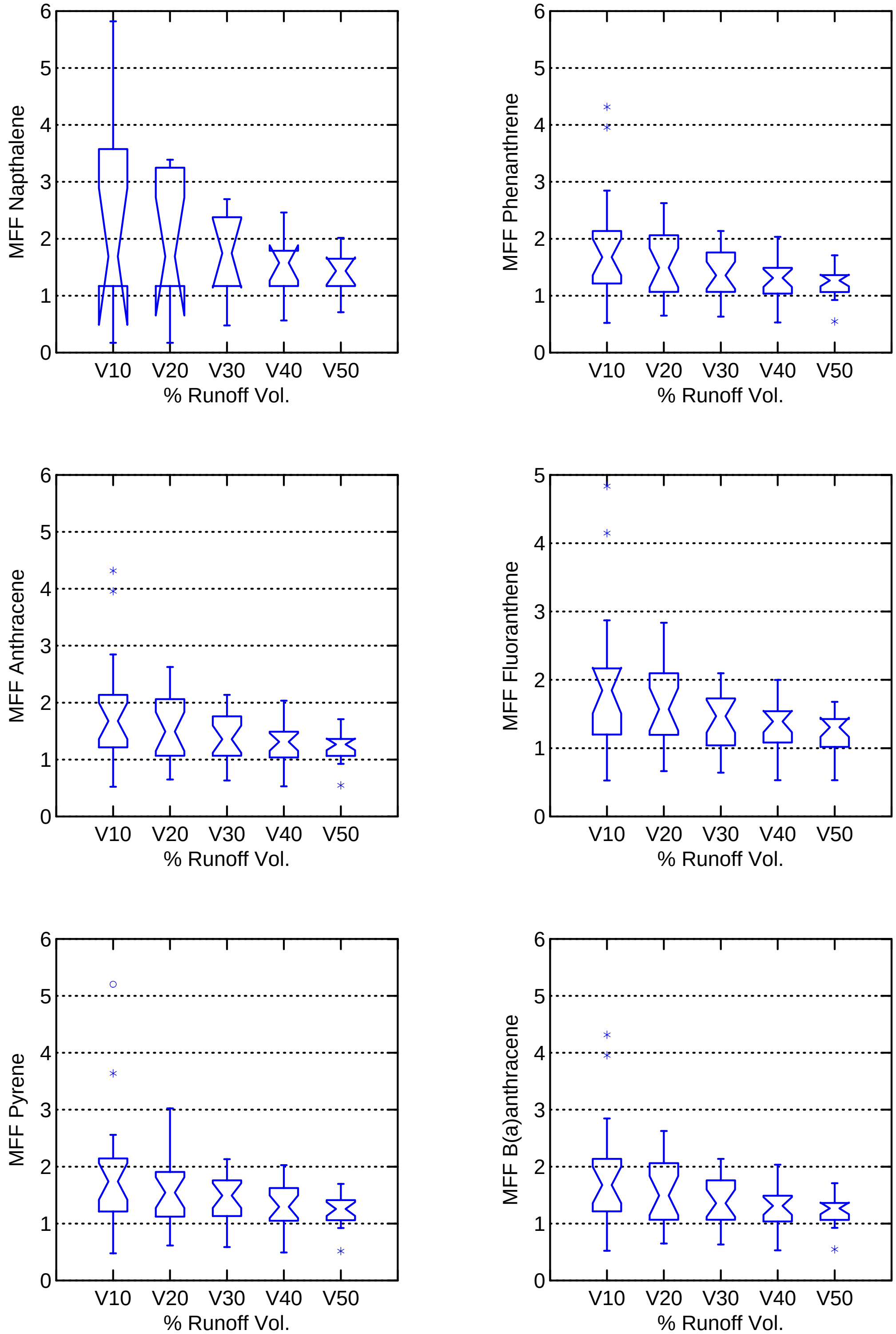


Figure 4.4 Notched bar graphs showing MFF ratios for various PAHs.

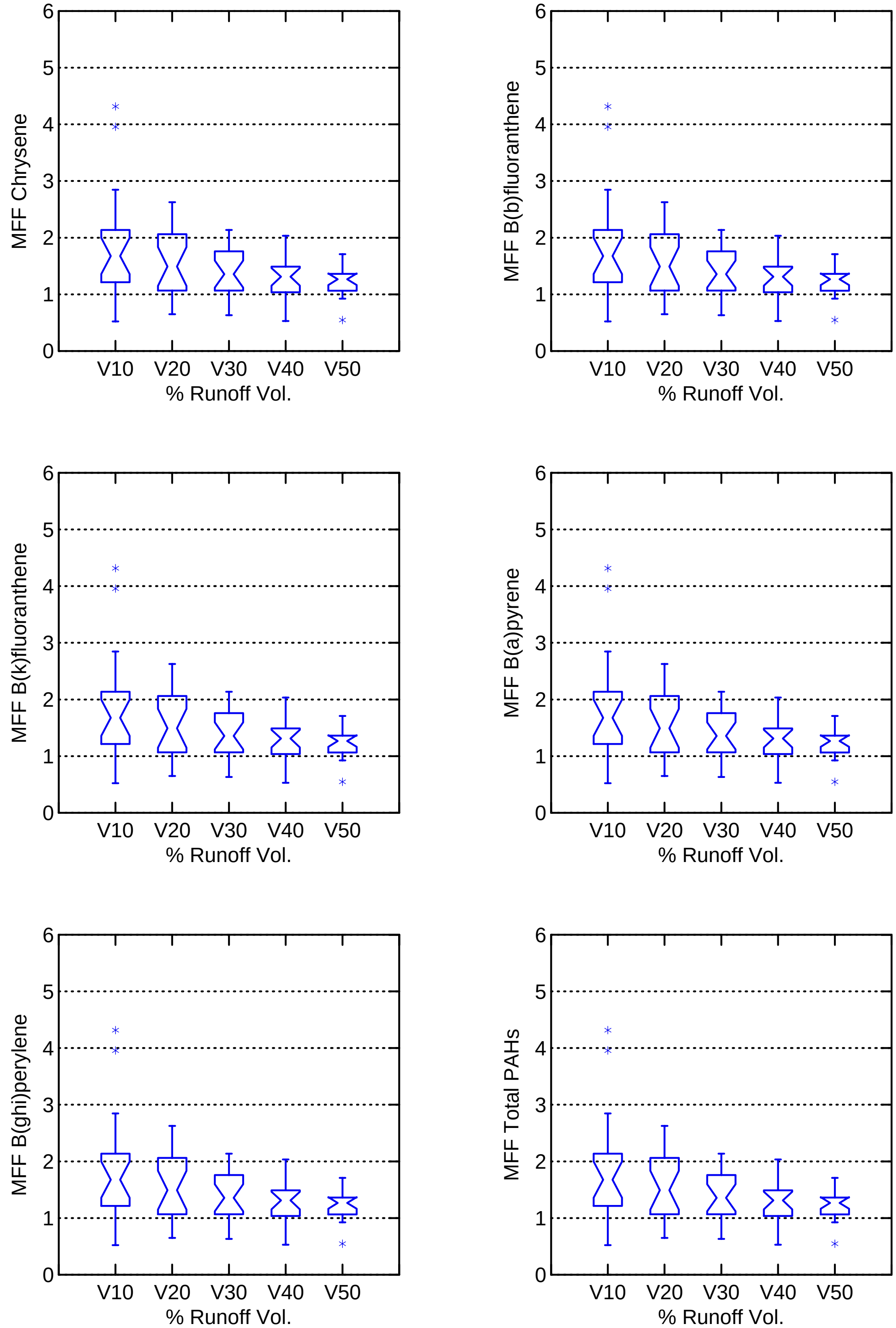


Figure 4.4 (Continued) Notched bar graphs showing MFF ratios for various PAHs.

PAHs generally showed a first flush in the same order as organic pollutants such as COD and DOC, and enhanced removal of PAHs will occur if BMPs that treat the first flush are used.

4.3 Litter First Flush

Litter is generally not considered a water quality parameter, but has been regulated by the Los Angeles Regional Water Quality Control Board under its total maximum daily load (TMDL) program. The Department's first flush criterion for litter is defined as the litter mass fraction within the first two hours of the storm event. If more than 50% of the mass is emitted during the first two hours, it is called a first flush. The litter first flush observation based on the litter ratio is presented in Table 4.3 for selected events. The occurrence of a first flush was not consistently observed at all monitoring sites during the same storm event. Similarly, review of the litter pollutographs and load-graphs indicate that the first flush phenomenon was occasionally observed in all sites during certain storm events. Table 4.3 shows that site 6-20F most consistently exhibited a first flush. During the storm event of January 10, 2001, site 6-20F, 8-23C and 23 showed significant first flush effects, but there was none present for site 7-202 and 7-203. This storm event also had the highest relative rainfall intensity of the season.

Table 4.3 Fraction of litter occurring in the first 2 h of runoff [a]

Parameters		Gross Pollutant Wet Weight	Gross Pollutant Wet Volume	Litter Wet Weight	Litter Wet Volume	Litter Air Dry Weight	Litter Air Dry Volume	Biodegradable Dry Weight	Biodegradable Dry Volume
7-202	10/26/01	0.02	0.03	0.04	0.05	0.03	0.06	0.03	0.04
	1/8/01	0.98	0.95	0.98	0.97	0.96	0.97	0.97	0.98
	1/10/01	0.05	0.11	0.53	0.39	0.48	0.5	0.5	0.63
7-203	10/26/01	0.92	0.73	0.85	0.62	0.81	0.61	0.64	0.4
	1/8/01	0.94	0.9	0.98	0.96	0.98	0.96	0.98	0.95
	1/10/01	0.2	0.27	0.59	0.31	0.38	0.34	0.49	0.37
	2/10/01	0.25	0.26	0.15	0.13	0.12	0.1	0.15	0.1
	2/19/01	0.61	0.57	0.85	0.71	0.92	0.74	0.75	0.57
6-20F	10/26/00	0.23	0.29	0.33	0.35	0.29	0.34	0.24	0.31
	1/10/01	0.98	0.96	0.94	0.96	0.96	0.94	0.97	0.94
	1/26/01	0.87	0.88	0.94	0.96	0.96	0.96	1	0.93
	2/10/01	0.97	0.95	0.99	0.93	0.99	0.94	0.99	0.93
8-23C	10/26/00	0.19	0.2	0.14	0.12	0.12	0.12	0.16	0.14
	1/10/01	0.77	0.68	0.58	0.7	0.53	0.62	0.77	0.7
	2/24/01	0.22	0.32	0.37	0.43	0.37	0.33	0.46	0.33

[a] Due to low rainfall in 2001-2002 monitoring season, limited litter data were collected.

Gross pollutant and litter data were also reviewed and compared on a multi-event basis to evaluate a potential effect of the first storm event of the season. It was hypothesized that the first storm event of the season would have the highest relative amount of litter mass, volume and mass loading compared to subsequent storm events. Table 4.3 shows that the first monitored storm event of the season did not produce a relatively greater amount of litter when compared to the subsequent storm events. The existence of a first flush and the mass of gross pollutants may be a function of the total or maximum intensity of rainfall. Gross pollutants are retained on the surfaces and in catch basins and pipes, and a minimum flow may be required to mobilize them. If the first rainfall of the season is large but lengthy with low intensity, gross pollutants may not be mobilized. Conversely, a short, intense rainfall may mobilize more pollutants.

The ratio of biodegradable to non-biodegradable litter was calculated for each event and site. The values varied considerably during each storm event. Site 6-20F, the site with the highest normalized litter mass loading, consistently had higher amounts of biodegradable litter. Site 7-202 had more non-biodegradable litter. On average for all sites, a slightly greater percentage (approximately 60%) of biodegradable litter was measured in the first flush of the storm events. This was consistent with individual storm event observations where lighter biodegradable litter appeared to be washed out first, leaving the relatively heavier non-biodegradable litter to wash out with the remainder of the storm event during the peak flow periods.

Gross pollutant and litter data were evaluated as pollutographs (concentration versus time) and load-graphs (mass loading rate versus time) for each event and site. The litter concentrations were calculated as the dry litter mass divided by the total flow volume during the time of the litter sample collection. The litter mass loading rates were calculated as the dry litter mass divided by the elapsed time of litter collection, and normalized by the catchment area. These plots were compared to the respective hydrographs to determine the potential relationships to flow intensity and storm duration. The plots were also used to determine whether a first flush effect (i.e., relatively higher litter concentrations early in the event, followed by a decrease in concentration after a period of time) was present. Figure 4.5 shows an example of combined litter pollutograph and load-graph for the first event of the season. The first event of the season at site 7-201 shows very high dry litter concentration and load in first hour.

Evaluation of the litter load-graphs, however, presented no clear observations of a first flush phenomenon. In many instances, the litter mass loading rates were not highest during the first portion of a storm event; the highest litter mass loading rate was observed later in the storm event, after the peak flow had occurred.

Figure 4.6 shows the normalized wet gross, vegetation and litter rates for each event at site 7-203. The storm event, October 30, 2001, is the first storm at site 7-203. The mass rate is not higher compared to other events. The mass rates vary to event-to-event and influenced by several factors such as antecedent dry days and total rainfall. A regression model was developed to describe litter EMC as a function of antecedent dry days and total rainfall. Detail information on regression model and additional litter characterization is presented elsewhere (Kim, et al., 2004).

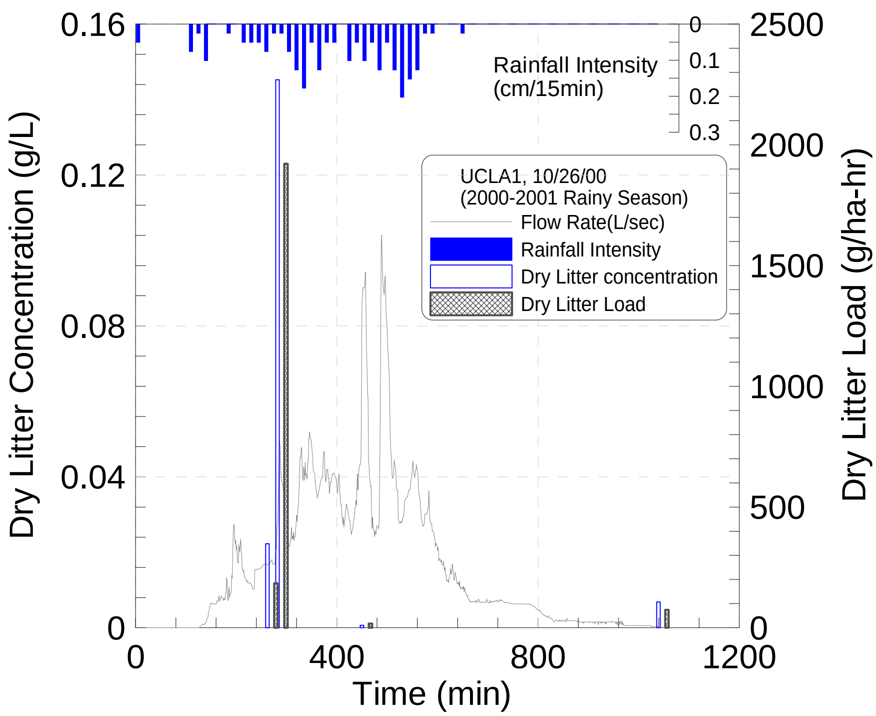


Figure 4.5 Litter polluto- and load-graphs for a storm event
(with hydrograph shown in background).

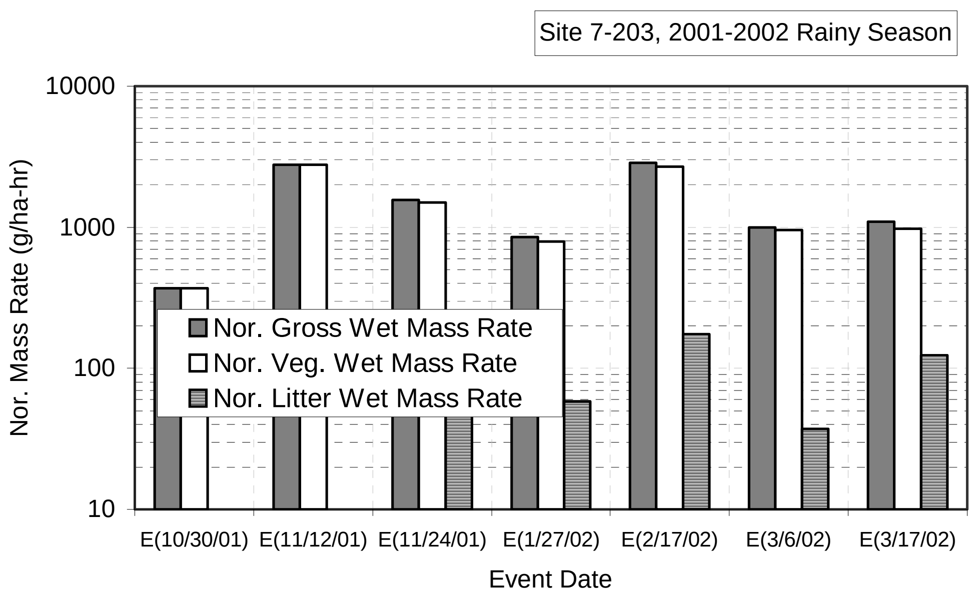


Figure 4.6 Normalized mass rates as function of catchment area and storm duration.

4.4 Particle First Flush

During the third year of the project, a particle size analyzer was acquired which can measure the number of particles from 2 to 1000 μm (Nicomp, Santa Barbara, California, PSS AccuSizer 780 Optical Particle Sizer module equipped with an auto-dilution system and a LE1000-2SE Light Scattering/Extinction sensor). This instrument has never been used in stormwater monitoring and required new protocols to be developed to reliably and accurately quantify the particles in highway runoff. The work on this topic is embryonic, and is the subject of our future work. The appendices include the entire text of a technical memorandum on its use.

The developed protocol included the following components:

1. Storage time. Sample storage is limited to 6 hours. After 6 hours, there is a noticeable aggregation in particle size. Therefore composite samples cannot be used (the time in the sampler is usually longer than 6 hours)
2. Bottle cleaning. Sample bottles must be rigorously clean and a protocol was developed that limited spurious particles to less than 250/ml, which was adequately compared to the range of particles in stormwater, which was 10^4 to 10^7/ml.
3. Mixing. Samples stored in bottles for even a few minutes need to be mixed so that a representative subsample can be collected. A mixing protocol was developed that insured a representative sample. The mixing had to be adequate to resuspend all particles without shearing them into smaller particles.
4. A series of reproducibility measurements were made. Generally the reproducibility of the method is within 5% for particles less than 30 μm, where many particles are usually present. For the larger ranges (200 μm and larger), the reproducibility may only be 20 to 50%, which can be created by one additional particle or one less particle.

Particle analysis was performed on 3 storms. Figure 4.7 shows pollutographs as well as the particle size distributions for the series of grab samples. The upper graphs show the runoff flow, rainfall intensity, TSS, turbidity, conductivity, median particle size and the particle size distribution for each grab sample. The upper graph shows the points in the pollutographs where grab samples were collected. The lower graphs show the number of particles as a function of particle size. Each grab sample corresponds to a line on the lower graphs. Sampling times are shown to locate the particle size function to a point on the pollutographs. It is easily observed that the number of particles declines dramatically as the storm progresses. Samples later in the storm have many fewer particles (note the scale change on the lower PSD axis in Figure 4.7). The median particle diameter decreases as the storm proceeds, which means that the larger particles are washed out faster than the smaller particles.

Figure 4.8 shows the Particle number first flush ratios (PNFF) which are calculated exactly the same as MFF ratios, except that particle numbers are used instead of concentrations. The PNFF can be calculated for the entire size distribution or for smaller intervals. Figure 4.8 shows that the smaller particles had $PFFN_{20}$ as low as 2.0. The larger particles had median ratios higher than 3.0.

The work on particle analysis is just beginning, but we expect to be able to develop quantitative designs for sedimentation-type BMPs based on the particle size and the pollutant concentrations on the particles. Work is being done as part of our follow-on project in 2004-2005 to measure pollutant concentrations as a function of particle size, as well as collecting more particle size information.

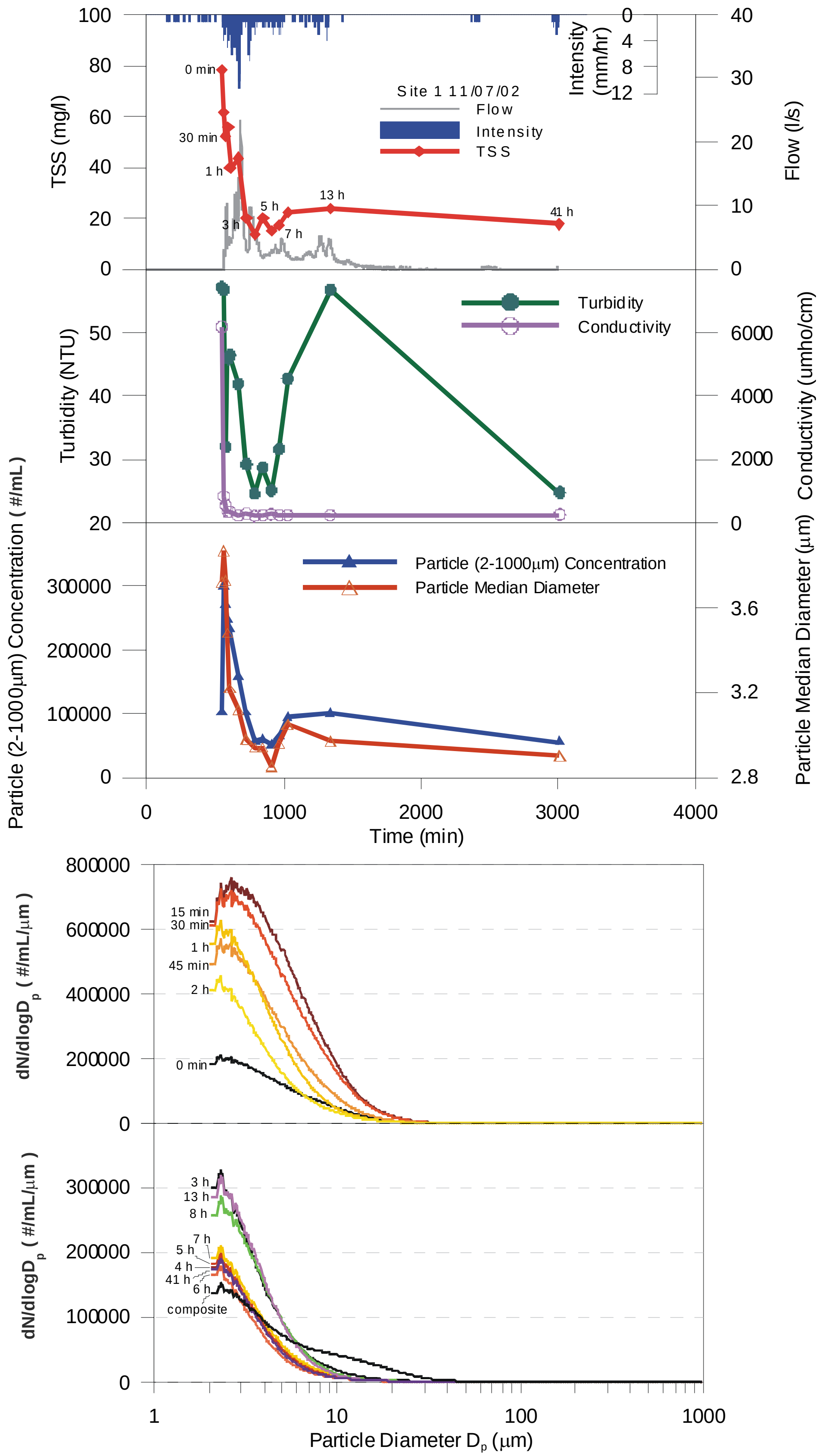


Figure 4.7 Pollutograph and particle size distribution for Site 7-201, even 11/07/02

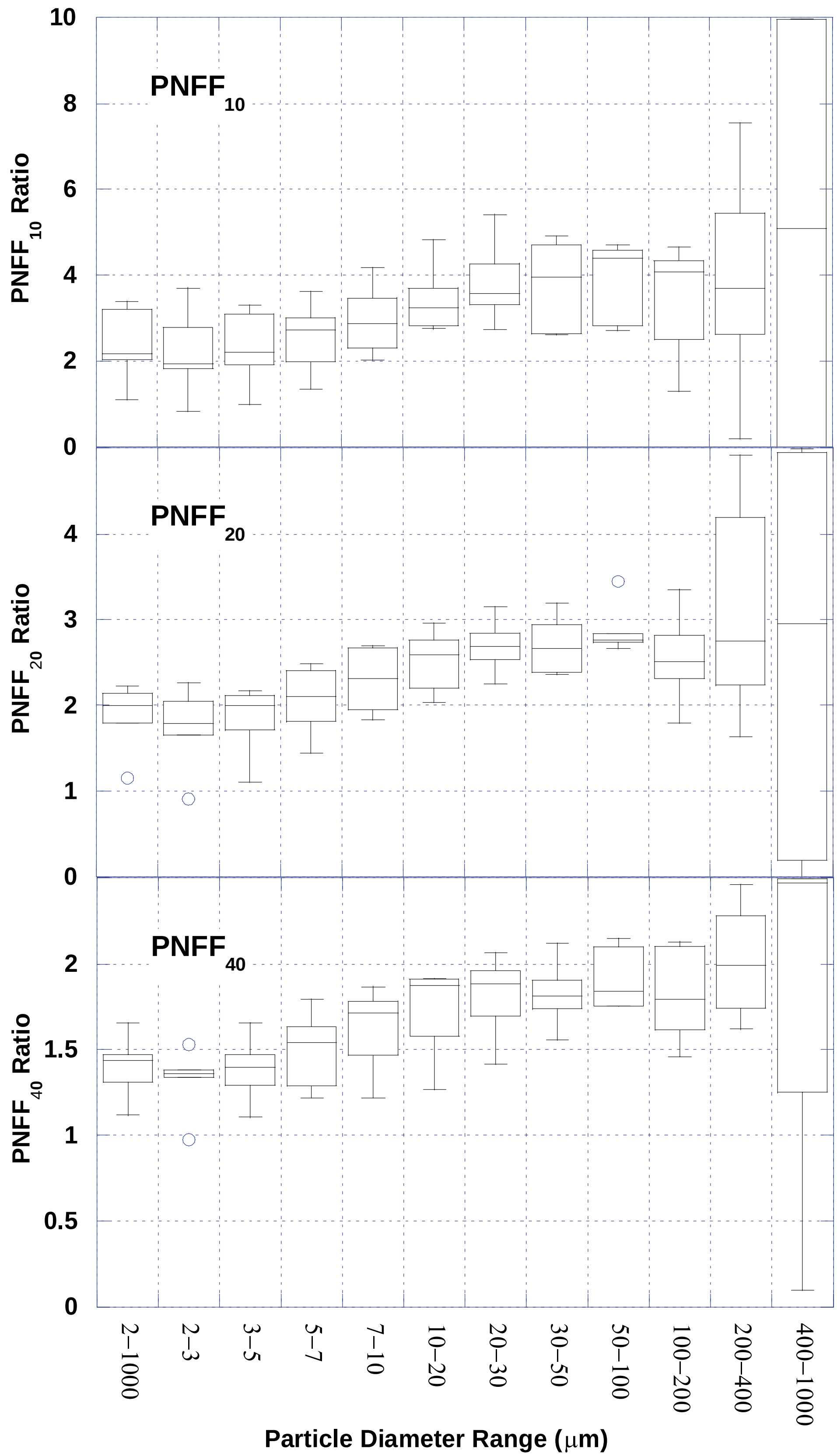


Figure 4.8 Particle number first flush ratio

4.5 Seasonal First Flush

The same method of quantifying an event first flush can be applied to seasonal first flush. Most parts of California have wet and dry seasons, often characterized as a Mediterranean climate. Figure 2.5 showed the rainfall season for Southern California as November to March, with most rain occurring in January and February. Figure 4.9 shows the average California rainfall patterns in Los Angeles and Sacramento and compares them to two locations in New England (Connecticut).

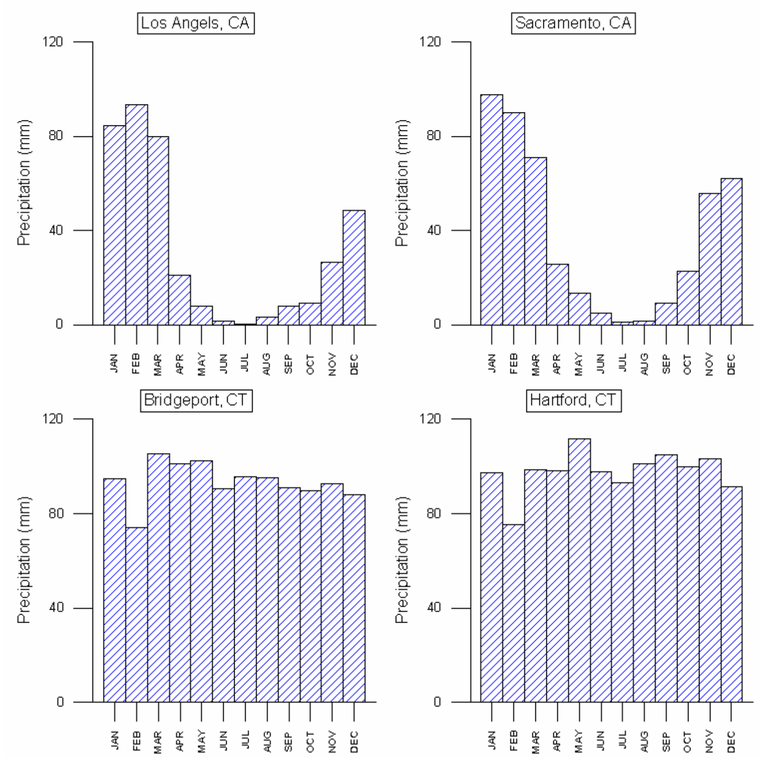


Figure 4.9 Monthly average Rainfall in Los Angeles, Sacramento, Bridgeport, and Hartford during 1971-2000

The long periods of dry weather in California, essentially from April to October, provide a long period for pollutant build up. The existence of the long dry period should be viewed as an opportunity as opposed to a problem. For example, the Department has already taken advantage of the seasonal rainfall by scheduling its insert cleaning in the late summer or early autumn. This should be viewed as an opportunity because the Department, in a single cleaning, can collect approximately 6 months of accumulated debris and litter. In a more common rainfall environment, monthly cleanings would be required to collect 6 months of accumulation, and even then, debris would be discharged with the frequent rains.

To examine the magnitude of the seasonal first flush and its impact on BMP design, several datasets were examined to determine the differences in runoff of the first storm of the season or early storms of the season and later storms (see Table 4.4). It was necessary to enlarge our study because the required analysis must pool each season's rainfall events into a single observation. Therefore, even though the first flush data collected in this study are, to the authors knowledge, the most extensive highway runoff dataset in existence, still more data were needed. The first flush data were combined with the data from the Department's statewide monitoring program, as well as two other datasets collected in or near Los Angeles County. The other datasets had, in so far as possible, similar landuses to transportation landuse. The Industrial General Permit dataset covered some transportation landuse, but many landuses were similar to the Department's maintenance facilities and parking areas.

Table 4.4 Summary of datasets used for seasonal first flush evaluation

Name of Monitoring Program	Sponsoring or Managing Agency	Monitoring year	Monitoring Area	Primary Land Use	No. observations
Industrial Activities General Permit	Los Angeles Regional Water Quality Control Board, (LARWQCB)	from 1992 to 2003	County of Los Angeles	Industrial	~ 6500 events from many sites over two years
Land Use Monitoring	Los Angeles County Department of Public Works (LACDPW)	from 1996 to 2001	near LAX	Transportation	24 events from 1 site over three years
First Flush Highway Runoff Characterization [a]	California Department of Transportation (Department)	from 1999 to 2003	IS 405 and US 101 freeway near UCLA (3 sites)	Transportation (Highway)	71 events from 3 sites over three years
Statewide Highway Runoff Monitoring [b]	California Department of Transportation (Department)	from 1997 to 2003	California (statewide)	Transportation (Highway)	237 events from 25 sites over three years

[a] Performed by the Civil & Environmental Engineering Department, University of California, Los Angeles.
[b] Part of the Department's state-wide stormwater runoff monitoring program, Department (2003).
[C] Transportation includes surface roads, while highway includes only freeways.

In order to compare different seasons and different sites and monitoring programs, a common parameter to reflect the point in the rainy season was needed. Ideally, the runoff of each site could be used, and added to produce an accumulated runoff for the entire season. Unfortunately, such runoff data was rarely available, and even the Department's statewide monitoring program does not have such data (not all storms were sampled, and in some cases, the actual runoff data is too voluminous to be reported). For other studies such as the Industrial Activities General Permit, runoff is not required and is not usually measured (Stenstrom and Lee, 2005).

To create a common parameter for all datasets, rainfall was used. Rainfall data were collected from the nearest gauge and added to produce an accumulated rainfall. For some datasets it was difficult to locate the correct rain gages. For the Department's datasets, this was much easier since rainfall was usually measured at the monitoring station. The accumulated rainfall was then normalized, so that all years would produce a scale from 0 to 1.0. Next, the concentrations of the pollutants of interest were plotted as a function of accumulated rainfall.

Figure 4.10 shows four graphs of various pollutants for selected years of data from this study. The rainfall of each storm is plotted along the top, as well as the ADD. Because the rainfall is cumulative, it is not possible to determine the time between rainfall events from the horizontal axis. The horizontal axis is frequently used for time in stormwater studies, and it natural to assume that the horizontal axis is linear in time. The cumulative rainfall is the appropriate parameter to plot for this analysis, since the rainfall washes out the pollutants. The rainfall is not a linear function of time. The opportunity for pollutants to accumulate between rainfall events is quantified by ADD.

It is clear from the graph that the first storms of the season have higher concentrations. In some cases the first storm was small which biased the concentration, but in general, with very few exceptions, and declining trend in concentrations is observed for almost every parameter. The appendices to this report include a copy of the technical memorandum devoted to the topic, and can be consulted for more information on individual events or datasets.

The MFF ratios can be applied to those datasets with runoff volume. Both of the Department's datasets can be analyzed in this way. Figure 4.11 shows the load graph for four metals, TSS and COD for the first flush study. Each point represents a storm in each season. The MFF ratio is equal to the Y coordinated divided by the X coordinate. Values above the diagonal indicated a seasonal first flush. The vast majority of the points are above the diagonal, with points for copper being commonly found in the upper part of the figure. The majority of the points for lead are below the diagonal line.

Figure 4.12 shows a similar analysis for the data from the Department's statewide sampling program. Virtually all the metals show a seasonal first flush.

As stated before, the existence of a seasonal first flush provides an opportunity. The first storms of the season carry a higher mass load of pollutants; therefore developing BMPs that treat all of the first storms will be a better strategy than trying to treat a fraction of all storms throughout the season. An example might be infiltration basins that dry out over the summer, which allows them to capture and retain the first few storms of the wet season.

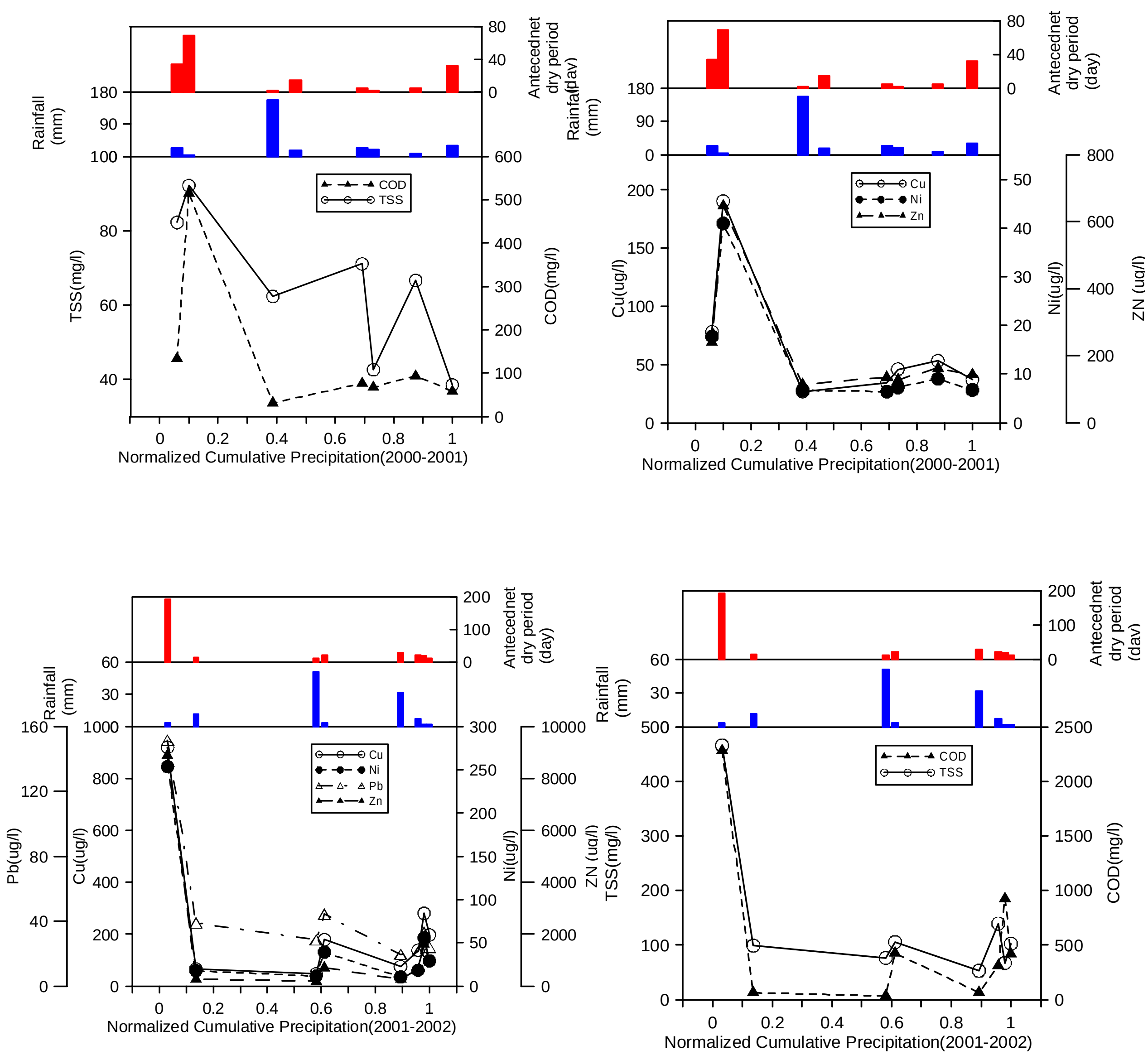


Figure 4.10 Concentrations of various pollutants versus normalized cumulative rainfall for selected monitoring events for the first flush highway runoff dataset

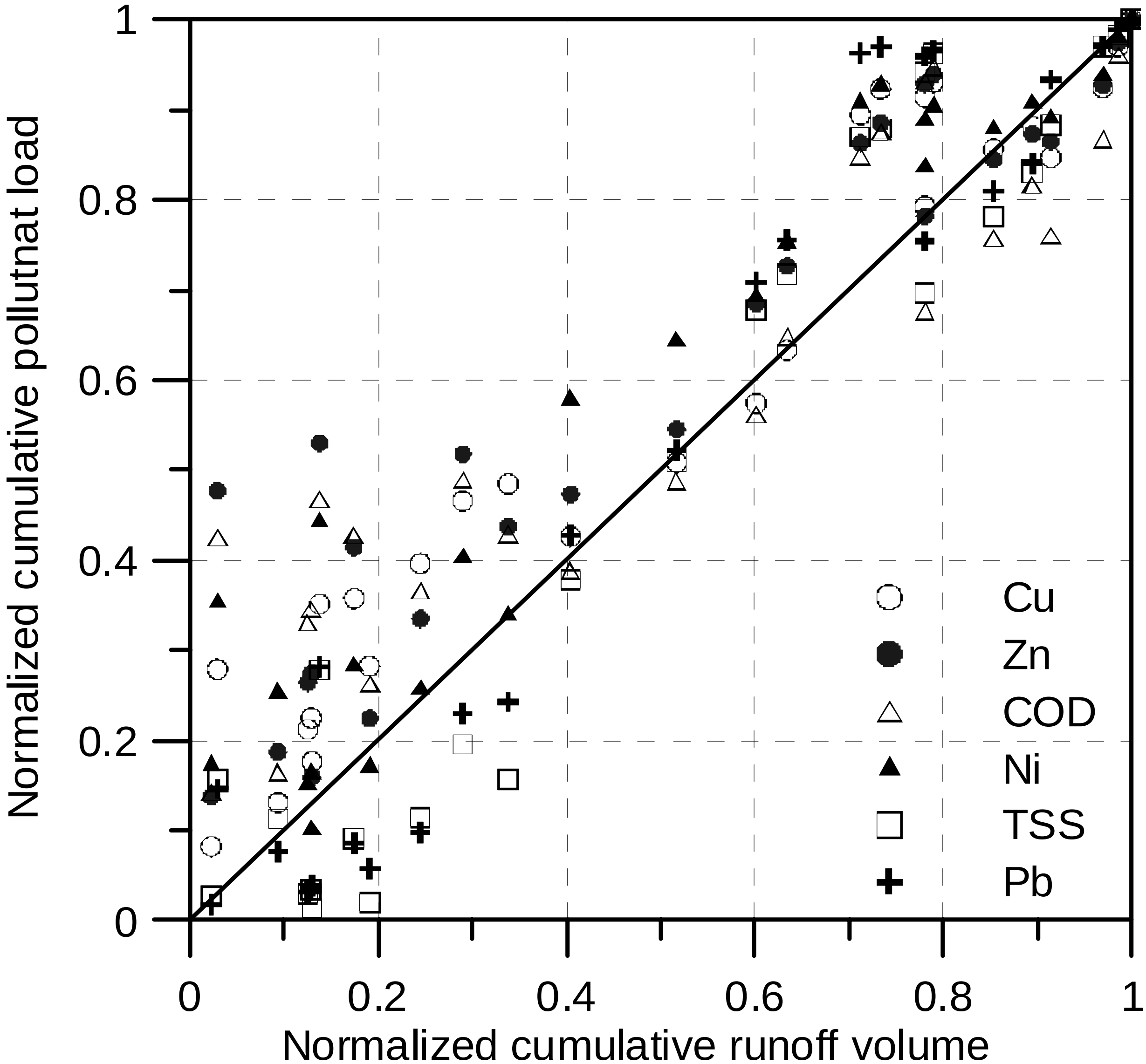


Figure 4.11 Load graphs of four metals, TSS and COD for the first flush study sites

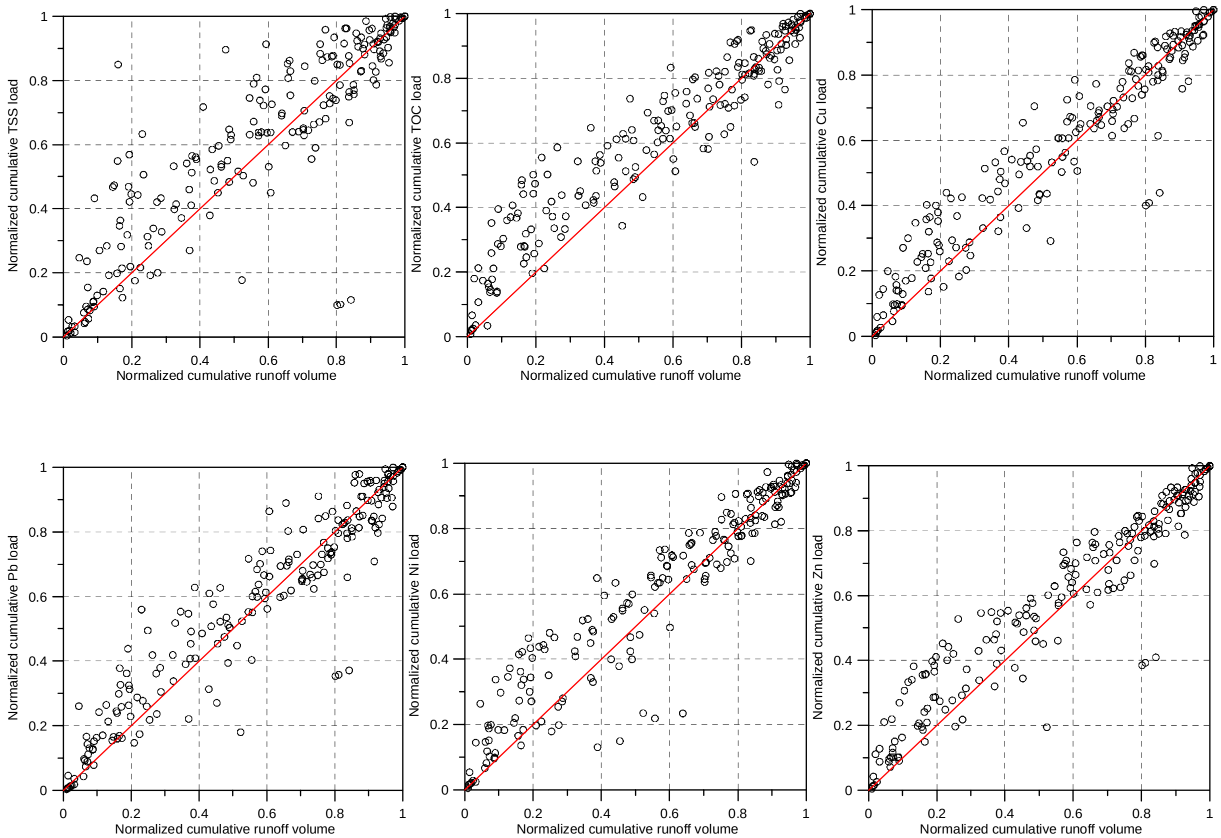


Figure 4.12 Load graphs for metals for the Department's statewide monitoring program sites

5. TOPICS RELATED TO FIRST FLUSH

5.1 Treatment Strategies with Respect to First Flush Pollutant Load

The MFF ratios plotted and tabulated in the figures and appendices can be very useful to the Department in estimating potential removals of BMPs. Since it will not be possible to design and construct BMPs that can treat all of the runoff from all sites for all storms, there must be a probabilistic goal for treatment.

The Los Angeles Regional Water Quality Control Board's example is useful for demonstration. The Board adopted a regulation that requires all new developments to capture or treat the runoff from first 25 mm (1 inch) of rainfall. This rainfall corresponds to a 60% storm for the monitored sites, as shown in Figure 2.6. For storms larger than 60%, some portion of the flow must be bypassed. For very large storms, perhaps only 30 or 40% of the flow can be treated. If only 30% of the flow is treated, the BMP, because of the first flush, has an opportunity to remove not just 30% of the pollutants, but 30% times the MFF_{30} ratio of the pollutants. Using COD as an example, the MFF_{30} is approximately 1.6, and a BMP that treats 30% of the flow would in fact treat 48% of the COD mass.

MFFs can be used to better define the potential removal of BMPs that are "first flush friendly." This term is coined to describe a BMP that treats the first runoff and bypasses later runoff, without washing out the material retained from the earlier part of the storm. Detention basins are one example of a BMP that can be operated in first flush friendly mode. BMPs operated as first-flush friendly may be 2 to 4 times as effective as other BMPs when only a portion of the runoff volume can be treated. Other, more detailed examples of this advantage will be presented later.

Using the MFF ratios provided through this study, the Department can revise upwards its predictions for BMP removal rates, based upon the expected volumes to be treated. For small storms that are completely captured by BMPs, the removals will not change, but for larger storms, which are the most expensive to manage, the mass removals will be greater.

In order to estimate the potential benefits of treating early runoff as compared to runoff later in the season, we defined an effectiveness factor as a function of cumulative runoff volume. In the expected situation of having limited funding for BMP construction, applying BMPs to runoff with higher pollutant concentrations will generally be more beneficial. Also there is growing evidence that suggests that BMPs removal efficiencies are higher in runoff with higher concentrations (Strecker et al., 2001; Lau and Stenstrom, 2002).

The effectiveness factor at a specific cumulative runoff volume is calculated as follows:

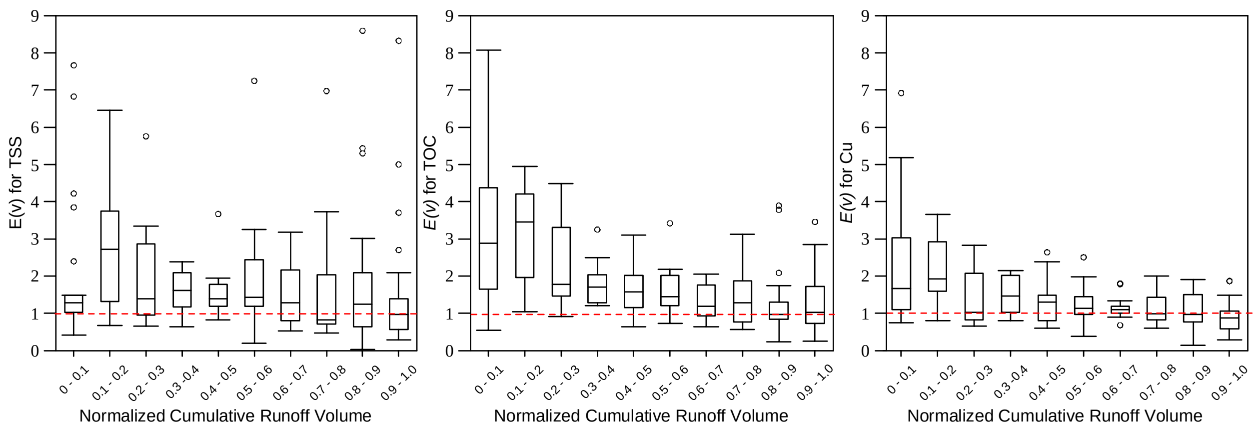
$$E(V) = \frac{(Mv/v)}{(1-Mv)/(1-v)} \tag{5.1}$$

where *E(V)* is the effectiveness factor at a specific cumulative runoff volume *V*, and *Mv* is the normalized cumulative mass at a specific normalized cumulative runoff volume, *v*.

The effectiveness factor has the same utility as the MFF ratio. Values close to 1 are obtained if there is no first flush. Higher values are observed with greater first flush.

Figure 5.1 shows the effectiveness factor calculated for TSS, TOC and four metals for the Department's state wide monitoring program results. The factor was calculated at 10 runoff volume intervals. The dashed line at 1.0 shows the expected value of the effectiveness factor for constant pollutant concentrations or no first flush. The data are plotted as box plots (no confidence intervals).

It is readily apparent that treating the early runoff in the season is several times more effective than treating the later runoff. The results suggest that the Department's efforts to implement BMPs should address the early storms as effectively and completely as possible. Such a strategy will maximize the benefits of the applied BMPs.



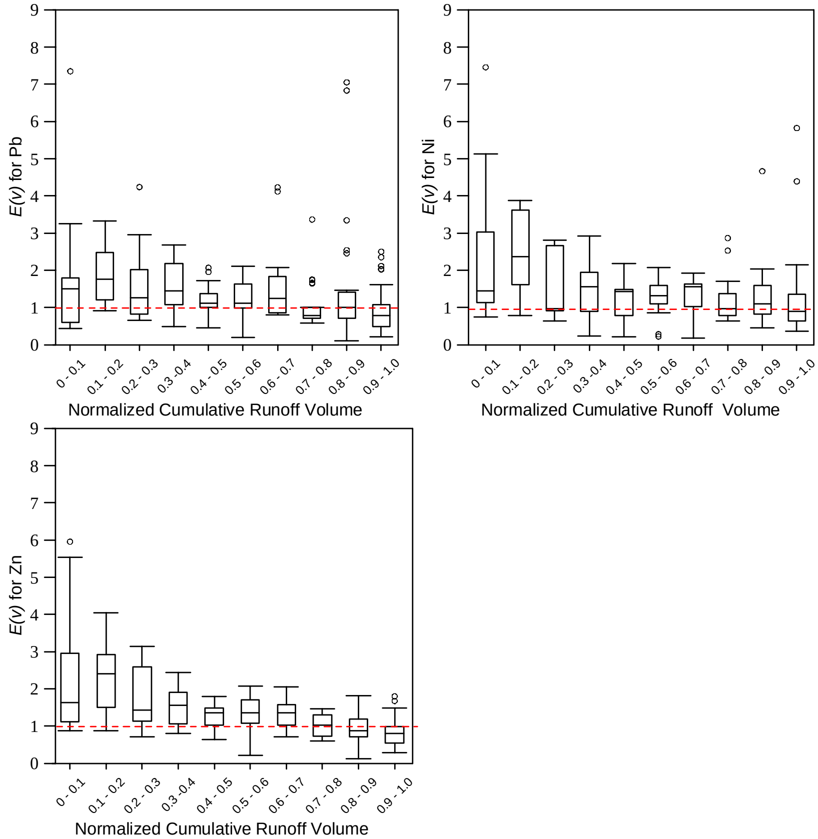


Figure 5.1 Effectiveness factor calculated for ten volume intervals for data from the Department's statewide monitoring program

5.2 A New Methodology to Monitor Oil and Grease

Monitoring for O&G presents special problems because automated samples are not recommended for O&G samples collection (American Public Health Association 1998). Carry over from one sample to the next is caused by oil and grease retention in the sampler tubing. Automated samplers are also avoided when measuring toxicity, due to the introduction of artifactual toxicity from tubing, pumps and containers. Otherwise, automated samplers generally work well, can be left unattended and can be triggered automatically to insure that the very beginning of runoff is sampled. The sampler is programmed to collect many small samples over the entire storm event to insure representativeness.

It is difficult to measure the EMC of O&G in stormwater because a series of grab samples must be collected. If ten samples are collected, the analytical costs are ten times greater and the additional sampling labor maybe even more expensive. Also, the first part of a storm event maybe missed by the sampling team, since the rains will occur at an inconvenient times and the sampling team may have a great distance to cover.

To avoid the complexity and cost of collecting a series of grab samples, a single grab sample is often substituted for the composite sample or the series of grab samples. This strategy reduces the cost, but potentially creates bias due to the timing of the grab sample.

O&G usually exhibits a first flush and Table 4.1 showed that the MFF ratios for O&G were among the highest. Earlier publications document some of the findings on O&G first flush (Lau et al. 2002; Ma et al. 2002). Therefore, a sample collected early in the runoff event will have higher concentration than a sample collected later in the storm event. The critical question is when to collect the grab sample so that it most closely approximates the EMC.

The first flush dataset presented a unique opportunity to develop a methodology for predicting the best time for collecting a grab sample. The existence or more than 60 storm events monitored with 12 grab samples each was used to answer the question of when to sample. Also, correlations were investigated to determine if other parameters might be more useful in estimating the EMC.

Figure 5.2 shows the concept of best time to sample. The O&G concentration declines from a high value at the beginning of the storm to a low value at the end of the storm. This was typically observed in our samples. It is readily apparent from this graph that a sample collected early in the storm overestimates the EMC and a sample collected later in the storm underestimates the EMC. For this event, the idea time to collect a sample is at 133 minutes. Unfortunately there is no way for the sampling team to know this, and if they were to take multiple grabs to determine the best time, it would defeat the purpose of knowing the best time.

To estimate the best time, oil and grease samples from the first three years of the study were analyzed. A Matlab program was written to "read" the pollutographs and calculate the best time. The same program was also written to interpolate between data points on the pollutographs, so sampling times could be simulated. In this way the Matlab program could tabulate the best time for all pollutographs, as well as indicating the O&G concentration that would have been measured if a specific sampling time had been used.

The Matlab program could then be used to calculate the answer to the question "What if all storms had been sampled at 30 minutes" or similar questions. Using this program, a range of sampling strategies was evaluated. The first strategy simulated was random sampling. A random time was selected for sampling each storm and the results were tabulated. Next, fixed times were used, such as 15 minutes into the storm, 1 hour, etc., or at the end of the storm. Next, averages and regressions were used. For example, regressions were performed between storm characteristics and the best times to sample. In some cases, the storm parameters are not known before the storm, which means that weather predictions would have to be used, further complicating the samplers' job.

Finally, correlations with other parameters were investigated. Both dissolved organic carbon and COD measure the O&G. They also include organic compounds or oxygen demanding compounds that are not O&G. Correlations were made to determine if consistent ratios among the parameters exist.

Table 5.1 shows the results of all strategies. The left most column describes the sampling strategy. The next column shows the number of storms that was included in the analysis. The next three columns show the goodness of fit in different ways. For regression, the R^2 are shown and for other cases the root mean square errors (RMS, equal to the square root of the sum of squares divided by the number of observations) are shown. Finally, the last column shows the bias. The bias is the average difference between the observed EMC and the predicted EMC from the sampling strategy. The observed EMC is the EMC calculated from the series of 8 to 12 grab samples.

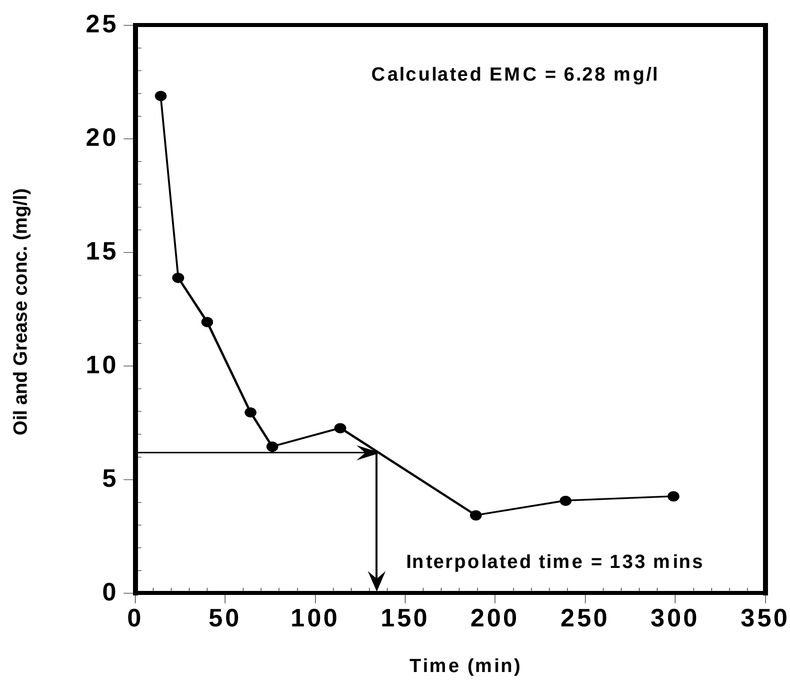


Figure 5.2 Illustration of the best time to collect a grab sample to approximate the EMC

Table 5.1 Results of best sampling time simulations and regressions

Sampling strategy or regression method	No. of Obs.	R^2	RMS Error (mg/L)	Bias (mg/L)
Random grab sampling time	22	0.54	9.40	1.15
Strategy 1: Timed sample strategies after beginning of runoff				
0.25 hr	22		32.4	23.8
1 hr	22		3.47	1.39
2 hr	22		3.91	-2.07
3 hr	18		3.92	-2.54
4 hr	15		3.59	-0.88
5 hr	14		3.13	-1.21
6 hr	9		2.19	-1.38
Storm end	22		3.52	-1.96
Strategy 2: Best sampling time from event and site variables				
Post storm measured parameters				
Total rainfall	22	0.96	1.99	-0.27
Duration of runoff	22	0.92	2.64	-0.22
Total rainfall and duration of runoff	22	0.96	1.96	-0.26
Total rainfall, duration of runoff, and ADD	22	0.97	2.72	0.73
Predicted parameters				
Total rainfall	22	0.89	2.98	0.39
Duration of runoff	22	0.95	2.22	-0.40
Total rainfall and duration of runoff	22	0.88	3.19	0.37
Total rainfall, duration of runoff, and ADD	22	0.92	3.46	1.18
Strategy 3: *EMC* of O&G from site and event variables				
ADD	22	0.82	3.84	-0.01
ADD and total rainfall	22	0.83	3.79	0.00
Logarithm of ADD and total rainfall	22	0.84	3.60	-0.42
Strategy 4: Correlation to composite COD or DOC measurement				
COD Eq. (13)	22	0.90	2.90	0.07
DOC Eq. (14)	22	0.90	2.84	0.01

The first strategy is random timing, which is probably the most common current strategy. The sampling team travels to the site and collects the grab sample when they are able. This strategy had an RMS error of 9.4 mg/L and on average was 1.15 mg/L higher than the EMC. The timed strategies produced the expected results. Samples collected in the first 15 minutes were much higher than the EMC, on average being 23.8 mg/L higher than the EMC. If the storm is sampled after 1 to 4 hours, the grab sample is pretty good and the bias ranges from -1.39 to 2.45 mg/L. Sampling at the end of the storm is also biased on the negative side.

The second set of strategies shows the results of the regression methods. The time to sample in these methods was based upon regressions of the storm parameters. The first group used the post storm parameters, and it is not realistic because they are not known until after the storm. The second group used simulated weather predictions, which provided estimates that were +/- 50% of the actual values. This group of simulations provided results with RMS errors of 2 to 3.5 mg/L, and the bias was nearly zero, which is expected from a regression.

The third group used ADD and total rainfall for predicting the oil and grease concentration. This strategy used no sample for O&G, just a regression from the ADD and./or the total rainfall. The RMS error for this method was only slightly larger than the error associated with strategies that used a sample.

The final group used a simple correlation with COD or DOC. This is the method of choice and provides an accurate answer with the least sampling effort. If COD and DOC are being measured it is a simple matter to estimate the O&G EMC from the COD or DOC EMC. The value of R^2 is nearly as high as the other methods, and no O&G sample is required.

$$O\&G_{EMC} = 3.705 + 0.037 \times COD_{EMC} \qquad R^2 = 0.90 \tag{5.2}$$

$$O\&G_{EMC} = 0.15 + 0.28 \times DOC_{EMC} \qquad R^2 = 0.90 \tag{5.3}$$

These results have important consequences for the Department. It is recommended that the Department end O&G sampling, and correlate O&G to either COD or DOC. This change may require regulatory approval, but the analysis provides powerful support for its approval.

A word of caution is needed. The reason the correlation of O&G to COD or DOC works well is the nature of the stormwater. The organics in highway runoff are mostly compounds that are classified as O&G. For other stormwaters or wastewaters, the correlation may be poor, since the organics in the waters may be carbohydrates or proteins, which do not extract into the organic phase during O&G analysis. A general discussion and review of O&G is helpful in understanding the makeup of O&G (Stenstrom, et al, 1986). The appendices of this report contain the full text of the technical memorandum on this topic.

5.3 Sampling Issue: Composite Samples versus Grab Samples

In order to evaluate different sampling strategies, it is necessary to simulate many events and to add stochastic component (noise) to make the simulation realistic. A COD regression model was used top perform this simulation, as follows:

$$E(\log COD \mid \mathbf{x}) = 6.08 - 0.60 \log CumRs + 0.40 \log AtDry - 0.16 \log AtRs \tag{5.4}$$

where,
COD = chemical oxygen demand concentration (mg/L),
CumRs = cumulative rainfall, corresponding to grab sample collection time, (0.01 inch increments),
AtDry = antecedent dry period before monitored events, days and
AtRs = previous event's precipitation before the monitored event, (0.01 inch increments)

Figure 5.3 shows the model's fitted values vs. the observations. The COD model can be used to predict any number of concentrations for a given hydrograph. In this way, collecting any number of grab samples can be simulated. A random component is added (white noise) which has mean zero and a variance equal to the variance in the original data. A special simulation will use equation (4.4) to generate COD concentrations at one-minute intervals. This special simulation will be used as the benchmark in simulation tasks and is the shortest possible sampling frequency, since the rainfall and flow data are collected at one-minute intervals. The EMC is then calculated using equation 3, where the weights are the discharge rates.

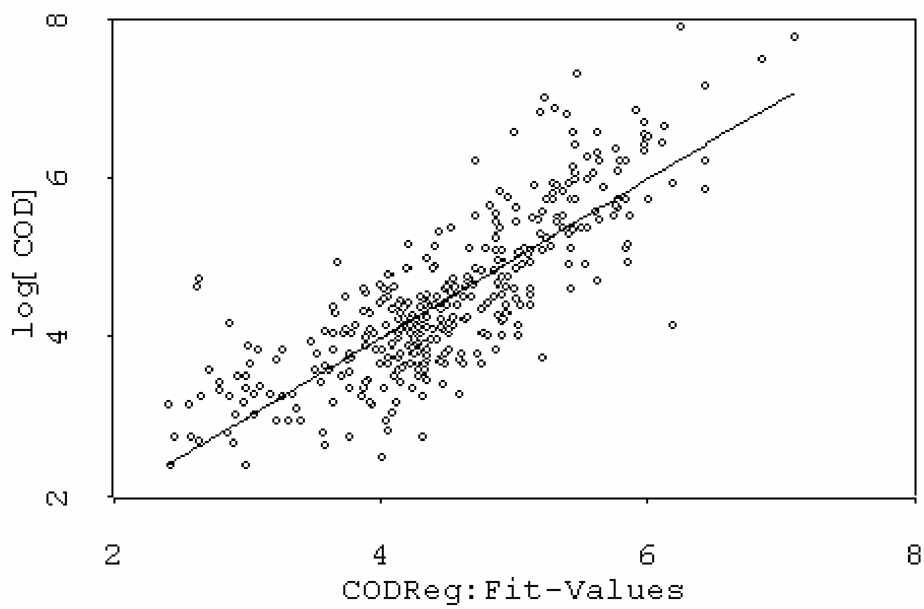


Figure 5.3 Regression's fitted values vs. observation

In order to illustrate this one-minute simulation, one real event is used for demonstration. Figure 5.4 shows the original and the smoothed event hydrographs. The smoothed hydrograph will be used in simulation to correct fluctuations in original data. Figure 5.5 shows the histogram of 1000 simulated EMCs. The original sample mean is 116.36 (mg/L), and the mean of the simulations is 116.25 (mg/L).

To compare other sampling strategies, simulations were performed using different numbers and different strategies for collecting samples during typical storm events (e.g., random, equally spaced in time, equal volume, etc.). A total of 35 different rainfall patterns, corresponding to actual observed patterns in our monitoring program, were used. Table 5.2 summaries the events. Each type of simulation will generate a distribution of EMCs after multiple runs. Simulations that use more samples will produce EMCs that are closer to the original sample EMC. The value of differing numbers of samples as well as the strategy can be compared.

Five types of sampling strategies were evaluated. Type 1 used random timing of the samples. The simulation assumes a sample set with specified size (*n*) that is randomly collected from all possible time elements during each tested event. It is a random permutation of size *n* for a sequence. Theoretically, this is the most general case for a sample set with fixed size. The influence of sample size on EMC results is evaluated simulating 10, 20, 40, 60, and 100 samples per event. Type 2 used equal-time sampling. To avoid the extreme result of a sample sequence, each selected sample sequence was randomly shifted forward or backward in a range (10 minutes). Type 3 used equal-rainfall interval sampling by simulating the sample collection at equal intervals of rainfall depths. Type 4 used equal discharge-volume sampling. No weighting noise was assumed in this task (i.e., the weightings are perfectly known, without measurement error). Type 5 was similar to Type 4, except that random noise was applied to the weighting factors (i.e., the discharged volumes cannot be perfectly measured).

Table 5.2 Hydrologic characteristics for 35 monitored events

Hydrologic Property	Average	StdDev	Minimum	Median	Maximum
Total Rainfall (in)	1.17	1.54	0.08	0.67	6.14
Max Rain Intensity (in/hr)	0.31	0.33	0.02	0.19	1.28
Discharge Volume (gal)	75022	99293	1799.5	36808	374217
Max Discharge Rate (gpm)	340	304	17	258	1465
Rain Duration (min)	660.5	512.7	93	610	2376

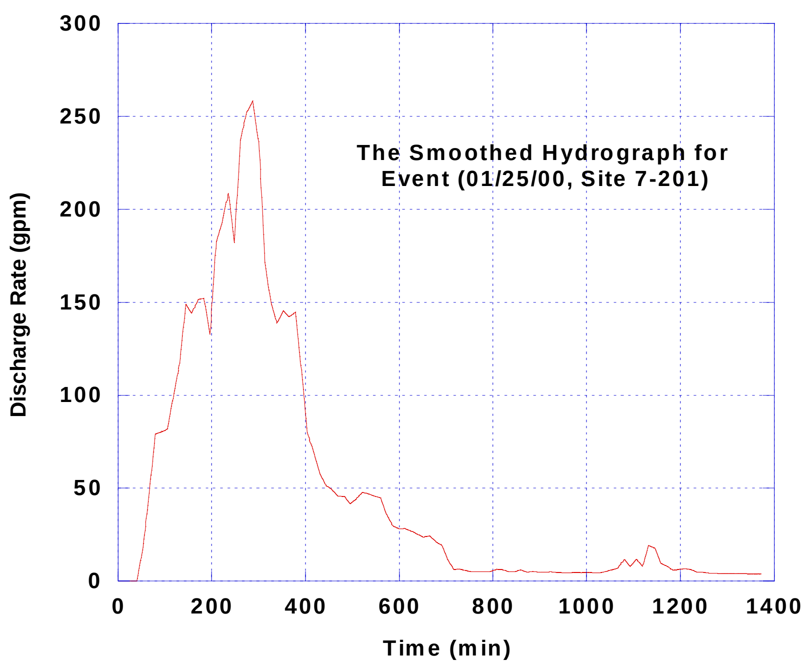


Figure 5.4 Smoothed hydrographs (event recorded on 01/25/00, Site 7-201)

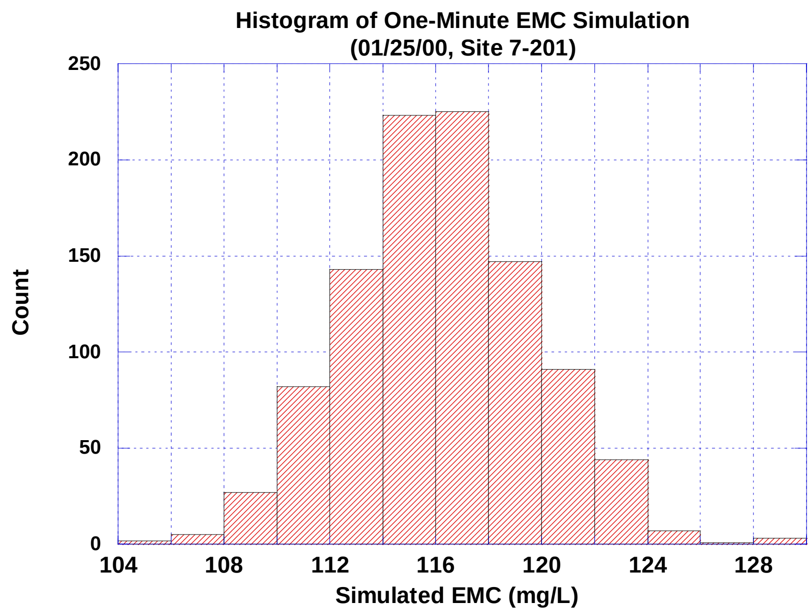


Figure 5.5 Sampling distribution for one-minute EMC simulation
(event recorded on 01/25/00, Site 7-201

The results of the various simulations for different types of sampling strategies are presented in a series of figures. The figures show the distribution of simulated EMCs for each number of samples. Figure 5.6 (top) is a box plot and shows the results for Type 1. The worst error percentage can be up to 80% for n = 10. The average error percentages for n = 10, 20, 40, 60, and 100, are 47.0%, 30.2%, 19.5%, 15.3%, and 11.6% respectively. The medians of errors are slightly lower than the averages. The corresponding standard deviations are 13.9%, 7.2%, 4.1%, 2.9% and 2.2%. Type 1 is a benchmark on the influence of sample size for estimating EMCs, and is the most general sampling strategy.

Figure 5.6 (middle) shows the sample distributions Type 2. Only one outlier was found for each n. The worst case is for n = 10 with error of approximately 66%, which is much improved over Type 1. The average error percentages for n = 10, 20, 40, 60, and 100, are 37.2%, 21.7%, 15.2%, 12.4%, and 9.2% respectively. The medians of errors are generally the same as the averages. The corresponding standard deviations are 11.1%, 4.4%, 2.7%, 2.8% and 1.7%. These statistics show an improvement over random sampling.

Figure 5.6 (bottom) shows the sample distributions from Type 3. Although several outliers were found for n = 10, the worst case is approximately 30%, which is much improved over Type 2. The average error percentages for n = 10, 20, 40, 60, and 100, are 23.9%, 17.5%, 13.5%, 11.9%, and 10.5% respectively. The medians of errors are generally the same as the averages. The corresponding standard deviations are 2.2%, 2.2%, 2.6%, 3.2% and 3.7%, a large improvement over time sampling.

Figure 5.7 (top) shows the sample distributions from Type 4. It is obvious on plot that this is the best result from the aspect of outliers, averages, or variances. The average error percentages for n = 10, 20, 40, 60, and 100, are 23%, 16.6%, 12.0%, 9.7%, and 7.5% respectively. The medians are generally the same as the averages. The corresponding standard deviations are 2.5%, 1.6%, 1.2%, 1.0% and 0.7%. Figure 5.7 (bottom) shows the sample distributions for Type 5. This is the same strategy as Type 4, except that the weights are not perfectly measured. The average error percentages for n = 10, 20, 40, 60, and 100, are 23.5%, 17.1%, 12.3%, 10.1%, and 7.8% respectively. The corresponding standard deviations are 2.1%, 1.6%, 1.3%, 0.9% and 0.8%. The effect of imperfect weights is not very large.

This analysis has shown that a flow weighted composite sample can be viewed as a series of grab samples summed with weights that reflect the flow. To evaluate the error of using a limited number of grab samples and the strategy for collecting the samples, a series of simulations was performed using a COD correlation, random noise and hydrographs from 35 different storm events.

The results show that a series of 10 grab samples provides a relatively poor estimate of the EMC, with median errors of 40% for randomly timed samples to 23% for samples collected at equal flow volumes. If the number of grab samples increases to 20, the error is reduced to 30% for randomly timed samples to 16% for samples collected at equal flow volumes. Even if 100 samples are collected, the error is still nearly twice as large as the minimum possible error, when samples are collected each minute.

The best strategy is to collect the grab samples at equal flow volume intervals. Equal rainfall interval is the second choice, with equal timing and random timing being less desirable strategies.

The results show that automatic flow weighted composite samples, which can be programmed to collect several hundred samples per storm, are far superior to a series of grab samples, even if 100 grab samples are used. If automatic composite samplers can be used without chemical or physical biases (e.g., such as the concerns of sample carry-over when sampling for oil and grease, or the introduction of artifactual toxicity), they are always preferred.

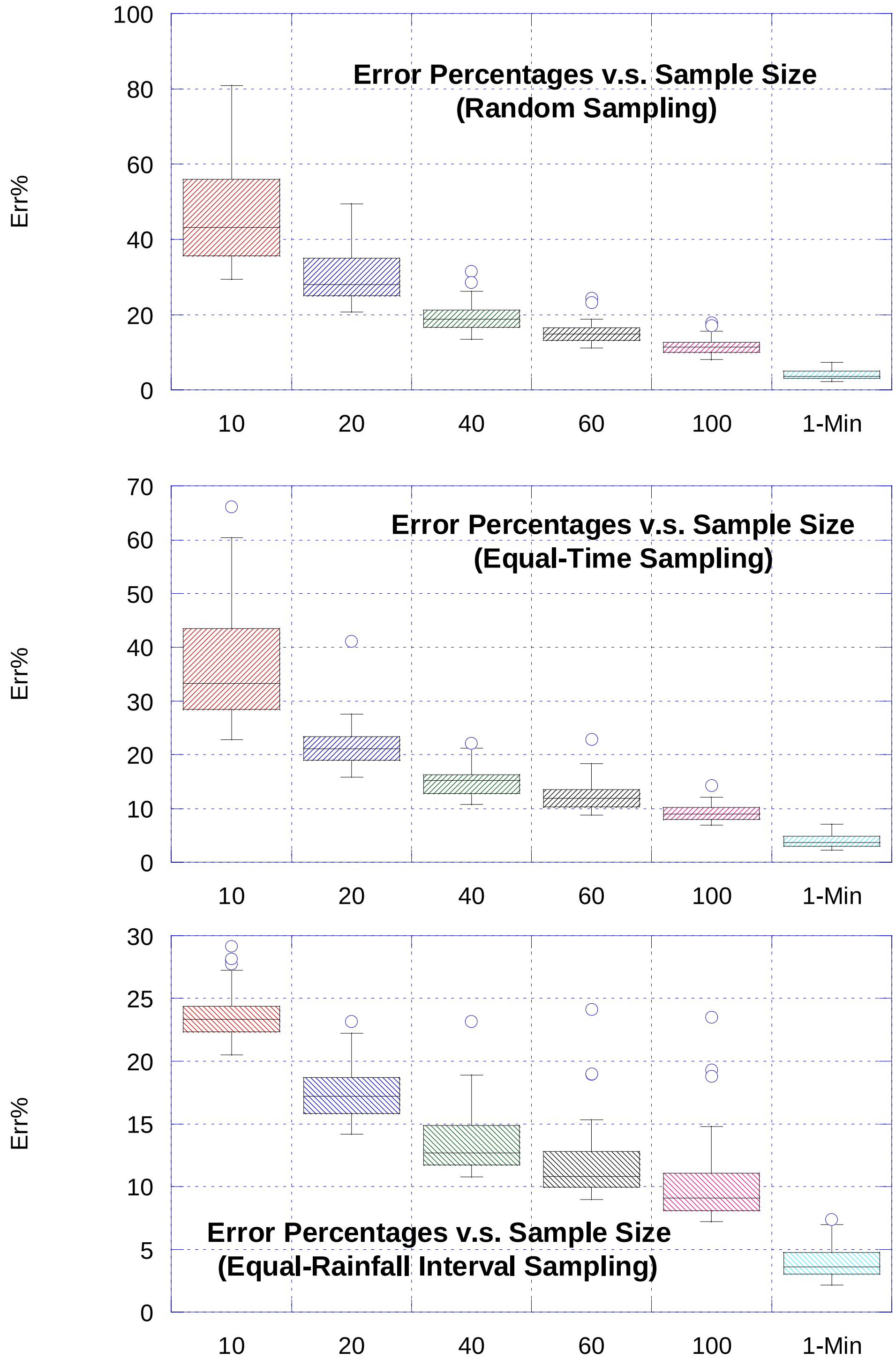
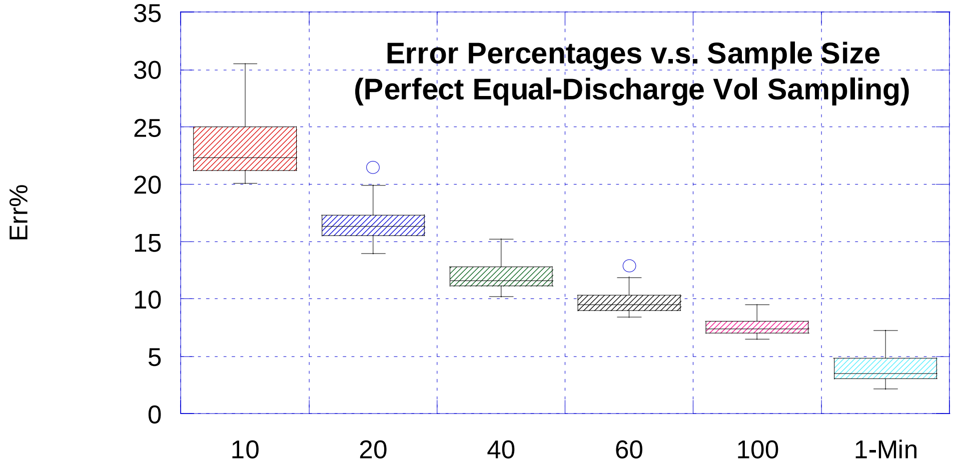


Figure 5.6 Sampling distributions for random time (top), equal time (middle) and equal rainfall interval (bottom) (with n = 10, 20, 40, 60, and 100) plus one-minute simulation



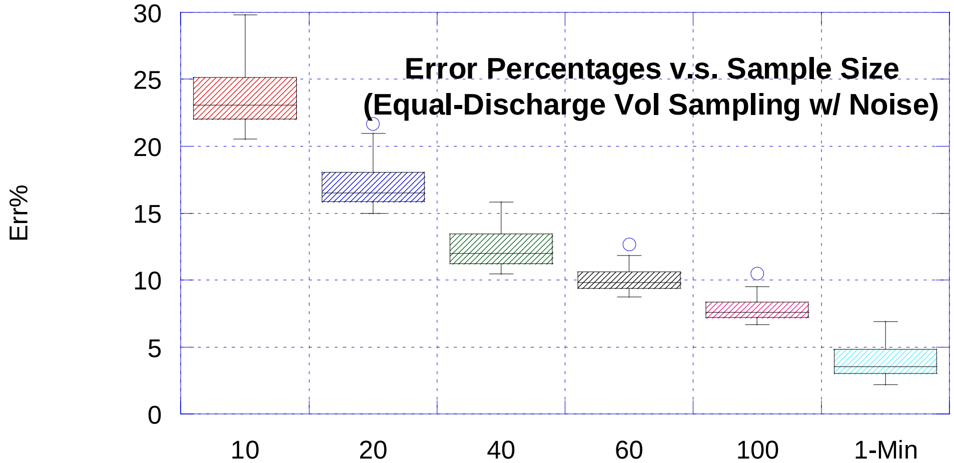


Figure 5.7 Sampling distributions for perfect equal-discharge volume sampling (top) and equal-discharge volume sampling with noise (bottom) (as n = 10, 20, 40, 60, and 100) plus one-minute simulation

6. SUMMARY

The California Department of Transportation sponsored a four-year stormwater monitoring study to investigate first flush phenomenon. The Department of Civil and Environmental Engineering at the University of California, Los Angeles (UCLA) in collaboration with the Center for Environmental and Water Resources Engineering at the University of California, Davis (UCD) conducted the investigation. UCLA collected the bulk of data and performed the analysis of the results. Consultants under contract with the Department sampled several sites in the first two years of the study, and assisted in the initial set up the sites and monitoring equipment.

Three highly urbanized representative highway sites near UCLA were selected for this study. Two sites were located on IS 405 near Santa Monica Boulevard and the Getty Center and the third site was located on the intersection of US 101 and IS 405. The sites were instrumented with rain gauges, flow meters and automatic composite samplers. Consultants monitored two different sites in the 1999-2000 and three different sites in the 2000-2001. Nearly all analysis and discussion presented in this report are based on the results obtained from the UCLA monitoring data, although data from both consults are included with the UCLA monitoring data in the Appendix.

In the first year, five grab samples were collected during the first hour of runoff followed by two or three manually composited samples in the following two to three hours. In the second, third and forth years, five grab samples were again collected in the first hour, followed by one grab sample per hour for the next 7 hours, providing a total of 12 grab samples. For storms lasting less than 8 hours, fewer grab samples were collected. For storms lasting longer than 8 hours, an additional one or two grab samples were collected in the period from 8 hours to the end of the storm.

The grab samples were collected from the storm drain outfall (or drain pipe) using a polypropylene scoop, and then transferred to 4-L amber glass bottles. In all cases samples were collected from a free waterfall. The bottles were transported to the laboratory at UCLA immediately after collection and refrigerated at 4°C until analyzed. Generally the first 5 bottles were transported to the laboratory after the first hour, and one or two more trips were made as the storm progress. The time between the sample collection and receipt of samples at UCLA laboratory was less than 4 hours. This became important in the last year of the study, when particle size distribution (PSD) was being measured. Measurable changes in PSD occurred within 12 hours after sample collection.

Numerous water quality parameters, nutrients, metals (particulate and dissolved), oil and grease were routinely monitored for the duration of the study. Other constituents that were monitored less frequently include indicator organisms and polynuclear aromatic hydrocarbon (PAHs). All analyses were performed within the recommended holding time using US EPA and Standard Method protocols. In addition, during the second and third year of the study, litter samples were collected. A large mesh, draw-string bag (6 mm opening) was placed over the entire flow from each site to collect litter. Three bags were collected for each site for each storm. The first bag was installed before the beginning of the storm, and removed after 1 hour of runoff. A second bag was installed and was removed after 8 hours or the end of grab samples. The third bag was installed and was left in place until the end of the storm.

It was retrieved and all bags for all sites were transported to an outside lab under contract with the Department for performing the litter analysis.

Major results and findings of the study are summarized in the following paragraphs.

6.1 Definition of First Flush Phenomenon

First-flush is a phenomenon that is associated with the belief that the first runoff in a storm event is the most contaminated. Most researchers believe that the first runoff does have higher contaminant concentrations, but opinions vary as to the importance of the increased concentrations, and whether the actual first flush mass is a significant portion of the total runoff mass. Lay people generally believe there is a first flush, and associate hazardous driving conditions with the onset of rainfall. The study has devoted a great deal of effort to developing a quantitative definition of first flush. In areas which have distinct seasonal rainfall patterns, such as California, a similar concept, called seasonal first flush exists. A mathematical concept was developed (described in section 4) that can be applied to different types of first flush phenomena, defined as follows:

> First flush – the concept that pollutants are more concentrated at the beginning of a rainfall event than in the later parts of a rainfall event. The concept can be applied to the mass discharge of contaminants (e.g., mass first flush) or the concentration (e.g. concentration first flush).
>
> Seasonal first flush - the concept that pollutants are more concentrated in the runoff of the first few storms of a rainy season than in the storms that occur later in the season. The concept can be applied to the mass discharge of contaminants (e.g., mass first flush) or the concentration (e.g. concentration first flush). The existence of a seasonal first flush requires an extended dry period before the rainy season.

6.2 Pollutograph and First Flush of Pollutants

The EMC measured through flow-weighted composite samples is perhaps the best, single descriptor of stormwater contaminant concentration and is generally preferred in any monitoring study. Unfortunately, the EMC provides no information on the temporal variability of contaminant concentrations. It cannot be used to characterize first flush. Analysis of a series of grab samples, while more expensive, provides the temporal pollutant variability throughout the storm hydrograph. This temporal variability is usually illustrated through pollutographs by plotting constituent concentration vs. duration of the storm event. A large concentration of pollutant at the beginning of the event with a gradual decrease of the pollutant concentration towards the end of the storm event is an indication of first flush.

The results of this study revealed a large change in concentration of most contaminants as a storm progresses. For example, the first sample may have had more than 500 mg/L chemical oxygen demand (COD) but the EMC may have been only 100 mg/L. The reduction occurs because the pollutant mass may be washed out of the site, or may be diluted by higher runoff flow rate as the storm progresses. By reporting only the EMC concentrations, the high initial concentrations are not recognized. This may be significant for BMP selection, since BMPs generally perform better at higher influent concentrations. Using the EMC for BMP evaluation may underestimate overall BMP removal rates.

6.3 Load-graph and Mass First Flush Ratio

The graph of normalized cumulative mass versus normalized cumulative volume is usually referred to as "load-graph" and can be used to examine the mass first flush phenomenon. The mass first flush ratio is defined as the normalized discharged constituent mass divided by the normalized runoff volume for a specific runoff volume. For example, a MFF_{10} ratio of 4.5 implies that 45 percent of pollutant mass is transported in the first 10 percent of the runoff volume. The greater the MMF_n ratio, the larger the mass first flush. The MFF always approaches 1.0 as the normalized runoff volume approaches 1.0. For a pollutant to have a first flush the mass first flush ratio (MFF_n), must be greater than 1.

6.4 Organic (PAHs) First Flush

Dissolved polyaromatic hydrocarbons (PAHs) were generally at or below detection limits. However, particulate PAHs were dominant and in most cases, first flushes of particulate PAHs were exhibited. The mass first flush ratio generally was above 2 for the first 20% of the runoff volume, and in some cases as high as 2.8. The results suggest that best management practices (BMPs) that address particulate phase contaminants in the initial runoff can have greater effectiveness for particulate PAH removal than other types of BMPs.

6.5 Litter First Flush

Results obtained indicate that a first flush of gross pollutants was generally observed. Gross pollutants were defined as being larger than 6 mm and were classified into three categories: vegetation, biodegradable litter, and non-biodegradable litter. The gross pollutants were 90% vegetation and 10% litter. Approximately 50% of the litter was composed of biodegradable materials. However, a greater percentage of biodegradable litter was normally collected in the first flush. No statistically significant correlations of litter production were noted, although the event mean concentrations show an increasing trend with antecedent dry days and a decreasing trend with total runoff volume or total rainfall. The mass emission rates will be useful to estimate total litter production for developing total maximum daily loads for litter.

6.6 Seasonal First Flush

The seasonal first flush issue was addressed by plotting the concentrations of the various water quality parameters as a function of normalized rainfall for several years. Results revealed that the constituents' concentrations decline as the season progresses. This indicates that treating stormwater early in the season is more effective than treating runoff late in the season. The engineering opportunities to exploit these differences were beyond the scope of this study and have not been explored. Similar trends in other water quality parameters and the data from the Department's statewide monitoring program (Department's report CTSW-RT-03-065.51.42) also show a seasonal first flush.

6.7 Particle First Flush

In the fourth year of the study, particle size distribution was measured during the various stages of the hydrograph. The numbers of particles were measured over the range of 2 to 1000 μm. It was observed that the numbers of particles declined dramatically as the storm progressed. Preliminary analysis of particle size distribution indicated the occurrence of a natural aggregation. This natural aggregation of particles required that analysis be performed as soon as possible, but in no case longer than six hours after sample collection of the sample. Analysis of samples older than six hours could be biased due to particle aggregation. Samples collected using automatic composite samplers had lesser numbers of small particles and greater numbers of large particles than grab samples. The holding time during the composite sample collection allowed particles to aggregate. Therefore, composite samplers are not recommended for collecting samples for PSD analysis.

More than 97% of the particles were less than 30 μm in diameter. Particle concentration and size generally decreased rapidly as the storm progressed. Rapid increases in particle numbers occurred after rapid increases in rainfall or runoff, and were accompanied by increases in turbidity and total suspended solids concentration. Particles showed an obvious first flush, with median of PFF_{20} of approximately 2, indicating that 40 % of total particles were carried in the first 20 % of runoff volume. Larger particles showed a stronger first flush effect than smaller particles.

The availability of particle size distribution measurements will greatly increase our understanding of treatment mechanisms. BMPs can be sized to remove particles larger than a specific size, which will allow more scientific evaluation of BMPs. Work is underway to measure pollutant concentrations as a function of the particle size.

6.8 BMP Evaluation based on First Flush

As part of this study, the MFF ratios have been calculated for all storms and monitored constituents. The mean mass first flush ratios at 10, 20, 30, 40 percent runoff volume were computed and ranked for all constituents. The use of the MFF ratios, as opposed to an arbitrary definition of first flush, allows BMPs to be evaluated for a continuum of conditions. The MFF values can be used in evaluating BMPs, especially those that are “first flush friendly,” meaning that the treatment system can capture or treat the early runoff and associated pollutant mass.

To estimate the potential benefits of treating pollutants in the early runoff, either as the first flush of a storm event or a seasonal first flush, a treatment effectiveness factor (TEF_n) as a function of MFF_n was introduced. Computation of TEF for 10, 20, 30 and 40 percent of the normalized cumulative runoff volume showed a value between 2 to as high as 7. A TEF_{10} of 7 means that treating the first 10 percent of the stormwater runoff volume will be 7 times more effective than treating an equal volume of runoff at a later time in the storm event.

6.9 Correlation among Water Quality Parameters

Results showed that there are strong correlations among many of the water quality parameters and particularly among parameters that measure organic content (e.g., COD, total or dissolved organic carbon, etc). COD shows a particularly high correlation with other parameters. There are strong correlations among metals, such as zinc and copper, and the dissolved and particulate phase concentrations are highly correlated as expected. TSS is not as well correlated to other water quality contaminants as we have previously thought. The high degree of correlation among parameters raises questions about the need for such extensive monitoring of all parameters. It may not be necessary to measure all parameters for routine monitoring. For example, it may be possible to measure only one organic quality parameter, such as TOC or COD. TOC is easy to measure and generates no laboratory hazardous wastes as COD. It is easier and more reliable than oil and grease measurement. The degree of correlation is very high among soluble and total metals. Therefore it may be possible to measure only total metals. The utility in reducing the number of parameters will depend on the monitoring purpose. For BMP selection, the difference in soluble and total metals is important, since most BMPs generally cannot remove soluble metals. For routine monitoring, it may be possible to substitute total metals and calculate the soluble metal from the correlation.

6.10 New Method to Measure Oil and Grease Concentration

Oil and grease can generally not be sampled with an automatic sampler because the oil adheres to tubing and sample bottle surfaces. The adsorbed oil reduces the sampled value and can carry over to the following sample. Most agencies choose to take one grab sample instead of a composite sample. If the oil and grease sample is collected early in the storm, it will likely be greater than the EMC. If it is collected later in the storm, it can be lower. There is no distinct time in a storm event to collect a single oil and grease sample to be representative of the entire storm event. The most representative time to collect a sample ranges from 2 to 5 hours after the beginning of rainfall, and depends on many factors.

Correlation between O&G and other organic constituents, such as chemical oxygen demand (COD) or dissolved organic carbon (DOC) was shown to be a better method to estimate the oil and grease EMC. Most importantly, COD and DOC can be collected using automatic samplers. Strong correlation (R^2= 0.9) between these aggregate organic constituents and oil and grease were found. A linear mathematical relationship was derived and for highway runoff, and the composite sample analyzed for DOC was the best method to estimate O&G event mean concentration.

6.11 Sampling Issue: Automatic versus Grab Sampling

It is generally known that flow weighted composite samples provide more accurate and precise information than a grab sample. During the course of this research, questions were raised about the accuracy of flow-weighted automated composite samplers, and whether they provide better information than a series of composite samples that are flow-weight averaged to produce a calculated composite sample.

To answer this question, a series of simulations were performed to “mimic” the runoff flow rate and concentrations observed in the first two years of our study. Random noise was added to simulate the stochastic nature of stormwater. The degree of noise was selected to match the variability in the actual observations. Next an automated sampler and flow weighted grab samples were simulated. The automated sampler was simulated by rapidly sampling the runoff at short intervals, simulating the “squirts” that the automated composite samplers collect in proportion to flow rate. Grab samples were simulated in a similar fashion, but at randomly timed intervals.

More than 1000 simulations were performed and the result showed that and EMC estimated by averaging 10 grab samples will have a mean error of 42 % difference as compared to a flow weighed composite sample, collecting small sample volumes every minute. The error decreases with the number of samples and approaches 12% for 100 grab samples. In general, however, it is shown that a large number of grab samples is needed to approximate the flow weighted composite sample. Thirty grab samples per storm event provided a good estimate of a composite sample. To detect a first flush, it is necessary to take even more samples or to weight the samples towards the beginning of the storm. The superiority of the automatic sampling equipment is demonstrated, and the results show that investigators using only a few grab samples to characterize an event would not be able to observe a first flush.

In Conclusion

The existence of a first flush, either a storm or a seasonal first flush, may present opportunities for managers and regulators to affect better pollutant reduction programs. Treating early runoff that has higher contaminant concentrations may be a better policy than treating a similar fraction of the entire runoff volume. This will be true for two reasons. The first reason is the cost of treatment is generally more dependent more on the volume of water to be treated than the contaminant concentration. The second reason relates to the way that stormwater BMPs function; removal efficiency is greater at higher concentrations. Treatment efficiency at low concentrations is nearly zero, but significant removal can be obtained at higher concentrations. The emerging ASCE database on BMP trials shows this effect.

The Department's future development programs to reduce pollutants from stormwater may take advantage of first flush for removal of specific contaminate at local watershed basis.

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Welcome to the data query site for the Ventura Countywide Stormwater Quality Management Program

Mass Emission (ME) monitoring stations are located on the mainstem receiving water low in each of the three main watersheds. The letters after the dash in the site code indicate the watershed, e.g. Ventura River (ME-VR2), Calleguas Creek (ME-CC), and Santa Clara River (ME-SCR). Major Outfall (MO) monitoring stations are located on representative outfalls for each city and are assigned an applicable code according to location, e.g. MO-HUE for the major outfall station at Port Hueneme. Land Use sites represent the predominant land use in the area, e.g. agriculture (A), residential (R), industrial (I), commercial (C), open space (LV), mixed use (LC/MC/W-1/W-2); and subwatershed receiving waters (W-3/W-4).

The monitoring results can be queried here. Each step allows you to refine the data query for the information you are interested in. You can select sample dates and locations, weather conditions (wet or dry), classifications (e.g. bacteria, metals, nutrients etc.) and constituents of interest.

For questions about the Program’s monitoring data, please contact Kelly Hahs at kelly.hahs@ventura.org. For website issues, please contact Gabriel Ramirez at gabriel.ramirez@ventura.org.

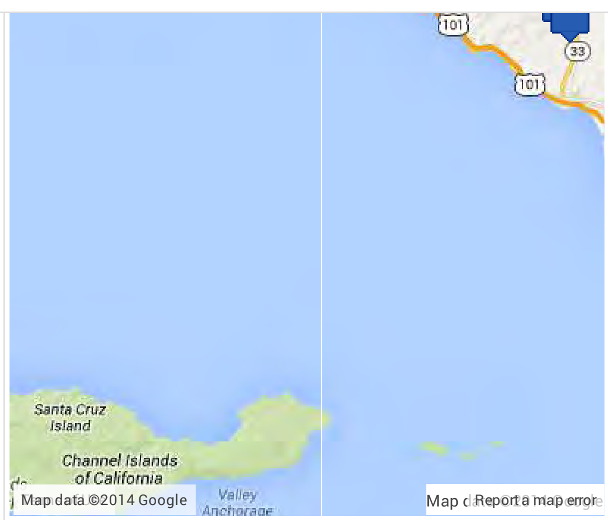
Map Legend

Mass Emissions

Major Outfall

Land Use

Close



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June 16, 2014
Project No. 04.62140059

County of Ventura Watershed Protection District
800 South Victoria Avenue
Ventura, California 93009-1610

Attention: Mr. David Kirby, P.E.

Subject: Limited Geotechnical Investigation Report, Percolation Test Data, Urban LID Retrofit at El Rio, Ventura County, California

Dear Mr. Kirby:

Fugro Consultants, Inc. (Fugro) appreciates the opportunity to provide consulting services for Ventura County Watershed Protection District's (County) project to construct an Urban Low Impact Development (LID) Retrofit in the unincorporated area of El Rio in Ventura County, California. This data report summarizes Fugro's work and findings related to the percolation testing we performed at four sites around the El Rio community. The drilling and percolation testing were carried out over a period of three days from May 28, 2014 through May 30, 2014. Our work was performed in general conformance with our proposal dated May 19, 2014 and authorized under our annual consulting services contract with the County of Ventura by work order PW14-161 executed on May 21, 2014.

PROJECT DESCRIPTION

Our knowledge of this project is based upon conversations with you and information provided in the Request for Proposal (RFP) dated May 15, 2014. We understand the County is interested in installing new stormwater Best Management Practices (BMP's) in the El Rio area to retrofit the existing runoff management systems. The County hopes to utilize the infiltration capacity of the subgrade soils to provide a LID solution. Fugro was consulted to perform site exploration, in-situ infiltration testing and laboratory analysis services for four site locations to determine the necessary design parameters for the development of those proposed infrastructure elements. Plate 1 - Vicinity Map indicates the locations of those four areas with relation to the surrounding streets and other landmarks.

WORK PERFORMED

PRE-FIELD PLANNING

Prior to initiating our subsurface exploration program, we visited the sites to assess potential drill hole locations and accessibility with regard to the drilling equipment. Fugro personnel took photographs of the sites, notified Underground Service Alert (USA), and marked the proposed drill hole locations for utility clearance. Per Fugro's policy, our staff re-visited the sites to observe the utility delineations prior to drilling and coordinated with the utility owners to verify that the proposed areas were cleared for work or marked appropriately.

Our staff coordinated with County personnel to secure the necessary Ventura County encroachment permit to work within the Ventura County Right-of-Way (ROW) at the proposed sites. As required by the encroachment permit, we placed "No Parking" signs along the anticipated work areas 72 hours prior to initiating our field exploration program. At the County's request, we also prepared brief notification letters documenting our planned activities, the duration of our field work, and the impact our work may have on the neighboring residences. While placing the "No Parking" signs, Fugro staff also delivered those letters to the mailboxes of the three closest homes on each side of our work areas and to those homes directly across the street from them.

Lastly, our personnel developed a project and site-specific health and safety plan for the use of all Fugro and subcontracted employees on-site.

HOLLOW-STEM-AUGER DRILL HOLES

The drilling subcontractor for the project was S/G Drilling Company of Lompoc, California (S/G). S/G used a truck-mounted CME-75 drill rig equipped with 8-inch-diameter hollow-stem-augers (HSA). On May 28, 2014, two (2) HSA drill holes (one shallow and one deeper) were excavated at each site to depths of approximately 4 feet bgs (shallow) and 12 feet bgs (deep). The locations of those eight (8) explorations are depicted on Plate 2 - Exploration Location Map.

As originally proposed, the drill holes were sampled at regular intervals using a 1-1/2-inch-outside-diameter Standard Penetration Test (SPT) sampler. The SPT sampler was driven by a 140-pound automatic-trip hammer with a 30-inch drop. Field blow counts shown on the drill hole logs indicate the number of blows from the hammer that were needed to drive the sampler 1 foot after the initial 6-inches seating into the material at the bottom of the hole.

The drill hole logs are presented in Appendix A - Subsurface Exploration and describe the earth materials encountered, sampling methods used, and field and laboratory tests performed. The logs also indicate the drill location, drill hole number, dates of start and completion, and the names of the logger and drilling subcontractor. The drill holes were logged by a Fugro engineer in general conformance with ASTM D2488 for visual-manual soil classification. The boundaries between soil types shown on the logs are approximate because the transition between different soil layers may be gradual and may change with time. The legend for interpretation of the drill hole logs is presented on Plate A-9 - Key to Terms & Symbols Used on Logs.

After completing the logging and sampling, the holes were cleaned out as much as possible by rotating the augers in place. The resulting cuttings were stockpiled adjacent to the work area for future abandonment. Using the augers as a tremie, S/G then placed several inches of drain rock at the bottom of the excavation, set a 2-inch diameter perforated polyvinyl-chloride (PVC) casing, and backfilled the annular space within the test interval with more drain rock to prevent the sidewalls from collapsing upon saturation. The temporary well configuration allowed water in the test interval to percolate through the drill hole side walls and the bottom of the excavation. Table 1 below summarizes the percolation hole locations and test depth intervals.

Table 1. Summary of Performed Percolation Test Information

Test Location[1]	Ground Surface Conditions	Test Intervals (feet below existing ground surface)
Southeast side of Balboa Street southwest of Lemar Avenue	Ventura County ROW Paved area	DH-01B, (1 to 4.5) DH-01A, (9 to 12)
Northeast side of Simon Way between Rene and Elaine Streets	Ventura County ROW Landscape area	DH-02B, (1 to 4) DH-02A, (9 to 12)
South side of Simon Way approximately 320 feet northwest of George Street	Ventura County ROW Paved area	DH-03B, (1 to 4) DH-03A, (9 to 12)
Southeast side of Balboa Street northeast of Helsam Avenue	Ventura County ROW Landscape area	DH-04B, (1 to 4) DH-04A, (9 to 12)

1) Locations depicted on Plate 2 - Exploration Location Map.

PERCOLATION TESTING

Fugro conducted percolation testing at the four sites (8 test holes) on May 29 and 30, 2014. Testing at each location was supervised by a Fugro Engineer and consisted of a pre-soak and percolation test period.

Pre-soak

After constructing the temporary test wells, water was added through the casing to saturate the anticipated test intervals. However, the pre-soak water percolated rapidly (on the order of feet per minute) into the subgrade and our staff determined that a short duration saturation period immediately prior to testing would be more feasible and still satisfy the requirements of the Ventura County Technical Guidance Manual for Stormwater Quality Control Measures (VCTGM, 2011). The shortened pre-soak period for each test hole consisted of introducing a minimum water volume equal to one test interval (casing and annular space) and allowing it to fully percolate into the subgrade materials.

Percolation Measurements

After the pre-soak period, our staff refilled the casing to the top of the test interval and initiated data collection. Once the initial water level was set, readings were taken at regular time intervals ranging from between 30 to 180 seconds (the actual time intervals were recorded with each reading). Although the VCTGM (2011) provides guidance to collect readings at 10 minutes intervals, the test holes typically absorbed the full test interval volume in just a few minutes. Due to the fast percolation rate and difficulty associated with frequently refilling the test hole in order to run a 1 hour test as outlined in the VCTGM (2011), we altered the test method to consider one full test as the duration required to infiltrate one entire test volume of water. After completion, the casing was filled back to the top of the test interval to restart the test. We completed a minimum of four full tests as defined above at each test hole. The water surface was measured inside the casing by use of an engineering tape at the shallow test hole locations and by an electric water level sounder in the deeper excavations. The reported measurements can be considered accurate to within 5 hundredths of a foot.

After testing was complete, our staff removed the perforated PVC casing leaving the drain rock in-place. The holes in unpaved areas were backfilled with cuttings generated during drilling and hand compacted with a tamping rod to minimize future settlement. Excess soil cuttings were stored adjacent to the work areas in 55-gallon drums and subsequently hauled away to a non-hazardous waste disposal facility by Environmental Recovery Services, Inc. (Enviroserv) of Gardena, California. Explorations in paved areas were backfilled hydrated bentonite chips (DH-01A and DH-01B) or 2-sack sand-cement slurry (DH-03A and DH-03B) and temporarily finished at the surface with asphalt concrete cold patch per our discussions with County staff. Per a project-specific agreement between manager David Kirby and the County transportation department, we understand that County maintenance staff will remove the cold patch and repair the pavement surface with hot mix asphalt concrete at a later date.

LABORATORY TESTING

Laboratory tests were performed on selected soil samples to estimate engineering characteristics of the various earth materials encountered. The methods used are described in the following subsections and the results are summarized on Plate B-1 – Summary of Laboratory Test Results.

Grain Size Distribution

Grain size distribution was determined for selected soil samples in accordance with standard test method ASTM D422. The grain size analysis results are plotted on Plate B-2 - Grain Size Curves with the percentages passing the No. 200 Sieve (fines contents) summarized on Plate B-1 and on the respective drill hole logs in Appendix A.

FINDINGS

EARTH MATERIALS

The following subsections provide general descriptions of the earth materials encountered at the drill hole locations for each site explored during this study. Our drill hole logs included in Appendix A provide more detailed descriptions of the subsurface conditions at the exploration points. The encountered materials appeared to consist of a surficial layer of artificial fill overlying sandy alluvial deposits to the explored depths. We postulate that the artificial fill materials were likely placed during grading for the surrounding development and do not appear to extend further than approximately 1 to 2 feet below the existing ground surface at our test hole locations.

Balboa and Lemar

The earth materials excavated near the intersection of Balboa Street and Lemar Avenue generally consisted of a pavement section underlain by alluvial deposits to the total depth explored of 12 feet bgs. We also encountered a thin veneer of silty sand artificial fill materials directly below the pavement section and extending to approximately 1-1/2 feet bgs. The pavement section consisted of 4 to 4-1/2 inches of asphalt concrete directly overlying approximately 14 inches of silty sand pseudo-base material containing some coarse gravel. The alluvial soils generally consisted of medium dense poorly graded sand. Our field engineer also noted the presence of some gravel in the samples retrieved during drilling. Laboratory data suggests fines contents on the order of approximately 7 to 8 percent consistent throughout the profile. Those grain size analyses also indicated that approximately 20 to 40 percent of the tested samples consisted of gravel or larger diameter particles. Observations regarding drilling effort and material retrieved from the auger flight cuttings indicate the presence of some larger gravels and cobbles not retrieved during sampling and thus not represented in our laboratory test results.

Simon and Rene

The earth materials excavated near the intersection of Rene Street and Simon Way generally consisted of alluvial soils to the ultimate depth explored of 12 feet bgs. Our field staff noted a surficial layer of silty sand extending to approximately 2-1/2 feet deep that was likely disturbed during previous grading work for the surrounding development. Lab results indicate increased silt content below approximately 10 feet, as noted in the field. That data suggests that fines contents below the surficial silty sand layer range from approximately 1 to 4 percent and gravel contents rang from approximately 5 to 10 percent. Field blow counts indicate that those alluvial deposits range in consistency from loose to medium dense. Observations regarding drilling effort and material retrieved from the auger flight cuttings indicate the presence of some larger gravels and cobbles not retrieved during sampling and thus not represented in our laboratory test results.

Simon Way

The earth materials excavated northwest of the intersection of Simon Way and George Street generally consisted of alluvial deposits to the total depth explored of 12 feet bgs. We also encountered a thin veneer of silty sand artificial fill materials directly underlying the pavement section and extending to approximately 2-1/2 feet bgs. The pavement section consisted of approximately 3-1/2 inches of asphalt concrete directly overlying the encountered silty sand fill material. Our field engineer also noted the presence of some gravel encountered in the fill materials. The alluvial soils appear to generally consist of loose to medium dense poorly graded sand. Laboratory data suggests that fines content of those materials is on the order of approximately 6 to 8 percent and appears consistent throughout the profile.

Balboa and Helsam

The earth materials excavated near the intersection of Balboa Street and Helsam Avenue generally consisted of alluvial soils to the ultimate depth explored of 12 feet bgs. Our field staff noted a surficial layer of silty sand extending to approximately 5 feet deep. The upper 2 to 3 feet of material has likely been disturbed during previous grading for the surrounding development. Our laboratory data indicates a fines content of approximately 38 percent in the upper 5 feet of soil strata, and on the order of approximately 5 percent in the underlying poorly graded sand. Those results also suggest gravel contents on the order of about 11 to 20 percent. Field blow counts indicate that those materials range in consistency from loose to medium dense. Observations regarding drilling effort and material retrieved from the auger flight cuttings indicate the presence of some larger gravels and cobbles not retrieved during sampling and thus not represented in our laboratory test results.

GROUNDWATER AND MOISTURE CONDITIONS

No groundwater was encountered in the explorations to the depths explored, nor any perched or seeping zones. However, our staff engineer qualitatively assessed the moisture conditions of the sampled earth materials during drilling. Soils nearer the ground surface were typically noted as dry to moist and conditions generally increased in moisture with depth.

PERCOLATION RESULTS

Table 2 summarizes the corrected and uncorrected results of the percolation testing program for this project. The corrected values represent the equivalent field percolation rate for an 8-inch-diameter drill hole installed with 4-inch diameter slotted casing and gravel annular backfill as shown in the VCTGM (2011). The volume of water displaced by the annular backfill was determined by filling a 1000 mL graduated cylinder with drain rock and then adding water until all of the void space was filled. Our staff noted the volume of water required to saturate the void spaces and extrapolated the resulting void ratio to correct our raw field percolation data and obtain the corrected field percolation rates provided below.

Table 2. Field Percolation Testing Results

Location	Test Interval (feet bgs)	Stabilized Field Test Percolation Rate (in/hr)	
		Uncorrected (Field Data)	Corrected (Eq. for 4-inch casing)
Southeast side of Balboa Street southwest of Lemar Avenue	DH-01B, (1 to 4.5)	200	180
	DH-01A, (9 to 12)	290	250
Northeast side of Simon Way between Rene and Elaine Streets	DH-02B, (1 to 4)	220	190
	DH-02A, (9 to 12)	72	63
South side of Simon Way approximately 320 feet northwest of George Street	DH-03B, (1 to 4)	240	210
	DH-03A, (9 to 12)	140	130
Southeast side of Balboa Street northeast of Helsam Avenue	DH-04B, (1 to 4)	58	51
	DH-04A, (9 to 12)	620	540

In general, the test results indicate that, for the intervals tested, the percolation rates measured from all of the sites are significantly higher than 2.4 inches per hour (the threshold value that requires upstream runoff treatment). Laboratory measured fines contents appear to corroborate those results and generally ranged from 1 to 8 percent with the exception of the sample retrieved from drill hole DH-04B near the intersection of Helsam Avenue and Balboa Street. Based upon our hydrometer results, that sample contained 38 percent fine-grained material with as much as about 12 percent clay fraction assuming a maximum clay particle diameter of 5 microns (μm). The infiltration rate measured for the interval from 1 to 4 feet bgs at DH-04B was also the lowest measured from any of the testing locations.

We generally expect that soils with low fines contents allow more rapid water percolation into the subgrade. Our laboratory tests appear to support that conclusion considering the high rates measured on-site. Other factors that may have contributed to the soils' high propensity to accept water include the following; however, we feel that the percolation rates provided herein are a reasonable estimate of the conditions encountered.

- The presence of gravel, cobbles and boulders at depth not represented in the 1-1/2 inch diameter samples retrieved during drilling;
- The in-place density of the soils within the percolation test interval are low, contributing to a higher percolation rate than expected solely on the basis of grain size distribution (larger gravel and cobble particles may have artificially inflated sampler blow counts);
- The drilling procedures and auger equipment that were used to construct the field percolation test holes may have disturbed the excavation sidewalls causing percolation test rates to differ from what you might expect to occur within the natural deposit. However, it is likely that construction of an infiltration system would disturb the system sidewalls in a similar manner;
- Grain size distribution results may have been biased due to judgments made in the laboratory during selection of a representative sample for analysis.

CLOSURE

This report has been prepared for the exclusive use of Ventura County Watershed Protection District and its agents for the specific application to the proposed Urban LID Retrofit at El Rio in Ventura County, California. The findings presented herein were prepared in accordance with generally accepted geotechnical engineering practices of the project region. No other warranty, express or implied, is made.

Soil and rock deposits will vary in type, strength, and other geotechnical properties between discreet sample intervals, and points of observation and exploration. Additionally, groundwater and soil moisture conditions can also vary seasonally or for other reasons. Therefore, we do not and cannot have complete knowledge of the subsurface conditions underlying the site. The data presented in this report are based upon the findings at the points of exploration, and interpolation or extrapolation of information between and beyond the locations of observation, and are subject to confirmation during construction.

The scope of our services presented in this report did not include any environmental site assessment for the presence or absence of hazardous/toxic/biological materials in the soil, groundwater, surface water, or the presence of wetlands or the presence of environmentally sensitive areas, endangered or candidate wildlife or vegetation, or culturally significant zones within the project area. Any statements or absence of statements in this report or data presented herein regarding odors, unusual or suspicious items, or conditions observed are strictly for descriptive purposes and are not intended to convey engineering judgment regarding potential hazardous/toxic assessment.

Fugro appreciates the opportunity to provide our services for this project. If you have any questions regarding the contents of this data report please do not hesitate to contact our office.

Sincerely,

FUGRO CONSULTANTS, INC.

Justin R. Martos, EIT
Senior Staff Engineer

Reviewed By:

Loree A. Berry, P.E.
Senior Project Engineer

Attachments: Plate 1 - Vicinity Map
Plate 2 - Subsurface Exploration Plan
Appendix A - Subsurface Exploration
Appendix B – Laboratory Testing

Copies Submitted: (PDF) Addressee

Ref:

County of Ventura (2011), Ventura County Technical Guidance Manual for Stormwater Quality Control Measures.

PLATES

County of Ventura Watershed Protection District
Project No. 04.62140059

BASE MAP SOURCE: Thomas Guide 2007, Ventura County (p.522, 523, 492, & 493).

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FEET

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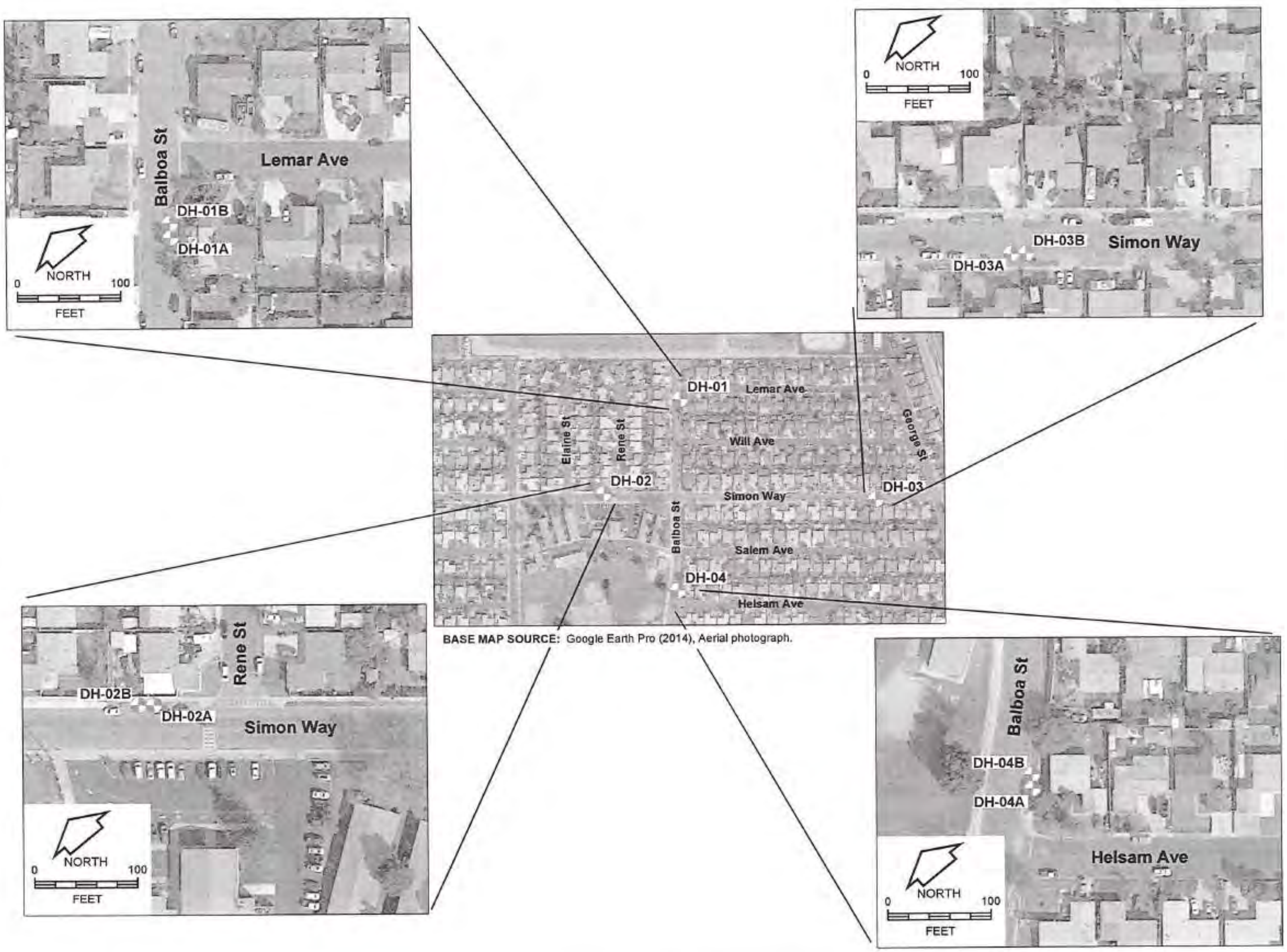
VICINITY MAP
Urban LID Retrofit at El Rio
Ventura County, California

PLATE 1

County of Ventura Watershed Protection District
Project No. 04.62140059



BASE MAP SOURCE: Google Earth Pro (2014), Aerial photograph.

LEGEND

DH-01 Approximate drill hole/ percolation test location

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EXPLORATION LOCATION MAP

Urban LID Retrofit at El Rio
Ventura County, California

PLATE 2

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Ventura County
Watershed Protection District
Water & Environmental Resources Division
Surface Water Quality Section
MEMORANDUM

DATE: May 28, 2014

TO: Ewelina Mutkowska - Engineering Manager

FROM: David Kirby, PE – Water Quality Engineer

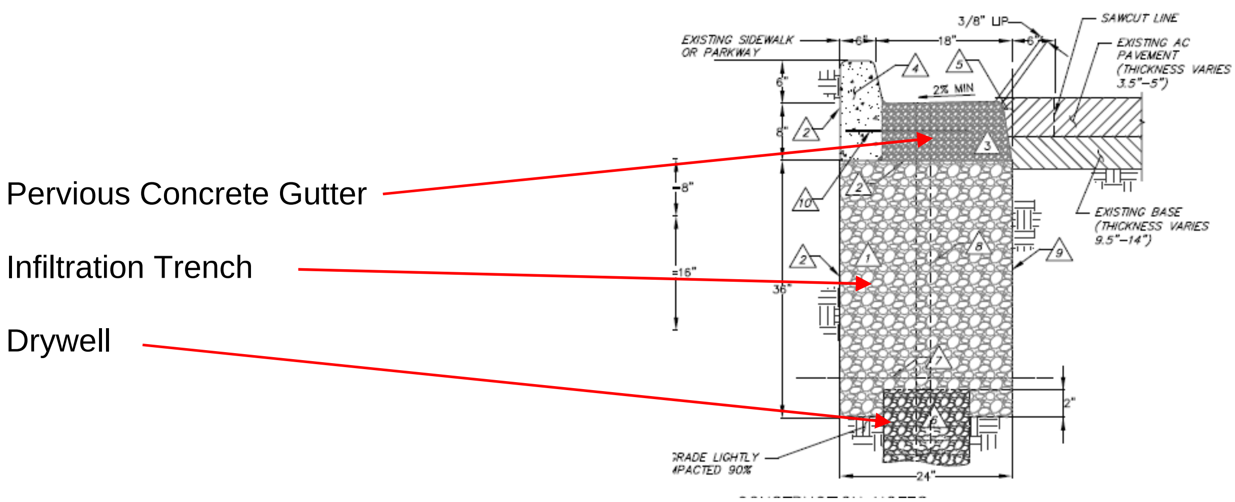
SUBJECT: DESIGN FOR EL RIO RETROFIT FOR GROUNDWATER RECHARGE

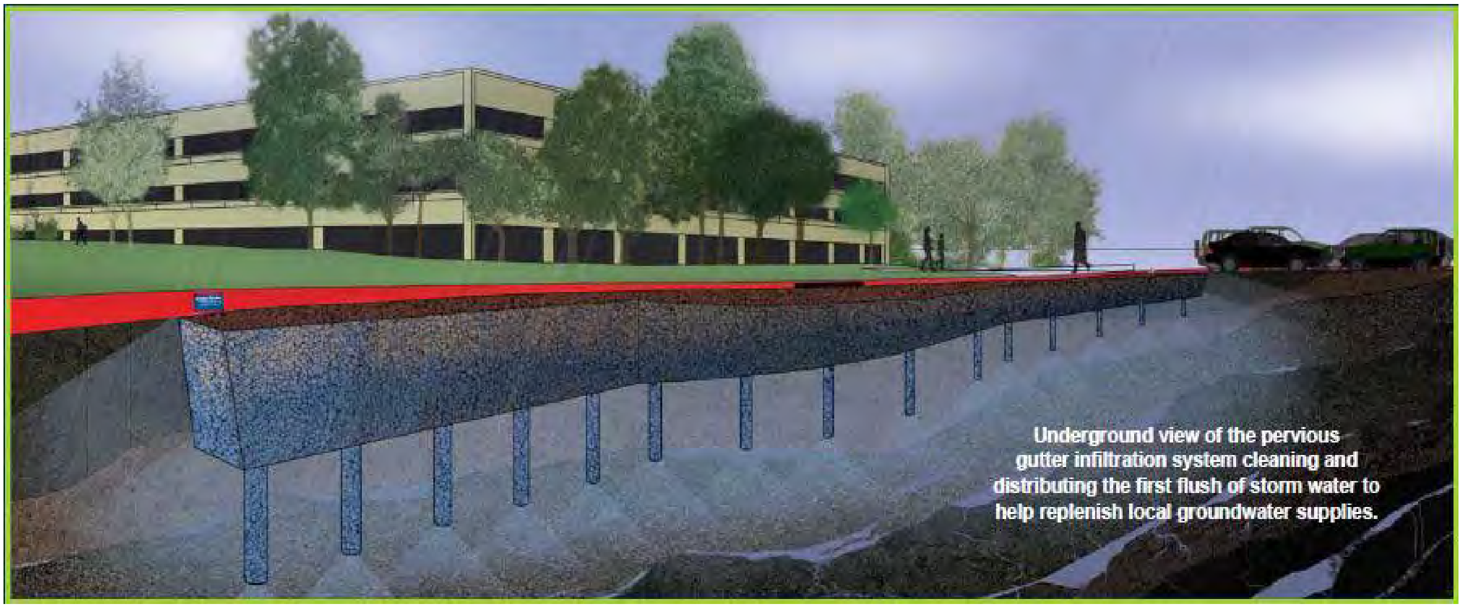
When the 2014 Integrated Regional Water Management (IRWM) Drought Solicitation grant funding opportunity was announced we started looking for potential locations within Ventura County's unincorporated urban area under our Municipal Separate Stormwater Sewer System (MS4) jurisdiction. In order to meet the project criteria as listed within the released draft Proposal Solicitation Package (PSP) we knew any project we proposed would have to:

1. Provide immediate drought preparedness through groundwater recharge; and
2. Due to the expedited schedule the project needs to be shovel ready.

In 2012 the County completed a pervious concrete gutter pilot project in Lots A and B of the Government Center in Ventura, CA. Phase II of this project, which is funded through the Proposition 84 Grant Program (Prop 84), is currently under construction with completion estimated for the end of August 2014. This project utilized a low-cost, low-maintenance infiltration BMP to capture, treat and infiltrate the first flush of storm events as well as 100% of dry-weather flows from the 39 acres of impervious parking lot area. Instead of replacing all impervious pavement with pervious pavement, the design of the Government Center project focused on improving only the parking lot perimeter curb and gutters with a vertical storage and infiltration system in order to minimize the overall BMP footprint drastically reducing construction and long term maintenance costs. The BMP section incorporates pervious concrete gutters atop aggregate filled infiltration trenches supplemented with 1-foot diameter & 15 feet deep drywells to allow stormwater runoff to reach infiltratable soils. On-site geotechnical investigations showed that soils were not acceptable for infiltration until approximately 13 feet below the existing surface. Therefore, this unique vertical BMP design minimizes disturbance to existing improvements due to its very small surface-level footprint while allowing for mass storage of runoff within the infiltration trenches while water flows down and infiltrates into the soils at the bottom of the drywells with a goal of recharging groundwater. A section of this BMP can be seen below along with a graphical representation of the BMP that was used within the educational outreach campaign of the Prop 84 funded project at the Government Center. The last page included herein shows the preliminary infiltration testing results for the El Rio area which are very promising.

Contact me if you have any questions (805) 662-6737 or david.kirby@ventura.org.

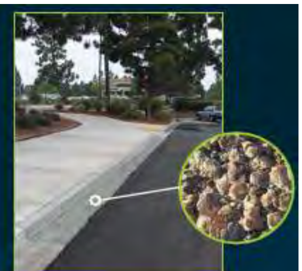




Infiltration Trench
Infiltration trenches are long narrow trenches filled with coarse gravel where water is stored in the spaces between the gravel. Microbes that live on the surface of the gravel help break down pollutants like oil and grease, excess nutrients and bacteria.

Drywells
Drywells are drilled holes filled with coarse gravel that increase the volume of water retained and help water to soak into the ground and replenish groundwater supplies.

Infiltration System
Stormwater flows through the gravel-filled infiltration trenches and drywells. It then seeps into the adjacent soil through filter fabrics that line the bottom and sides of the infiltration system.



Pervious Concrete
Pervious concrete contains small spaces that allow water to pass through and into the ground below. When built over infiltration trenches, the volume of water captured is increased. Pervious concrete can be used for large pavement areas or in strategic gutter locations that capture stormwater from large areas.

Preliminary Infiltration Testing Results (Fugro 2014-06-02)

Drill Hole	Location Description	Test Interval (ft)	Percolation Rate (in/hr)
DH-01A	Balboa Between Lemar and Will	12	220
DH-01B	Balboa Between Lemar and Will	4	220
DH-02A	Simon between Elaine and Rene	12	63
DH-02B	Simon between Elaine and Rene	4	190
DH-03A	Simon between Balboa and George	12	130
DH-03B	Simon between Balboa and George	4	210
DH-04A	Balboa between Salem and Helsam	12	540
DH-04B	Balboa between Salem and Helsam	4	40
	Average at 4-foot depth =		**165**
	Average at 12-foot depth =		**238**

Note:

1) Standard pervious concrete rate of infiltration must be greater than 100 in/hr in order to be accepted. Therefore, our infiltration volume will be limited based on how fast the water gets through the pervious pavement as opposed to the infiltration rates of the soils.

TOTAL MAXIMUM DAILY LOADS FOR INDICATOR BACTERIA IN SANTA CLARA RIVER ESTUARY AND REACHES 3, 5, 6 AND 7

PREPARED BY

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD

LOS ANGELES REGION

320 WEST 4TH STREET

LOS ANGELES, CALIFORNIA 90013

FINAL: JULY 8, 2010

TABLE OF CONTENTS

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LIST OF FIGURES

LIST OF ACRONYMS

ACL	Administrative Civil Liabilitie
BMP	Best Management Practice
Caltrans	California Department of Transportation
CASQA	California Stormwater Quality Association
CDO	Cease and Desist Order
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CWA	Clean Water Act
DWR	Department of Water Resources
EPA	Environmental Protection Agency
FIB	Fecal Indicator Bacteria
FSF	Free Surface Flow
LA	Load Allocation
LADPW	County of Los Angeles Department of Public Works
LAR	Los Angeles River
LARWQCB	Los Angeles Regional Water Quality Control Board
MGD	Million Gallons per Day
ml	Milliliters
MPN	Most Probable Number
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NTS	Natural Treatment System

OAL	Office of Administrative Law
QAPP	Quality Assurance Project Plan
REC-1	Water Contact Recreational Use
REC-2	Non-contact Recreational Use
SCCWRP	Southern California Coastal Water Research Project
SCR	Santa Clara River
SCVSD	Santa Clarita Valley Sanitation District
SMB	Santa Monica Bay
SSF	Sub-Surface Flow
SSO	Sanitary Sewer Overflow
TMDL	Total Maximum Daily Load
USEPA	Unites States Environmental Protection Agency
USGS	United States Geological Survey
UWCD	United Water Conservation District
VCWPD	Ventura County Watershed Protection District
WDR	Waste Discharge Requirement
WLA	Waste Load Allocation
WQA	Water Quality Assessment
WQO	Water Quality Objective
WRF	Wastewater Reclamation Facility
WRP	Water Reclamation Plant
WTP	Wastewater Treatment Plant

1 INTRODUCTION

This document covers the required elements of the Total Maximum Daily Load (TMDL) for the bacteria water quality impairments in the Santa Clara River (SCR) Estuary, and SCR Reaches 3, 5, 6 and 7, as well as providing the supporting technical analysis used in the development of the TMDL by the California Regional Water Quality Control Board, Los Angeles Region (Regional Board). The goal of this TMDL is to determine and set forth measures needed to prevent impairment of water quality due to elevated bacteria densities in the SCR Estuary and Reaches 3, 5, 6, and 7. The target bacteria indicators addressed are fecal coliform, total coliform, enterococcus, and E. coli.

This TMDL complies with 40 CFR 130.2 and 130.7, Section 303(d) of the Clean Water Act and U.S. Environmental Protection Agency (EPA) guidance for developing TMDLs in California (U.S. EPA, 2000a). It is based on information provided by other entities concerning bacteriological water quality in the SCR Estuary and Reaches 3, 5, 6, and 7.

1.1 Regulatory Background

The California Water Quality Control Plan, Los Angeles Region (Basin Plan) sets water quality standards for the Los Angeles Region, which includes beneficial uses for surface and ground water, numeric and narrative objectives necessary to support beneficial uses, and the state's antidegradation policy; and describes implementation programs to protect all waters in the region. The Basin Plan establishes water quality control plans and policies for the implementation of the Porter-Cologne Water Quality Control Act within the Los Angeles Region and serves as the State Water Quality Control Plan applicable to regulating bacteria in the SCR Estuary and Reaches 3, 5, 6 and 7 and their tributaries, as required pursuant to the federal Clean Water Act (CWA).

Section 303(d)(1)(A) of the CWA requires each state to conduct a biennial assessment of its waters, and identify those waters that are not achieving water quality standards. The resulting list is referred to as the 303(d) list. The CWA also requires states to establish a priority ranking for waters on the 303(d) list of impaired waters and to develop and implement TMDLs for these waters.

A TMDL specifies the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and allocates the pollutant loadings to point and nonpoint sources. The elements of a TMDL are described in 40 CFR 130.2 and 130.7 and Section 303(d) of the CWA, as well as in U.S. EPA guidance (U.S. EPA, 1991). A TMDL is defined as the "sum of the individual waste load allocations for point sources and load allocations for nonpoint sources and natural background" (40 CFR 130.2) such that the capacity of the waterbody to assimilate pollutant loads (the loading capacity) is not exceeded. The Regional Board is also required to develop a TMDL taking into account seasonal variations and including a margin of safety to address uncertainty in the analysis (40 CFR 130.7(c)(1)). Finally, TMDLs must be included in the State's water quality management plan, or referenced as part of the water quality management plan if contained in separate documents (40 CFR section 130.6(c)(1)).

The U.S. EPA has oversight authority for the 303(d) program and is required to review and either approve or disapprove the state's 303(d) list and each TMDL developed by the state. If the state fails to develop a TMDL in a timely manner or if the U.S. EPA disapproves a TMDL submitted by a state, U.S. EPA is required to establish a TMDL for that waterbody (40 CFR 130.7(d)(2)).

As part of its 1996 and 1998 regional water quality assessments, the Regional Board identified over 700 waterbody-pollutant combinations in the Los Angeles Region where TMDLs would be required (LARWQCB, 1996, 1998). A 13-year schedule for development of TMDLs in the Los Angeles Region was established in a consent decree (*Heal the Bay Inc., et al. v. Browner, et al.* C 98-4825 SBA) approved on March 22, 1999.

For the purpose of scheduling TMDL development, the decree combined the over 700 waterbody-pollutant combinations into 92 TMDL analytical units. Analytical Unit 34 lists SCR Estuary and SCR Reach 6 (U.S. EPA 303(d) list Reach 8, West Pier Highway 99 to Bouquet Canyon Road Bridge) with impairments related to coliform bacteria.

SCR Reaches 5 and 7 were added to the 303(d) list in 1998 for high coliform counts. Additional data analysis conducted as part of TMDL development demonstrates an impairment for indicator bacteria in SCR Reach 3 as well. This TMDL therefore addresses indicator bacteria impairments in the SCR Estuary and Reaches 3, 5, 6, and 7.

On December 9, 2009, Regional Board staff held a kickoff meeting to receive comments on the development of a TMDL for indicator bacteria in the SCR Estuary and Reaches 3, 5, 6, and 7. At the kickoff meeting, Regional Board staff presented background on the TMDL, reviewed recent data, and solicited stakeholder involvement. About 20 stakeholders, including municipal stormwater permittees, publicly owned treatment works, farmers and farming groups, city and county representatives, and developers attended the meeting.

On February 25, 2010, Regional Board staff attended meetings of two Integrated Regional Water Management Plan groups in the lower and upper SCR watershed to present the TMDL and get stakeholder feedback. On March 2, 2010, an additional stakeholder meeting was conducted to facilitate the development of the TMDL.

On March 2, 2010, the Regional Board held a California Environmental Quality Act (CEQA) scoping meeting to solicit input from the public and interested stakeholders in determining the appropriate scope, content and implementation options of the proposed TMDL for bacteria in the SCR Estuary and Reaches 3, 5, 6 and 7. At the scoping meeting, the CEQA checklist of significant environmental issues and mitigation measures was discussed. This meeting fulfilled the requirements under CEQA (Public Resources Code, Section 21083.9).

1.2 Environmental Setting

The Santa Clara River (Figures 1-1 and 1-2) is the largest river system in Southern California that remains in a relatively natural state. The river originates on the northern slope of the San Gabriel Mountains in Los Angeles County, traverses Ventura County, and flows into the Pacific Ocean between the cities of San Buenaventura (Ventura) and Oxnard. The watershed is approximately 1600 square miles.

Municipalities within the watershed include Santa Clarita, Fillmore, Santa Paula, and Ventura. The SCR occupies a comparatively narrow, sinuous channel, and the river and its tributaries are underlain by an unconfined alluvial aquifer. The sandy channel is highly permeable over much of its length, and in places large quantities of water infiltrate through the streambed to the alluvial aquifer (Department of Water Resources (DWR), 1993).

The groundwater is discharged to the surface where the water table intersects the river bed at Highway 99 (bottom of Reach 6), Blue Cut (bottom of Reach 5), the Fish Hatchery (Reach 4), and Willard Road (bottom of Reach 3). The surface flow percolates into groundwater in the upper Piru Basin and in the upper Fillmore Basin (Reach 4). United Water Conservation District (UWCD) releases imported water from Lake Piru to maintain elevated groundwater levels, which are released to the Oxnard Plain to manage seawater intrusion.

The predominant land uses in the SCR watershed include agriculture, open space, and residential uses. Revenue from the agricultural industry within the SCR watershed is estimated at over $700 million annually. Residential use is increasing rapidly in both in the upper and lower watershed. The number of housing units in the watershed is estimated to increase by 187 percent from 1997 to 2025.

Figure 1-1: The Santa Clara River Watershed

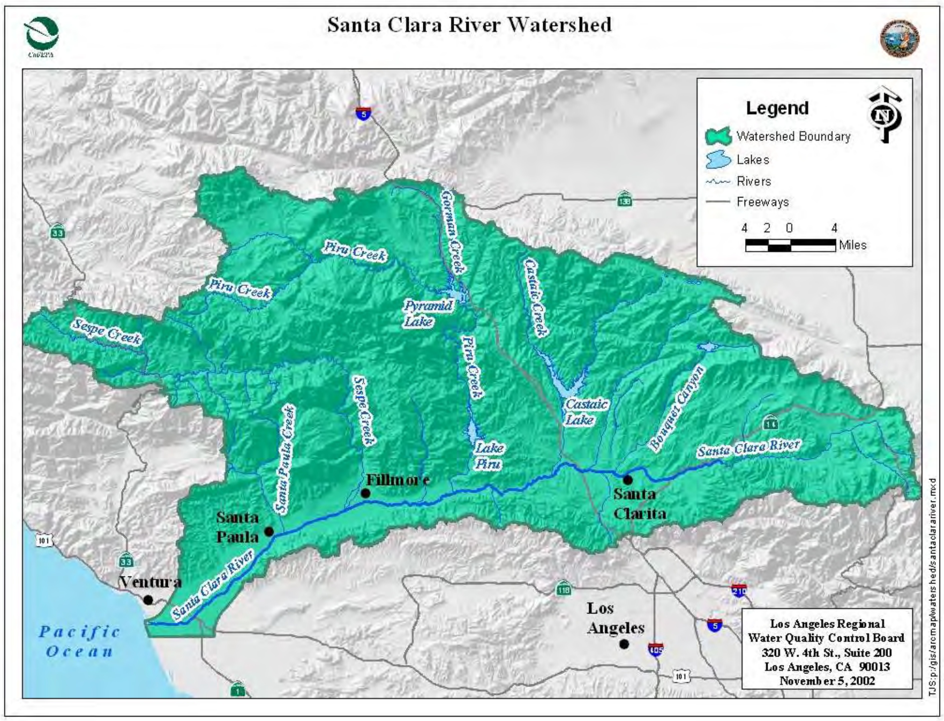
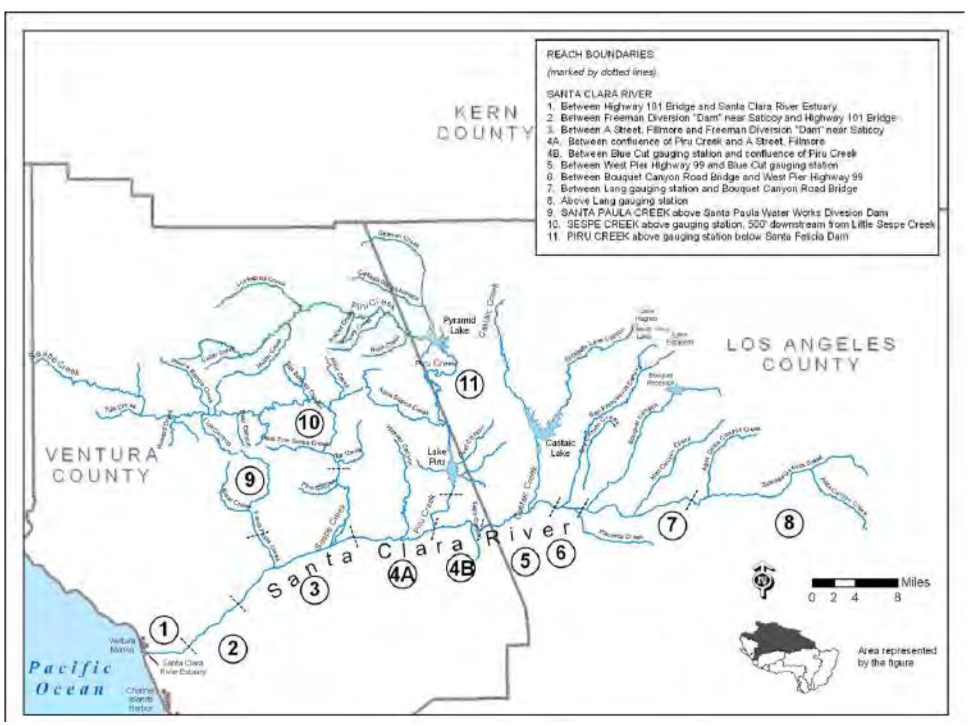


Figure 1-2: Santa Clara River Reach Boundaries



1.2.1 *Santa Clara River Estuary*

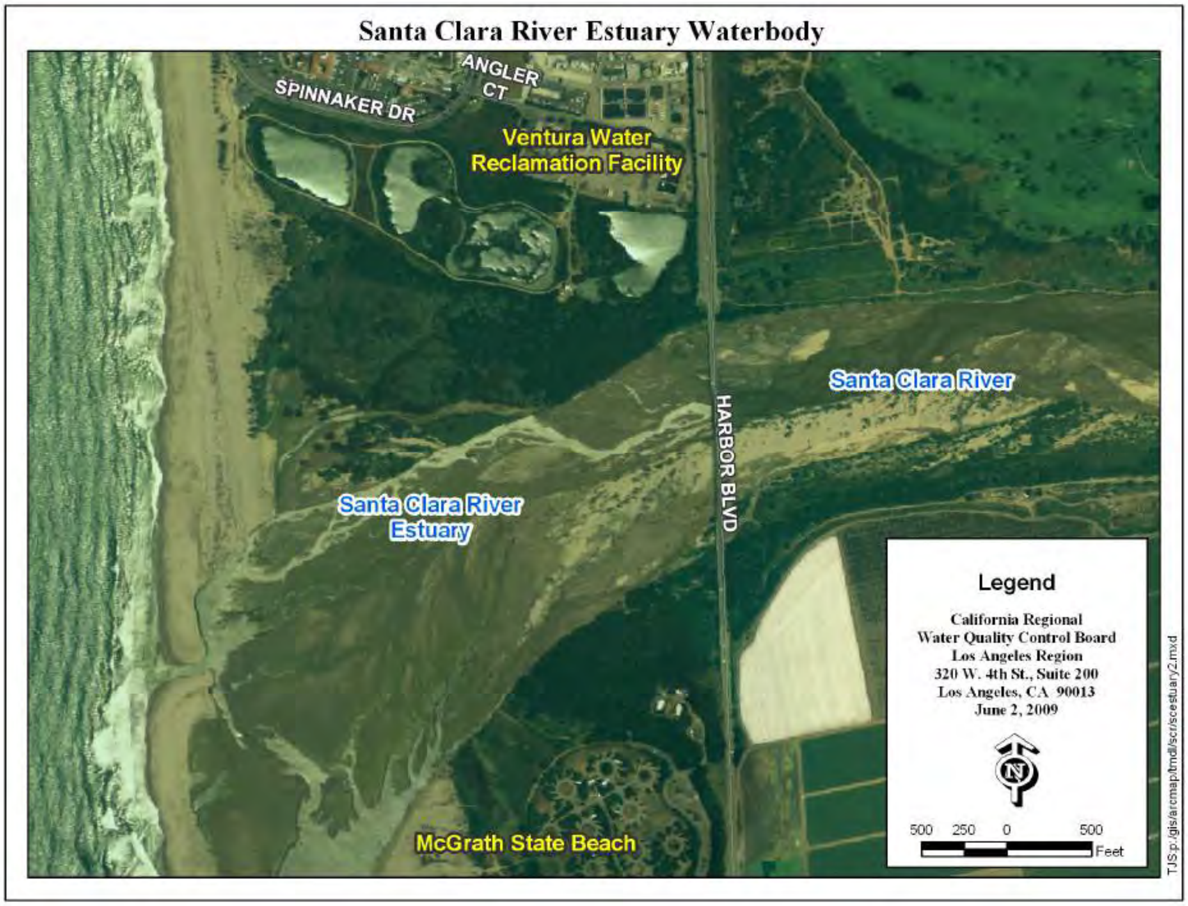
The SCR Estuary (Figure 1-3) is located in Ventura County, between the cities of Ventura and Oxnard, on McGrath State Beach in the Santa Clara River Estuary Natural Reserve. The estuary area extends from the ocean to just east of the Harbor Boulevard Bridge, which crosses the river a half mile from the mouth. The Ventura Water Reclamation Facility (WRF) is on the north side of the estuary. The Ventura Harbor is north of the Ventura WRF. A golf course lies to the east of Harbor Boulevard Bridge. To the south are agricultural fields and a state park campground. The Estuary is a designated Natural Preserve within McGrath State Beach. It is designated for conservation and resource protection in the City of Oxnard 2020 General Plan (CERES, 2009).

The estuary is closed by a berm, which forms at the mouth during periods of low flow. The berm is usually breached by storm water flows and/or wave overwashing, and closes again after varying lengths of time. In the marsh area outside the river channel the soils are course sand, sand, clay, sandy clay and loam. In the riverbed, sediment sizes range from silt to gravel (CERES, 2009).

Since 1855, the estuary has been modified by human activities. Agriculture, roads, urban development and levees have altered the estuary. By the late 1920s roads and agricultural fields had become established. The Ventura WRF, agricultural fields, Harbor Boulevard Bridge, and marina, all of which occupy the former delta, were in place by the late 1950s (CERES, 2009).

Flow upstream of the estuary is seasonal except for controlled releases and wastewater treatment discharges. The channel is braided, and the banks are reinforced with groins and levees along much of the lower river. The estuary receives approximately 8.5 million gallons per day (MGD) of treated wastewater from the Ventura WRF.

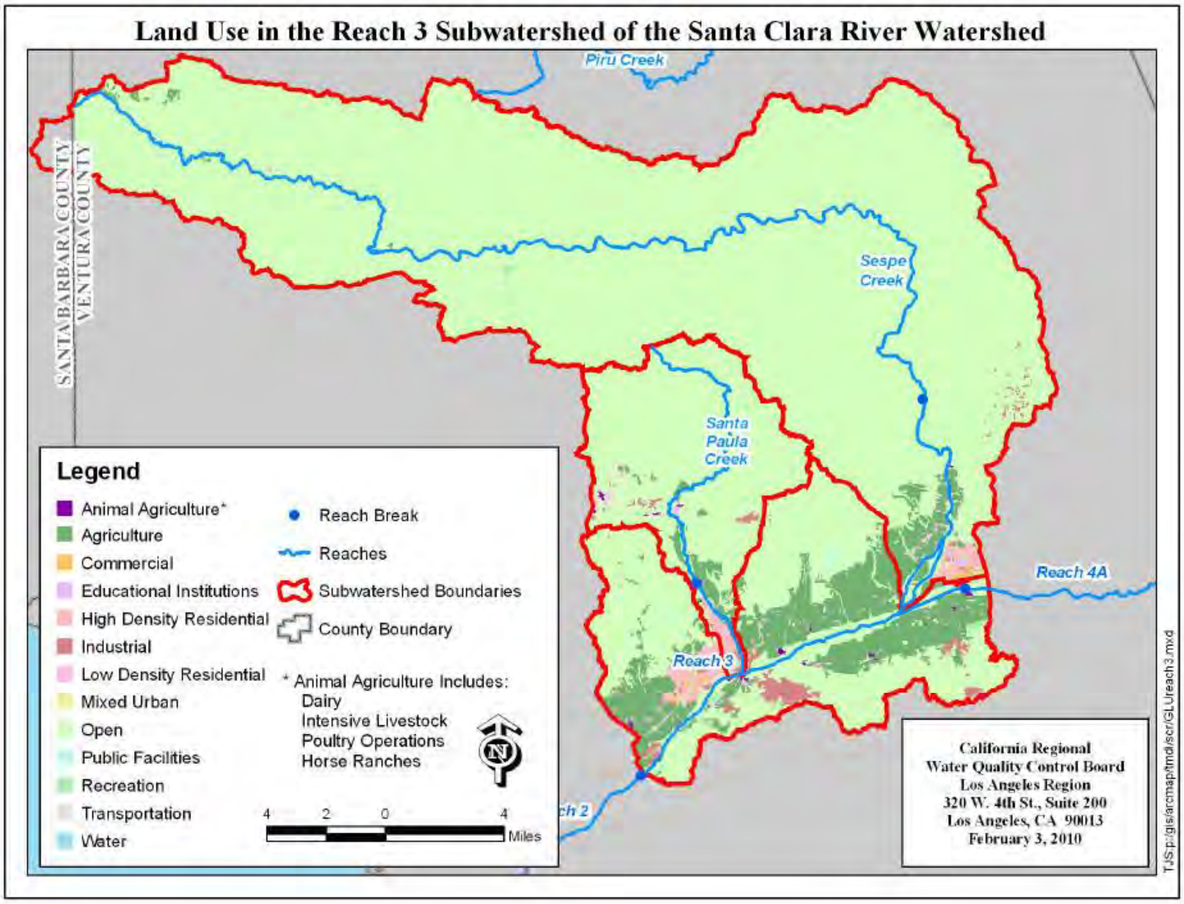
Figure 1-3: The Santa Clara River Estuary



1.2.2 *Santa Clara River Reach 3*

SCR Reach 3 (Figure 1-4) is between A Street, in Fillmore and the Freeman Diversion “Dam” near Saticoy. The Freeman Diversion is located at the dividing line for Reaches 2 and 3 of the SCR. The facility may divert a maximum of 375 cfs, and flows in excess of this amount spill over the structure and continue downstream. Diversions are typically suspended when the turbidity of the river exceeds 3000 NTU, as suspended sediment impairs the ability of spreading basins to percolate water. Natural groundwater recharge occurs in the Oxnard Forebay Basin downstream of the Freeman Diversion in the SCR, and downstream flow generally decreases between the diversion and the Highway 101 Bridge as river water percolates into the river bed. Between the 101 Bridge and the estuary a confining clay layer exists in the subsurface, and perennial flow generally exists in this reach.

Figure 1-4: The Santa Clara River Reach 3 Subwatershed



1.2.3 *Santa Clara River Reaches 5, 6 and 7*

The upper reaches of the SCR include Reaches 5, 6 and 7, which are located upstream of the Blue Cut gauging station that lies west of the Los Angeles - Ventura County line. The upper boundary extends to Lang Gaging Station, upstream of the City of Santa Clarita (Figures 1-5 to 1-7). The City of Santa Clarita lays in Reaches 5, 6, and 7.

Surface flow both infiltrates into groundwater basins underlying the Santa Clara River and is augmented, at some times and locations, by groundwater flow. At Reach 5, shallow, impermeable beds underlie the downstream end of the reach at Blue Cut. The overlying alluvial aquifers are thin and close to the surface. Groundwater is commonly discharged at this location from the underlying Santa Clara River Valley Basin and mixes with surface flow. During most of the year, all stream water percolates into the streambed before the beginning of the Dry Gap in Reach 4B. Below the Dry Gap, the SCR becomes perennial at the confluence with Piru Creek.

Upstream from Blue Cut, the Valencia Water Reclamation Plant (WRP) provides continuous discharge into Reach 5. In summer, conservation discharges from Castaic Lake also enter the river via Castaic Creek between Blue Cut and the Valencia WRP.

Reach 6 lies upstream of Reach 5, between Highway 99 and Bouquet Canyon Bridge. Groundwater is discharged from upstream basins and augmented by flows from the Saugus WRP, Bouquet Canyon and smaller flows from San Francisquito and Dry Canyons.

Reach 7 lies between Bouquet Canyon Bridge and Lang Gaging Station. Just upstream of the Bouquet Canyon Bridge the river is almost always dry. The major tributary in Reach 7 is Mint Canyon Creek.

Figure 1-5: The Santa Clara River Reach 5 Subwatershed

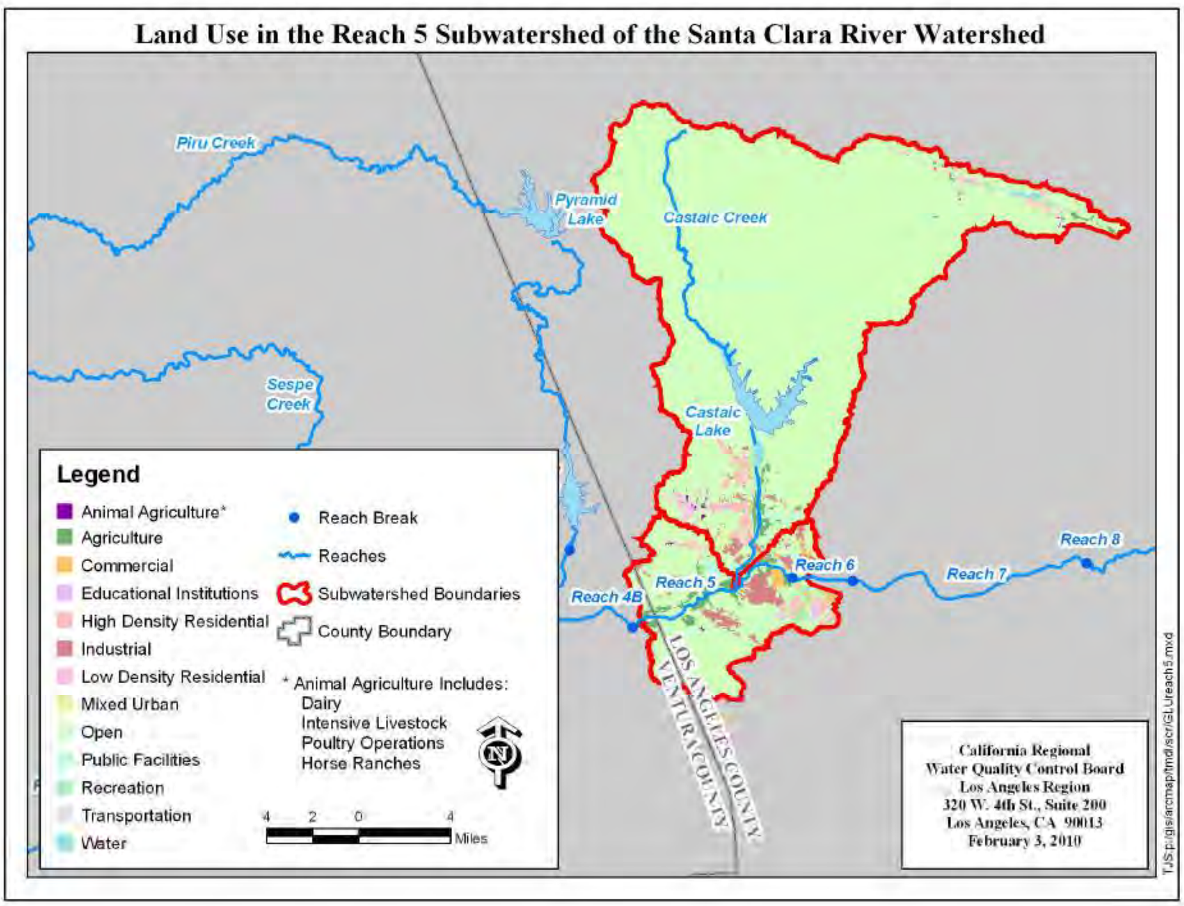


Figure 1-6: The Santa Clara River Reach 6 Subwatershed

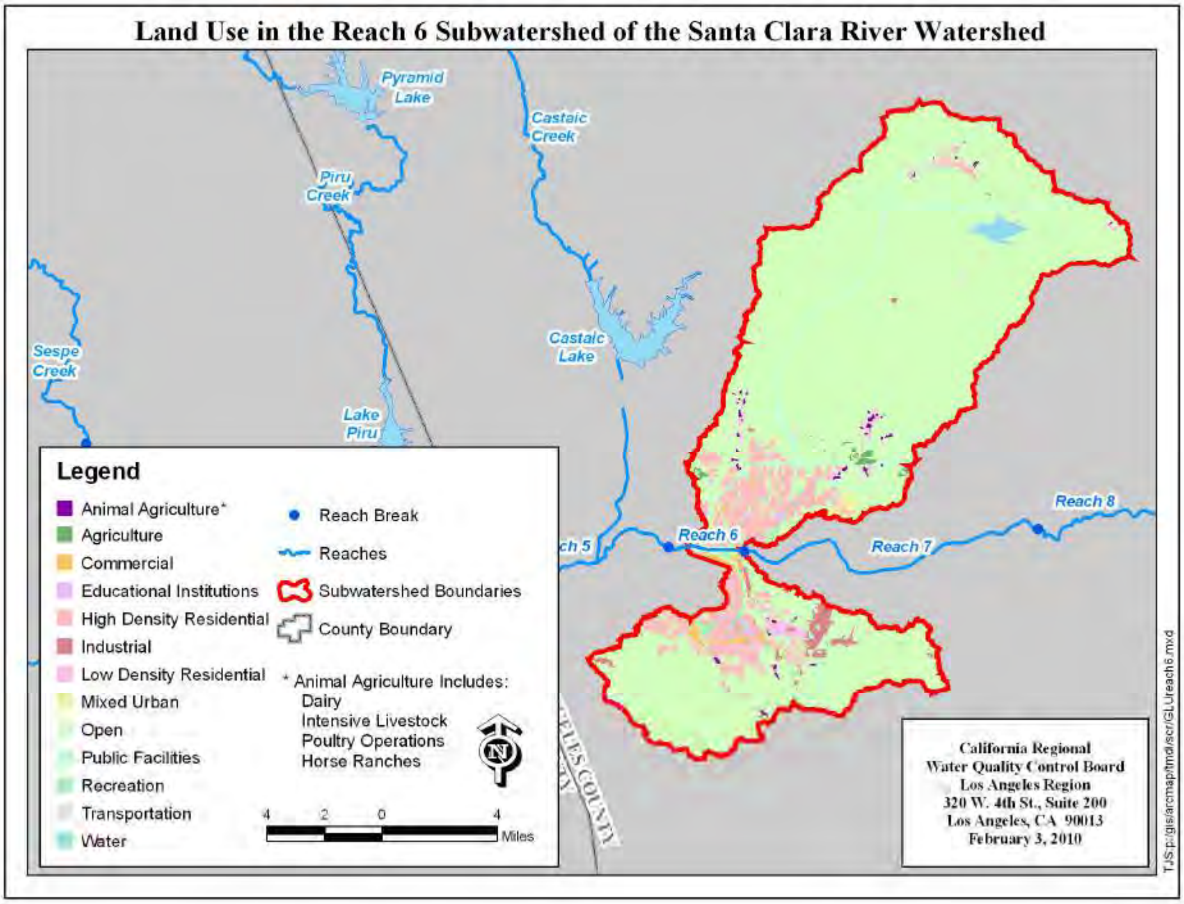
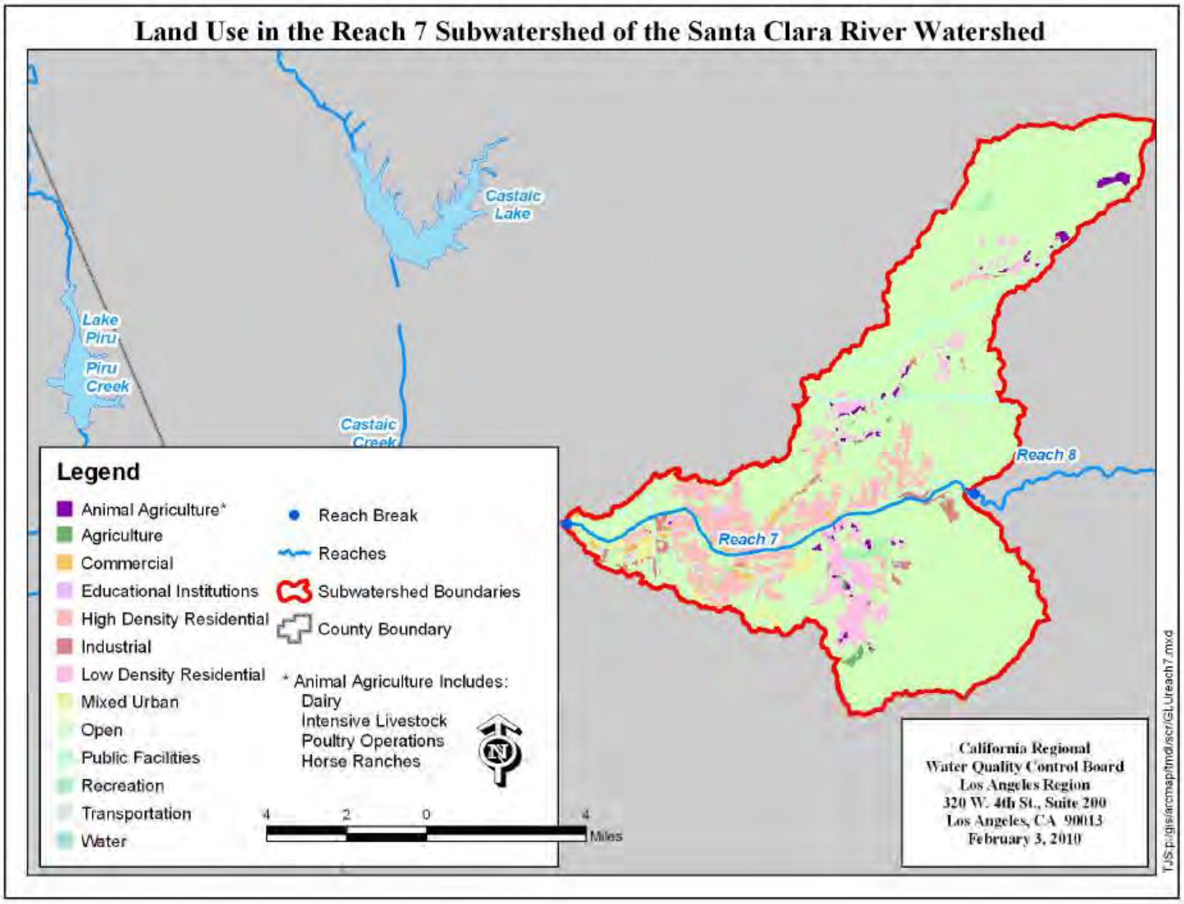


Figure 1-7: The Santa Clara River Reach 7 Subwatershed



2 PROBLEM IDENTIFICATION

This section discusses the water quality standards applicable to this TMDL, and provides some background on their development. Also a review of more recent water quality data is provided to verify the current 303(d) listings of the SCR Estuary and Reaches 5, 6 and 7 for bacteria, and document bacteria impairment in Reach 3.

2.1 Water Quality Standards

2.1.1 Beneficial Uses

The Basin Plan designates beneficial uses for water bodies in the Los Angeles Region. These are recognized as existing (E), potential (P), or intermittent (I) uses. SCR has a variety of beneficial use designations including Water Contact (REC-1) and Non-contact (REC-2) Recreation for the Estuary and Reaches 3, 5, 6 and 7 (See Table 2-1).

The REC-1 beneficial use is defined in the Basin Plan as "[U]ses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs" (Basin Plan, p. 2-2).

The REC-2 beneficial use is defined as "[U]ses of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to picnicking, sunbathing, hiking, beachcombing, camping, boating, tide-pool and marine life study, hunting, sightseeing, or aesthetics enjoyment in conjunction with the above activities" (Basin Plan, p. 2-2).

Table 2-1: Beneficial Uses of Santa Clara River Estuary and Reaches 3, 5, 6 and 7

SCR Watershed	Hydro Unit #	MUN	IND	PROC	AGR	GWR	FRSH	NAV	REC1	REC2	COMM	WARM	EST	MAR	WILD	BIOL	RARE	MIGR	SPWN	SHELL	WET[a]
Estuary	403.11							E	E	E	E		E	E	E		E[b]	E[c]	E[c]		E
Reach 3	403.21 & 403.31	P*	E	E	E	E	E		E[d]	E		E	E		E		E				E
Reaches 5 6, and 7	403.51	P*	E	E	E	E	E		E	E		E	E		E		E				E

Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.
E: Existing beneficial use
P: Potential beneficial use
E and P shall be protected as required
*: Asterixed MUN designations are designated under SB 88-63 and RB 89-03. Some designations may be considered for exemptions at a later date.
a: Waterbodies designated as WET may have wetlands habitat associated with only a portion of the waterbody. Any regulatory action may require a detailed analysis of the area.
b: One or more rare species utilize all oceans, bays, estuaries, and wetlands for foraging and/or nesting.
c: Aquatic organisms utilize all bays, estuaries, lagoons, and coastal wetlands, to a certain extent, for spawning and early development. This may include migration into areas that are heavily influenced by freshwater inputs.
d. Limited public access precludes full utilization.

Exceedance of bacteria objectives in these waterbodies results in impairments of beneficial uses associated with recreational uses (REC-1 and REC-2).

2.1.2 Water Quality Objectives

The Basin Plan contains bacteria water quality objectives to protect REC-1 and REC-2 uses. In 2001, the Regional Board updated the bacteria objectives for waters designated as REC-1 to be consistent with U.S. EPA's recommended criteria, which recommends the use of *E. coli* criteria for freshwater and enterococcus criteria for marine waters (See Regional Board Resolution R01-018). The updated bacteria objectives were subsequently approved by the State Water Resources Control Board (State Board) on July 18, 2002 (State Board Resolution 2002-0142), the Office of Administrative Law (OAL) on September 19, 2002 (OAL File No. 02-0807-01-S), and the U.S. EPA on September 25, 2002. The revised objectives include geometric mean limits and single sample limits for total coliform, fecal coliform, *E. coli*, and enterococcus. They are also consistent with those contained in state law (California Code of Regulations, Title 17, Section 7958, which implements Assembly Bill 411 (1997 Stats. 765)). Applicable water quality objectives (WQOs) are summarized in Table 2-2.

Table 2-2: Water Quality Objectives for SCR Estuary and SCR Reaches 3, 5, 6 and 7

Water Quality Objectives	Estuary (Marine REC-1)	Reaches 3, 5, 6 and 7 (Freshwater REC-1)
Single Sample		
E. coli	NA	235/100 ml
Fecal coliform	400/100 ml	400/100 ml
Enterococcus	104/100 ml	NA
Total coliform*	10,000/100 ml	NA
Geometric mean		
E. coli	NA	126/100 ml
Fecal coliform	200/100 ml	200/100 ml
Enterococcus	35/100 ml	NA
Total coliform	1,000/100 ml	NA

*Total coliform density shall not exceed 1,000/100 ml, if the ratio of fecal-to-total coliform exceeds 0.1.
NA: not applicable

The REC-1 bacteria objectives also state that "[t]he geometric mean values should be calculated based on a statistically sufficient number of samples (generally not less than 5 samples equally spaced over a 30-day period)" (LARWQCB, 2001).

Protecting REC-1 beneficial uses will result in the protection of REC-2 beneficial uses because REC-1 bacteria objectives are more stringent than REC-2 bacteria objectives.

2.1.3 Implementation Provisions for Bacteria Objectives

Implementation provisions for the bacteria objectives set to protect REC-1 were incorporated into the Basin Plan on December 12, 2002 (Regional Board Resolution No. R02-022).

This Basin Plan Amendment states:

The single sample bacteriological objectives shall be strictly applied except when provided for in a Total Maximum Daily Load. In all circumstances, including in the context of a TMDL, the geometric mean objectives shall be strictly applied. In the context of a TMDL, the Regional Board may implement the single sample objectives in fresh and marine waters by using a 'reference system/antidegradation approach' or 'natural sources exclusion' approach subject to the antidegradation policies as discussed below. A reference system is defined as an area and associated monitoring point that is not impacted by human activities that potentially affect bacteria densities in the receiving water body.

These approaches recognize that there are natural sources of bacteria, which may cause or contribute to exceedances of the single sample objectives for bacteria indicators. They also acknowledge that it is not the intent of the Regional Board to require treatment or diversion of natural water bodies or to require treatment of natural sources of bacteria from undeveloped areas. Such requirements, if imposed by the Regional Board, could adversely affect valuable aquatic life and wildlife beneficial uses supported by natural water bodies in the Region.

Under the 'reference system/antidegradation' implementation procedure, a certain frequency of exceedance of the single sample objectives shall be permitted on the basis of the observed exceedance frequency in the selected reference system(s) or the targeted water body. The 'reference system/antidegradation' approach ensures that bacteriological water quality is at least as good as that of a reference system and that no degradation of existing bacteriological water quality is permitted where existing bacteriological water quality is better than that of the selected reference system(s).

Under the natural sources exclusion implementation procedure, after all anthropogenic sources of bacteria have been controlled such that they do not cause or contribute to an exceedance of the single sample objectives and natural sources have been identified and quantified, a certain frequency of exceedance of the single sample objectives shall be permitted based on the residual exceedance frequency in the specific water body. The residual exceedance frequency shall define the background level of exceedance due to natural sources. The 'natural sources exclusion' approach subject to the antidegradation policies may be used if an appropriate reference system cannot be identified due to unique characteristics of the target water body. These approaches are consistent with the State Antidegradation Policy (State Board Resolution No. 68-16) and with federal antidegradation requirements (40 CFR §131.12).

TMDLs and associated waste load allocations (WLAs) and load allocations (LAs) (see Section 6) are vehicles for implementing water quality standards. Therefore, the appropriateness of a reference system/antidegradation approach will be evaluated within the context of TMDL development for a specific water body. WLAs will be incorporated into National Pollution Discharge Elimination System (NPDES) permits for Municipal Separate Storm Sewer System (MS4), non-storm water general NPDES permits, general industrial storm water permits, and general and individual permits. LAs for nonpoint sources will be implemented according to the "Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program" (Nonpoint Source Implementation and Enforcement Policy) (SWRCB, 2004) within the context of the TMDL and the Conditional Waiver for Discharges from Irrigated Lands (Conditional Waiver).

The reference system/antidegradation approach is the approach proposed in this TMDL. However, Regional Board Staff recognizes the most appropriate reference system may not be identified. The proposed TMDL schedule allows the Regional Board time to re-consider this issue after the effective date of the TMDL. New information will be considered by Regional Board Staff when assessing more appropriate reference systems.

2.1.4 Antidegradation

Both the State of California and the federal government have antidegradation policies for water quality. The State policy is formally referred to as the "Statement of Policy with Respect to Maintaining High Quality Waters in California" (State Board Resolution No.

68-16). This policy restricts degradation of surface or ground waters and protects water bodies where existing quality is higher than is necessary for the protection of beneficial uses. The federal Antidegradation Policy (40 CFR §131.12) was developed under the Clean Water Act. This TMDL complies with antidegradation policies by ensuring the protection of beneficial uses and by not setting any WLAs and LAs above existing numbers of exceedance days.

2.2 Water Quality Impairments

During the 1996 Water Quality Assessment, the Regional Board evaluated total and fecal coliform monitoring data for beaches and fecal coliform data for inland surface waterbodies. As a result, SCR Estuary was listed on the basis of exceeding fecal coliform objectives in 78-93% of samples, and SCR Reach 6 (U.S. EPA 303(d) list Reach 8, West Pier Highway 99 to Bouquet Canyon Road Bridge) was listed for fecal coliform exceedances. The 1998 Water Quality Assessment kept all these listings and added Reach 5 (U.S. EPA 303(d) list Reach 7, Blue Cut to West Pier Highway 99) and 7 (U.S. EPA Reach 9, Bouquet Canyon Road Bridge to above Lang Gaging Station) to the 303(d) list for high coliform counts. SCR Estuary and Reaches 5, 6 and 7 remain on the 2002 and 2006 303(d) lists.

2.3 Data Review

Bacteria water quality data sets were reviewed during the development of this TMDL to confirm 303(d) listed impairments and identify possible impairments in other reaches that should be addressed concurrently. The 303(d) listing assessment requires a minimum of 5 samples; therefore, where there were 5 or more samples from the same reach and the same source, these data were summarized and analyzed. Monitoring data from the same reach, but from different sources were not combined because they are considered different lines of evidence during the 303(d) listing process. The calculation of the rolling 30-day geometric mean generally requires at least five equally spaced samples to be statistically significant (LARWQCB, 2001). The rolling 30-day geometric mean was calculated where possible. Sampling sites are shown in Figure 2-1.

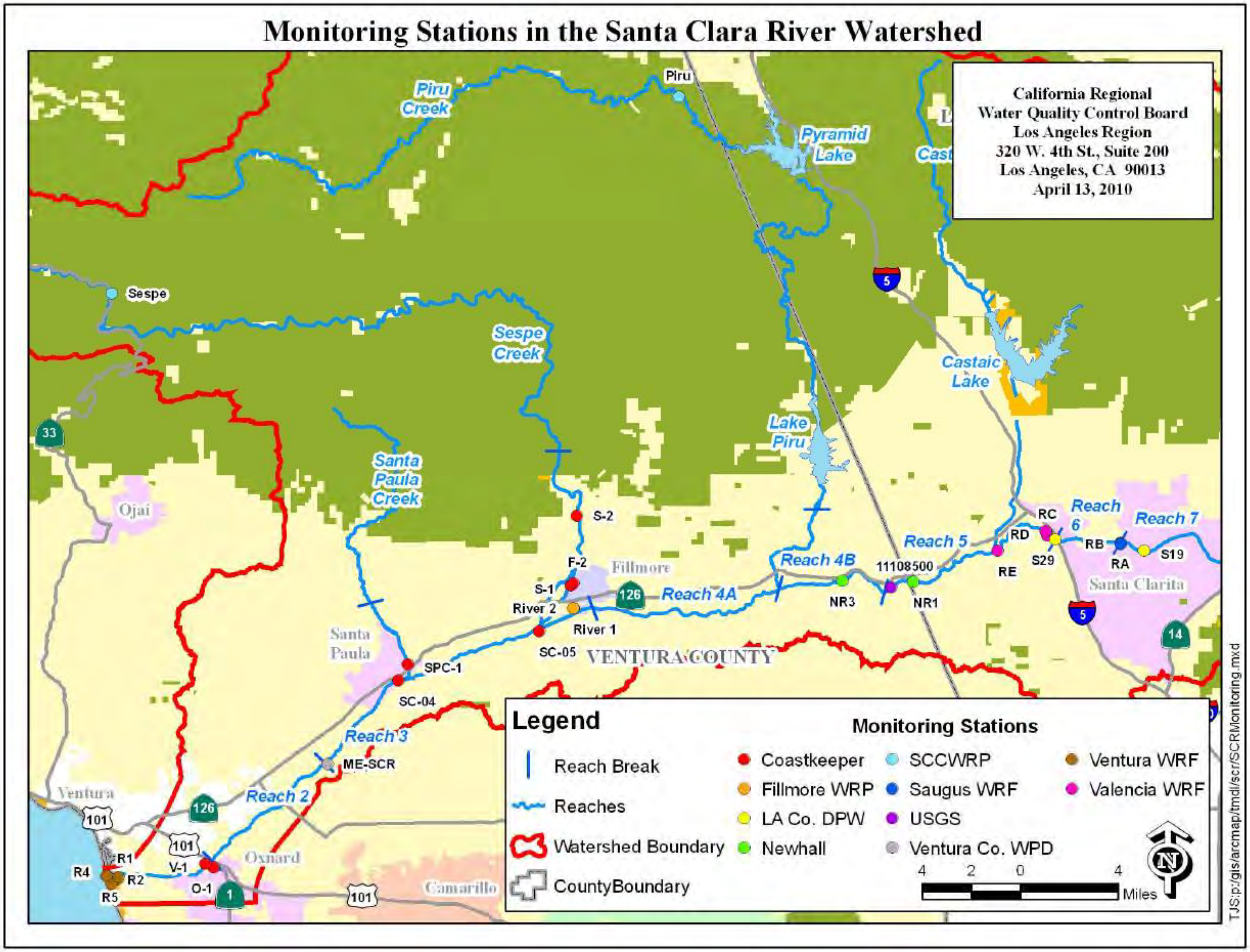
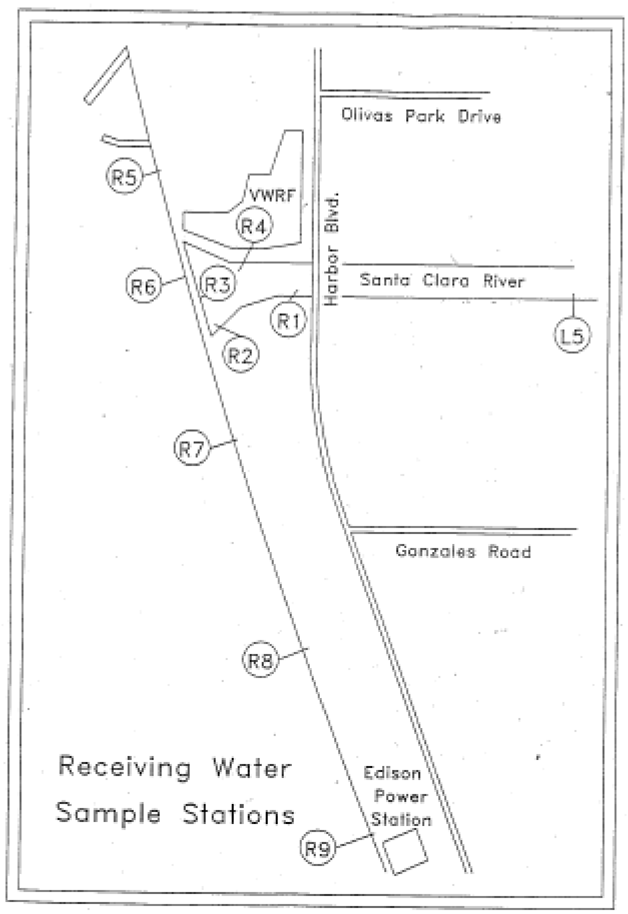


Figure 2-1. Monitoring Stations in the Santa Clara River Watershed

2.3.1 Santa Clara River Estuary

The Ventura WRF conducts weekly bacteria monitoring at 5 receiving water stations (R1, R2, R3, R4, and R5, previously named L5) in the SCR Estuary. Detailed locations of these monitoring sites are illustrated in Figure 2-2. The location of R5 (previously named L5) varies each year based on water level in the estuary. Available data for samples collected from January 1990 to April 2009 for the 5 receiving water stations are summarized in Tables 2-3 and 2-4. Data were compared against geometric mean objectives using a rolling 30-day geometric mean. Results suggest that the impairment is caused by both total coliform and fecal coliform exceedances. The number of exceedance days exceeds the minimum number of exceedances required for listing.

Figure 2-2. Ventura WRF Receiving Water Sample Stations (Santa Clara River Estuary)



* From Ventura WRF 1992 Annual Monitoring Report.

Table 2-3: Summary of single sample statistics for coliform bacteria at Ventura WRF receiving water monitoring stations in SCR Estuary

Site Name	*Total Coliform*			*Fecal Coliform*		
	No. of Samples	No. of Samples Exceeding 10000 MPN/100ml [1]	Percent Exceedance	No. of Samples	No. of Samples Exceeding 400 MPN/100ml	Percent Exceedance
R1	480	130	27%	355	93	26%
R2	560	179	32%	436	167	38%
R3	562	200	36%	437	184	42%
R4	563	208	37%	438	154	35%
L5	535	179	33%	410	125	30%
Total	2700	896	33%	2076	723	35%

[1] Or exceeding 1000 MPN/100 ml, if the ratio of fecal-to-total coliform exceeds 0.1.

Table 2-4: Summary of geometric mean statistics for coliform bacteria at Ventura WRF receiving water monitoring stations in SCR Estuary

Site Name	*Total Coliform*			*Fecal Coliform*		
	No. of Samples	No. of Samples Exceeding 1000 MPN/100ml	Percent Exceedance	No. of Samples	No. of Samples Exceeding 200 MPN/100ml	Percent Exceedance
R1	650	467	72%	515	146	28%
R2	965	565	59%	837	451	54%
R3	987	583	59%	848	498	59%
R4	997	775	78%	858	497	58%
L5	908	705	78%	769	360	47%
Total	4507	3095	69%	3827	1952	51%

2.3.2 Santa Clara River Reach 3

In compliance with the MS4 permit, the Ventura County Watershed Protection District (VCWPD) conducts the Stormwater Monitoring Program in Ventura County. The monitoring program in the SCR watershed includes one mass emission station at the Freeman Diversion (ME-SCR). Available monitoring data from June 2002 to February 2009 are summarized in Table 2-5. Geometric mean values were not calculated because there are less than 5 samples over a 30-day period. Results suggest that the impairment is caused by both fecal coliform and *E. coli* exceedances in Reach 3. The number of exceedance days exceeds the minimum number of exceedances required for listing.

Table 2-5: Summary of single sample statistics for coliform bacteria at VCWPD Mass Emission Station in Reach 3

Site Name	***Fecal Coliform***			***E. coli***		
	No. of Samples	No. of Samples Exceeding 400 MPN/100 ml	Percent Exceedance	No. of Samples	No. of Samples Exceeding 235 MPN/100 ml	Percent Exceedance
ME-SCR	38	19	50%	44	20	45%

The Fillmore Wastewater Treatment Plant (WTP) conducted monthly bacteria monitoring at 2 receiving water stations (River 1 and River 2) in SCR Reach 3. The Fillmore WTP is a secondary wastewater treatment plant located at "C" Street and River Street, in Fillmore. River 1 is located approximately 300 feet upstream from the discharge point, and River 2 is located approximately 300 feet downstream from the discharge point. Available data for samples collected from October 2004 to June 2008 for the 2 receiving water stations are summarized in Table 2-6. Geometric mean values were not calculated because there are less than 5 samples over a 30-day period. Results suggest that the impairment is caused by fecal coliform and *E. coli* exceedances. The number of exceedance days of the single sample objectives exceeds the minimum number of exceedances required for listing. As will be discussed in the source analysis section, Fillmore WTP will no longer discharge into the SCR. This data assessment shows the existing impairment.

Table 2-6: Summary of single sample statistics for coliform bacteria at Fillmore WTP receiving water monitoring stations (Reach 3)

Station Name	***Fecal Coliform***			***E. coli***		
	No. of Samples	No. of Samples Exceeding 400 MPN/100 ml	Percent Exceedance	No. of Samples	No. of Samples Exceeding 235 MPN/100 ml	Percent Exceedance
River 2	38	13	34%	38	18	47%
River 1	38	7	18%	38	8	21%
Total	76	20	26%	76	26	34%

Wishtoyo's Ventura Coastkeeper Watershed Monitoring Program conducted bacteria monitoring in the SCR Watershed. Available monitoring data from July 2009 to December

2009 are summarized in Table 2-7. Samples were taken from lower Santa Paula Creek and lower Sespe Creek, which, based on reach boundaries, are defined as part of Reach 3. Wishtoyo's Ventura Coastkeeper Watershed Monitoring Program collected, analyzed, and processed data in accordance with the quality assurance/quality control procedures and protocols set forth in the Wishtoyo Foundation's/Ventura Coastkeeper's quality assurance project plan (QAPP) for the Calleguas Creek Watershed, which has been certified and approved by the Regional Board. Geometric mean values were not calculated because there are less than 5 samples over a 30-day period. Data do not exceed bacteria water quality objectives.

Table 2-7. Summary of Wishtoyo's Ventura Coastkeeper Watershed Monitoring in tributaries of SCR Reach 3

Site Name	***E. coli***		
	No. of Samples	No. of Samples Exceeding 235 MPN/100ml	% Exceedances
S-1	2	0	0%
S-2	1	0	0%
SC-04	2	0	0%
SC-05	2	0	0%
SPC-1	2	0	0%
Total	9	0	0%

2.3.3 Santa Clara River Reach 4B

Newhall Ranch Company conducted bacteria monitoring from November 8, 2004 to November 12, 2004 (daily), on December 8, 2004, and on January 24, 2005. One of the two monitoring sites (NR3) is located at about 2.5 miles downstream of Blue Cut Gaging Station in Reach 4B. Available data are summarized in Tables 2-8 and 2-9. It should be noted that this is a small data set. There is one exceedance for both the fecal coliform and *E. coli* single sample objectives out of 7 samples. There are no exceedances for both the fecal coliform and *E. coli* geometric mean objectives out of 7 samples (a total of 2 samples when calculated using a 30-day rolling geometric mean). The number of exceedance days did not reach the minimum number of exceedances required for listing.

Table 2-8: Summary of single sample statistics for coliform bacteria at Newhall Ranch monitoring stations (Reach 4B and Reach 5)

Site Name	***Location***	***Fecal Coliform***			***E. coli***		
		No. of Samples	No. of Samples Exceeding 400 MPN/100 ml	Percent Exceedance	No. of Samples	No. of Samples Exceeding 235 MPN/100 ml	Percent Exceedance
NR3	Reach 4B	7	1	14%	7	1	14%
NR1	Reach 5	7	1	14%	7	1	14%

Table 2-9: Summary of geometric mean sample statistics for coliform bacteria at Newhall Ranch monitoring stations (Reach 4B and Reach 5).

Site Name	***Location***	***Fecal Coliform***			***E. coli***		
		No. of Samples	No. of Samples Exceeding 200 MPN/100 ml	Percent Exceedance	No. of Samples	No. of Samples Exceeding 126 MPN/100 ml	Percent Exceedance
NR3	Reach 4B	2	0	0%	2	0	0%
NR1	Reach 5	2	0	0%	2	0	0%

2.3.4 Santa Clara River Reach 5

SCVSD conducted weekly bacteria monitoring at 3 receiving water stations (RC, RD, RE) in Reach 5 of the SCR. Available data for samples collected from September 2004 to August 2009 for these stations are summarized in Tables 2-10 and 2-11. Results suggest that the impairment is caused by fecal coliform and *E. coli* exceedances. The numbers of exceedances days of the single sample and geometric mean objectives exceed the minimum number of exceedances required for listing. RC, which is close to and downstream of Los Angeles Department of Public Works (LADPW) stormwater monitoring mass emission station S29, has the highest bacteria exceedances among all the 3 receiving water stations. Bacteria exceedances at the station downstream of the Valencia WRP (RD) are lower than those at the station upstream of the Valencia WRP (RC), suggesting that dilution occurs due to discharge from the Valencia WRP. Station RE is further downstream of Station RD. Bacteria exceedances at Station RE are also lower than those at Station RC.

Table 2-10. Summary of single sample statistics for coliform bacteria at Valencia WRP receiving monitoring stations (Reach 5)

Site Name	***Fecal Coliform***			***E. coli***		
	No. of Samples	No. of Samples Exceeding 400 MPN/100ml	% Exceedances	No. of Samples	No. of Samples Exceeding 235 MPN/100ml	% Exceedances
RC	229	63	28%	229	64	28%
RD	231	33	14%	231	31	13%
RE	231	27	12%	231	35	15%
Total	691	123	18%	691	130	19%

Table 2-11. Summary of geometric mean statistics for coliform bacteria at Valencia WRP receiving monitoring stations (Reach 5)

Site Name	***Fecal Coliform***			***E. coli***		
	No. of Samples	No. of Samples Exceeding 200 MPN/100ml	% Exceedances	No. of Samples	No. of Samples Exceeding 126 MPN/100ml	% Exceedances
RC	323	181	56%	323	135	42%
RD	333	63	19%	333	59	18%
RE	335	99	30%	335	90	27%
Total	991	343	35%	991	284	29%

USGS conducted nationwide water quality monitoring, including one site in the SCR watershed (USGS 11108500) at the Los Angeles –Ventura county line in Reach 5. Available monthly monitoring data from March 1979 to September 1988 are summarized in Table 2-12. It should be noted that these data are few and collected more than 20 years ago. The number of exceedances of fecal coliform did not reach the minimum number of exceedances required for listing.

Table 2-12. Summary of single sample statistics for fecal coliform at USGS Station 11108500 (Reach 5)

Site Name	***Fecal Coliform***		
	No. of Samples	No. of Samples Exceeding 400 MPN/100 ml	Percent Exceedance
USGS 11108500	50	8	16%

Newhall Ranch Company conducted bacteria monitoring during November 8, 2004 and November 12, 2004 (daily), on December 8, 2004, and on January 24, 2005. One of the two monitoring sites (NR1) is located at Los Angeles –Ventura county line in Reach 5. Available data are summarized in Tables 2-8 and 2-9. It should be noted that this is a small data set. There is one exceedance out of 7 samples for coliform and *E. coli*, respectively. The number of exceedance did not reach the minimum number of exceedances required for listing.

2.3.5 Santa Clara River Reach 6

The NPDES permit for municipal storm water and urban runoff discharges within Los Angeles County was adopted on December 13, 2001 (Regional Board Order No. 01-182) and amended by Regional Board Orders R4-2006-074 on September 14, 2006, R4-2007-0042 on August 9, 2007, and R4-2009-0130 on December 10, 2009. In compliance with the permit, LADPW conducts the stormwater monitoring in Los Angeles County. The current monitoring program in the SCR watershed includes mass emission station S29. Station S29 is located in Reach 6 near Interstate 5 about 1.5 miles west of the confluence with San Francisquito Canyon. (Data from a previous monitoring location (S19), located in Reach 7, are discussed in section 2.3.6.) Available monitoring data from S29 from October 2002 to February 2009 are summarized in Table 2-13. Results suggest that high percentages of exceedances occur for fecal coliform. The number of exceedance days for fecal coliform reaches the minimum number of exceedances required for listing.

Table 2-13: Summary of single sample statistics for fecal coliform at LADPW Mass Emission Stations in Reaches 6 (S29) and 7 (S19)

Site Name	***Fecal Coliform***		
	No. of Samples	No. of Samples Exceeding 400 MPN/100 ml	Percent Exceedance
S29	40	29	73%
S19	10	9	90%

The Santa Clarita Valley Sanitation District (SCVSD) conducts weekly bacteria monitoring at 2 receiving water stations (RA, RB) in Reach 6 of the SCR (Tables 2-14 and 2-15). Grab samples were taken and analyzed on a weekly basis from March 2005 to August 2009 for these stations. There are 5 out of 30 single samples that exceeded single sample water quality objectives at RA, and 1 out of 232 single samples that exceeded single sample water quality objectives at RB. RA and RB are located upstream and downstream of the Saugus WRP, respectively. The difference in number of exceedances between RA and RB suggests that discharges from the Saugus WRP caused dilution of coliform bacteria in the receiving water. Therefore, results from RA and RB cannot be combined when analyzing impairments caused by coliform bacteria at Reach 6. Results from RA indicate that Reach 6 is still impaired by coliform bacteria. The numbers of exceedance days at RA reach the minimum number of exceedances required for listing. Detailed analysis indicates that the exceedances at RA are caused by both fecal coliform and *E. coli* (Table 2-14).

Table 2-14. Summary of single sample statistics for coliform bacteria at Saugus WRP receiving water monitoring stations (Reach 6)

Site Name	***Fecal Coliform***			***E. coli***		
	No. of Samples	No. of Samples Exceeding 400 MPN/100ml	% Exceedances	No. of Samples	No. of Samples Exceeding 235 MPN/100ml	% Exceedances
RA	30	4	13%	30	5	17%
RB	232	0	0%	232	1	0%

Table 2-15. Summary of geometric mean statistics for coliform bacteria at Saugus WRP receiving water monitoring stations (Reach 6)

Site Name	*Fecal Coliform*			*E. coli*		
	No. of Samples	No. of Samples Exceeding 200 MPN/100ml	% Exceedances	No. of Samples	No. of Samples Exceeding 126 MPN/100ml	% Exceedances
RA	14	0	0%	14	0	0%
RB	343	0	0%	343	0	0%
Total	357	0	0%	357	0	0%

2.3.6 Santa Clara River Reach 7

The LADPW stormwater monitoring program in the SCR watershed previously included a mass emission station (S19). Station S19 is located in Reach 7 at Newhall Ranch Road, in Santa Clarita. Available monitoring data from October 1995 to June 1996 are summarized in Table 2-13. Results suggest that a high percentage of exceedances occur for fecal coliform. The number of exceedance days reaches the minimum number of exceedances required for listing.

2.3.7 Santa Clara River Reaches 10 and 11

Southern California Coastal Water Research Project (SCCWRP) conducted bacteria monitoring of natural landscapes in upper Sespe Creek in Reach 10 and upper Piru Creek in Reach 11 in the SCR Watershed. Available monitoring data from December 2004 to February 2006 are summarized in Table 2-16. These data include dry weather samples and one wet-weather sample from Sespe Creek. Results of all samples did not exceed single sample bacteria water quality objectives for *E. coli*.

Table 2-16. Summary of single sample statistics for *E. coli* for SCCWRP monitoring sites in Reaches 10 and 11

Site Name	*Reach*	*E. coli*		
		No. of Samples	No. of Samples Exceeding 235 MPN/100ml	% Exceedances
Sespe Creek	10	4	0	0%
Piru Creek	11	5	0	0%

In summary, all listed reaches in SCR are still impaired by indicator bacteria. Recent data also indicate that Reach 3 is impaired by indicator bacteria; therefore, Reach 3 is included as an impaired reach that is addressed by this TMDL.

3 NUMERIC TARGETS

The TMDL will have multi-part numeric targets based on the updated bacteria objectives for marine and fresh waters designated for contact recreation (REC-1). Both single sample and geometric mean limits apply.

Regional Board staff is in the process of updating the bacteria objectives for freshwaters designated as REC-1 to remove redundancy and maintain consistency with U.S. EPA's 1986 recommended criteria. The update of bacteria objectives will remove the fecal coliform objectives and use *E. coli* objectives as the sole objective for freshwaters. To be consistent with the update of bacteria objectives, the numeric targets for SCR Reaches 3, 5, 6 and 7 will be only the adopted Basin Plan objectives for *E. coli* for REC-1 in freshwaters. The numeric targets for SCR Estuary will be the same as the adopted Basin Plan objectives for REC-1 in marine waters. All applicable numeric targets are contained in Table 3-1.

Table 3-1: Numeric Targets for SCR Estuary and SCR Reaches 3, 5, 6 and 7

Numeric Targets	Estuary (Marine REC-1)	Reaches 3, 5, 6 and 7 (Freshwater REC-1)
Single Sample		
E. coli	NA	235/100ml
Fecal coliform	400/100ml	NA
Enterococcus	104/100ml	NA
Total coliform*	10,000/100ml	NA
Geometric mean		
E. coli	NA	126/100ml
Fecal coliform	200/100ml	NA
Enterococcus	35/100ml	NA
Total coliform	1,000/100ml	NA

*Total coliform density shall not exceed 1,000/100 ml, if the ratio of fecal-to-total coliform exceeds 0.1.
NA: not applicable.

To implement the single sample bacteria objectives for waters designated REC-1, and to set allocations based on the single sample targets, an allowable number of exceedance days is set for marine and fresh waters. The numeric target in the TMDL is expressed as 'allowable exceedance days' since bacterial density and the frequency of exceedances is most relevant to public health. The US EPA allows states to select the most appropriate measure to express the TMDL; and allowable exceedance days are considered an 'appropriate measure' consistent with the definition in 40 CFR 130.2(i).

The number of allowable exceedance days is based on two criteria: (1) bacteriological water quality at any site is at least as good as at a designated reference site, and (2) there is no degradation of existing bacteriological water quality if historical water quality at a particular site is better than the designated reference site. Applying these two criteria allows the Regional Board to avoid imposing requirements to treat natural sources of bacteria from undeveloped areas. This approach, including the allowable exceedance levels during dry weather and wet weather, is consistent with that used in other bacteria TMDLs previously approved in this region. The geometric mean targets, which are based on a 30-day period, must be strictly adhered to and may not be exceeded at any time.

4 SOURCE ASSESSMENT

The TMDL requires an estimate of loadings from point sources and nonpoint sources. In the development of a TMDL, WLAs are given for point sources and LAs for nonpoint sources. Point sources typically include discharges from a discrete human-engineered point (e.g., a pipe from a wastewater treatment plant, industrial facility, or separate storm sewer system). Nonpoint source by definition includes pollutants that reach waters from diffuse sources.

Monitoring data indicate that the SCR is impaired by coliform bacteria in multiple reaches during both dry and wet weather. During wet weather, surface flow is continuous and bacteria can be transported in stormwater from any location in the watershed to the impaired reaches. Therefore, the potential source area for this TMDL is the whole SCR watershed.

Land uses in the SCR watershed are 90.5% open space, 3.2% agriculture, 1.5% high density residential, 1.2% low density residential, 1.1% public facilities, 0.7% industrial, 0.4% recreation, and 0.2% commercial. Other land uses range from 0.0003% to 0.6%, including water, mixed urban, transportation, military, and education. Table 4-1 shows the percentage of lands uses in each reach of the SCR.

Table 4-1. Land uses in the SCR Watershed

Subwatershed	High Density Residential	Low Density Residential	Commercial	Industrial	Public Facilities	Mixed Urban	Open	Recreation	Agriculture	Education	Transportation	Military	Water	Total for all classes
Reach 1	0.01%	0.05%	0.00%	0.02%	0.15%	0.03%	20.6%	0.04%	0.21%	0.01%	0.02%	0%	0.01%	21.3%
Reach 2	0.15%	0.03%	0.01%	0.03%	0.02%	0.02%	1.5%	0.01%	0.47%	0.01%	0.01%	0%	0.05%	2.3%
Reach 3	0.07%	0.04%	0.02%	0.12%	0.04%	0.003%	2.5%	0.02%	1.1%	0.01%	0.01%	0%	0.001%	3.9%
Reach 4A	0.01%	0.01%	0.0004%	0.08%	0.04%	0.001%	2.6%	0.0001%	0.33%	0.00%	0.0003%	0%	0.003%	3.1%
Reach 4B	0.00%	0.002%	0%	0.01%	0.02%	0%	0.61%	0%	0.15%	0%	0%	0%	0%	0.79%
Reach 5	0.20%	0.09%	0.06%	0.25%	0.22%	0.03%	10.7%	0.08%	0.19%	0.02%	0.05%	0%	0.25%	12.1%
Reach 6	0.62%	0.10%	0.06%	0.10%	0.18%	0.03%	6.9%	0.06%	0.06%	0.04%	0.03%	0%	0.06%	8.3%
Reach 7	0.31%	0.19%	0.04%	0.04%	0.07%	0.05%	3.2%	0.04%	0.04%	0.02%	0.03%	0.00004%	0.001%	4.0%
Reach 8	0.01%	0.58%	0.01%	0.02%	0.18%	0.01%	6.8%	0.03%	0.09%	0.01%	0.04%	0.00026%	0.001%	7.8%
Reach 9	0.04%	0.02%	0.003%	0.03%	0.003%	0.0001%	2.1%	0.01%	0.10%	0.01%	0.003%	0%	0.004%	2.3%
Reach 10	0.05%	0.03%	0.01%	0.02%	0.01%	0.003%	12.6%	0.01%	0.23%	0.01%	0.001%	0%	0.001%	12.9%
Reach 11	0.01%	0.05%	0.002%	0.02%	0.15%	0%	20.6%	0.04%	0.21%	0.0002%	0.06%	0%	0.19%	21.3%
Total	1.5%	1.2%	0.21%	0.74%	1.1%	0.18%	90.5%	0.35%	3.2%	0.12%	0.27%	0.0003%	0.57%	100%

4.1 Description of Sources and Data Review

While the data review in Section 2 is to confirm 303(d) listed impairments and identify possible impairments in other reaches, the data review in this section focuses on identifying potential sources. Monitoring data for MS4 discharges, WRP effluents, and natural landscapes are reviewed to identify potential sources. Loads from different sources are calculated (section 4.2) where possible.

4.1.1 Point Sources Data and Description

Point source discharges are regulated through an NPDES permit, typically issued in the form of Waste Discharge Requirements (WDRs) by the Regional Board. The NPDES permits in the SCR Watershed include two (2) MS4 permits, the California Department of Transportation (Caltrans) storm water permit, individual NPDES permits, general construction storm water permits, general industrial storm water permits, and general NPDES permits (Table 4-1). Urban runoff to the SCR is regulated as a point source discharge under three municipal separate storm sewer system (MS4) NPDES permits. The first is the County of Los Angeles MS4 Permit, which was most recently amended in December 2009 and is on a five-year renewal cycle. There are 85 co-permittees covered under this permit including 84 cities and the County of Los Angeles and Los Angeles County Flood Control District. The second is the County of Ventura MS4 Permit, which was most recently renewed in May 2009 and is on a five-year renewal cycle. The Ventura County Watershed Protection District is the principal permittee. There are 11 co-permittees covered under this permit including 10 cities and the County of Ventura. The third is a separate statewide storm water permit specifically for Caltrans. Runoff from construction and industrial activities is also subject to statewide general NPDES permits for storm water. There are five major NPDES permits in the watershed for the Saugus WRP, Valencia WRP, Fillmore WTP, Santa Paula WRF, and Ventura WRF. Other NPDES permits issued in the SCR watershed are for minor or general discharges, as listed in Table 4-2. Data are available from monitoring of effluents and receiving waters from wastewater treatment plants and from MS4 monitoring sites.

Table 4-2. NPDES permits in the SCR watershed

Type of NPDES Permit	Number of Permits
Municipal Separate Storm Sewer System (MS4)	2
California Department of Transportation Storm Water	1
General Construction Storm Water	416
General Industrial Storm Water	235
Individual NPDES Permits (Major)	5
Individual NPDES Permits (Minors)	5
General NPDES Permits	27
Total	**691**

MS4 permit data and description

Runoff from residential, industrial, and commercial areas can be an important source of bacteria. Most of the major residential and commercial areas are in the cities of Santa Clarita, Fillmore, Santa Paula, and Oxnard. Lower density residential areas are scattered in other small cities and unincorporated county areas of the SCR watershed. The potential sources of bacteria from these areas include fertilizer used for lawns and landscaping; organic debris from gardens, landscaping, and parks; trash such as food wastes; domestic animal waste; and human waste from areas inhabited by the homeless. Bacteria build up, particularly on impervious surfaces, and are washed into the waterways through storm drains when it rains. These loads are typically highest during the first major storms after extended dry periods, when the pollutants have accumulated (Tiefenthaler, et al., 2008). Activities such as the watering of lawns and the washing down of parking lots and driveways can contribute pollutants between storms during dry weather. SCCWRP Technical Report 510 (2007) investigated sources, patterns and mechanisms of storm water pollutant loading from watersheds and land uses of the greater Los Angeles area. Technical Report 510 found that coliform bacteria exceedances occurred consistently and uniformly at all mass emission sites. Mean bacteria concentrations and fluxes were significantly greater at mass emission sites from developed compared to undeveloped watersheds. This study also found that bacteria concentrations in rivers were strongly influenced by the length of antecedent dry condition but not with amount of rainfall.

Stormwater monitoring data are available for mass emission stations from the VCWPD (ME-SCR) and LADPW (S29) stormwater monitoring programs, for land use monitoring sites from the VCWPD stormwater monitoring program, and for MS4 discharges from Wishtoyo's Ventura Coastkeeper Watershed Monitoring Program. The data from mass emission stations, which were previously summarized in section 2.3, are presented here again to demonstrate the differences in bacteria concentrations in wet weather and dry weather.

Monitoring Data from Mass Emission Stations

The VCWPD stormwater monitoring program Station ME-SCR is located at the Freeman Diversion in Reach 3. The Los Angeles County stormwater monitoring program Station S29 is located near Interstate 5 about 1.5 miles west of the confluence with San Francisquito Canyon in Reach 6, and historical Station S19 is located at Newhall Ranch Road in Santa Clarita in Reach 7. Available monitoring data from June 2002 to February 2009 for ME-SCR, from October 2002 to February 2009 for S29, and from October 1995 to June 1996 for S19 are summarized in Table 4-3 as shown below. The numbers of samples exceeding the single sample bacteria objectives are listed for reference. The objectives for both marine water and freshwater are shown because discharges to Reaches 3, 6, and 7 can cause exceedances of freshwater objectives applicable to these reaches as well flow downstream and cause exceedances of marine water objectives applicable to the Estuary.

At ME-SCR, a high percentage of exceedances occurs for all types of coliforms during wet weather. A lower percentage of exceedances occurs during the dry season. At S29, a high percentage of exceedances occurs for both total coliform and fecal coliform during the wet season. A lower percentage of exceedances occurs for both total coliform and fecal coliform during the dry season. At S19, a high percentage of exceedances occurs for both total coliform and fecal coliform during wet and dry weather. The percentage of exceedances is lower in wet weather than in dry weather at this site.

Table 4-3. Summary statistics for coliform bacteria at mass emission stations ME-SCR, S29, and S19

Site Name	***Reach***	***Season***	***Total Coliform***			***Fecal Coliform***			***E. coli***		
			No. of Samples	No. of Samples Exceeding 10000 MPN/100ml[1]	% Exceedances	No. of Samples	No. of Samples Exceeding 400 MPN/100ml	% Exceedances	No. of Samples	No. of Samples Exceeding 235 MPN/100ml	% Exceedances
ME-SCR	3	Wet	26	24	92%	23	16	70%	24	18	75%
ME-SCR	3	Dry	19	8	42%	15	3	20%	17	1	6%
S29	6	Wet	26	26	100%	26	25	96%	NA[2]	NA	NA
S29	6	Dry	14	7	50%	14	4	29%	NA	NA	NA
S19	7	Wet	4	3	75%	4	3	75%	NA	NA	NA
S19	7	Dry	6	6	100%	6	6	100%	NA	NA	NA

[1] or exceeding 1000 MPN/100 ml, if the ratio of fecal-to-total coliform exceeds 0.1.

[2] NA indicates not available.

Monitoring Data from Land Use Sites

The VCWPD stormwater monitoring program in the SCR watershed includes two downstream land use sites (I-2 at Ortega St., and R-1 at Swan St. and Macaw Ave.). Station I-2 is intended to monitor storm water flow from an industrial area, and station R-1 is intended to monitor storm water flow from a residential area. Available monitoring data for total coliform, fecal coliform, and *E. coli* from January 1993 to October 2004 are summarized in Table 4-4 as shown below. The numbers of samples exceeding the single sample bacteria objectives are listed for reference. The objectives for both marine water and freshwater are shown because discharges to Reaches 1 and 2 can cause exceedances of freshwater objectives applicable to Reaches 1 and 2 as well flow downstream and cause exceedances of marine water objectives applicable to the Estuary. The data show high concentrations of bacteria coming from industrial and residential areas.

Table 4-4. Summary statistics for coliform bacteria at land use sites I-2 and R-1

Site Name	Reach	Season	Total Coliform			Fecal Coliform			E. coli		
			No. of Samples	No. of Samples Exceeding 10000 MPN/100 ml[1]	% Exceedances	No. of Samples	No. of Samples Exceeding 400 MPN/100 ml	% Exceedances	No. of Samples	No. of Samples Exceeding 235 MPN/100 ml	% Exceedances
I-2	1	Wet	17	16	94%	24	23	96%	3	3	100%
R-1	2	Wet	18	18	100%	25	25	100%	3	3	100%

[1] or exceeding 1000 MPN/100 ml, if the ratio of fecal-to-total coliform exceeds 0.1.

Monitoring Data for MS4 Discharges from Wishtoyo's Ventura Coastkeeper Watershed Monitoring Program

Wishtoyo's Ventura Coastkeeper Watershed Monitoring Program conducted bacteria monitoring of MS4 discharges in the SCR Watershed. Three sites were monitored: (1) O-1 is El Rio Drain, a covered drain discharging to SCR Reach 1 that drains an urbanized area (95% urban) of 1374 acres; (2) V-1 is Moon Ditch, an open channel discharging to SCR Reach 1 that drains an urbanized area (92% urban) of 707 acres; and (3) F-2 is North Fillmore Drain, an open channel discharging to Sespe Creek that drains a mostly urbanized area (58% urban) of 762 acres. Available monitoring data from July 2009 to November 2009 are summarized in Table 4-5. A high percentage of exceedances occurred for both total coliform and *E. coli*.

Table 4-5. Summary of MS4 discharge monitoring by the Wishtoyo's Ventura Coastkeeper Watershed Monitoring program.

Site Name	Reach	Total Coliform			E. coli		
		No. of Samples	No. of Samples Exceeding 10000 MPN/100ml	% Exceedances	No. of Samples	No. of Samples Exceeding 235 MPN/100ml	% Exceedances
O-1 MS4	1	2	2	100%	2	1	50%
V-1 MS4	1	5	5	100%	5	3	60%
F-2 MS4	3	2	2	100%	2	2	100%

WRP permit data and description

Staff reviewed daily effluent monitoring data collected from 2005 to 2009 for the Ventura WRF and Saugus and Valencia WRPs and found that most of the monitoring results are non-detect. Bacteria were detected occasionally in effluents but generally well below the bacteria water quality objectives for marine and fresh waters. Therefore, staff used permit limits to calculate bacteria loads from WRPs (see Section 4.3).

While Sanitary Sewer Overflows (SSOs) and exfiltration from sewer systems has been indentified by U.S. EPA as a potential source of pathogens in surface water (U.S. EPA 2000b and 2001), because of their unpredictability, SSOs are most appropriately addressed through enforcement actions such as Administrative Civil Liabilities (ACLs) and Cease and Desist Orders (CDOs). In addition, U.S. EPA documents indicate that although exfiltration may be possible given certain conditions, "no data or narrative information in the literature demonstrate, or even suggest, that sewer exfiltration has directly contaminated surface waters"(U.S. EPA 2000b).

4.1.2 Nonpoint Sources Data and Description

Nonpoint sources in the SCR watershed include inputs from the ocean and natural landscapes, wildlife, golf courses, horses and livestock, onsite wastewater treatment systems, irrigated lands, and in-stream sources. This section provides a discussion of each source and presents data to characterize each source, where available.

Monitoring Data from the Ventura WRF for the Shoreline Adjacent to the Estuary

The Ventura WRF conducted weekly total coliform monitoring at 5 stations from January 1990 to October 2000 along the Pacific Ocean shore adjacent to the Estuary. Locations of these monitoring stations are illustrated in Figure 2-1. Of the 125 samples from each station, no exceedances were found (Table 4-6) for total coliform. During this same period, samples collected from the Estuary (see section 2.3.1), showed a total of 82 exceedances of the total coliform objective of 10000 MPN/100ml. This indicates that coliform exceedances in the Estuary are caused by watershed sources, instead of sources from the Pacific Ocean.

Table 4-6: Summary statistics for coliform bacteria at Ventura WRF shoreline monitoring stations

Location	***Total Coliform***		
	No. of Samples	No. of Samples Exceeding 10000 MPN/100ml	Percent Exceedance
R5	125	0	0%
R6	125	0	0%
R7	125	0	0%
R8	125	0	0%
R9	125	0	0%

Monitoring Data from SCCWRP Study for Natural Landscapes

SCCWRP conducted bacteria monitoring of natural landscapes in Sespe Creek and Piru Creek in the SCR Watershed. Available wet- and dry-weather monitoring data from December 2004 to February 2006 are summarized in Table 4-7. These data were presented in section 2.3.7 to determine if there were bacteria impairments in these tributaries, but they are presented here as well to determine the potential loading of natural landscapes to the SCR. Results of all samples did not exceed bacteria water quality objectives for either total coliform or *E. coli*.

Table 4-7. Summary of single sample statistics for coliform bacteria for SCCWRP natural landscapes monitoring sites

Site Name	***Reach***	***Total Coliform***			***E. coli***		
		No. of Samples	No. of Samples Exceeding 10000 MPN/100ml	% Exceedances	No. of Samples	No. of Samples Exceeding 235 MPN/100ml	% Exceedances
Sespe Creek	10	4	0	0%	4	0	0%
Piru Creek	11	5	0	0%	5	0	0%

Wildlife

Wildlife wastes can contribute to the bacterial loads from the large undeveloped portions of the watershed, and may be the only source of bacteria from these areas. Over 88 percent of the entire Santa Clara River Watershed is undeveloped wildland. The abundance of wildlife varies among the different habitat and vegetation types. Potential loads from wildlife are accounted for through the use of a reference system/antidegradation approach.

Golf Courses

Golf courses are a potential source of bacteria since, typically, fertilization and watering rates are high. Golf courses also attract large numbers of birds. The bacteria may be transported to waterways by irrigation and storm runoff. Most of the golf courses in the SCR watershed are adjacent to waterways. There are 9 golf courses in Santa Clarita, 1 in Fillmore, 2 in Santa Paula, 2 in Satcoy, and 6 in Oxnard (Google map, 2010). Based on available data, the contribution from golf courses cannot be quantified, but they are considered potential sources and are assigned LAs.

Horses and Livestock

Manure produced by horses, cattle, sheep, and goats in the SCR Watershed is a source of both nutrients and coliforms. In the SCR watershed, there are about 2.2 acres of horse ranches in Los Angeles County and 0.3 acre in Ventura County. These areas were obtained from 2005 Southern California Association of Governments land use data. There are low-density residential properties within the watershed with horses located on the properties. The horse-related activities on these residential properties are not accounted for in the estimation of horse ranch acreage in the watershed. The actual area of horse-impacted land uses may be greater than 2.2 acres. About 0.1 acre of dairy/intensive livestock is located in the SCR watershed. Bacteria loads can be introduced directly to the receiving waters in the case of livestock wading in streams, or may occur as nonpoint sources during storm runoff. Based on available data, the contribution from horses and livestock cannot be quantified, but they are considered potential sources and are assigned LAs.

Onsite Wastewater Treatment Systems

Onsite wastewater treatment system (or septic system) discharges occur in the SCR watershed. When properly sited and operated, it is assumed that onsite wastewater treatment systems remove nearly 100% of the fecal coliform bacteria. However, onsite wastewater treatment systems can be significant sources of bacteria when the systems provide inadequate treatment and discharge directly to groundwater in close proximity to surface waters or discharge directly to surface water via overland flow. Inadequate treatment may be due to insufficient vertical separation to the groundwater, insufficient horizontal separation or surface discharge from a failed disposal field.

There are an estimated 10,000 people served by septic systems in the Los Angeles County portion of the watershed, and it is assumed that they are distributed in proportion to land area outside the Santa Clarita area (LARWQCB, 2003a). There are about 1916 septic systems in the Ventura County portion of the watershed (County of Ventura Environmental Health, 2010). Based on available data, the contribution from onsite wastewater treatment systems cannot be quantified, but given the groundwater-surface water interaction in the SCR watershed, these systems are considered potential sources and are assigned LAs.

Irrigated Lands

Irrigated lands may be another source of bacteria. Sources of bacteria from irrigated lands may include irrigation with bacteria-polluted water, application of manure, and wild animals living on irrigated lands. Nonpoint source discharges from irrigated lands tend to contain higher quantities of nutrients like nitrogen and phosphorus, which promote bacterial growth. There were no requirements for monitoring discharges from agricultural lands before 2005. On November 3, 2005, the Los Angeles Regional Board adopted a Conditional Waiver for Discharges from Irrigated Lands (Order No. R4-2005-0080). Currently, there is no requirement for monitoring bacteria in the Irrigated Lands Conditional Waiver program. However, irrigated lands are considered potential sources and it is anticipated that the next term of the Conditional Waiver will include bacteria monitoring. Based on available data, the contribution from irrigated lands cannot be quantified, but they are considered potential sources and are assigned LAs.

In-channel Sources

Loads directly within the SCR and Estuary are potential non-point sources of bacteria. These loads may include loads from homeless persons living in or along the SCR, illicit/illegal discharges, wildlife and birds, regrowth and/or suspension of sediment-associated bacteria, regrowth of bacteria in the water column, and resuscitation of injured bacteria discharged with disinfected wastewater effluent, etc.

4.2 Estimation of Loading

Available monitoring data indicate that the major contributors of bacteria loading to the SCR and Estuary are dry- and wet-weather urban runoff discharges from the storm water conveyance system. Exceedances of single sample targets occur more frequently in wet weather than in dry weather. This section provides an estimation of the loadings from the

MS4 mass emission stations and other point sources in the watershed to characterize their relative contributions to bacteria in the Santa Clara River.

Ventura WRF

The Ventura WRF has the capacity to treat and discharge up to 14 MGD of tertiary-treated sewage. On average, the plant presently discharges 7.6 MGD. Effluent is transferred to a wildlife pond with a design capacity of 34 million gallons. The wildlife pond provides 4 days of detention at the current average daily outfall flow rate. There is a loss of approximately 1.0 MGD effluent from the wildlife pond each year through percolation. Approximately 1.0 MGD of reclaimed water from the wildlife pond has been used each year for irrigation of golf courses, Marina Park, and commercial landscaping. The remaining effluent in the wildlife pond is discharged to the SCR estuary.

Ventura WRF's permit requires that all the wastewater be chlorinated to a 7-day median of 2.2 organisms per 100 milliliters (ml) for total coliform, and the number of total coliform organisms does not exceed 23 per 100 ml in more than one sample within any 30-day period. The fecal coliform loads discharged to the SCR estuary from the Ventura WRF were estimated from annual average flow and the permit limit of 2.2 total coliform organisms per 100 ml. Fecal coliform loads were assumed to be equal to total coliform loads. Based on this analysis, the annual fecal coliform loading from the Ventura WRF is on the order of 190 to 294 billion counts per year (Table 4-8). It is assumed that most of the fecal coliform is *E. Coli*, and the water quality objectives are for *E. coli*. However, the loads are presented here as fecal coliform so that they may be compared with the loads estimated for the stormwater mass emission site (see Table 4-12).

Table 4-8. Annual gross loading of fecal coliform to the SCR Estuary in Ventura WRF effluent*

Year	2004	2005	2006	2007	2008
Permit Limit (MPN/100 ml)	2.2	2.2	2.2	2.2	2.2
Average Flow (cfs)	9.67	11.81	12.60	13.30	14.97
Load (billion counts/year)	190.0	232.0	247.6	261.3	294.2

* Fecal coliform loads were assumed to be equal to total coliform loads. This is a conservative assumption, and it is expected that the actual fecal coliform loads may be lower.

Santa Paula WRF

The Santa Paula WRF has the capacity to treat and discharge up to 2.55 MGD of secondary treated municipal wastewater. Treated wastewater is discharged to the lined Peck Road storm drain, then flows into a natural, unlined channel, and then enters the SCR in Reach 3. Santa Paula WRF's permit also requires that all the wastewater be chlorinated to a 7-day median of 2.2 organisms per 100 ml for total coliform, and the number of total coliform organisms does not exceed 23 per 100 ml in more than one sample within any 30-day period. The fecal coliform loads discharged to the SCR from Santa Paula WRF were estimated from annual average flow and the permit limit of 2.2 organisms per 100 ml. Fecal coliform loads were assumed to be equal to total coliform loads. Based on this analysis, the annual fecal coliform loading from the Santa Paula WRF is on the order of 68 to 75 billion counts per year (Table 4-9). It is assumed that most of the fecal coliform is *E. Coli*, and the water quality objectives are for *E. coli*. However, the loads are presented here as fecal coliform so that they may be compared with the loads estimated for the stormwater mass emission site (see Table 4-12).

Table 4-9. Annual gross loading of fecal coliform to the SCR in Santa Paula WRF effluent*

Year	2004	2005	2006	2007	2008
Permit Limit (MPN/100 ml)	2.2	2.2	2.2	2.2	2.2
Average Flow (cfs)	3.46	3.64	3.56	3.45	3.84
Load (billion counts/year)	68.0	71.5	69.9	67.8	75.4

* Fecal coliform loads were assumed to be equal to total coliform loads. This is a conservative assumption, and it is expected that the actual fecal coliform loads may be lower.

On April 27, 2005, the City of Santa Paula filed a Report of Waste Discharge and applied to the Regional Board for new WDRs for disposal and reuse of treated wastewater from a proposed new treatment plant. The new plant will eliminate the discharge to the Santa Clara River or any other surface water body. On May 3, 2007, the Regional Board adopted new WDRs (Order No. R4-2007-0028) for the proposed new plant. The City is required to complete construction of the new plant by September 15, 2010 and achieve full compliance with the WDRs by December 15, 2010. The construction of the plant is currently on schedule.

Fillmore WTP

The final treated wastewater effluent of the Fillmore WTP is discharged to the ground through five percolation/evaporation ponds and/or to a subsurface percolation field regulated under WDRs contained in Order No. 97-038, adopted by the Regional Board on April 7, 1997. When the ponds and subsurface percolation fields are unavailable to dispose of the effluent, the treated effluent is discharged into the Santa Clara River under separate requirements contained in NPDES Permit No. CA0059021, as adopted by Regional Board

Order No. R4-2003-0136. However, Fillmore WTP has eliminated the discharge to the Santa Clara River since 2007.

On December 10, 2008, the Regional Board issued Order No. R4-2009-0127 relative to termination of Order No. R4-2003-0136. On May 11, 2006, the Regional Board adopted new WDRs (Order No. R4-2006-0049) for a proposed new plant for discharges to ground. The effluent will initially be discharged into reconstructed ponds at the existing Fillmore WTP pond site and distributed to subsurface driplines. In the event of an extreme flood event, such as a 100-year flood, the Discharger may use the C Street Park to be constructed as an unlined emergency storage facility for treated wastewater only. The new plant is currently operating.

Saugus WRP

The Saugus WRP has the capacity to treat and discharge up to 6.5 MGD of tertiary treated municipal wastewater. Saugus WRP's permit requires that all the wastewater be chlorinated to a 7-day median of 2.2 per 100 ml for total coliform organisms, and the number of total coliform organisms does not exceed 23 per 100 ml in more than one sample within any 30-day period. The fecal coliform loads discharged to the SCR from Saugus WRP were estimated from annual average flow and the permit limit of 2.2 total coliform organisms per 100 ml. Fecal coliform loads were assumed to be equal to total coliform loads. Based on this analysis, the annual fecal coliform loading from the Saugus WRP is on the order of 123 to 154 billion counts per year (Table 4-10). It is assumed that most of the fecal coliform is *E. Coli* and the water quality objectives are for *E. coli*. However, the loads are presented here as fecal coliform so that they may be compared with the loads estimated for the stormwater mass emission site (see Table 4-12).

Table 4-10. Annual gross loading of fecal coliform to the SCR in Saugus WRP effluent*

Year	2004	2005	2006	2007	2008
Permit Limit (MPN/100 ml)	2.2	2.2	2.2	2.2	2.2
Average Flow (cfs)	6.26	6.49	7.52	7.66	7.86
Load (billion counts/year)	123.0	127.6	147.7	150.4	154.4

* Fecal coliform loads were assumed to be equal to total coliform loads. This is a conservative assumption, and it is expected that the actual fecal coliform loads may be lower.

Valencia WRP

The Valencia WRP has the capacity to treat and discharge up to 27.6 MGD of tertiary treated municipal wastewater. Valencia WRP's permit requires that all the wastewater be chlorinated to a 7-day median of 2.2 per 100 ml for total coliform organisms, and the number of total coliform organisms does not exceed 23 per 100 ml in more than one sample within any 30-day period. The fecal coliform loads discharged to the SCR from Saugus WRP were estimated from annual average flow and the permit limit of 2.2 total coliform organisms per 100 ml. Fecal coliform loads were assumed to be equal to total coliform loads. Based on this analysis the annual fecal coliform loading from the Valencia WRP is on the order of 449 to 516 billion counts per year (Table 4-11). It is assumed that most of the fecal coliform is *E. Coli* and the water quality objectives are for *E. coli*. However, the loads are presented here as fecal coliform so that they may be compared with the loads estimated for the stormwater mass emission site (see Table 4-12).

Table 4-11. Annual gross loading of fecal coliform to the SCR in Valencia WRP effluent*

Year	2004	2005	2006	2007	2008
Permit Limit (MPN/100 ml)	2.2	2.2	2.2	2.2	2.2
Average Flow (cfs)	22.85	26.26	24.78	24.75	24.55
Load (billion counts/year)	448.8	515.8	486.9	486.3	482.3

* Fecal coliform loads were assumed to be equal to total coliform loads. This is a conservative assumption, and it is expected that the actual fecal coliform loads may be lower.

Stormwater

Stormwater loadings at mass emission station S29 were calculated when both total runoff volume and fecal coliform concentrations for a storm event were available from the LADPW annual monitoring reports. The number of sampling events and the total loadings for these sampling events are listed in Table 4-12. Results show that wet-weather fecal coliform loading for a given year based on the sum of loadings from only 3-5 storm events sampled per year ranges from 2795 to 1,187,473 billion counts per year. The estimated stormwater loadings from just 3-5 storm events are 6 to 2646 times greater than the estimated total annual loadings from the Valencia WRP (Table 4-11) and 19 to 9654 times greater than the estimated total annual loadings from the Saugus WRP (Table 4-10). It should be noted that only loadings from storm events that have data available were calculated and the total loading from all storm events in a storm year is expected to be higher.

Table 4-12. Stormwater loadings of fecal coliform at mass emission station S29

Storm Year	No. of Sampling Events	Total Loading (Billion Counts)
2008 - 2009	4	9349
2007 - 2008	3	6980
2006 - 2007	5	2795
2003 - 2004	3	1,187,473

Stormwater loadings at mass emission station ME-SCR are not calculated because the measured flow rate at the Freeman Diversion during wet weather only represents a fraction of total flow. The Santa Clara River flows through two possible routes at the Freeman Diversion during wet-weather conditions. One route is through the river diversion gate structure where the majority of wet-weather flow passes. The other route is over the diversion dam, a situation which occurs only during high flows generated by large storm events. Presently, wet-weather flow can only be measured at the diversion dam because there is no flow meter installed at the river diversion gate (Ventura Countywide Stormwater Monitoring Program Water Quality Monitoring Report, 2009).

4.3 Summary of Source Assessment

Based on available data and estimation of loadings, surface runoff loads from urbanized areas via the MS4 are a significant source of bacteria to the SCR. MS4 mass emission data show elevated levels of bacteria in the river. Data from natural landscapes in the region indicate that open space loading is not a significant source of bacteria. Data from storm drains and channels draining urban areas show elevated levels of bacteria, indicating that urban areas are a source. Data from throughout the Los Angeles Region further demonstrate that bacteria concentrations are significantly greater in developed areas. A calculation of bacteria loadings in the SCR shows that average annual loadings from WRPs are significantly less than wet-weather loadings and that most of the annual bacteria loading to the SCR is associated with wet weather. Based on this information, staff concludes that runoff from urban areas served by the storm drain system is a significant source of bacteria. Storm drain system discharges may have elevated levels of bacteria indicators due to sanitary sewer leaks and spills, illicit connections of sanitary lines to the storm drain system, runoff from homeless encampments, pet waste, and illegal discharges from recreational vehicle holding tanks, among others. Other point and nonpoint sources were analyzed and found to be less significant or there were not enough data to quantify their contribution. Nonetheless, all potential sources of bacteria are assigned WLAs and LAs in the TMDL.

5 LINKAGE ANALYSIS

The source analysis in this report showed that dry weather urban runoff and storm water, both conveyed by storm drains, are the primary sources of elevated bacterial indicator densities to the SCR and Estuary during dry and wet weather. Other point and nonpoint sources may also potentially contribute to elevated bacterial indicator densities. Therefore, all point and nonpoint sources will be assigned WLAs and LAs. Data on natural runoff in the region demonstrate that natural background loading is not a significant source. Certain concepts of the linkage analysis for this TMDL are the same, or similar to, the other Los Angeles Region bacteria TMDLs.

1. In Southern California, in dry weather, local sources of bacteria principally drive exceedances (LARWQCB, 2002a; 2003b; 2004).

2. In Southern California, in wet weather, upstream or watershed sources principally cause the bacteria exceedances (LARWQCB, 2002b; 2003b; 2004).

3. Based on three experiments conducted by Noble et al. (1999) to mimic natural conditions in or near Santa Monica Bay (SMB), two in marine water and one in fresh water, bacteria degradation was shown to range from hours to days. Based on the results of the marine water experiments, a first-order decay rate for bacteria of 0.8 d^{-1} (or 0.45 per day) is assumed. Degradation rates were shown to be as high as 1.0 d^{-1} (Noble et al., 1999). These studies show that bacterial degradation and dilution during transport through the watershed do not significantly affect bacterial indicator densities in receiving waters.

Therefore, loading capacity for the SCR and Estuary is defined in terms of bacterial indicator densities and is equivalent to the numeric targets in Section 3. This is consistent with the approach used in other Los Angeles Region bacteria TMDLs, including the Santa Monica Bay Beaches Bacteria TMDLs.

5.1 Critical Condition

The critical condition in a TMDL defines an extreme condition for the purpose of setting allocations to meet the TMDL numeric target. While a separate element of the TMDL, it may be thought of as an additional margin of safety such that the allocations are set to meet the numeric target during an extreme (or above average) condition.

Unlike many TMDLs where the critical condition is during low-flow conditions or summer months, the critical condition for bacteria loading is during wet weather. This is because intermittent or episodic loading from sources such as urban runoff can have maximal impacts at high (i.e. storm) flows (U.S. EPA, 2001). Local and Bight-wide shoreline monitoring data show a higher percentage of daily exceedance of the single sample targets during wet weather, as well as more severe bacteriological impairments indicated by higher magnitude exceedances and exceedances of multiple indicators (Noble et al., 2000, Schiff et al., 2001). This also appears to be the case for the SCR Estuary and Reaches 3, 5, 6, and 7 based on the data review in Section 2.3.

The SMB Beaches Bacteria TMDL identified the critical condition within wet weather more specifically, in order to set the allowable number of daily exceedances of the single sample targets. The 90th percentile storm year in terms of wet days was used as the reference year. The 90th percentile year was selected for several reasons. First, selecting the 90th percentile year avoids an untenable situation where the reference system is frequently out of compliance. Second, selecting the 90th percentile year allows responsible jurisdictions and responsible agencies to plan for a 'worst-case scenario', as a critical condition is intended to do. Finally, the Regional Board expects that there will be fewer exceedance days in drier years, since structural controls will be designed for the 90th percentile year. The same approach will be used to determine the critical year for this TMDL.

The 90th percentile storm year in terms of wet days was identified by constructing a cumulative frequency distribution of annual wet weather days using historical rainfall data. This means that only 10% of years should have more wet days than the 90th percentile year. The number of wet days was selected instead of total rainfall because a retrospective evaluation of data showed that the number of sampling events during which greater than 10% of samples exceeded the fecal coliform objective on the day after a rain was nearly equivalent for rainstorms less than 0.5 inch and those greater than 0.5 inch, concluding that even small storms represent a critical condition (Noble et al., 2000). This is particularly true since the TMDL's numeric target is based on number of days of exceedance, not on the magnitude of the exceedance.

Historical rainfall data are available at multiple meteorological stations located in the SCR watershed. Staff considered four stations to calculate the 90th percentile year and the number of wet days in the critical year. The four stations are located in the Estuary area, Santa Paula Creek, Reach 5, and Reach 6 of the SCR watershed. For the station in Estuary area, staff combined data from 4 nearby stations (Ventura-Old Olivas Adobe, Station # 216, data available from 10/01/1964 to 09/30/1983; Ventura Marina – CINP, Station # 216A, data available from 09/30/1983 to 09/30/1989; Ventura Marina – Port District, Station # 216B, data available from 10/01/1989 to 09/30/2008; and Ventura Harbor, Station # 216C, data available from 10/01/2008 to 09/30/2009). The other three selected stations are Santa Paula Canyon – Ferndale Ranch in Santa Paula Creek (Stations # 173 and 173A, data available from 09/30/1956 to 09/30/2009), Piru-Newhall Ranch in Reach 5 (Station # 025, data available from 10/2/1927 to 09/30/2009) and Newhall S Fc32ce in Reach 6 (data available from 11/1/1949 to 10/31/1996). Rain data from Newhall S Fc32ce was not collected continuously; therefore, this station was not used for further calculation. The 90th percentile year was found to be 1995 for the Estuary area stations (82 wet days), 1957 for Santa Paula Canyon – Ferndale Ranch (86 wet days), and 1995 for Piru-Newhall Ranch (81 wet days). The Santa Paula Canyon – Ferndale Ranch has the highest number of wet days due to its relatively high elevation. The same storm year (1995) and similar number of wet days (82 and 81) were found at the Estuary area stations and the Piru-Newhall Ranch station. The Piru-Newhall Ranch station was chosen to calculate the number of exceedances days for this TMDL because this station has the longest record of rain data (1927-2009), this station results in a similar number of wet days to other stations, and this station is located in the middle area of the SCR watershed.

5.2 Margin of Safety

An implicit margin of safety was assumed by directly applying the numeric water quality standards and implementation procedures as WLAs. This ensures that there is little uncertainty about whether meeting the TMDLs will result in meeting the water quality standards. An implicit margin of safety is incorporated in the allocations through the use of a conservative assumption of no (0) bacterial decay in discharges from storm drains to the receiving water when determining compliance with allocations.

6 POLLUTANT ALLOCATIONS AND TMDLs

WLAs are allocations of bacteria loads to point sources and LAs are allocations of bacteria loads to nonpoint sources. WLAs and LAs are expressed as the number of daily or weekly sample days that may exceed single sample targets at appropriate monitoring sites. WLAs and LAs are expressed as allowable exceedance days because the bacteria density and frequency of single sample exceedances are the most relevant to public health protection. Allowable exceedance days are "appropriate measures" consistent with the definition in 40CFR §130.2(i).

6.1 Selection of Reference Systems

In determining an appropriate reference system for the SCR, staff considered technical reports prepared as part of the development of the Los Angeles River (LAR) Bacteria TMDL. For freshwater systems, the LAR Bacteria TMDL Technical Reports suggested using a freshwater reference system based on monitoring by SCCWRP, which has conducted three studies that included bacteria monitoring of freshwater reference sites. There are 22 freshwater sites from "Assessment of Water Quality Concentrations and Loads from Natural Landscapes" (Technical Report 500, 2007), 12 freshwater sites from "Fecal Indicator Bacteria (FIB) Levels During Dry Weather from Southern California Reference Streams" (Technical Report 542, 2008), and 4 freshwater sites from "Microbiological Water Quality at Reference Beaches in Southern California During Wet Weather" (Technical Report, 2005). Samples were collected from fall 2004 to spring 2007 in these studies. The LAR Bacteria TMDL Technical Reports combined and analyzed data from the freshwater SCCWRP sites to calculate the exceedance probabilities of the geometric mean and single sample objectives during dry weather and wet weather. The exceedance probabilities are equal to the total number of exceedances of the objective divided by the total number of samples collected from the 38 reference sites. The raw data used to calculate the exceedances probabilities are presented in Appendix A. This approach is used for SCR Reaches 3, 5, 6, and 7.

For the SCR Estuary, data from San Mateo State Beach and the San Onofre State Beach are used as the local reference system. These beaches were studied as part of the SCCWRP study entitled, "Microbiological water quality at non-human impacted reference beaches in southern California during wet weather" (Technical Report 495, 2006). They represent a larger reference system that is more appropriate for the Santa Clara River watershed than the reference system used in previous TMDLs (i.e., Leo Carillo Beach). The San Mateo Beach is located at the mouth of San Mateo Creek in San Diego County, and the San Onofre State Beach is located at the mouth of San Onofre Creek in San Diego County. These two reference beaches are open with breaking waves and have freshwater inputs (Technical Report 495, 2006).

6.2 Calculation of Allowable Exceedance Days

Allowable exceedance days in an impaired reach will equal the water quality objective exceedance probability in the reference system times the number of days during the critical year. For the SCCWRP reference system for freshwaters, allowable exceedance days are set on an annual basis as well as for two other time periods. These two periods are (1) dry-weather and (2) wet-weather (defined as days of 0.1 inch of rain or more plus three days following the rain event). For the San Mateo/San Onofre Beach reference system for the Estuary, allowable exceedance days are set on an annual basis as well as for three other time periods. These three periods are (1) winter dry weather (November 1 to March 31), (2) summer dry weather (April 1 to October 31) and (2) wet weather (defined as days of 0.1 inch of rain or more plus three days following the rain event). As discussed earlier, Regional Board staff found 1995 as the critical year and there are 81 wet days in 1995. The allowable exceedance days of the numeric targets were calculated on an annual and a dry weather and wet weather basis as listed in Table 6-1.

Table 6-1. Annual allowable exceedance days of numeric targets

Reference System	Reaches 3, 5, 6, and 7		Estuary[4]		
	Dry Weather	Wet Weather	Summer Dry Weather (April 1 to October 31)	Winter Dry Weather (November 1-March 31)	Wet Weather
% WQO Exceedance Probability	1.6%	19%	4.7%	13.4%	30%
Allowable Exceedance Days of Single Sample Objectives[1, 2, 3]	5	16	10	12	25
Allowable Exceedance Days of Geomean Objectives	0	0	0	0	0

[1] Allowable exceedance days calculated by the following equation: Allowable Exceedance Days = WQO Exceedance Probability in Reference System(s) x Number of Days during 1995.

[2] Consistent with the Santa Monica Bay Beaches TMDL, where the fractional remainder for the calculated allowable exceedance days exceeds 1/10th then the number of days are rounded up (e.g., 4.12 is rounded up to 5). In instances where the tenth decimal place for the allowable exceedance days (or weeks or months) is lower than 1/10th then the number of days are rounded down (e.g., 4.02 is rounded down to 4).

[3] The calculated number of exceedance days assumes that daily sampling is conducted. To determine the number of allowable exceedances for less frequent sampling, a ratio is used

[4] The exceedance probability for the Estuary is based on the average of the exceedance probabilities for the San Onofre and San Mateo Beaches, as presented in SCCWRP Technical Report 495.

6.3 WLAs

WLAs for the MS4 permittees will be equal to allowable exceedance days listed in Table 6-1. Furthermore, the WLAs include no allowable exceedances of the geometric mean targets. The Los Angeles County MS4 permittees in the SCR watershed include Los Angeles County, Los Angeles County Flood Control District, and the City of Santa Clarita. The Ventura County MS4 permittees in the SCR watershed include Ventura County, VCWPD, the City of Fillmore, the City of Oxnard, the City of San Buenaventura, and the City of Santa Paula.

Because the wastewater treatment plants have demonstrated the ability to comply with bacteriological receiving water limits, the WLAs for the Saugus WRP, Valencia WRP, Fillmore WTP, Santa Paula WRF, and Newhall WRP are set equal to a 7-day median of 2.2 MPN/100 mL of *E. coli* and a daily max of 235 MPN/100 mL of *E. coli* to ensure zero (0) allowable exceedance days. No exceedances of the geometric mean targets shall be permitted.

The WLAs for the Ventura WRF are set equal to a 7-day median of 2.2 MPN/100 mL of total coliform to ensure zero (0) allowable exceedance days. No exceedances of the geometric mean targets shall be permitted.

General NPDES permits, individual NPDES permits, the Statewide Industrial Storm Water General Permit, the Statewide Construction Activity Storm Water General Permit, the Statewide Stormwater Permit for Caltrans Activities, and WDR permittees in the SCR watershed are assigned WLAs of zero (0) days of allowable exceedances for all time periods for the single sample targets and no exceedances of the 30-day geometric mean targets because they are not expected to be significant source of indicator bacteria. Compliance with an effluent limit based on the bacteria water quality objectives will be used to demonstrate compliance with the WLA.

Permittees that discharge to Reaches 1 and 2 have WLAs based on allowable exceedance days for the Estuary. Permittees that discharge to Reach 3 or above have WLAs based on allowable exceedance days for Reaches 3, 5, 6, and 7.

6.4 LAs

LAs will be equal to allowable exceedance days listed in Table 6-1. Furthermore, LAs include no exceedances of the geometric mean targets.

LAs for irrigated agricultural lands will be implemented through requirements in the Conditional Waiver or other order that are consistent with the LAs. The Conditional Waiver is in effect for a period of five years and will be reconsidered at the end of five years in 2010. Though potential load contributions of agriculture have not been characterized, monitoring and new data may better quantify the bacteria loading potential of agriculture and be incorporated into the Conditional Waiver.

LAs for onsite wastewater treatment systems will be implemented through WDRs or waivers of WDRs. The responsible agencies are the county and city health departments and/or other local agencies that oversee installation and operation of on-site wastewater treatment systems. However, owners of on-site wastewater treatment systems are responsible for actual discharges.

LAs for other nonpoint sources will be implemented through the Nonpoint Source Implementation and Enforcement Policy.

Sources that discharge to Reaches 1 and 2 have LAs based on allowable exceedance days for the Estuary. Sources that discharge to Reach 3 or above have LAs based on allowable exceedance days for Reaches 3, 5, 6, and 7.

6.5 Interim LAs and MS4 WLAs

Interim LAs and MS4 WLAs will be equal to the allowable exceedance days listed in Table 6-2. Interim allocations are based on the historical exceedance probability of single sample bacteria objectives at existing monitoring locations to ensure no degradation of water quality. For the Estuary, the current exceedance probability is based on all five Estuary monitoring locations, where an exceedance at any one location of any objective on any day counts as an exceedance. For Reaches, 3, 5, 6, and 7, the exceedance probability is based on station ME-SCR in Reach 3 (see Table 4-3). This location was used because it has *E. coli* data collected in both dry and wet weather over a long time period.

Table 6-2. Annual allowable exceedance days for Interim LAs and MS4 WLAs.

Reference System	Reaches 3, 5, 6, and 7		Estuary		
	Dry Weather	Wet Weather	Summer Dry-Weather (April 1 - October 31)	Winter Dry-Weather (November 1 - March 31)	Wet Weather
% WQO Exceedance Probability	5.9%	75%	74.9%	58.4%	76.0%
Allowable Exceedance Days of Single Sample Objectives[1,2,3]	17	61	150	49	62

[1] Allowable exceedance days calculated by the following equation: Allowable Exceedance Days = Current WQO Exceedance Probability x Number of Days during 1995.

[2] Consistent with the Santa Monica Bay Beaches TMDL, where the fractional remainder for the calculated allowable exceedance days exceeds 1/10th then the number of days are rounded up (e.g., 4.12 is rounded up to 5). In instances where the tenth decimal place for the allowable exceedance days (or weeks or months) is lower than 1/10th then the number of days are rounded down (e.g., 4.02 is rounded down to 4).

[3] The calculated number of exceedance days assumes that daily sampling is conducted. To determine the number of allowable exceedances for less frequent sampling, a ratio is used.

7 IMPLEMENTATION PLAN

This section describes implementation procedures that could be used to provide reasonable assurances the waste load and load allocations developed for the SCR Indicator Bacteria TMDL can be met. However, the Porter-Cologne Water Quality Control Act prohibits the Regional Board from prescribing the method of achieving compliance with water quality standards, and likewise TMDLs. Below staff have identified some potential implementation strategies; however, there is no requirement to follow the particular strategies proposed herein as long as the WLAs and LAs, expressed as maximum allowable exceedance days for each time period, are not exceeded.

7.1. Responsible Jurisdictions, Agencies and Entities

The cities of Santa Clarita, Fillmore, Santa Paula, and Ventura, the Counties of Los Angeles and Ventura, and the Los Angeles County Flood Control District and Ventura County Watershed Protection District are responsible for meeting the WLAs assigned to MS4 discharges. Cities and counties with co-mingled stormwater are jointly and severally responsible for meeting WLAs assigned to MS4 discharges, unless the dischargers demonstrate that their discharges did not cause or contribute to the exceedances. The cities and the counties may jointly or individually decide how to achieve the necessary reductions in exceedance days at each compliance point by employing one or more of the implementation strategies discussed below or any other viable strategy. Staff expects that the monitoring and source characterization outlined in the monitoring plan in Section 8 will assist municipalities in focusing their implementation efforts on key land uses, critical sources and storm periods.

Responsible parties must provide an Implementation Plan to the Regional Board outlining how each intends to individually or cooperatively achieve compliance with the WLAs. The report shall include implementation methods, an implementation schedule, proposed milestones, and proposed outfall monitoring to determine compliance. Proposed milestones will be considered by the Regional Board as potential permit conditions when the MS4 is reopened or reissued. For responsible jurisdictions and agencies who will be proposing wet-weather load-based compliance at MS4 outfalls, the plan shall include an estimate of existing load and the allowable load from MS4 outfalls to attain the allowable number of exceedance days in-stream. The plan shall include a technically defensible quantitative linkage to the WLAs. The plan shall include quantitative estimates of the water quality benefits provided by the proposed implementation approach.

Other stakeholders are individually responsible for their WLAs and LAs. WLAs for point sources will be implemented through NPDES permits. LAs for irrigated agricultural lands will be implemented through requirements in the Conditional Waiver or other order that are consistent with the LAs. The LAs for onsite wastewater treatment systems will be regulated by WDRs or waivers of WDRs. LAs for other nonpoint sources such as horses/livestock, aquaculture, onsite wastewater treatment systems, and golf courses, will be implemented through the State's Nonpoint Source Implementation and Enforcement Policy. The Nonpoint Source Implementation and Enforcement Policy specifies that the regional boards have the authority to regulate nonpoint source discharges through WDRs, waivers, and prohibitions.

7.2. Implementing Strategies for Achieving Allocations

A variety of strategies exist to reduce bacteria concentration and loading to the SCR. Rather than any single strategy, a combination of strategies may be required to reduce bacteria exceedances to acceptable levels. These strategies are categorized as structural Best Management Practices (BMPs) and non-structural BMPs.

7.2.1 Structural BMPs

Structural BMPs involve the use of structural methods to treat or divert water at either the point of generation or point of discharge to either the storm system or to receiving waters. Structural BMPs may be sub-regional or regional in scope.

Sub-Regional Structural BMPs

Sub-regional structural BMPs consist of a single or a series of BMPs designed to treat flows for limited sub-regions within the watershed. Sub-regions can vary in size from small parking lots to several city blocks. These sub-regional implementation strategies typically have multiple pollutant treatment potential (MDRWRA, 2007). Listed below are sub-regional structural BMPs and a brief description of each.

Local Capture Systems

Local capture systems contribute to the control of bacteria in the watershed by reducing the volume of runoff and reducing peak flows. BMPs within this category include rain barrels, cisterns, and other containers used to hold rainwater for reuse or recharge. These systems are usually designed to capture runoff from relatively clean surfaces, such as roofs, so that the water may be reused without treatment. Tank capacities range from around 55 gallons to several thousand cubic feet and can be above or below ground. Local capture systems contribute to control of bacteria in the watershed by reducing the volume of runoff and reducing peak flows.

Vegetated Treatment Systems

Through a combination of biofiltration, retention, infiltration, and evapotranspiration, BMPs within this category can provide a significant contribution to bacteria control for small areas and can be applied across the watershed. BMPs in this category include swales, filter strips, bioretention areas, and storm water planters (McCoy et al., 2006). These can be installed as on-site features of developments or in street medians, parking lot islands, or curb extensions. Vegetated systems involve the use of soils and vegetation to filter and treat stormwater prior to discharge into surface or sub-surface water.

Infiltration, along with soil soaking and evapotranspiration, reduces the volume of storm water runoff, and therefore reduces required sizes of downstream facilities.

Biofiltration can remove some particulates and the associated bacteria loading from storm water runoff. Additional bioslopes, infiltration trenches, soil grading alterations, bioretention ponds, and the use of selective vegetation can further increase the efficiency of vegetative biofiltration systems. In areas where biofiltration is not practical, modification includes design of bioslopes and infiltration trenches, which utilize amended soil and promote subsurface flow.

Vegetated bioswales are constructed drainages used to convey stormwater runoff. Vegetation in bioswales allows for the filtering of pollutants, and infiltration of runoff into groundwater. Broad swales on flat slopes with dense vegetation are the most effective at reducing the volume of runoff and pollutant removal. Bioswales planted with native vegetation offer higher resistance to flow and provide a better environment for filtering and trapping pollutants from stormwater. Vegetated bioswales generally have a trapezoidal or parabolic shape with relatively flat side slopes. Individual vegetated bioswales generally treat small drainage areas (five acres or less).

Local Infiltration Systems

Local infiltration systems contribute to bacteria control by reducing the potentially contaminated runoff from houses, streets, parking lots, and agriculture, and mitigating peak flows. Local infiltration systems utilize methods to increase on-site infiltration including the use of alternative paving materials, retention grading and infiltration pits, but effectiveness is based primarily on soil characteristics. Specific BMPs in this category include permeable paving, pervious concrete, pervious asphalt, pervious paving blocks, grass pavers, gravel pavers, pervious crushed stone, retention grading, and infiltration pits. Local infiltration systems can be effective for management of stormwater runoff from areas ranging from an individual lot to several city blocks.

Media Filtration

Media filtration in storm water is primarily used to separate fine particulates and associated pollutants, but might also be used for enhanced treatment to remove bacteria and nutrients. To maximize bacteria removal benefits, these facilities should be strategically placed in locations with high observed or suspected bacteria loadings. In this process, stormwater is captured and either directed by gravity or pumped through media such as sand, anthracite, compost, zeolite and combinations of natural and engineered substrates. These systems do not provide volume reduction benefits, but may provide limited flow attenuation for small size storms depending on size and type of facility. Media filters could be integrated directly into existing storm drain systems, but are generally off-line facilities requiring a diversion structure.

On-Farm BMPs

On-farm BMPs would focus on individual growers implementing BMPs on individual parcels throughout the watershed. Effective BMPs to reduce pollutant loading would focus on sediment and erosion management practices. Irrigation management practices are also important to reduce and/or eliminate dry weather runoff from fields. Listed below are some practices that may be implemented by individual growers.

- Avoid bare fields by planting cover crops or leaving plant debris in field
- Minimize road erosion by grading or using gravel on roads
- Capture and reuse irrigation/storm water runoff on site
- Use sediment traps at the end of fields to capture sediment from runoff
- Mitigate runoff before it leaves property with grassed swales and filter strips
- Conduct tests of irrigation systems to ensure efficiency and uniformity
- Inspect irrigation systems for breaks and leaks
- Divert water from non-cropped areas
- Use current weather information to determine irrigation requirements
- Stop irrigation if runoff occurs

Equestrian Related BMPs

Equestrian related BMPs contribute to bacteria control by controlling bacteria at their source. Buffers and filter strips provide separation between pollution generating areas and waterbodies and provide biofiltration for runoff from these areas. Equestrian related BMPs include buffers and filter strips protecting streams and drainages, improved manure storage areas and designated horse-wash areas with connections to sanitary sewers. Presence of exclusion fences would prohibit livestock and horses from grazing adjacent to water courses, potentially reducing bacterial loadings.

Regional Structural BMPs

Regional structural BMPs contain many similarities to sub-regional structural BMPs but differ in both the scope and scale of implementation strategies. Treatment areas can range from several sub-regions to the entire watershed. Regional structural BMPs retain the multiple treatment potential of sub-regional BMPs. Listed below are regional structural BMPs and a brief description of each.

Regional Infiltration Systems

A regional infiltration facility is generally a large basin capable of detaining the entire volume of a design storm and infiltration volume over a specified period. Regional biofiltration systems, including sub-surface flow wetlands, promote hydrolysis, oxidation, and rhizodegradation from soil filtration through the aerobic and anaerobic zones of the soil matrix (Halverson, 2004). These systems can treat a variety of different pollutants and can be utilized for flood mitigation. This is primarily accomplished by impounding water and allowing it to slowly percolate in surface soil and eventually to groundwater. These facilities can be applied as a stand-alone treatment feature for bacteria control on a subwatershed scale. In the event of a large storm, some flow would bypass infiltration and discharge to the receiving water untreated. However, treatment of a large percentage of flow would still be achieved. Application of a regional facility depends on suitability of soils for infiltration and appropriately-located open space.

Regional Detention Facility

Regional detention systems help reduce flow volume and promote sedimentation (McCoy et al., 2006). This type of facility consists of a large basin equipped with outlet structures that regulate rates of release. It can be used upstream of an infiltration facility, constructed wetland or disinfection plant to equalize flows and reduce sediment loads. These basins can be shallow, lined with vegetation, and separated into multiple bays to improve their water quality functions; unlike infiltration systems they do not require favorable soils. Detention facilities can also be deep, steep-wall basins, or underground vaults when space is a limiting factor. However, they are not effective as a stand-alone treatment option for bacteria.

Regional Natural Treatment Systems

Regional Natural Treatment Systems (NTS) are vegetated treatment systems, and primarily constructed water quality treatment wetlands. Constructed wetlands imitate processes carried out by natural wetlands and waste water treatment plants. Unlike natural wetlands, regional NTS are vegetated treatment systems, which are constructed, designed and maintained primarily for water quality treatment. Constructed wetlands can be applied either as on-line or off-line facilities or can be integrated into other habitat enhancement projects. The two most common regional NTS are free surface flow (FSF) and sub-surface flow (SSF) wetlands. FSF wetlands are characterized by shallow ponded water at varying depths above the ground surface; solar irradiation is supposedly the process involved in bacterial removal in this type of wetland. For the SSF wetlands, water flows through the sub-surface soil matrix, rarely surfacing; here the presence of the anoxic zone contributes to the bacterial removal mechanism. This method requires comparatively large areas of relatively flat land to mimic natural function. Also, these facilities are not intended to provide stand-alone treatment of storm water runoff. Often, a detention facility can be integrated upstream to mitigate peak flows and provide a more steady inflow, and biofiltration facilities, media filters or sedimentation basins can be integrated to reduce sedimentation loads and to further provide longevity and better performance of the NTS.

Diversion and/or Treatment

A diversion and/or treatment BMP routes urban runoff from canyons, streets and small watersheds away from the storm drain system or waterway, and redirects it into the sanitary sewer system or other treatment system, where the contaminated runoff then receives treatment and filtration before being re-used or discharged. As the name suggests, the unit collects street runoff and, through a series of tanks and pumps, diverts the liquid flow into the sanitary sewer system (City of Los Angeles Storm Water Program Website, 2007). Depending on the water quality of the flow, it might have to be passed through a wastewater treatment facility that uses UV irradiation, chlorination, ozonolysis or Biocides and Peracetic acids. Chlorination is one of the most used methods of disinfection, wherein chlorine being a strong oxidant breaks the cell membranes of bacteria and kills them. UV light with a wavelength of 220 to 320 nanometers can be used to inactivate pathogens. Ozone is generated onsite and the compound is an extremely reactive oxidant that inactivates pathogens through lysis. Peracetic acids deactivate outer cell membranes and can be applied for de-activation of bacteria and viruses; further, they are a more effective oxidant than chlorine and do not have harmful by-products.

After treatment, water could be channeled to receiving waters, to a nearby pond or lake or for a secondary usage.

7.2.2 Non-structural BMPs

Non-structural BMPs include prevention practices designed to improve water quality by reducing bacteria sources. Non-structural BMPs provide for the development of bacteria control programs that include, but are not limited to prevention, education, and regulation. These programs are described below.

Administrative Controls

Administrative controls require less initial investment of time compared to structural BMPs. However, for continuous implementation, administrative actions may require greater time. These actions include better enforcement of existing pet disposal ordinances, better enforcement of existing litter ordinances, posting additional signage, continuing feral cat population control, proposing stricter penalties, and other actions of an administrative nature.

Outreach and Education

Education and outreach to residents may minimize the potential for contamination of stormwater runoff by encouraging residents to clean up after their pets, pick up litter, minimize runoff from agricultural, residential, and commercial facilities, and control excessive irrigation. The public is often unaware of the fact that excess water discharged on streets and lawns ends up in receiving waters, or of the contamination caused by the polluted runoff.

Local agencies can provide educational materials to the public via television, radio, online, and print media, distribute brochures, flyers, and community newsletters, create information hotlines to outreach to educators and schools, develop community events, and support volunteer monitoring and cleanup programs

Storm Drain Stenciling

Storm drain inlet stenciling is another means of educating the public about the direct discharge of stormwater to receiving waters and the effects of polluted runoff on receiving water quality. Stenciling can be conducted in partnership with other agencies and organizations to garner greater support for educational programs (U.S. EPA, 2005).

Street Cleaning

Street and parking lot cleaning may minimize trash and pollutant loading to urban storm drains. This management measure involves employing pavement cleaning practices such as street sweeping on a regular basis to minimize trash, sediment, debris and other pollutants that might end up in receiving waters.

Storm Drain Cleaning

Routine cleaning of the storm drain system reduces the amount of trash and other pollutants entering the river, prevents clogging, and ensures the flood control capacity of the system. A successful storm drain cleaning program includes regular inspection and cleaning of catch basins and storm drain inlets, increased inspection and cleaning in areas with high trash accumulation, accurate recordkeeping, cleaning immediately prior to the rainy season to remove accumulated trash and other pollutants, and proper storage and disposal of collected material (CASQA, 2003).

7.3. Implementation Schedule

The proposed implementation schedule shall consist of a phased approach as discussed below and outlined in Table 7-1. The implementation schedule allows the responsible jurisdictions and responsible agencies time to gather additional monitoring data to better quantify bacteria loading to the SCR and prioritize implementation actions. The schedule would allow 8 years from the effective date to meet the dry-weather load and waste load allocations and 14 years from the effective date to meet the wet-weather load and waste load allocations in the SCR Estuary and Reaches 3, 5, 6, and 7.

Table 7-1: Implementation Schedule

Deadline	Task
Effective date of the TMDL	WLAs assigned to non-MS4 point sources must be attained.
1 year after the effective date of the TMDL	Responsible jurisdictions and agencies for the MS4 WLAs must submit a comprehensive in-stream bacteria water quality monitoring plan for the SCR Watershed. The plan must be approved by the Executive Officer before the monitoring data can be considered during the implementation of the TMDL. Once the coordinated monitoring plan is approved by the Executive Officer, monitoring shall commence within 6 months.

Deadline	Task
3 years after the effective date of this TMDL	Responsible jurisdictions and agencies for the MS4 WLAs shall submit a draft Implementation Plan to the Regional Board outlining how each intends to cooperatively or individually achieve compliance with the WLAs. The report shall include implementation methods, an implementation schedule, proposed milestones, and outfall monitoring.
4 years after the effective date of this TMDL	Interim LAs and MS4 WLAs apply.
No longer than 4 years after the effective date of this TMDL	The Regional Board shall reconsider this TMDL if: (1) monitoring and any voluntary local reference system studies justify a revision, or (2) US EPA publishes revised recommended bacteria criteria, or (3) the Regional Board adopts a separate Basin Plan amendment, suspending recreational uses during high flows.
5 years after the effective date of this TMDL	Responsible jurisdictions and agencies for the MS4 WLAs shall provide a verbal update to the Regional Board on the progress of TMDL implementation.
6 months after receipt of Regional Board comments on the draft Implementation Plan	Responsible jurisdictions and agencies for the MS4 WLAs shall submit a final Implementation Plan and begin additional outfall monitoring.
11 years after effective date of this TMDL	For SCR Estuary: Achieve compliance with the applicable LAs and MS4 WLAs, expressed in terms of geometric mean objectives and allowable exceedance days of the single sample objectives for summer dry weather (April 1 to October 31) and winter dry weather (November 1-March 31). For SCR Reaches 3, 5, 6, and 7: Achieve compliance with the applicable LAs and MS4 WLAs, expressed in terms of geometric mean objectives and allowable exceedance days of the single sample objectives for dry weather.

Deadline	Task
17 years after the effective date of this TMDL	For SCR Estuary and Reaches 3, 5, 6, and 7: Achieve compliance with the applicable LAs and MS4 WLAs, expressed in terms of geometric mean objectives and allowable exceedance days of the single sample objectives for wet weather.

8 Monitoring Program

8.1 Ambient Monitoring

Responsible jurisdictions and agencies for the MS4 WLAs are jointly responsible for developing and implementing a comprehensive monitoring plan to assess compliance with the waste load allocations in the TMDL. The monitoring plan should include all applicable bacteria water quality objectives and the sampling frequency must be adequate to assess compliance with the 30-day geometric mean objectives. Responsible jurisdictions and agencies may build upon existing monitoring programs in the SCR watershed when developing the bacteria water quality monitoring plan. At a minimum, at least one sampling station will be located in each impaired reach.

8.2 Compliance Monitoring

Compliance monitoring will assess attainment of the geometric mean water quality objectives and allowable exceedances of the single sample objectives for the SCR Estuary and Reaches 3, 5, 6, and 7. Compliance with interim WLAs will be assessed using in-stream monitoring. Compliance with final WLAs will be assessed using both in-stream monitoring and outfall monitoring as described in the following section.

8.2.1 MS4 Compliance Monitoring

Responsible jurisdictions and agencies for the MS4 WLAs shall submit an outfall monitoring plan as part of their implementation plan. The outfall monitoring plan shall propose an adequate number of representative outfalls to be sampled, a sampling frequency, and protocol for enhanced outfall monitoring as a result of an in-stream exceedance. Responsible jurisdictions and agencies can use existing outfall monitoring stations in the Ventura MS4 permit, where appropriate for both the permit and TMDL objectives.

Responsible jurisdictions and agencies shall assess compliance at the outfall monitoring sites identified in the implementation plan. Compliance shall be based on the allowable number of exceedance days, except in wet-weather, compliance can alternatively be based on an allowable load.

Responsible jurisdictions and agencies must also assess compliance at in-stream monitoring sites. If the number of exceedance days is greater than the allowable number of exceedance days, then the responsible jurisdictions and agencies shall conduct additional outfall monitoring, beyond the routine outfall monitoring proposed in the implementation plan. If the collective outfall monitoring shows attainment of WLAs, then MS4 discharges shall not be held responsible for in-stream exceedances for this time period.

8.2.2 Non-MS4 Permittee and Nonpoint Source Monitoring

Monitoring will also be implemented as part of WDR and waiver requirements, and through implementation of the Nonpoint Source Enforcement Policy. NPDES Permittees will conduct monitoring for all applicable bacteria water quality objectives to ensure that they are attaining WLAs and water quality objectives are being met. NPDES permits for the Saugus and Valencia WRPs shall include effluent monitoring for *E. coli* and the NPDES permit for the Ventura WRF shall include effluent monitoring for total coliform, fecal coliform, and enterococcus. The Conditional Waiver will require bacteria monitoring for discharges from irrigated lands.

8.3 Special Studies

Responsible jurisdictions and agencies within the watershed may conduct special studies designed to help refine waste load allocations and/or assist with TMDL implementation. The following are potential special studies

- Monitoring a local inland reference watershed to quantify the loading of indicator bacteria from background/natural sources.
- Source characterization.
- Water quality modeling to better define the effectiveness of implementation strategies.

9 Cost Considerations

The purpose of this cost analysis is to provide the Regional Board with a reasonable range of potential costs of implementing this TMDL and to address stakeholder concerns about costs. This cost estimate attempts to account for a range of economic factors and requires a number of assumptions regarding the extent and cost of implementing many of the measures. This section describes how the costs were derived for various implementation strategies and provides a summary of costs for each strategy. In many cases, cost estimates for previous bacteria TMDLs, such as the Ballona Creek Bacteria TMDL, were extrapolated to the SCR watershed. While land use data and other conditions were specific to the SCR watershed, some of the unit costs and other assumptions were pulled from previous TMDLs.

In reviewing the cost estimates, it should be noted that there are multiple additional benefits associated with the implementation of these strategies. Many of the structural and non-structural BMPs to address bacteria loading could also reduce the loading of other contaminants, which could assist in meeting the requirements of other Santa Clara River TMDLs.

9.1 Non-Structural BMPs

The costs for a number of non-structural source control measures have been estimated for the entire Los Angeles Region (Devinny et al., 2004), which has an area of 3,100 square miles. The source control measure costs for the SCR watershed were scaled down proportionally. The SCR watershed is approximately 1,600 square miles. The watershed is 5.7% urban (Table 4-1), resulting in 91 square miles of urban area that could need to be treated to comply with the TMDL. The following represent the approximate values for the SCR watershed for source control measures:

- Enforcement of litter ordinances - $0.26 million per year
- Public education - $0.15 million per year
- Improved street cleaning - $0.21 million per year
- Increased storm drain cleaning - $0.79 million per year

In addition to the costs for these source control measures, an estimated $1 million per year was added for additional bacteria source control specifically, such as finding and eliminating hot spots, sewer overflows and other sources of elevated bacteria that may affect either dry or wet weather flows. It is assumed that non-structural controls can be used to treat 20% of the urbanized portion of the watershed.

Summary:

- Annual Costs: $2.41 million per year

9.2 Structural BMPs

In the implementation section of this report (section 7.2), structural BMPs were discussed in terms of regional and sub-regional BMPs. Regional and sub-regional BMPs are very similar except that they differ in scope and scale (e.g., regional infiltration systems vs. local infiltration systems). Therefore, for the purposes of the cost analysis, costs are estimated for general BMP types, which could be scaled up or down depending on if sub-regional or regional BMPs were implemented. In all cases, land acquisition costs were excluded from the cost estimate.

9.2.1 Local Capture Systems

Cisterns are a common type of local capture system. To estimate costs of cisterns, it is assumed that cisterns will be installed only at schools and public facilities, since these types of controls are more easily implemented on these land uses, as opposed to residential or commercial sites. Schools and public facilities cover 1.2% of the SCR watershed (Table 4-1), resulting in an area of 19.2 square miles. Thus, schools and public facilities represent approximately 20% of the urbanized portion of the watershed treated with cisterns.

In the Ballona Creek Bacteria TMDL, it was estimated that it would take up to 2,260 cisterns to treat the 3.9 square miles of school/government land in the Ballona Creek watershed. Scaling this to the SCR watershed, up to 11,126 cisterns could be installed in the SCR Watershed to manage the flow from all schools and public facilities. Assuming a unit cost of $1/gallon and a cistern size of 10,000 gallons, the total cost would be $111 million.

Operation and maintenance costs for cisterns are based on the amount of water pumped. Based on the Ballona Creek Bacteria TMDL, it is assumed that approximately 70,000 gallons per year of runoff would be captured by each cistern. Additional assumptions include:

- 3 horsepower pump;
- Flow rate of 10 gallons per minute;
- Unit energy cost of $0.10 per kilowatt-hour.

Using the standard equation of W=Power*Volume/Flow, which for these assumptions is:

W = (3hp) * (.745kW/hp) * (70,000gal/yr/cistern) / ((10gal/min) * (60min/hr)) = 261 kW-hr/cistern/yr

For 11,126 cisterns and using an energy cost of $0.10 per kilowatt-hour, the total operation and maintenance cost for electrical power is $0.3 million per year.

Summary:

- Capital costs – $111 million
- Operation and Maintenance Costs - $0.3 million per year

9.2.2 Vegetated Treatment Systems

Vegetated swales are a typical vegetated treatment system. Based on case studies, the ratio of swale surface area to drainage area is 1,000 square feet per acre (CASQA, 2003). The mid range cost to construct a swale for treatment of a 10-acre drainage area is approximately $19,000 (adjusted to 2010 dollars) (CASQA, 2003). Assuming swales are used to treat 20% of the urbanized portion of the SCR watershed (20% of 90.1 square miles, or 11,533 acres), the capital cost would be approximately $22 million dollars. The annual maintenance cost is estimated at 5% of the construction cost; annual maintenance costs are estimated at $1 million dollars.

Summary:

- Capital costs – $22 million
- Operation and Maintenance Costs - $1 million per year

9.2.3 Infiltration Systems

Local, on-site or subwatershed-based infiltration projects may be placed in parks, public land, vacant property, and other open spaces within the SCR Watershed. Assuming infiltration devices are used to treat 20% of the urbanized portion of the watershed, the area to be treated would be equal to 11,533 acres. Staff determined that 2307 infiltration trenches, each designed to treat 0.5 inches of runoff from a five-acre area, could be used to treat 11,533 acres. Based on an estimated construction cost of $7 per cubic feet (CASQA, 2003, adjusted for inflation), it would cost $63,000 per infiltration device to treat 0.5 inches of runoff from a five-acre area. This results in a total cost of $145 million. The annual maintenance cost is estimated at 5% of the construction cost; annual maintenance costs are estimated at $7.3 million dollars.

Summary

- Capital Costs - $145 million
- Operation and Maintenance Costs - $7.3 million per year

9.2.4 Media Filtration

The construction cost of a sand/organic filter system depends on the drainage areas, expected efficiency, and other design parameters. Case studies conducted in 1997 indicate cost ranges from $6,600 to $11,000 to treat a drainage area of 5 acres or less. Assuming that 20% of the urbanized portion of the watershed will be treated with sand filters designed for a 5-acre drainage area and a unit construction price of $12,000 dollars (adjusted for inflation), the estimated construction cost of sand/organic filters for 20% of the urbanized portion of the watershed would be $28 million dollars. Annual maintenance costs average approximately 5% of construction costs; annual maintenance costs are estimated at $1.4 million dollars.

Summary

- Capital Costs - $28 million
- Operation and Maintenance Costs - $1.4 million per year

9.2.5 On-Farm BMPs

The Natural Resources Conservation Service (NRCS) provides knowledgeable assistance to farmers in reducing soil mobilization. NRCS staff can provide technical assistance on installing on-farm BMPs. The NRCS website (http://efotg.nrcs.usda.gov/treemenuFS.aspx) provides cost estimates for various on-site BMPs. On-farm BMPs may include buffer crops, filter strips and sedimentation basins. The cost of implementing each of these BMPs would vary depending on the extent with which they are installed. The costs may further increase if productive land is replaced by non-productive BMPs. Table 9-1 summarizes the estimated costs for various on-farm BMPs.

Table 9-1. Per acre costs for potential on-farm BMPs

BMP	Cost (per acre)	Annual O & M Cost (per acre)
Field Border	$373	$8.15
Filter Strip	$1002	$15.28
Sedimentation Basin	$10,000	$196

(NRCS, 2000)

Often replacing a traditional irrigation system with a drip irrigation system can aid in reducing the mobilization of sediment (and associated contaminants). Improved maintenance of the systems may further reduce farm runoff. Maintenance for micro-irrigation systems cost about $40/acre/year (NRCS, 2000).

9.2.6 Diversion and/or Treatment

The cost estimates for storm drain diversions are based on the cost analysis for the Santa Monica Bay Beaches Bacteria TMDL, the Marina del Rey Harbor Mothers Beach and Back Basins Bacteria TMDL, and the Los Angeles Harbor Bacteria TMDL (Inner Cabrillo Beach and Main Ship Channel) (LARWQCB, 2002a, 2002b, 2003b, 2004). The annualized capital cost to construct 10 low-flow diversions is estimated at $717,386, assuming financing for 20 years at 7 percent. The operation and maintenance costs, for all 27 diversions, are estimated at $1.7 million. The number of low-flow diversions necessary to attain the SCR Bacteria TMDL is unknown. Flow modeling may determine the optimum number of low-flow diversions necessary to comply with the WLAs.

9.3 Costs of Monitoring

The costs of monitoring are based on the in-stream monitoring requirements and the MS4 outfall monitoring requirements. For a purpose of a cost estimate, it is assumed that one in-stream monitoring will be sampled in each impaired reach, for a total of 5 monitoring sites. Based on prices of bacteriological analysis from a local laboratory, the cost per sample is $34 for analyzing *E. coli* and total coliform, $40-$65 for analyzing total coliform and fecal coliform, and $70 for analyzing enterococcus. Assuming a monitoring frequency of 5 times a month for each monitoring site, the annual cost for in-stream monitoring is estimated at $7350 for the Estuary and $8160 for Reaches 3, 5, 6, and 7. The cost for outfall monitoring is estimated at $123 per sample for permittees located at the Estuary and Reaches 1 and 2, and $34 per sample for permittees located at Reach 3 and above. The number of outfall monitoring locations in the watershed will be proposed as part of the implementation plan.

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Appendix A

Data Used to Calculate Freshwater Reference System Exceedance Probabilities

Wet Weather ***E.coli***

Exceedance	19%
Number of Data Points	70
Number > WQO	13

Waterbody	NumQual	E.coli	SampleDate	Study*
Deer Creek	=	86	10/27/04	Beach
Deer Creek	=	140	10/28/04	Beach
Deer Creek	=	10	10/29/04	Beach
Deer Creek	<	10	10/30/04	Beach
Deer Creek	=	220	12/5/04	Beach
Deer Creek	=	150	12/6/04	Beach
Deer Creek	<	10	12/7/04	Beach
Deer Creek	=	10	12/8/04	Beach
Deer Creek	<	10	1/29/05	Beach
Deer Creek	<	10	1/30/05	Beach
Deer Creek	<	10	1/31/05	Beach
Deer Creek	<	10	2/1/05	Beach
Deer Creek	<	10	2/12/05	Beach
Deer Creek	=	10	2/13/05	Beach
Deer Creek	<	10	2/14/05	Beach
Deer Creek	=	10	2/15/05	Beach
Leo Carrillo	=	190	1/29/05	Beach
Leo Carrillo	=	150	1/30/05	Beach
Leo Carrillo	=	370	1/31/05	Beach
Leo Carrillo	=	75	2/1/05	Beach
Leo Carrillo	=	41	2/12/05	Beach
Leo Carrillo	=	870	2/13/05	Beach
Leo Carrillo	=	41	2/14/05	Beach
Leo Carrillo	=	90	2/15/05	Beach
San Mateo	=	31	1/18/05	Beach
San Mateo	=	41	1/25/05	Beach
San Mateo	=	169	2/1/05	Beach
San Mateo	=	52	2/8/05	Beach
San Mateo	=	10	2/16/05	Beach
San Mateo	=	20	2/17/05	Beach
San Onofre	=	6815	10/27/04	Beach
San Onofre	=	3654	10/28/04	Beach
San Onofre	=	684	10/29/04	Beach
San Onofre	=	98	11/9/04	Beach

Waterbody	NumQual	E.coli	SampleDate	Study*
San Onofre	<	10	12/14/04	Beach
San Onofre	=	74	1/18/05	Beach
San Onofre	=	132	1/29/05	Beach
San Onofre	=	20	2/8/05	Beach
San Onofre	=	457	2/12/05	Beach
San Onofre	=	158	2/13/05	Beach
San Onofre	=	84	2/14/05	Beach
San Onofre	=	20	2/15/05	Beach
San Onofre	=	20	2/16/05	Beach
San Onofre	=	84	2/17/05	Beach
Solstice Creek	=	1400	10/27/04	Beach
Solstice Creek	=	120	10/28/04	Beach
Solstice Creek	=	110	10/29/04	Beach
Solstice Creek	=	65	10/30/04	Beach
Solstice Creek	=	3000	12/5/04	Beach
Solstice Creek	=	100	12/6/04	Beach
Solstice Creek	<	10	12/7/04	Beach
Solstice Creek	=	20	12/8/04	Beach
Solstice Creek	=	10	1/29/05	Beach
Solstice Creek	=	20	1/30/05	Beach
Solstice Creek	=	41	1/31/05	Beach
Solstice Creek	=	63	2/1/05	Beach
Solstice Creek	=	52	2/12/05	Beach
Solstice Creek	=	10	2/13/05	Beach
Solstice Creek	=	20	2/14/05	Beach
Solstice Creek	=	10	2/15/05	Beach
Cristianitos Creek	=	1160	1/8/05	NL
Bell Canyon Creek	=	58.5	1/7/05	NL
Bell Creek	=	182.0	1/3/06	NL
Fry Creek	=	12.5	2/12/05	NL
Fry Creek	=	254.9	3/29/06	NL
Sespe Creek	=	10	12/4/04	NL
Bear Creek Matilija	=	10	12/4/04	NL
Arroyo Sequit	=	1583.3	12/28/04	NL
Arroyo Sequit	=	469.9	1/7/05	NL
Arroyo Sequit	=	431.2	4/5/06	NL

* Beach: Microbiological Water Quality at Reference Beaches in Southern California During Wet Weather (SCCWRP Technical Report 448)
NL: Assessment of Water Quality Concentrations and Loads from Natural Landscapes (SCCWRP Technical Report 500)

Dry Weather ***E. coli***

		Single Sample Maxium
	Exceedance	1.6%
	Number of Data Points	450
	Number > WQO	7

Waterbody	NumQual	Result	SampleDate	Season	Study*
Arroyo Seco	=	15	6/9/05	Summer	NL
Arroyo Seco	=	10	9/6/05	Summer	NL
Arroyo Seco	<	10	05/31/2006	Summer	FIB
Arroyo Seco	=	52	06/07/2006	Summer	FIB
Arroyo Seco	=	30	06/14/2006	Summer	FIB
Arroyo Seco	=	31	06/21/2006	Summer	FIB
Arroyo Seco	=	41	06/28/2006	Summer	FIB
Arroyo Seco	=	74	07/05/2006	Summer	FIB
Arroyo Seco	<	10	07/11/2006	Summer	FIB
Arroyo Seco	=	122	07/18/2006	Summer	FIB
Arroyo Seco	=	110	07/25/2006	Summer	FIB
Arroyo Seco	=	20	08/01/2006	Summer	FIB
Arroyo Seco	<	10	08/08/2006	Summer	FIB
Arroyo Seco	<	10	08/15/2006	Summer	FIB
Arroyo Seco	<	10	08/22/2006	Summer	FIB
Arroyo Seco	=	10	08/29/2006	Summer	FIB
Arroyo Seco	<	10	09/05/2006	Summer	FIB
Arroyo Seco	<	10	09/12/2006	Summer	FIB
Arroyo Seco	=	31	09/19/2006	Summer	FIB
Arroyo Seco	=	148	09/26/2006	Summer	FIB
Arroyo Seco	=	10	10/03/2006	Summer	FIB
Arroyo Seco	=	10	10/10/2006	Summer	FIB
Arroyo Seco	=	30	10/17/2006	Summer	FIB
Arroyo Seco	<	10	10/24/2006	Summer	FIB
Arroyo Seco	<	10	10/31/2006	Summer	FIB
Arroyo Seco	<	10	11/07/2006	Winter	FIB
Arroyo Seco	<	10	11/14/2006	Winter	FIB
Arroyo Seco	<	10	11/21/2006	Winter	FIB
Arroyo Seco	<	10	11/28/2006	Winter	FIB
Arroyo Seco	<	10	12/05/2006	Winter	FIB
Arroyo Seco	<	10	12/19/2006	Winter	FIB

Waterbody	NumQual	Result	SampleDate	Season	Study*
Arroyo Seco	<	10	12/26/2006	Winter	FIB
Arroyo Seco	<	10	01/02/2007	Winter	FIB
Arroyo Seco	<	10	01/11/2007	Winter	FIB
Arroyo Seco	<	10	01/18/2007	Winter	FIB
Arroyo Seco	<	10	01/23/2007	Winter	FIB
Arroyo Seco	<	10	02/06/2007	Winter	FIB
Arroyo Seco	<	10	02/15/2007	Winter	FIB
Arroyo Seco	<	10	02/20/2007	Winter	FIB
Arroyo Seco	=	10	03/06/2007	Winter	FIB
Arroyo Seco	<	10	03/13/2007	Winter	FIB
Arroyo Seco	<	10	03/20/2007	Winter	FIB
Arroyo Seco	<	10	03/27/2007	Winter	FIB
Arroyo Seco	=	10	04/03/2007	Summer	FIB
Arroyo Seco	=	74	04/10/2007	Summer	FIB
Arroyo Seco	<	10	04/17/2007	Summer	FIB
Arroyo Seco	<	10	04/26/2007	Summer	FIB
Arroyo Seco	<	10	05/01/2007	Summer	FIB
Arroyo Seco	<	10	05/08/2007	Summer	FIB
Bear Creek Matilija	=	10	6/22/05	Summer	NL
Bear Creek Matilija	=	5	9/15/05	Summer	NL
Bear Creek Matilija	=	20	6/2/06	Summer	NL
Bear Creek WFSGR	=	10	6/17/05	Summer	NL
Bear Creek WFSGR	=	5	9/8/05	Summer	NL
Bear Creek WFSGR	=	17.3	6/1/06	Summer	NL
Bell Canyon Creek	=	52	9/2/05	Summer	NL
Bell Canyon Creek	=	173	05/17/2006	Summer	FIB
Bell Canyon Creek	=	10	05/25/2006	Summer	FIB
Bell Canyon Creek	<	10	05/31/2006	Summer	FIB
Bell Canyon Creek	=	241	06/09/2006	Summer	FIB
Bell Canyon Creek	=	63	06/15/2006	Summer	FIB
Bell Canyon Creek	=	20	06/21/2006	Summer	FIB
Bell Canyon Creek	=	820	06/30/2006	Summer	FIB
Bell Canyon Creek	=	209	07/07/2006	Summer	FIB
Bell Canyon Creek	=	20	07/12/2006	Summer	FIB
Bell Canyon Creek	=	75	07/18/2006	Summer	FIB
Bell Canyon Creek	=	373	07/25/2006	Summer	FIB
Bell Canyon Creek	=	146	08/04/2006	Summer	FIB
Boden Canyon Creek	=	63	05/17/2006	Summer	FIB
Boden Canyon Creek	=	18600	05/26/2006	Summer	FIB
Boden Canyon Creek	=	98	06/02/2006	Summer	FIB

Waterbody	NumQual	Result	SampleDate	Season	Study*
Boden Canyon Creek	=	31	06/07/2006	Summer	FIB
Boden Canyon Creek	=	20	06/14/2006	Summer	FIB
Boden Canyon Creek	=	20	06/21/2006	Summer	FIB
Boden Canyon Creek	=	10	06/28/2006	Summer	FIB
Boden Canyon Creek	<	10	03/07/2007	Winter	FIB
Boden Canyon Creek	<	10	03/15/2007	Winter	FIB
Boden Canyon Creek	=	41	03/21/2007	Winter	FIB
Boden Canyon Creek	=	52	03/28/2007	Winter	FIB
Boden Canyon Creek	=	41	04/04/2007	Summer	FIB
Boden Canyon Creek	=	146	04/11/2007	Summer	FIB
Boden Canyon Creek	=	272	04/18/2007	Summer	FIB
Boden Canyon Creek	<	10	04/26/2007	Summer	FIB
Boden Canyon Creek	=	120	05/02/2007	Summer	FIB
Boden Canyon Creek	<	10	05/09/2007	Summer	FIB
Boden Canyon Creek	<	10	05/16/2007	Summer	FIB
Boden Canyon Creek	=	10	05/23/2007	Summer	FIB
Boden Canyon Creek	=	226	05/30/2007	Summer	FIB
Cattle Creek EFSGR	=	10	6/17/05	Summer	NL
Cattle Creek EFSGR	=	25.5	9/8/05	Summer	NL
Cattle Creek EFSGR	=	14.1	6/1/06	Summer	NL
Cold Creek	=	40.5	6/9/05	Summer	NL
Cold Creek	=	5	9/6/05	Summer	NL
Cold Creek	<	10	05/15/2006	Summer	FIB
Cold Creek	<	10	05/26/2006	Summer	FIB
Cold Creek	=	30	05/31/2006	Summer	FIB
Cold Creek	=	20	06/06/2006	Summer	FIB
Cold Creek	=	52	06/13/2006	Summer	FIB
Cold Creek	=	74	06/20/2006	Summer	FIB
Cold Creek	=	41	06/27/2006	Summer	FIB
Cold Creek	<	10	07/06/2006	Summer	FIB
Cold Creek	=	10	07/12/2006	Summer	FIB
Cold Creek	<	10	07/19/2006	Summer	FIB
Cold Creek	=	10	07/26/2006	Summer	FIB
Cold Creek	<	10	08/02/2006	Summer	FIB
Cold Creek	=	20	08/09/2006	Summer	FIB
Cold Creek	=	108	08/16/2006	Summer	FIB
Cold Creek	=	74	08/23/2006	Summer	FIB
Cold Creek	<	10	08/30/2006	Summer	FIB
Cold Creek	=	10	09/06/2006	Summer	FIB
Cold Creek	<	10	09/13/2006	Summer	FIB

Waterbody	NumQual	Result	SampleDate	Season	Study*
Cold Creek	<	10	09/20/2006	Summer	FIB
Cold Creek	<	10	09/27/2006	Summer	FIB
Cold Creek	<	10	10/04/2006	Summer	FIB
Cold Creek	<	10	10/11/2006	Summer	FIB
Cold Creek	=	41	10/18/2006	Summer	FIB
Cold Creek	<	10	10/25/2006	Summer	FIB
Cold Creek	<	10	11/01/2006	Winter	FIB
Cold Creek	<	10	11/08/2006	Winter	FIB
Cold Creek	<	10	11/15/2006	Winter	FIB
Cold Creek	=	10	11/20/2006	Winter	FIB
Cold Creek	<	10	11/29/2006	Winter	FIB
Cold Creek	<	10	12/06/2006	Winter	FIB
Cold Creek	<	10	12/20/2006	Winter	FIB
Cold Creek	<	10	01/03/2007	Winter	FIB
Cold Creek	<	10	01/10/2007	Winter	FIB
Cold Creek	<	10	01/24/2007	Winter	FIB
Cold Creek	<	10	02/07/2007	Winter	FIB
Cold Creek	<	10	02/14/2007	Winter	FIB
Cold Creek	=	10	02/21/2007	Winter	FIB
Cold Creek	<	10	03/01/2007	Winter	FIB
Cold Creek	<	10	03/07/2007	Winter	FIB
Cold Creek	<	10	03/14/2007	Winter	FIB
Cold Creek	<	10	03/21/2007	Winter	FIB
Cold Creek	<	10	03/28/2007	Winter	FIB
Cold Creek	<	10	04/05/2007	Summer	FIB
Cold Creek	<	10	04/11/2007	Summer	FIB
Cold Creek	<	10	04/18/2007	Summer	FIB
Cold Creek	<	10	04/27/2007	Summer	FIB
Cold Creek	=	20	05/02/2007	Summer	FIB
Cold Creek	=	20	05/09/2007	Summer	FIB
Coldbrook NFSGR	=	10	6/17/05	Summer	NL
Coldbrook NFSGR	=	15	9/8/05	Summer	NL
Coldbrook NFSGR	=	14.1	6/1/06	Summer	NL
Cristianitos Creek	=	25.5	6/7/05	Summer	NL
Cucamonga Creek	<	10	05/16/2006	Summer	FIB
Cucamonga Creek	<	10	05/26/2006	Summer	FIB
Cucamonga Creek	<	10	05/30/2006	Summer	FIB
Cucamonga Creek	<	10	06/06/2006	Summer	FIB
Cucamonga Creek	<	10	06/13/2006	Summer	FIB
Cucamonga Creek	<	10	06/20/2006	Summer	FIB

Waterbody	NumQual	Result	SampleDate	Season	Study*
Cucamonga Creek	<	10	06/27/2006	Summer	FIB
Cucamonga Creek	<	10	07/05/2006	Summer	FIB
Cucamonga Creek	<	10	07/11/2006	Summer	FIB
Cucamonga Creek	<	10	07/18/2006	Summer	FIB
Cucamonga Creek	<	10	07/25/2006	Summer	FIB
Cucamonga Creek	=	6	08/01/2006	Summer	FIB
Cucamonga Creek	<	10	08/15/2006	Summer	FIB
Cucamonga Creek	<	10	08/22/2006	Summer	FIB
Cucamonga Creek	=	40	08/29/2006	Summer	FIB
Cucamonga Creek	<	10	09/05/2006	Summer	FIB
Cucamonga Creek	<	10	09/19/2006	Summer	FIB
Cucamonga Creek	=	10	09/26/2006	Summer	FIB
Cucamonga Creek	<	10	10/03/2006	Summer	FIB
Cucamonga Creek	<	10	10/10/2006	Summer	FIB
Cucamonga Creek	<	10	10/17/2006	Summer	FIB
Cucamonga Creek	=	10	10/24/2006	Summer	FIB
Cucamonga Creek	<	10	10/31/2006	Summer	FIB
Cucamonga Creek	=	10	11/07/2006	Winter	FIB
Cucamonga Creek	<	10	11/21/2006	Winter	FIB
Cucamonga Creek	<	10	11/28/2006	Winter	FIB
Cucamonga Creek	<	10	12/05/2006	Winter	FIB
Cucamonga Creek	=	180	12/12/2006	Winter	FIB
Cucamonga Creek	<	10	12/20/2006	Winter	FIB
Cucamonga Creek	<	10	12/27/2006	Winter	FIB
Cucamonga Creek	<	10	01/03/2007	Winter	FIB
Cucamonga Creek	<	10	01/16/2007	Winter	FIB
Cucamonga Creek	<	10	01/23/2007	Winter	FIB
Cucamonga Creek	<	10	01/30/2007	Winter	FIB
Cucamonga Creek	<	10	02/06/2007	Winter	FIB
Cucamonga Creek	=	30	02/13/2007	Winter	FIB
Cucamonga Creek	<	10	02/20/2007	Winter	FIB
Cucamonga Creek	<	10	02/28/2007	Winter	FIB
Cucamonga Creek	<	10	03/06/2007	Winter	FIB
Cucamonga Creek	<	10	03/20/2007	Winter	FIB
Cucamonga Creek	=	10	03/27/2007	Winter	FIB
Cucamonga Creek	<	10	04/03/2007	Summer	FIB
Cucamonga Creek	<	10	04/17/2007	Summer	FIB
Cucamonga Creek	<	10	04/24/2007	Summer	FIB
Cucamonga Creek	<	10	05/01/2007	Summer	FIB
Day Creek Canyon	<	10	05/17/2006	Summer	FIB

Waterbody	NumQual	Result	SampleDate	Season	Study*
Day Creek Canyon	<	10	05/26/2006	Summer	FIB
Day Creek Canyon	=	10	05/31/2006	Summer	FIB
Day Creek Canyon	=	160	06/07/2006	Summer	FIB
Day Creek Canyon	=	10	06/14/2006	Summer	FIB
Day Creek Canyon	<	10	06/21/2006	Summer	FIB
Day Creek Canyon	=	10	06/28/2006	Summer	FIB
Day Creek Canyon	=	10	07/05/2006	Summer	FIB
Day Creek Canyon	=	10	07/12/2006	Summer	FIB
Day Creek Canyon	=	10	07/19/2006	Summer	FIB
Day Creek Canyon	<	10	07/26/2006	Summer	FIB
Day Creek Canyon	=	20	08/02/2006	Summer	FIB
Day Creek Canyon	=	20	08/09/2006	Summer	FIB
Day Creek Canyon	=	4	08/16/2006	Summer	FIB
Day Creek Canyon	<	10	08/23/2006	Summer	FIB
Day Creek Canyon	<	10	08/30/2006	Summer	FIB
Day Creek Canyon	=	10	09/06/2006	Summer	FIB
Day Creek Canyon	<	10	09/13/2006	Summer	FIB
Day Creek Canyon	<	10	09/20/2006	Summer	FIB
Day Creek Canyon	<	10	09/27/2006	Summer	FIB
Day Creek Canyon	<	10	10/04/2006	Summer	FIB
Day Creek Canyon	<	10	10/11/2006	Summer	FIB
Day Creek Canyon	<	10	10/18/2006	Summer	FIB
Day Creek Canyon	=	30	10/25/2006	Summer	FIB
Day Creek Canyon	<	10	11/01/2006	Winter	FIB
Day Creek Canyon	<	10	11/08/2006	Winter	FIB
Day Creek Canyon	<	10	11/15/2006	Winter	FIB
Day Creek Canyon	<	10	11/22/2006	Winter	FIB
Day Creek Canyon	<	10	11/29/2006	Winter	FIB
Day Creek Canyon	<	10	12/06/2006	Winter	FIB
Day Creek Canyon	<	10	12/13/2006	Winter	FIB
Day Creek Canyon	<	10	12/19/2006	Winter	FIB
Day Creek Canyon	<	10	12/27/2006	Winter	FIB
Day Creek Canyon	<	10	01/03/2007	Winter	FIB
Day Creek Canyon	<	10	01/10/2007	Winter	FIB
Day Creek Canyon	<	10	01/17/2007	Winter	FIB
Day Creek Canyon	=	10	01/24/2007	Winter	FIB
Day Creek Canyon	<	10	01/31/2007	Winter	FIB
Day Creek Canyon	<	10	02/07/2007	Winter	FIB
Day Creek Canyon	<	10	02/14/2007	Winter	FIB
Day Creek Canyon	=	10	02/21/2007	Winter	FIB

Waterbody	NumQual	Result	SampleDate	Season	Study*
Day Creek Canyon	=	20	02/27/2007	Winter	FIB
Day Creek Canyon	=	10	03/07/2007	Winter	FIB
Day Creek Canyon	<	10	03/14/2007	Winter	FIB
Day Creek Canyon	<	10	03/21/2007	Winter	FIB
Day Creek Canyon	<	10	03/28/2007	Winter	FIB
Day Creek Canyon	<	10	04/04/2007	Summer	FIB
Day Creek Canyon	<	10	04/11/2007	Summer	FIB
Day Creek Canyon	<	10	04/18/2007	Summer	FIB
Day Creek Canyon	<	10	04/25/2007	Summer	FIB
Day Creek Canyon	<	10	05/02/2007	Summer	FIB
Day Creek Canyon	=	10	05/09/2007	Summer	FIB
Fry Creek	=	10	6/13/05	Summer	NL
Fry Creek	=	10	5/18/06	Summer	NL
Hurkey Creek	=	5500	05/31/2006	Summer	FIB
Hurkey Creek	=	10	06/07/2006	Summer	FIB
Hurkey Creek	=	31	06/14/2006	Summer	FIB
Hurkey Creek	<	10	06/21/2006	Summer	FIB
Hurkey Creek	=	41	06/28/2006	Summer	FIB
Hurkey Creek	=	20	07/05/2006	Summer	FIB
Hurkey Creek	<	10	07/12/2006	Summer	FIB
Hurkey Creek	=	10	01/03/2007	Winter	FIB
Hurkey Creek	<	10	01/10/2007	Winter	FIB
Hurkey Creek	=	10	01/17/2007	Winter	FIB
Hurkey Creek	=	150	01/24/2007	Winter	FIB
Hurkey Creek	=	30	01/31/2007	Winter	FIB
Hurkey Creek	=	10	02/07/2007	Winter	FIB
Hurkey Creek	<	10	02/21/2007	Winter	FIB
Hurkey Creek	=	10	03/07/2007	Winter	FIB
Hurkey Creek	<	10	03/14/2007	Winter	FIB
Hurkey Creek	<	10	03/23/2007	Winter	FIB
Hurkey Creek	<	10	03/28/2007	Winter	FIB
Hurkey Creek	<	10	04/04/2007	Summer	FIB
Hurkey Creek	<	10	04/11/2007	Summer	FIB
Hurkey Creek	<	10	04/18/2007	Summer	FIB
Lachusa Canyon	=	132	05/15/2006	Summer	FIB
Lachusa Canyon	=	52	05/26/2006	Summer	FIB
Lachusa Canyon	=	20	06/02/2006	Summer	FIB
Lachusa Canyon	=	108	06/06/2006	Summer	FIB
Lachusa Canyon	=	10	06/13/2006	Summer	FIB
Lachusa Canyon	=	63	06/20/2006	Summer	FIB

Waterbody	NumQual	Result	SampleDate	Season	Study*
Lachusa Canyon	=	20	06/27/2006	Summer	FIB
Lachusa Canyon	<	10	07/06/2006	Summer	FIB
Lachusa Canyon	=	52	07/12/2006	Summer	FIB
Lachusa Canyon	=	31	07/19/2006	Summer	FIB
Lachusa Canyon	<	10	07/26/2006	Summer	FIB
Lachusa Canyon	=	10	08/02/2006	Summer	FIB
Lachusa Canyon	=	31	08/09/2006	Summer	FIB
Lachusa Canyon	<	10	08/16/2006	Summer	FIB
Lachusa Canyon	=	10	08/23/2006	Summer	FIB
Lachusa Canyon	<	10	08/30/2006	Summer	FIB
Lachusa Canyon	<	10	09/06/2006	Summer	FIB
Lachusa Canyon	=	41	09/13/2006	Summer	FIB
Lachusa Canyon	<	10	09/20/2006	Summer	FIB
Lachusa Canyon	=	161	09/27/2006	Summer	FIB
Lachusa Canyon	<	10	10/04/2006	Summer	FIB
Lachusa Canyon	<	10	10/11/2006	Summer	FIB
Lachusa Canyon	=	10	10/18/2006	Summer	FIB
Lachusa Canyon	<	10	10/25/2006	Summer	FIB
Lachusa Canyon	=	10	11/01/2006	Winter	FIB
Lachusa Canyon	=	10	11/08/2006	Winter	FIB
Lachusa Canyon	=	10	11/15/2006	Winter	FIB
Lachusa Canyon	<	10	11/20/2006	Winter	FIB
Lachusa Canyon	=	10	11/29/2006	Winter	FIB
Lachusa Canyon	=	20	12/06/2006	Winter	FIB
Lachusa Canyon	=	10	12/20/2006	Winter	FIB
Lachusa Canyon	<	10	01/03/2007	Winter	FIB
Lachusa Canyon	<	10	01/10/2007	Winter	FIB
Lachusa Canyon	=	10	01/24/2007	Winter	FIB
Lachusa Canyon	<	10	02/07/2007	Winter	FIB
Lachusa Canyon	=	10	02/14/2007	Winter	FIB
Lachusa Canyon	<	10	02/21/2007	Winter	FIB
Lachusa Canyon	<	10	03/01/2007	Winter	FIB
Lachusa Canyon	=	52	03/07/2007	Winter	FIB
Lachusa Canyon	<	10	03/14/2007	Winter	FIB
Lachusa Canyon	=	20	03/21/2007	Winter	FIB
Lachusa Canyon	=	10	03/28/2007	Winter	FIB
Lachusa Canyon	<	10	04/05/2007	Summer	FIB
Lachusa Canyon	<	10	04/11/2007	Summer	FIB
Lachusa Canyon	=	10	04/18/2007	Summer	FIB
Lachusa Canyon	=	10	04/27/2007	Summer	FIB

Waterbody	NumQual	Result	SampleDate	Season	Study*
Lachusa Canyon	=	63	05/02/2007	Summer	FIB
Lachusa Canyon	=	10	05/09/2007	Summer	FIB
Mill Creek	=	10	6/20/05	Summer	NL
Mill Creek	=	5	9/12/05	Summer	NL
Mill Creek	<	10	05/16/2006	Summer	FIB
Mill Creek	<	10	05/26/2006	Summer	FIB
Mill Creek	<	10	05/30/2006	Summer	FIB
Mill Creek	<	10	06/06/2006	Summer	FIB
Mill Creek	<	10	06/14/2006	Summer	FIB
Mill Creek	<	10	06/21/2006	Summer	FIB
Mill Creek	<	10	06/27/2006	Summer	FIB
Mill Creek	<	10	07/03/2006	Summer	FIB
Mill Creek	=	10	07/12/2006	Summer	FIB
Mill Creek	=	2	07/19/2006	Summer	FIB
Mill Creek	=	3.1	07/25/2006	Summer	FIB
Mill Creek	=	5.1	08/02/2006	Summer	FIB
Mill Creek	=	1	08/08/2006	Summer	FIB
Mill Creek	=	2	08/16/2006	Summer	FIB
Mill Creek	=	2	08/22/2006	Summer	FIB
Mill Creek	=	6.3	08/29/2006	Summer	FIB
Mill Creek	=	20.9	09/05/2006	Summer	FIB
Mill Creek	=	1	09/13/2006	Summer	FIB
Mill Creek	=	3.1	09/19/2006	Summer	FIB
Mill Creek	=	1	09/26/2006	Summer	FIB
Mill Creek	=	1	10/03/2006	Summer	FIB
Mill Creek	=	1	10/10/2006	Summer	FIB
Mill Creek	=	2	10/17/2006	Summer	FIB
Mill Creek	=	3.1	10/24/2006	Summer	FIB
Mill Creek	=	1	10/31/2006	Summer	FIB
Mill Creek	<	1	11/07/2006	Winter	FIB
Mill Creek	<	1	11/15/2006	Winter	FIB
Mill Creek	<	1	11/22/2006	Winter	FIB
Mill Creek	<	1	12/05/2006	Winter	FIB
Mill Creek	=	1	12/12/2006	Winter	FIB
Mill Creek	=	1	12/19/2006	Winter	FIB
Mill Creek	<	1	01/02/2007	Winter	FIB
Mill Creek	<	1	01/11/2007	Winter	FIB
Mill Creek	<	1	01/17/2007	Winter	FIB
Mill Creek	<	1	01/23/2007	Winter	FIB
Mill Creek	=	2	01/30/2007	Winter	FIB

Waterbody	NumQual	Result	SampleDate	Season	Study*
Mill Creek	=	8.5	02/06/2007	Winter	FIB
Mill Creek	=	1	02/13/2007	Winter	FIB
Mill Creek	<	1	02/21/2007	Winter	FIB
Mill Creek	<	1	03/06/2007	Winter	FIB
Mill Creek	<	1	03/13/2007	Winter	FIB
Mill Creek	<	1	03/21/2007	Winter	FIB
Mill Creek	<	1	04/03/2007	Summer	FIB
Mill Creek	<	1	04/10/2007	Summer	FIB
Mill Creek	<	1	04/18/2007	Summer	FIB
Mill Creek	<	1	05/01/2007	Summer	FIB
Mill Creek	<	1	05/08/2007	Summer	FIB
Mill Creek	=	1	05/15/2007	Summer	FIB
Mill Creek	=	1	05/22/2007	Summer	FIB
Mill Creek	<	1	05/29/2007	Summer	FIB
Piru Creek	=	10	6/22/05	Summer	NL
Piru Creek	=	5	9/16/05	Summer	NL
Piru Creek	=	41	6/2/06	Summer	NL
San Juan Creek	=	25	5/23/05	Summer	NL
San Juan Creek	=	52	9/1/05	Summer	NL
San Juan Creek	=	20	05/17/2006	Summer	FIB
San Juan Creek	=	30.5	5/18/06	Summer	NL
San Juan Creek	=	75	05/25/2006	Summer	FIB
San Juan Creek	=	31	05/31/2006	Summer	FIB
San Juan Creek	=	187	06/09/2006	Summer	FIB
San Juan Creek	=	259	06/15/2006	Summer	FIB
San Juan Creek	=	110	06/21/2006	Summer	FIB
San Juan Creek	=	41	06/30/2006	Summer	FIB
San Juan Creek	=	173	07/07/2006	Summer	FIB
San Juan Creek	=	41	07/12/2006	Summer	FIB
Santiago Creek	=	10	6/7/05	Summer	NL
Santiago Creek	=	15	9/2/05	Summer	NL
Santiago Creek	=	10	05/17/2006	Summer	FIB
Santiago Creek	<	10	05/25/2006	Summer	FIB
Santiago Creek	<	10	05/31/2006	Summer	FIB
Santiago Creek	=	10	06/09/2006	Summer	FIB
Santiago Creek	=	134	06/15/2006	Summer	FIB
Santiago Creek	=	10	06/21/2006	Summer	FIB
Santiago Creek	=	20	06/30/2006	Summer	FIB
Santiago Creek	=	41	07/07/2006	Summer	FIB
Santiago Creek	=	31	07/12/2006	Summer	FIB

Waterbody	NumQual	Result	SampleDate	Season	Study*
Santiago Creek	=	121	07/18/2006	Summer	FIB
Sespe Creek	=	10	6/22/05	Summer	NL
Sespe Creek	=	5	9/15/05	Summer	NL
Sespe Creek	=	52	6/2/06	Summer	NL
Seven Oaks Dam	=	10	6/20/05	Summer	NL
Seven Oaks Dam	=	5	9/12/05	Summer	NL
Silverado Creek	=	46.5	5/25/05	Summer	NL
Silverado Creek	=	12.5	9/1/05	Summer	NL
Silverado Creek	=	10	5/17/06	Summer	NL
Solstice Canyon	=	20	05/15/2006	Summer	FIB
Solstice Canyon	=	52	05/26/2006	Summer	FIB
Solstice Canyon	=	41	06/02/2006	Summer	FIB
Solstice Canyon	=	135	06/06/2006	Summer	FIB
Solstice Canyon	=	20	06/13/2006	Summer	FIB
Solstice Canyon	=	131	06/20/2006	Summer	FIB
Solstice Canyon	=	52	06/27/2006	Summer	FIB
Solstice Canyon	<	10	07/06/2006	Summer	FIB
Solstice Canyon	<	10	07/12/2006	Summer	FIB
Solstice Canyon	=	10	07/21/2006	Summer	FIB
Solstice Canyon	=	20	07/26/2006	Summer	FIB
Solstice Canyon	=	20	08/02/2006	Summer	FIB
Solstice Canyon	=	10	08/09/2006	Summer	FIB
Solstice Canyon	=	10	08/16/2006	Summer	FIB
Solstice Canyon	=	20	08/23/2006	Summer	FIB
Solstice Canyon	=	20	08/30/2006	Summer	FIB
Solstice Canyon	=	20	09/06/2006	Summer	FIB
Solstice Canyon	=	200	09/13/2006	Summer	FIB
Solstice Canyon	=	20	09/20/2006	Summer	FIB
Solstice Canyon	<	10	09/27/2006	Summer	FIB
Solstice Canyon	<	10	10/04/2006	Summer	FIB
Solstice Canyon	<	10	10/11/2006	Summer	FIB
Solstice Canyon	=	10	10/18/2006	Summer	FIB
Solstice Canyon	<	10	10/25/2006	Summer	FIB
Solstice Canyon	<	10	11/01/2006	Winter	FIB
Solstice Canyon	<	10	11/08/2006	Winter	FIB
Solstice Canyon	=	10	11/15/2006	Winter	FIB
Solstice Canyon	<	10	11/20/2006	Winter	FIB
Solstice Canyon	<	10	11/29/2006	Winter	FIB
Solstice Canyon	=	160	12/06/2006	Winter	FIB
Solstice Canyon	<	10	12/20/2006	Winter	FIB

Waterbody	NumQual	Result	SampleDate	Season	Study*
Solstice Canyon	<	10	01/03/2007	Winter	FIB
Solstice Canyon	=	20	01/10/2007	Winter	FIB
Solstice Canyon	<	10	01/24/2007	Winter	FIB
Solstice Canyon	<	10	02/07/2007	Winter	FIB
Solstice Canyon	<	10	02/14/2007	Winter	FIB
Solstice Canyon	<	10	02/21/2007	Winter	FIB
Solstice Canyon	<	10	03/01/2007	Winter	FIB
Solstice Canyon	=	41	03/07/2007	Winter	FIB
Solstice Canyon	=	10	03/14/2007	Winter	FIB
Solstice Canyon	=	10	03/21/2007	Winter	FIB
Solstice Canyon	=	20	03/28/2007	Winter	FIB
Solstice Canyon	<	10	04/05/2007	Summer	FIB
Solstice Canyon	<	10	04/11/2007	Summer	FIB
Solstice Canyon	<	10	04/18/2007	Summer	FIB
Solstice Canyon	<	10	04/27/2007	Summer	FIB
Solstice Canyon	=	20	05/02/2007	Summer	FIB
Solstice Canyon	=	20	05/09/2007	Summer	FIB
Tenaja Creek	=	20.5	6/15/05	Summer	NL
Tenaja Creek	=	10	5/18/06	Summer	NL

* NL: Assessment of Water Quality Concentrations and Loads from Natural Landscapes (SCCWRP Technical Report 500)
FIB: Fecal Indicator Bacteria (FIB) Levels During Dry Weather from Southern California Reference Streams (SCCWRP Technical Report 542)

Report:
Comparing Traditional Concrete to Permeable Concrete for a Community College Pavement Application

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Background

It is well documented that storm water runoff has contributed to environmental decline in the form of stream degradation, intermittent flooding, first flush pollution in creeks, lakes and sounds, and loss of fish species[1,2]. The accumulation of pavement has also resulted in urban heat islands which create elevations in air temperature[3], disturb urban weather patterns, and cause summer storm water to upset watersheds with their elevated temperature. The amount of imperviousness has even been quantified in relationship to watershed species decline, with 10% imperviousness – amounting to a density of about 4 people per acre -- being the level at which streams display negative impact[1].

To counteract the decline in our watersheds, a few years ago the EPA began mandating the management of storm water runoff in new construction, issuing the National Pollutant Discharge Elimination System (NPDES) Phase II requirements[4]. These regulations require storm water retention ponds and/or other storm water Best Management Practices (BMPs), making traditional development more expensive than in the past.

Available land is also becoming less plentiful. All of these pressures, combined with government pressure to step up the preservation of watersheds, have led to interest in development practices that are Low Impact[5,6]. Among these is the use of pervious pavement.

Definition of Pervious Pavement

Pervious concrete is concrete that has a low water-cement ratio and contains none or very little sand.[7] It typically has a voids content of 15% to 25%, creating a structure resembling a Rice Krispies® treat and allowing as much as eight gallons of water per square foot to pass through per minute[8]. These drainage properties allow pervious concrete to filter storm water directly into

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[1] Schueler, T. R., (1994). The importance of imperviousness. *Watershed Protection Techniques 1*(3):100-111, pp 100-103.

[2] Booth DB, Hartley D, and Jackson R. (2002, June) Forest cover, impervious surface area, and the mitigation of stormwater impacts. *Journal of the American Water Resources Association 38*(3), p 836.

[3] Golden, JS and Kaloush KE. (2005) A hot night in the big city. Public Works Magazine, December 2005. Retrieved 21 July, 2007 from the Public Works Online Web site: http://www.pwmag.com/industry-news.asp?sectionID=770&articleID=268116&artnum=1, pp 1, 2.

[4] State takes aim at #1 water quality problem – storm water for Western Washington. (2007, January) *U.S. Federal News Service*, 16 January, 2007. Retrieved 21 July, 2007 from Proquest database, para 9.

[5] Portland Green Streets Program (2007, April). Retrieved 5 July, 2007 from the Portland Bureau of Environmental Services Green Streets Web site: http://www.portlandonline.com/bes/index.cfm?c=eeeah&, para 3.

[6] Low Impact Development. (2006, December) Puget Sound Partnership (Formerly Puget Sound Action Team, appointed by Washington State Governor Christine Gregoire). Retrieved 5 July, 2007 from the Puget Sound Partnership Web site: http://www.psp.wa.gov/our_work/stormwater/lid.htm, para 1-2.

[7] Offenberg, M. (2005, March). Producing Pervious Pavements. *Concrete International*. March, 2005, p 50. Retrieved 5 July, 2007 from Proquest database, p 50.

[8] Ready mixed concrete. (n.d.). Retrieved 4 August, 2007 from the National Ready Mixed Concrete Association Web site: http://nrmca.org/aboutconcrete/types.asp, para 4.

the ground, making the material a BMP for managing storm water runoff according to the NPDES Phase II requirements[3]. It holds tremendous potential to scale back the negative impact that pavement has had on the environment, by eliminating storm water runoff, removing pollutants, preventing runoff damage to streams and aquatic animals, allowing watersheds to return to normal, and even by helping capture storm water for water-poor areas. Currently, though, many developers fail to see beyond initial costs of pervious implementations, and adoption has therefore been slow.[9]

David Wu (D-OR), who chairs the Innovation and Technology Subcommittee of the U.S. House of Representatives Science and Technology Committee, recently commented on pervious concrete during a hearing on Green Transportation Infrastructure. He pointed out the tremendous benefits possible from a technology that is currently available and asked why these technologies are not being used more often. In answering his own question, Wu stated that the "biggest impediments are state and federal regulations"[10].

Purpose

While commonly used on the East Coast in hurricane communities and in areas where traffic safety is compromised by standing water[11], pervious pavement has not yet been widely used in the Pacific Northwest. It is relevant to look at how it compares here – in terms of up-front cost and other factors -- with traditional pavement techniques for applications such as sidewalks, driveways, and parking lots. The purpose of the current research project is to perform such a comparison.

Scope of study

For this research project, I am using a combination of article, book, and Internet research, and have interviewed knowledgeable engineers and concrete contractors in the field. I have collected data for traditional concrete and pervious concrete according to the following criteria:

- Cost
- Available skilled contractors, and

[9] Huffman, DJ. (2007, May) Statement before the Committee on Science and Technology, Subcommittee on Technology and Innovation, United States House of Representatives, on green transportation infrastructure. Retrieved 4 August, 2007 from the NRMCA Web site, http://democrats.science.house.gov/ Media/File/Commdocs/hearings/ 2007/tech/10may/huffman_testimony.pdf, p 2.

[10] As cited in News from the House Science and Technology Committee (2007, May). Wu leads look into green transportation infrastructure. Retrieved 4 August, 2007 from the Committee on Science and Technology Web site, http://science.house.gov/press/PRArticle.aspx?NewsID=1819 para 6.

[11] Hun-Dorris, T (2005, March/April). Advances in porous pavement. (An interview with Bruce K. Ferguson, who wrote *Porous Pavements*.) *Stormwater. The Journal for Surface Water Quality Professionals.* Retrieved 10 July, 2007 from the journal's Web site: http://www.erosioncontrol.com/sw_0503_advances.html, para 36.

- Future outcomes, including:
    - Durability
    - Maintenance, and
    - Long-term savings

Purpose of report

In this report I present the data I have obtained by alternative (traditional concrete vs. pervious concrete), with each alternative organized by criteria. I compare the results for each alternative by criteria, and summarize the report with my recommendation for actions to take based on these findings.

Finally, I include a list of experts who contributed significant information for this report, and a list of concrete contractors who are certified (as of June 2007) by the National Ready Mix Concrete Association for installation of pervious concrete.

New Technology is Core to Bellevue's Civic Spirit

Bellevue is a forward-thinking city. Headquarters to 13 of the state's 100 largest public companies and nine of the largest private ones, it fosters some of the fastest-growing employers in the country[12]. It is the fifth largest city in the state, but does not yet have implementations of pervious concrete for storm water management[13].

Bellevue is also a gem in terms of beauty. Bellevue city limits encompass a wealth of natural resources such as wetlands, lowland conifer-hardwood forest, four major stream systems, and the lakes the streams feed into. It has miles of riparian corridors and a rich diversity of plants and animals.[14] In 2005, an independent environmental consultant – using data from 2003 -- reported the impact of human-induced degradation of streams and plant communities due to storm water runoff and development within riparian areas. The report concluded the city should implement specific recommendations for reducing storm water runoff.[15]

As Bellevue enters a phase of unprecedented development, it is appropriate to begin using technologies which preserve the city's unique beauty and at the same time ensure the health of the environment and the people who live and work here.

Bellevue Community College's Unique Opportunity

Bellevue Community College, as the premier learning institution east of Lake Washington, is also in a unique position to showcase new technology. The approaches the school takes to instruction, to leadership, and to community involvement, all set an example that is far reaching. BCC students, faculty, and staff come from all walks of life and include current decision-makers and drivers of policy, as well as individuals who will be our leaders in the coming decades.

With the imminent construction of the new Science building, BCC has an opportunity to be the first in Bellevue to implement pervious concrete in sidewalks, walkways, and parking areas for the new structure. This would be as an example of smart storm water management practices for the rest of the region to evaluate and adopt. With so much current interest in this technology among engineers and policy makers, BCC can gain attention for the school by showcasing its commitment to new technology while at the same time taking steps to protect the environment. What I show with this report is whether resources exist and whether it is feasible for the school to implement a pervious solution right now.

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[12] The 2005 Bellevue economic profile. (2005) Major employers and business patterns. Retrieved 3 August, 2007 from the City of Bellevue Web site: http://www.ci.bellevue.wa.us/economic_profile.htm, p 96.

[13] Watson, R., PE, Head, Low Impact Development Program, City of Bellevue (2007, personal communication).

[14] Bellevue Parks and Community Services Department (2003, September). Bellevue parks and open space system plan. Retrieved 3 August, 2007 from the City of Bellevue Web site, http://bellevuewa.gov/pdf/Parks/2003_Bellevue_WA_Park_Plan.pdf, p 30.

[15] Herrera Environmental Consultants (2005) City of Bellevue: Best available science review: Chapter 5, streams and riparian areas. Retrieved 2 August, 2007 from the City of Bellevue Web site, http://www.ci.bellevue.wa.us/pdf/best_available_science.pdf, pp 20-23.

Traditional pavement

Below I present data for traditional pavement.

Cost

- According to Chris Webb, founder of 2020 Engineering – the engineering firm for the first LEED™ Gold project in Washington State, basic installation costs for traditional concrete are $3 - $4 per square foot. He comments that conventional solid asphalt is $2 - $ 3 per square foot. [16]

  Both paving materials require catch basins, storm pipes, detention and treatment to meet EPA regulations, which increases the overall cost. Mr.Webb cannot predict the additional cost without first examining the site.[16] My best guess, after reviewing the literature, is a factor of between 10% and 20% over the total cost of conventional concrete pavements.[17]

- The Puget Sound Partnership listed the following projects as costing $6 – $9 per square foot[18]. Andrew Marks, Managing Director of the Puget Sound Concrete Specifications Council, remarks as follows: *"these projects are small and thus have typically higher unit costs. Recent bids have been in the $4 -$6 per square foot range. Increase in project size typically results in lower unit costs. Specific project requirements and non-typical specifications tend to drive prices higher*."[19]

  - Four blocks of sidewalks on N. 145th Street, Seattle
  - 400 feet of sidewalks at 100th Ave., Marysville
  - Six parking lots at Fort Lewis
  - Sidewalk on North Street in Olympia
  - Plaza at Greenwood Park, Seattle
  - Alley in Bellingham
  - Parking lot for Washington Aggregates & Concrete Assoc. office, Des Moines
  - Nine parking spaces at Bayview Corner, Whidbey Island

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[16] Webb, C, PE., LEED-AP, Chris Webb and Associates, Inc., P.S. Bellingham, WA 98227-1721 (2007, personal communication)

[17] Huffman, D. (2005). Understanding pervious concrete. *The Concrete Specifier* (2005, December) Retrieved 27 July, 2007 from the Northwest Cement Producers Group Sustainable Streets Kit Web site, Section Four, http://www.northwestcement.org/pdf/csimagazineperviousarticle.pdf, p 44.

[18] As cited in Natural approaches to storm water management – permeable pavement. (n.d.) Puget Sound Action Team Publications. Retrieved 5 July, 2007 from the Puget Sound Action Team Online Web site: http://www.psat.wa.gov/Publications/LID_studies/permeable_pavement.htm, para 1-5.

[19] Marks, A., PE. Managing Director, Puget Sound Concrete Specifications Council (2007, personal communication)

- For an independent contractor bid, the cost to install traditional concrete is $4.87 per square foot[20,21].

  This does not include catch basins, piping, or other techniques needed to meet EPA Phase II regulations.

- Recent bid histories from the City of Sammamish listed bids for traditional concrete for three different street projects[22]. These bids ranged from $4.22 per square foot to $6.43 per square foot.

- The City of Olympia performed a cost analysis of traditional and pervious concrete sidewalks. This study evaluated cost of installation, as well as cost of storm water retention and long-term maintenance. The cost of traditional concrete for sidewalks is estimated at $11.24 per square foot. This cost includes an estimate for installing a storm water retention pond system needed to meet the requirements of the *2005 City of Olympia Stormwater Manual* to manage runoff from the sidewalks, which was $3,262,870. This brought the total cost of installation for traditional concrete to $5,003,000. [23]

Available skilled contractors

I have not been able to obtain an exact number of all the concrete contractors in Washington State. One issue is that many general contractors self-perform their own work, and another is that many concrete contractors do other things than the specialty for which they are listed[24]. However, it appears possible the number is a substantial one.

The Yellow Pages listed 49 pages of concrete contractors in Washington State, for a total of 486 listings[25].

The American Concrete Institute (ACI), which provides a standard certification program for the concrete industry, lists 27 individuals in Washington State who hold the ACI Concrete Flatwork Finisher & Technician certification and 43 who hold the ACI Concrete

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[20] Wyles, S. Owner: Blue Chip Construction (2007, personal communication).
[21] Jacobsen, J. Rinker Materials (2007, personal communication).
[22] Brauns, J, PE. City of Sammamish (2007, personal communication).
[23] McFadden, M. (2005). Traditional vs. pervious concrete sidewalks construction and maintenance cost. Analysis Summary Memorandum. Retrieved 20 July, 2007 from the City of Olympia's Science and Innovations – Porous Pavement Web site: http://www.olympiawa.gov/NR/rdonlyres/B32AC0F1-A7A7-4C70-88B1-167E329C6687/0/TraditionalvsPerviousConcreteSidewalksMemo.pdf, p1.
[24] Marks, A., PE. (2007, personal communication).
[25] Dex (2007) *Official Directory – Quest. Greater Eastside*. 2006 Dex Media, Inc., pp 192-194.

Flatwork Technician certification. A few individuals hold both certifications, so it is likely that the total number of people certified by ACI for flatwork is around 65[26].

Future outcomes

Future outcomes include a number of long-term issues, three of which are measured in the following summaries.

Durability

According to the American Concrete Pavement Association, concrete has an average life span of 30 years, adding 10% to its original strength over the life of the pavement.[27]

Durability, defined by the Portland Cement Association, is the "ability of concrete to resist weathering action, chemical attack, and abrasion while maintaining its desired engineering properties."[28] Concrete is well known to be a very durable paving, and there are several types of durable concrete, each chosen as demanded by different conditions. Loss of durability has generally been ascribed to placement of pavements in locations where materials related stress is caused by the particular environment, regardless of the pavement's original durability. [29]

Roadways constructed within the last 20 years are composed of high performance grade concrete, taking environmental conditions into account (a program called Superpave) and are designed to last 75 to 100 years[30]. However, even concrete roads constructed as far back as the 1950s are still in service with little or no maintenance.[31]

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[26] ACI Certified Personnel Directory (n.d.). American Concrete Institute. Retrieved 4 August, 2007 from the ACI Web site, http://www.concrete.org/certification/cert_search.asp, para 1.

[27] Why is concrete such a great pavement choice? (n.d.) From the American Concrete Pavement Association's Why Concrete Pavement section. Retrieved 29 July, 2007 from the American Concrete Pavement Association Web site: http://www.pavement.com/Concrete_Pavement/About_Concrete/Why_Concrete_Pavement/index.asp, para 2.

[28] Durability (n.d.) Retrieved 29 July, 2007 from the Portland Cement Association Concrete Technology Web site: http://www.cement.org/tech/cct_durability.asp, para 1.

[29] Transport properties and durability of concrete: literature review and research plan. (2002) *Federal Highway Administration's Office of Research, Development, and Technology*. National Technical Information Service. Retrieved 29 July, 2007 from EBSCO Host database, para 1.

[30] From interstates to city streets. (1999, April) *Roads and Bridges 37*(4), pp 34-37. Retrieved 29 July, 2007 from EBSCO Host database., para 21.

[31] Kuennen, T. (1997, March) America rethinks the 20 year highway design. *Construction Equipment 95*(3): p 28. Retrieved 29 July, 2007 from Proquest database, para 10.

Maintenance

Traditional concrete requires very little maintenance, if any. The American Concrete Pavement Association (ACPA) states that concrete pavements are the best long-term value, "because of their longer life expectancies and minimal maintenance requirements".[27]

State highway agencies monitor the service lives of highways, with many highways lasting 25 to 40 years before resurfacing. Robert Packard, Director of Engineering and Design for the ACPA, in a summary of pavement costs and quality, points out that concrete is often selected for higher-traffic routes (as opposed to asphalt), and the pavements frequently outlast their estimated life without maintenance[32].

In its evaluation of seven sidewalks, the city of Olympia calculated there would be long-term costs for maintaining traditional concrete, from the standpoint of maintaining the storm water retention pond required to meet the city's storm water regulations. These maintenance costs were estimated at $155, 610.[33]

Long-term savings

For traditional concrete, long term savings are usually measured compared to asphalt, which is often implemented due to a lower initial cost. The studies cited above point out that total pavement costs are less impacted by the initial cost, and more by the length of service life and maintenance required.

Maintenance costs vary depending on transportation jurisdiction and funds available, and vary from several hundred to several thousand dollars per mile annually. In California, for example, during the years studied, virtually no maintenance was performed on streets, resulting in a savings over asphalt of more than 8 to 1.[32] Data from the Oklahoma Department of Transportation (DOT) shows that on U.S. 77, concrete was more than $100,000 more expensive to install than asphalt. However, maintenance costs for the 24 year period monitored after installation came to a total of only $9545, whereas an equal stretch of roadway surfaced in asphalt required $128,000 to maintain over the same period. In another survey of highway agencies, concrete was initially more expensive to install than asphalt, but proved to be $1,000 cheaper per mile per year to maintain over the long term.[34]

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[32] Packard, RG. (1994) Pavement costs and quality. *Concrete International* (1994, August). Retrieved 29 July, 2007 from the ACPA Sustainable Streets Web site at http://northwestcement.org/pdf/pcq3.pdf, p 1
[33] McFadden, M. (2005), p 1.
[34] Packard, RG. (1994), p 2

Pervious concrete

Below I present data for pervious pavement.

Cost:

- ♦ According to Chris Webb, the basic installation cost for pervious concrete is $4 - $5 per square foot.[35]

- ♦ The Puget Sound Partnership listed the following projects as costing $6 – $9 per square foot[18.] Again, notes Andrew Marks, "*these projects are small and thus have typically higher unit costs. Recent bids have been in the $4 -$6 per square foot range. Increase in project size typically results in lower unit costs. Specific project requirements and non-typical specifications tend to drive prices higher*."[36]

    - Four blocks of sidewalks on N. 145th Street, Seattle
    - 400 feet of sidewalks at 100th Ave., Marysville
    - Six parking lots at Fort Lewis
    - Sidewalk on North Street in Olympia
    - Plaza at Greenwood Park, Seattle
    - Alley in Bellingham
    - Parking lot for Washington Aggregates & Concrete Assoc. office, Des Moines
    - Nine parking spaces at Bayview Corner, Whidbey Island

- ♦ For an independent contractor bid, the cost to install pervious concrete is $6.26 per square foot[37,38].

- ♦ Recent bid histories for different sidewalks within the City of Sammamish listed bids for pervious concrete at $5.25 per square foot[39].

- ♦ The City of Olympia performed a cost analysis of traditional and pervious concrete sidewalks. This study evaluated cost of installation, as well as cost of long-term maintenance over a ten-year period. Cost of pervious concrete for sidewalks is estimated at $6.02 per square foot, for a total cost of $2,615,000. [40]

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[35] Webb, C, PE., LEED-AP, (2007, personal communication)
[36] Marks, A., PE. (2007, personal communication)
[37] Wyles, S. (2007, personal communication).
[38] Jacobsen, J. (2007, personal communication).
[39] Brauns, J.,PE, (2007, personal communication).
[40] McFadden, M. (2005), p 1.

- At the Evergreen State College, pervious parking retrofits that were added as part of the school's emphasis on zero discharge were described as costing "the same as, or lower than, traditional alternatives using new treatment and detention systems." [41,42]

Available skilled contractors

Bruce Chattin, Executive Director of the Washington Aggregates and Concrete Association, provided me with a list of 55 concrete contractors in Washington State currently identified as Pervious Certified Technicians by the National Ready Mix Concrete Association[43].

The Technician title is awarded upon completion of a written exam. A Pervious Craftsman title is awarded to Technicians who also document 1500 hours of work experience and pass a performance exam. Applicants must already hold certification from the American Concrete Institute (ACI) in the Craftsman program (Flatwork Finisher).[44]

Future outcomes

Durability

According to the National Ready Mix Concrete Association, pervious concrete could provide 20 to 40 years of service with minimal maintenance[45], although it is best suited for lower traffic areas such as sidewalks, parking lots, curb-side parking strips on city streets, and driveways.

There is some anecdotal evidence that pervious concrete, when placed in streets with truck traffic, experiences raveling[46]. However, other sources comment that knowledge of the proper cement mixture (especially water content and proper

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[41] As cited in Natural approaches to storm water management – permeable pavement: Pervious Paving Parking Lots Modification Project, The Evergreen State College. (n.d.) Retrieved 5 July, 2007 from the Puget Sound Action Team Online Web site: http://www.psat.wa.gov/Publications/LID_studies/ permeable_pavement.htm, para 1.

[42] Hooseim, A, PE, PMP, Assistant Director of Facilities Services for Planning and Construction, Evergreen State College (2007, personal communication)

[43] As cited in the NRMCA Pervious Concrete Database (June 12, 2007). Retrieved 31 July, 2007 from the National Ready Mix Concrete Association Web site: http://www.nrmca.org/certifications/pervious/ certified%20personnel%20061107.pdf, p 80

[44] Developments. (2007). *Concrete Products 108*(8), p 8. Retrieved 11 July, 2007 from Proquest database, para 4.

[45] Inspection and maintenance. (n.d.) Retrieved 21 July, 2007 from the pervious concrete section of the National Ready Mix Concrete Association Web site: http://www.perviouspavement.org/ inspection%20and%20maintenance.htm, para 4.

[46] Wyles, S. (2007, personal communication).

curing) is key to preparing a durable surface, and that durability is not an issue.[47,48]

It bears mentioning here that pervious concrete has been extensively studied with respect to freeze-thaw cycles.[46,49] There is even evidence to show that pervious concrete makes for a safer roadway in winter, as the open cells of the material encourage snowmelt and draw moisture away from the surface to prevent accumulations of ice.[50]

Maintenance

According to the National Ready Mix Concrete Association, most pervious concrete pavements need little to no surface maintenance. A key is proper site design so that surrounding landscapes do not erode and drain into the pavement surface[51].

Cleaning of the pervious pavement is usually required annually or more often; this is commonly accomplished by vacuuming. Power blowing and pressure washing are other alternatives for periodic cleaning. The NRMCA notes that maintenance practices for pervious pavements are still being developed.[51]

In its planning budgets, the City of Olympia estimated its pervious sidewalks require sweeping every 6 months and pressure washing every 5 years. This maintenance cost was estimated at $147,000.[52]

The EPA estimated the cost of maintenance, in the form of vacuuming and pressure washing, was approximately $200 per acre per year. [53]

Long-term savings

According to the Center for Watershed Protection, installing traditional storm drain inlets, piping, and retention basins for storm water management can cost two to three times more than low-impact strategies such as pervious concrete for

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[47] Hun-Dorris, T (2005, March/April), para 16.
[48] Offenberg, M. (2005, March), p 52.
[49] Brown, HJ (2006). Pervious concrete research compilation: past, present and future. Publication of the RMC Research Foundation with the Concrete Industry Management Program, Middle Tennessee State University. Retrieved 5 July, 2007 from Proquest database, p 4.
[50] Huffman, DJ. (2007), p 5.
[51] Inspection and maintenance. (n.d.) From the pervious concrete section of the National Ready Mix Concrete Association Web site: http://www.perviouspavement.org/ inspection%20and%20maintenance.htm, para 4.
[52] McFadden, M. (2005), p 1.
[53] EPA Storm water technology fact sheet – porous pavement. (1999). Retrieved 20 July, 2007 from the EPA Publications Database, http://www.epa.gov/npdes/pubs/porouspa.pdf, p 5.

handling runoff. Projects that use pervious concrete typically don't need sewer tie-ins, eliminating the cost of installing underground piping and storm drains[54].

In the Stratford Place development, Washington's first development using pervious pavement for all hardscape (sidewalks, roads, and driveways), the installation of pervious concrete saved a total of $260,000 over conventional storm water management systems and recaptured two lots which ordinarily would have been devoted to such systems[55,56]. This amount of savings does not include projected net revenue that will be gained from development of the additional two lots.[57]

In another situation cited in the literature, one 12 acre development project that included an 8 acre parking lot was able to eliminate a 1.5 acre retention pond and drainage system using pervious concrete. The overall savings in this example were $400,000.[58]

As calculated by the City of Olympia, while there were costs in maintaining pervious concrete, there were savings as well. These were calculated to be $9,000.[59]

Long term savings can also be considered from the standpoint of effectiveness of storm water management systems; if systems are not effective at treating storm water runoff, money has been ill-spent. In a landmark evaluation of current storm water management techniques, storm water retention ponds were shown to be damaging in their ineffectiveness. For example, several watershed sites in King County downstream of the detention centers displayed hydrologic and empirical evidence of storm water impact.[60] The same authors constructed large pervious pavement facilities to measure attributes of storm water runoff. They determined that pervious pavements were extremely effective at managing storm water and filtering impurities. Chemical analyses showed that petroleum hydrocarbons from vehicle fuel and lubricants appeared to be removed completely by infiltration; other chemicals and heavy metals all showed subdetectable or relatively low levels.

[54] As cited in "Pervious concrete is economical." (2006, June) *Michigan Contractor and Builder 100*(24): p 16. Retrieved 21 July, 2007 from Proquest database, para 11.
[55] Morrison, CL (2006, August). Pervious concrete, the smart storm water solution. *Environmental Design & Construction 9*(7), pp13 – 14. Retrieved 5 July, 2007, from EBSCO Host database, p 14.
[56] O'dahl, CA. (2006, June) Pioneering pervious pavement at Stratford Place. Task force assists City of Sultan and developer, Craig Morrison of CMI, Inc. *Elements: Sustainable Snohomish County II* (5). Retrieved 5 July, 2007 from the Pervious Concrete, Inc. Web site: http://www.perviouscrete.com/en/articles/pioneering_pervious_pavement/, para 9.
[57] Huffman, DJ (2007), p 4.
[58] Huffman, D. (2005), p 44.
[59] McFadden, M. (2005) p 1.
[60] Booth, DB. and Leavitt, J. (1999) Field evaluation of permeable pavement systems for improved stormwater management. Journal of the American Planning Association *65*(3): 314-326. Retrieved 4 August, 2007, from EBSCO Host database, para 6.

Cost

Below I show cost in tabular form, using estimates obtained for traditional and pervious concrete, along with a chart summarizing this data.

Table 1. Cost for Installing Traditional Concrete (per square foot)

Chris Webb[16]	Puget Sound Partnership[18]	Independent Contractor [20,21]	City of Sammamish[22]	City of Olympia[23]
$3 - $4*	$6 - $9	$4.87*	$4.22 - $6.43	$11.24

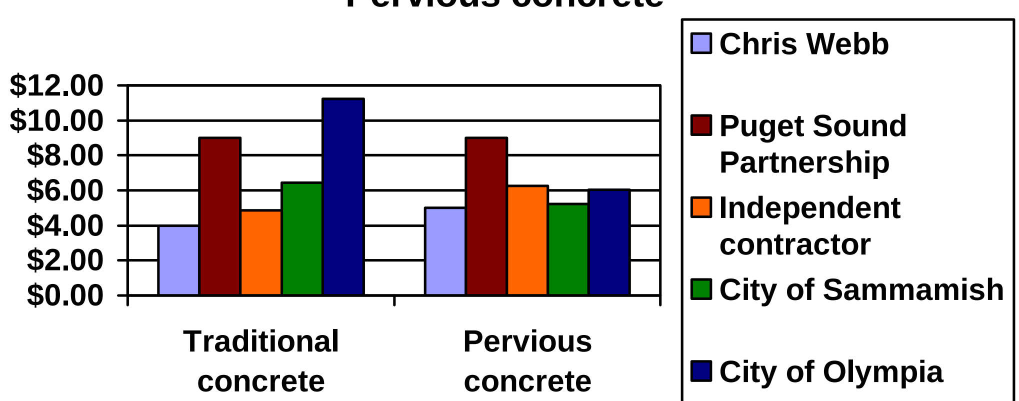
*** - Bid does not include storm water management system**
Range for Traditional concrete: $3 to $11.24 per square foot.

Table 2. Cost for Installing Pervious Concrete (per square foot)

Chris Webb[35]	Puget Sound Partnership[36]	Independent Contractor [37,38]	City of Sammamish[39]	City of Olympia[40]
$4 - $5	$6 - $9	$6.26	$5.25	$6.02

Range for Pervious concrete: $4 to $9 per square foot.

Fig. 1. Cost per square foot for Traditional and Pervious concrete



Comparing the cost of traditional concrete to pervious concrete, one thing is evident:

Traditional concrete is not clearly cheaper in terms of cost. Quotes that were listed as lower for traditional concrete did not include the cost of storm water management, so the lower cost is a little misleading. Bids that factored in the cost of storm water management (Sammamish, Olympia, and Puget Sound Partnership) showed the same or lower cost for pervious concrete.

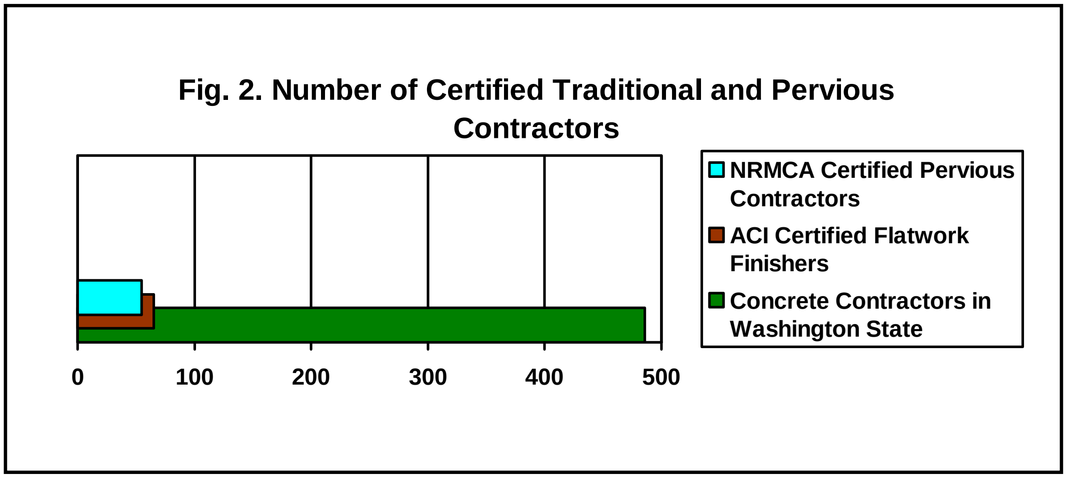
Available skilled contractors

Below is an estimate of the number of contractors available for traditional or pervious concrete installation, using ACI certification as a barometer for traditional concrete, and NRMCA certification as a barometer for pervious concrete. The estimate for total contractors comes from the Yellow Pages and is not an indication of certification.

Table 3. Number of Concrete Contractors in Washington State

Total Concrete Contractors[25]	**Certified Flatwork Finishers[26]**	**Certified Pervious Contractors[43]**
486	65	55

Figure 2 summarizes this data graphically:



While the number of certified pervious concrete contractors is a fraction of the total number of concrete contractors in the state, ***the number is very close to the number of concrete contractors certified to lay traditional concrete***. While neither certification is required for working in the industry, they do demonstrate breadth of knowledge of the material. That the numbers are similar means there should be no bigger barrier finding a contractor to work with pervious than finding a contractor to work with traditional concrete.

Commenting on the number of contractors certified for pervious concrete, Andrew Marks, of the Concrete Specifications Council, states the following:

"*The technology is mainstream enough that there is a certification program for contractors. Even though the technology is recent in the Northwest, since about 2000, there are a number of large -- and many small -- projects completed and being completed daily. There are a number of contractors who have become certified* ***and others who have not yet become certified, but who have built successful projects****.*

The installation of pervious concrete is not difficult – in fact, it is much easier to construct than conventional concrete. There are a few critical steps that must be performed correctly, but it is easy to do so, and can be performed by any competent contractor, with a little instruction or training."[61]

[61] Marks, A., PE (2007, personal communication)

Durability and Maintenance

Below is a table summarizing statements about durability and maintenance of traditional and pervious concrete.

Table 4. Durability and Maintenance for Traditional Concrete	
Durability	**30 years**[27]
Maintenance	• **Little to none for pavement alone**[27] • **Pressure washing every 5 years**[33]
Maintenance of Storm water system	• **Varies with type of storm water system**[16] • **$155,610 (Olympia**[33]**)**

Table 5. Durability and Maintenance for Pervious Concrete	
Durability	**30 years possible**[45]
Maintenance	• **Biannual vacuuming**[51] • **Pressure washing every 5 years**[52] • **$200 per acre/year**[53] • **$147,000 (Olympia**[52]**)**

Traditional concrete does not show a clear advantage in terms of durability and maintenance. Pervious concrete is just as durable, and -- while it requires vacuuming and/or sweeping in areas where there can be build-up of soils upon the surface – has none of the hidden maintenance costs that accompany traditional pavement. Traditional pavement requires storm water management systems which require maintenance, the cost of which depends upon the type of system installed.

Long term savings

Below is a table summarizing statements about long term savings for traditional and pervious concrete.

Table 6. Examples of Long Term Savings for Traditional and Pervious Concrete

Highway: $118,455 savings over asphalt[34]	**Residential: $260,000 savings over traditional concrete (excluding development revenue)[55,56]**
Highway: $1,000 per mile per year cheaper than asphalt overlay[34]	**Residential: $400,000 savings over traditional concrete[58]**
	Sidewalk: $9,000 savings over traditional concrete[59]

As with durability and maintenance, ***traditional concrete does not show a clear advantage in terms of long term savings.*** There are significant costs associated with installing and maintaining storm water systems aside from the traditional concrete installation itself. In many cases, when a site has been well evaluated and care has been taken to design the concrete installation around the site requirements, a pervious concrete installation has a very sound advantage.

When traditional concrete is compared to pervious concrete across criteria of cost, availability of contractors, and future outcomes such as durability, maintenance, and long term savings, pervious concrete is clearly equal to traditional concrete where it is appropriate to be used. In many situations, it comes out ahead.

In addition, when other factors such as long-term impact on the environment are considered, pervious concrete proves superior. The infiltration properties of the material -- the ability to remove pollutants from storm water – show far greater effectiveness than some of the most popular storm water management systems. This demonstrates that a paving system which is nearly equal in cost to traditional concrete actually pays for itself over the long term, with a more effective storm water infiltration system than commonly used traditional storm water systems. It is therefore possible to employ an environmentally sound pavement solution while saving money.

Based on the data and interviews I have obtained in this project, I recommend that Bellevue Community College talk with a pervious expert about implementing pervious concrete in sidewalk, entryway, and parking areas of the new Science building. The Science building will have a long life and it is worth implementing a solution that will have the lowest possible impact on the environment.

Pervious concrete has other important long-term effects. They include the following[62]:

- Pervious concrete reduces urban heat island effects – thus lessening a number of the problems associated with elevated air and surface temperatures.

- Pervious concrete allows air and moisture to reach tree roots, promoting natural growth. Trees can be placed close to the edge of the concrete to reproduce a more natural environment and in return, the pavement can be kept even cooler in the summer due to shading.

- Pervious pavement is less noisy than traditional pavement, due to the open nature of the aggregate.

- Pervious pavement is safer for walkways and driveways in the winter time, as the open aggregate encourages snow to melt faster, providing better traction.

Knowing it is possible to implement an environmentally sound pavement solution without a significant increase in cost, and given both the timing of the Science building and BCC's history of being environmentally sensitive, it makes sense to investigate pervious concrete for the current building project.

Interest in pervious concrete in Washington State is new enough that its implementation would be likely to garner significant visibility for the school.

In the process of writing this report, I spoke to many local experts and found them to be easily accessible, responsive, and thoroughly knowledgeable about designing concrete solutions. Any of these experts would be able to work with the school's current construction contractor to provide expertise on fitting pervious concrete to the site as it is planned for traditional concrete. Since ground has just been cleared and existing pavement broken, it is an optimal time to evaluate the site without incurring any additional costs.

The Appendix provides contact information for the core group of individuals who provided data for this project, and the list of contractors certified by the NRMCA as pervious technicians.

[62] Huffman, DJ. (2007) pp 5-7.

Below is a glossary of terms that appear in this document:

BMP: Best Management Practice. Mitigation practice (i.e. retention pond, bio-swale, etc.) that meets U.S. Environmental Protection Agency National Pollution Discharge Elimination System Phase II regulations.[63] The NPDES Phase II regulations are the bare minimum that a facility must comply with; state and local regulations are often more stringent. At minimum, sites of one acre or more must have a Storm Water Pollution Prevention Plan identifying pollution mitigation as well as practices to reduce volume and discharge rates, and improve quality.

First flush: Delivery of a highly concentrated pollutant loading during the early stages (first 38 mm or 1.5 inches) of a rain event due to the washing effect of runoff on pollutants that have accumulated on the land.[64]

LID: Low Impact Development. A development technique designed to mimic the natural flow of water on the land, where water is taken up primarily by the ground, tree leaves and roots, leaving less than 1% as runoff.[65]

Pervious concrete: Concrete material that permits water to enter the ground by virtue of its porous nature or by large spaces in the material.[66]

Riparian areas: Stream banks and edge areas of natural waterways such as creeks and ponds. Such areas form the transition from aquatic life to terrestrial life.[67]

Urban heat island effect: A concentrated, local increase in air and surface temperature caused by the use of dark pavement materials, such as black-top asphalt and other pavements in place of natural landscape. Change in temperatures can cause other long-term effects.[68]

[63] Problems associated with stormwater (n.d.) U.S. Environmental Protection Agency, National Pollutant Discharge Elimination System (NPDES). Retrieved 8 August, 2007 from the U.S. EPA Web site, http://cfpub.epa.gov/npdes/stormwater/menuofbmps/bmp_background.cfm, para 1-7.

[64] Huffman, D. (2005), p 49.

[65] Low Impact Development (2006, December) para 1-3.

[66] Offenburg, M. (2005, March) p. 50.

[67] Glossary (n.d.) National Oceanic and Atmospheric Administration Calcasieu Estuary Watershed. Retrieved 8 August, 2007 from the NOAA Web site, http://mapping.orr.noaa.gov/website/portal/calcasieu/calc_html/resources/glossary.html#r, para 136.

[68] Pool, V. (2005) Concrete Results. *Retail traffic. Atlanta. 2005, November, 34*(11) pp 74-75. Retrieved 18 July, 2007 from Proquest database, pp. 74-75.

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List of Certified Pervious Contractors[69]

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FINAL

2010 URBAN WATER MANAGEMENT PLAN UPDATE

June 2011

Prepared for:
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Santa Paula, CA 93060

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SECTION 1: INTRODUCTION

1.1 Objectives

United Water Conservation District (United or District), among its many activities, operates the Oxnard-Hueneme System (OH System), which supplies drinking water to cities and urban areas on the Oxnard Plain. Figure 1-1 provides a Vicinity Map for the District, while Figure 1-2 displays the District's Service Area. The OH water supply is an important part of the infrastructure of those cities. A safe and reliable water supply is necessary to protect the health of residents and to maintain a healthy local economy. This Urban Water Management Plan (UWMP or Plan) provides planning information on the reliability and future availability of the OH water supply.

The District's UWMP was prepared in compliance with California Water Code. This 2010 UWMP Update is a public statement of the goals, objectives, and strategies needed to maintain a reliable water supply for the District's urban customers. It is important to understand that this UWMP should be viewed as a long-term, general planning document, rather than as policy for supply and demand management.

Primary objectives of this UWMP include the following:

- Summarize anticipated water demands over a 20-year period
- Identify and quantify water resources for existing and future demands, in normal, dry, and multiple dry years, over a 20-year period
- Clarify District strategy and action plans for advance preparation and crisis management in the event of a catastrophic interruption of water supplies
- Summarize water conservation and efficient use program
- Retail suppliers must summarize the baseline daily per capita water use, urban water use target, interim water use target, and compliance daily per capita water use. Wholesale suppliers will provide an assessment of their present and proposed future measures, programs, and policies to achieve water use reduction. United is an urban wholesale water supplier.

1.2 Authorization

The District authorized Milner-Villa Consulting (MVC) to provide consulting services related to preparation of this UWMP via contract dated 10 February 2011.

1.3 Scope of Document

This Urban Water Management Plan is limited primarily to the District's Oxnard-Hueneme drinking water system. Other facilities are evaluated herein only to the extent that they may affect the OH water supply.

This UWMP 2010 Update is divided into five primary sections. Section 2 describes the District's water service area. Section 3 defines the District's water demands. Section 4 defines the District's water supplies. Section 5 defines the District's water supply reliability and water shortage contingency planning. Section 6 describes water demand management (i.e., water conservation) activities. Global climate change impacts are summarized in Section 7. References are provided following Section 7, and definitions for selected abbreviations and terminology are included in Appendix A.

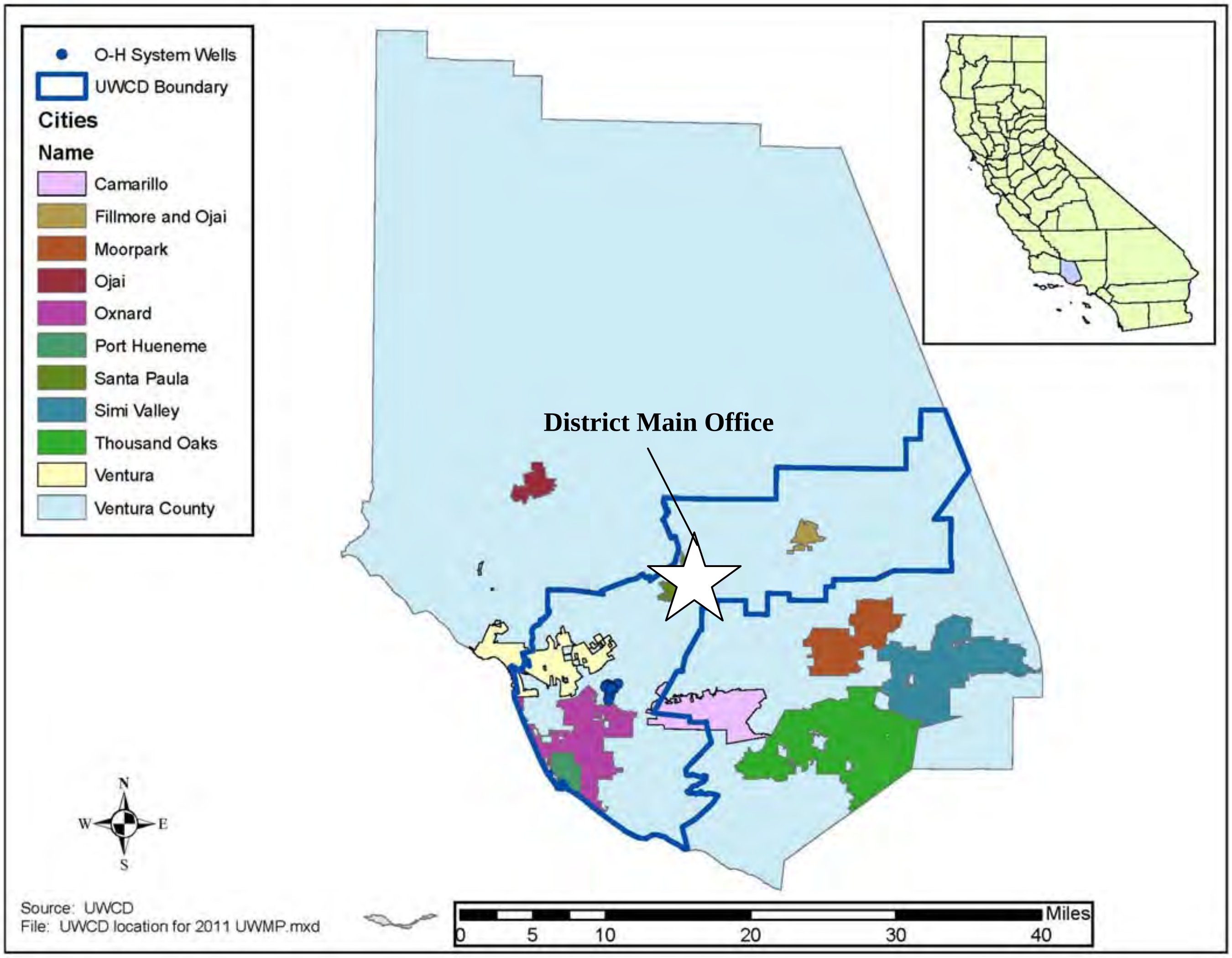
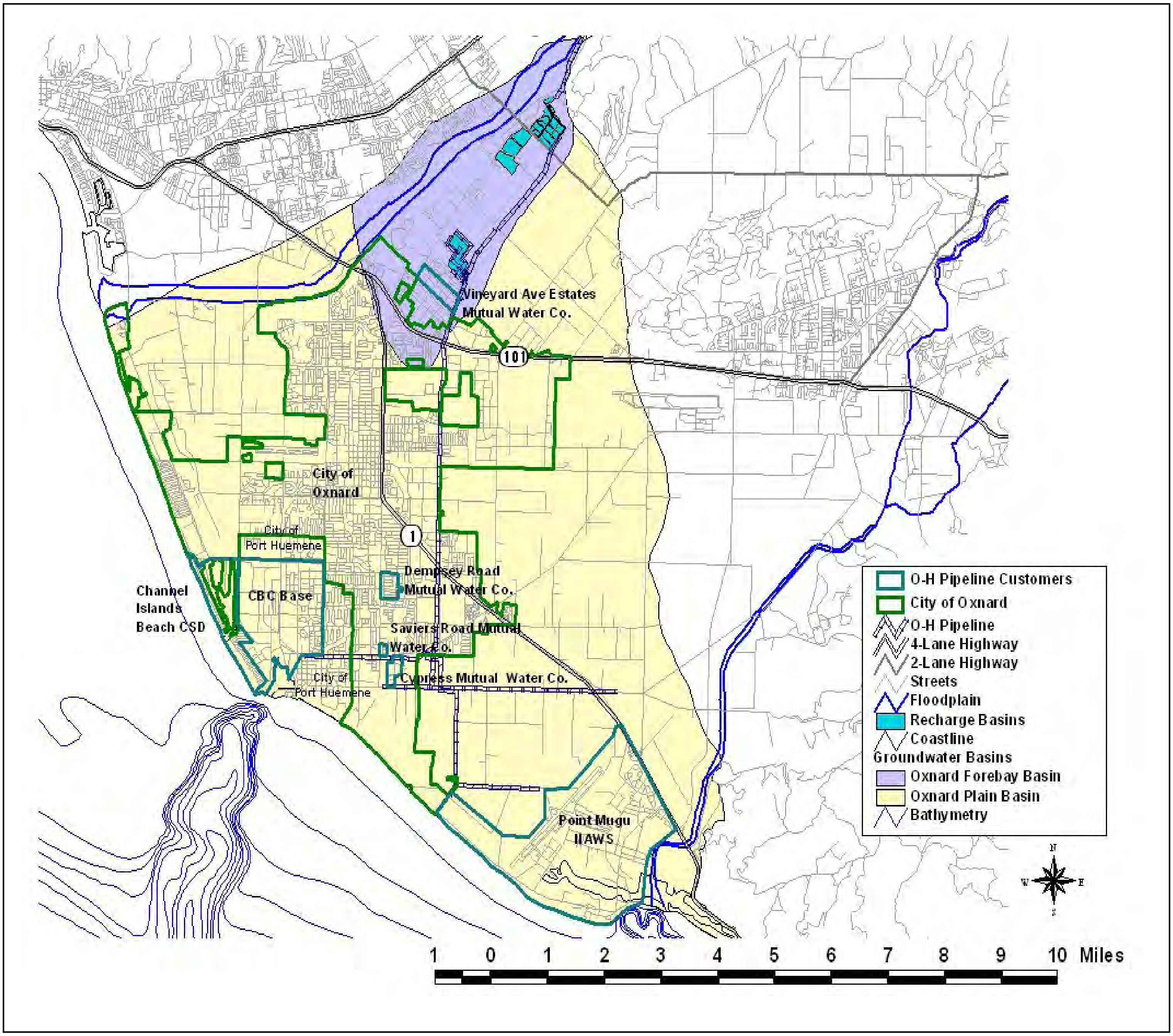


Figure 1-1
Vicinity Map
United Water Conservation District
April 2011



Source: UWCD

Figure 1-2
District Service Area
United Water Conservation District
April 2011

1.4 UWMP Requirements

To prepare its UWMP Update, the District was required to conduct the following:

- Coordinate the preparation of its plan with other appropriate agencies in the area, including other water suppliers that share a common source, water management agencies, and relevant public agencies, to the extent practicable. (California Water Code, Section 10620(d)(2))
- Notify, at least 60 days prior to the public hearing on the plan (as required by CWC, Section 10642), any city or county within which the supplier provides water, that the urban water supplier will be reviewing the plan and considering amendments or changes to the plan. Any city or county receiving such notice may be consulted and provide comments. (CWC, 10621(b))
- Provide supporting documentation that the UWMP and any amendments or changes have been adopted as described in Section 10640 et seq. (CWC, 10621(c))
- Provide supporting documentation that the urban water management plan has been or will be provided to any city or county within which it provides water, no later than 60 days after the submission of this urban water management plan. (CWC, 10635(b))
- Provide supporting documentation that the water supplier has encouraged active involvement of diverse social, cultural, and economic elements of the population within the service area, prior to, and, during the preparation of the plan. (CWC, 10642)
- Provide supporting documentation that the urban water supplier made the plan available for public inspection and held a public hearing regarding the plan. For public agencies, the hearing notice is to be provided pursuant to Section 6066 of the Government Code. The water supplier is to provide the time and place of the hearing to any city or county within which the supplier provides water. Privately owned water suppliers shall provide an equivalent notice within their service areas. (CWC, 10642)
- Provide supporting documentation that the plan has been adopted as prepared or modified. (CWC, 10642)
- Provide supporting documentation as to how the water supplier plans to implement its plan. (CWC, 10643)
- Provide supporting documentation that, in addition to submittal to DWR, the urban water supplier has submitted this UWMP to the California State Library and to any city or county within which the supplier provides water no later than 30 days after adoption. This also includes amendments or changes. (CWC, 10644(a))
- Provide supporting documentation that, not later than 30 days after filing a copy of its plan with the department, the urban water supplier has or will make the plan available for public review during normal business hours. (CWC, 10645).

1.5 History of Urban Water Management Planning Act

The Urban Water Management Planning Act (Water Code 10610 *et al*.) requires urban water suppliers to evaluate their current and projected water sources/supplies, water uses, supply reliability, comparison of supply and demand, water demand management (conservation) programs, wastewater recycling and drought contingency planning. United Water is required to prepare an UWMP because it supplies more than 3,000 acre-feet of water annually and treats water on behalf of one or more public water systems for the purpose of rendering it safe for human consumption.

In 1983, the California Legislature enacted the Urban Water Management Planning Act (AB 797; Water Code, Division 6, Part 2.6, Section 10610-10656). This Urban Water Management Planning Act (UWMP Act) requires water suppliers serving more than 3,000 customers or water suppliers providing more than 3,000 AF of water annually to prepare an UWMP to promote water demand management and efficient water use. Currently, the District serves more than 3,000 customers and provides more than 3,000 AF of water per year. The UWMP Act also required water suppliers to develop, adopt, and file an UWMP (or update) every five years until 1990. In 1990, the Legislature deleted this sunset provision (AB 2661). Accordingly, the UWMP must be updated a minimum of once every five (5) years on or before December 31 in the years ending in 0 and 5. A copy of the current Urban Water Management Planning Act is provided in Appendix B.

The Legislature enacted two measures that modified the UWMP Act in 1991. The first measure requires water suppliers to include an urban water shortage contingency analysis as part of its urban water management plan (AB 11). This measure also exempts the implementation of urban water shortage contingency plans from California Environmental Quality Act (CEQA). The second measure requires an UWMP to describe and evaluate water-recycling activities, to be updated once every five years. The update will include an estimate of projected potable and recycled water use, and a description of activities relating to water audits and incentives (AB 1869).

In 1993, the Legislature enacted a measure, which allows members of the California Urban Water Conservation Council (CUWCC) to submit to the state a copy of their annual report to the Council to satisfy current reporting requirements relating to urban water management plans (AB 892).
The Legislature enacted two measures in 1994. The first measure authorizes an urban water supplier to recover in its rates the costs incurred in preparing its plan and implementing the reasonable water conservation measures included in the plan (SB 1017). Any best water management practice that is included in the plan that is identified in the “Memorandum of Understanding Regarding Urban Water Conservation in California” (CUWCC, 2000) is deemed to be reasonable. The second measure requires water suppliers to give greater consideration to recycled water in their urban management plans (AB 2853).

In 1995, the Legislature enacted two additional measures that impacted the UWMP Act. The first measure requires urban water suppliers to include, as part of their urban water management plans, a prescribed water supply and demand assessment of the reliability of their water service to their customers during normal, dry, and multiple dry water years (AB 1845). The assessment shall compare total water supply sources available to the supplier with the total projected water use over the next 20 years, in 5-year increments. It also requires the supplier to provide the water service reliability assessment to any District or county within which it provides water within 60 days of the adoption of its urban water management plan. The second measure made the following changes to the Urban Water Management Plan Act (SB 1011):

- Revises the components required to be included in the plan.
- Requires urban water suppliers to update their plans at least once every five years on or before December 31 in the years ending in 5 and 0.
- Requires urban water suppliers to include a prescribed water supply and demand assessment.
- Requires suppliers to encourage active involvement of diverse social, cultural, and economic elements of the population within the service area prior to and during preparation of the plan.
- Prior to adopting the plan, the urban water supplier shall make the plan available for public inspection and shall hold a public hearing thereon.
- Deletes the provision requiring action alleging failure to adopt a plan to be commenced within 18 months after commencement or urban water service after January 1, 1984.

- Defines "demand management" and "recycled water," revises the definition of "plan" and deletes the definition of "conservation."
- Exempts suppliers who are implementing a conservation program from conducting a cost-benefit analysis of those conservation programs.
- Requires the Department of Water Resources to submit a report to the Legislature summarizing the status of plans on or before December 31 in the years ending in 1 and 6.

In September of 2000, the Legislature approved AB 2552, which requires urban water suppliers to submit their UWMPs to cities and counties where the water supplier provides water. The intent of this new requirement is to help ensure that District and county planning agencies have reliable water supply information on which to make growth decisions.

Additional changes approved in 2001 include AB 901, SB 221, SB 610, and SB 672. AB 901 requires UWMP to include information, relating to the water quality of source supplies and the manner in which the water quality affects water management strategies and supply reliability. This bill requires the plan to describe plans to supplement a water source that may not be available at a consistent level of use. SB 221 prohibits a city or county from approving a residential subdivision of more than 500 units unless the city council or the board of supervisors provides written verification from the area's water service provider that a sufficient water supply is available for the development. SB 610 requires additional information to be included as part of the UWMP for urban water supplies whose water supply includes groundwater. It requires a city or county that determines that a development project is subject to the California Environmental Quality Act, to identify any public water system that may supply water for the project, and, to request that system to prepare a specific water supply assessment. It requires urban water suppliers to include in the UWMP, a description of all water supply projects and programs that may be undertaken to meet total projected water use. This bill requires the DWR, in determining eligibility for funds made available pursuant to any program administered by DWR, to take into consideration whether an urban water supplier has submitted an updated UWMP. SB 672 requires urban water suppliers to describe in the UWMP, water management tools and other options used by that agency to maximize resources, and, minimize the need to import water from other regions.

1.6 Recent Changes to Urban Water Management Planning Act

There are many new requirements, adopted by the State over the period 2005 to 2010, that must be included in the District's UWMP Update. The following items must be included:

- 20x2020 analysis required of retail water suppliers, but not wholesalers. Thus District must only summarize data from retailers within District (applies to data only from the City of Oxnard and City of Port Hueneme)
- Water supplier must give at least 60 days advance notice to any District or county within which the supplier provides water supplies to allow opportunity for consultation on the proposed plan. (Water Code § 10621(b))
- Requires plan to include water use projections for single-family and multi-family residential housing needed for lower income and affordable households. (Water Code § 10631.1)
- Conditions eligibility for a water management grant or loan by DWR, SWRCB, or California Bay-Delta Authority on compliance with water demand management measures. (Water Code § 10631.5)
- Exempts projects funded by the American Recovery and Reinvestment Act of 2009 from the conditions placed on state funding for water management to urban water suppliers regarding

implementation of water conservation measures that were implemented under AB 1420. (Water Code § 10631.5(a)(2))

- Water suppliers that are members of the CUWCC and comply with the amended MOU, will be in compliance with the UWMP water demand management measures. (Water Code § 10631 (j))
- Clarifies that "indirect potable reuse" of recycled water should be described and quantified in the plan. (Water Code § 10633(d))
- Requires urban wholesale water suppliers to include in UWMPs an assessment of present and proposed future measures, programs, and policies to achieve water use reductions. (Water Code § 10608.200))
- Grants urban water suppliers an extension for submission of UWMPs due in 2010 to July 1, 2011 (Water Code § 10608.36)

1.7 Implementation

The District implemented the following for the 2010 UWMP Update:

- The District provided 60-day advanced notification (copy provided in Appendix C) to all OH system customers and applicable local agencies, regarding a hearing for the UWMP Update, including the following.
    - City of Oxnard
    - Port Hueneme Water Agency
    - Calleguas MWD
    - City of Ventura
    - Fox Canyon GMA/County of Ventura
    - Vineyard Avenue Estates
    - Dempsey Road Mutual Water Company
    - Cypress Mutual Water Company
    - Saviers Road Mutual Water Company
    - El Rio School District
    - Pleasant Valley County Water District
    - Frank B and Associates
    - In addition to city and county agencies, United values the input of social, cultural and economic community groups in the service area and encourages them to comment on this and any future UWMP.
- Prior to the hearing, the Public Review Draft UWMP Update was made available to the public and all OH system customers via United's website (www.unitedwater.org) for review and comment.
- A hearing for the UWMP Update was held on May 18, 2011, at United's regular Board meeting in Santa Paula. The hearing consisted of a brief presentation on the UWMP (Public Review Draft), and response to questions from the public and other agencies. A copy of the meeting notice is provided in Appendix C. The Draft UWMP was also posted on United's website at www.unitedwater.org.

- After the hearing, copies of the Public Review Final UWMP was made available to the public and all OH system customers via United's website (www.unitedwater.org) for review and comment.
- The District adopted the UWMP at another hearing at its regular Board Meeting on June 8, 2011. A copy of the meeting notice and Board Resolution are provided in Appendix C.
- The District submitted the UWMP to DWR prior to July 31, 2011.
- The District's adopted UWMP was made available for public review at 106 North 8th Street, Santa Paula, California, during normal business hours within 30 days of submitting the UWMP to DWR. It was also be posted on United's website at www.unitedwater.org.

SECTION 2: SYSTEM DESCRIPTION

2.1 UWMP Requirements

This section includes the following:

- Describe the water supplier service area. (CWC, 10631(a))
- Describe the climate and other demographic factors of the service area of the supplier. (CWC, 10631(a))
- Indicate the current population of the service area. Provide population projections for 2015, 2020, 2025, and 2030, based on data from State, regional, or local service area population projections. (CWC, 10631(a))
- Describe other demographic factors affecting the supplier's water management planning. (CWC, 10631(a)).

2.2 Background and History of United

United Water Conservation District manages groundwater and delivers water to cities and agriculture within a large part of Ventura County. Among United's urban water customers are the cities of Oxnard, Ventura, Port Hueneme, and the United States Naval Base Ventura County. The District got its name in 1954 when farmers and cities "united" to develop local water supplies. United Water is a public agency with an elected board of directors. Figure 1-2 (Section 1) identifies the District's Service Area, while Figure 2-1 provides an overview of the District's facilities.

The original founding organization for United Water was named the Santa Clara River Protective Association. It was formed in 1925 to protect the runoff of the Santa Clara River from being appropriated and exported outside the watershed. One reason local farmers formed the Association was to prevent the Los Angeles Department of Water and Power from exporting local water to Los Angeles. The Association was followed in 1927 by the Santa Clara Water Conservation District, which was formed to obtain water rights, recharge groundwater, and to serve river water to local farms. In those days, surface water from the Santa Clara River was diverted near Saticoy for use on farms in the valley and on the Oxnard Plain. The District began a systematic program of groundwater recharge in 1928, primarily by constructing spreading grounds along the Santa Clara River in Piru, Santa Paula, and Saticoy.

In the early 1900s, groundwater was so plentiful in the Oxnard Plain that water wells would run freely under artesian pressure. Seeping groundwater caused the ocean to be fresh near the coast, and ships refilled their water stores while anchored offshore. But by the early 1950s, over-pumping had caused seawater to intrude into about 20 square miles of the aquifer near the coast, causing some wells to become unusable. In 1954, cities and farmers "united" to solve these problems, and formed United Water Conservation District to recharge underground aquifers and to supply water to cities and farms. The former Santa Clara Water Conservation District, which was not allowed by statute to serve municipalities, was dissolved.

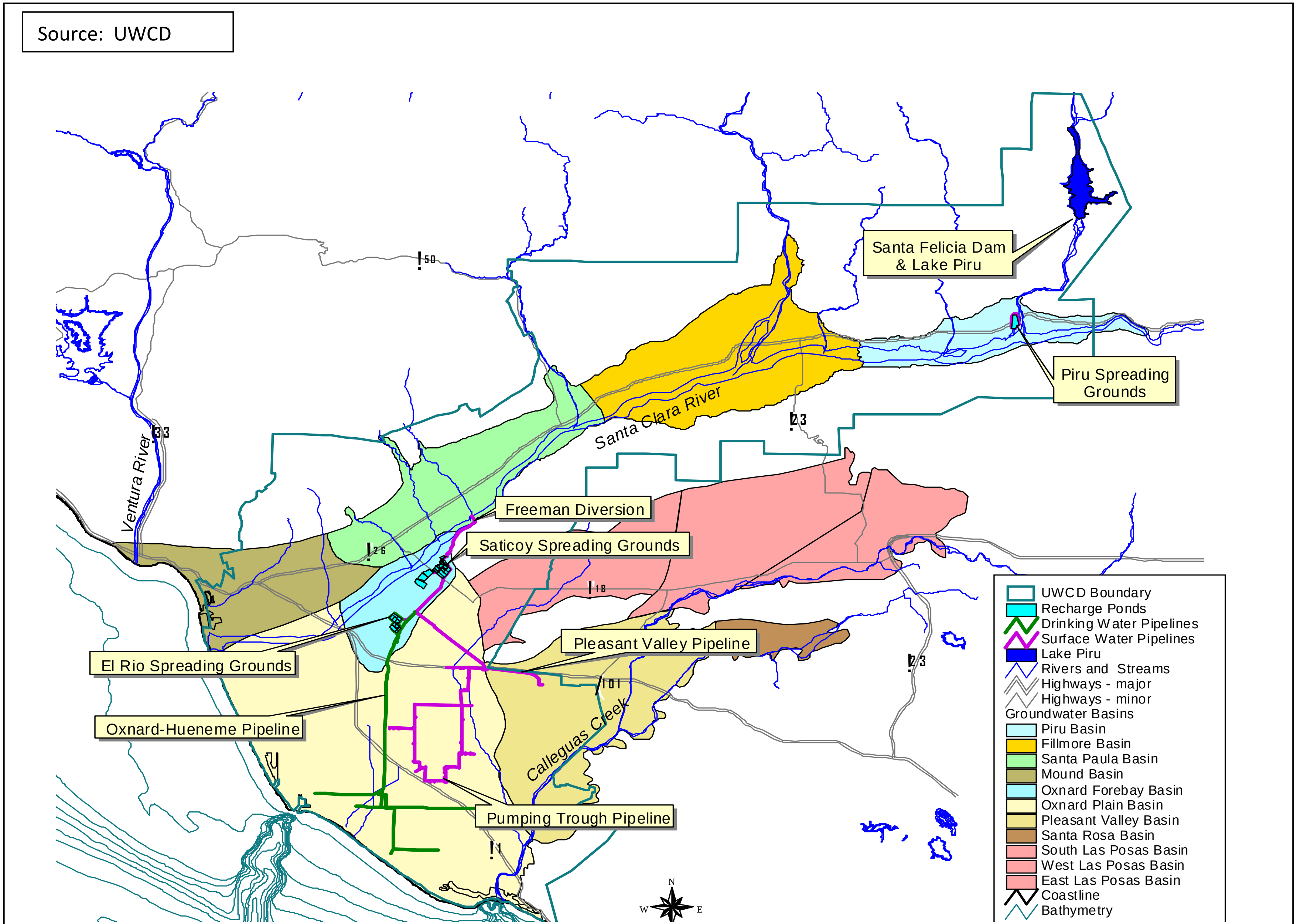


Figure 2-1
District Facilities
United Water Conservation District
April 2011

Many water of the District's facilities were built in the 1950s, including the Santa Felicia Dam (Lake Piru), new spreading grounds at Saticoy and El Rio, the OH drinking water system, and the Pleasant Valley pipeline (to replace canals on the Oxnard Plain). Since then, other facilities have been built as needed to manage local water, including the Pumping Trough Pipeline (serving agriculture on the Oxnard Plain), the improved Freeman Diversion Dam on the Santa Clara River, and the OH system improvements in 1998. Since it was formed in 1954, United has equally served both cities and farms within its service area. In many ways, United is a microcosm of water management practices within the State of California.

2.3 United's Mission Statement

United's goals are best exemplified in its mission statement:

> *United Water Conservation District shall manage, protect, conserve, and enhance the water resources of the Santa Clara River, its tributaries and associated aquifers, in the most cost-effective and environmentally balanced manner.*

Associated with the District's mission statement are several guiding principles. The guiding principle most closely associated with its drinking water system is as follows:

> *Deliver safe and reliable drinking water that meets current and future health standards to cities and urban areas.*

2.4 Service Area

The service area of the OH system is located on the Oxnard Plain, in the vicinity of Oxnard, as shown on Figure 1-2 (Section 1). The OH System supplies part of all of the drinking water supply for the wholesale customers listed below:

- City of Oxnard (Oxnard)
- Port Hueneme Water Agency (PHWA) consisting of the following:
    - City of Port Hueneme
    - Two U.S. Naval bases at Port Hueneme and Point Mugu, now jointly named Naval Base Ventura County
    - Channel Islands Community Services District (CIBCSD)
- Dempsey Road Mutual Water Company
- Cypress Mutual Water Company
- Saviers Road Mutual Water Company
- Vineyard Avenue Estates Mutual Water Company
- Rio Del Valle and Rio Real Schools.

In addition, there are a few small customers along the Mugu Lateral Pipeline, which was formerly part of the OH System. The Mugu Lateral has been leased by PHWA and those customers now receive water directly from PHWA.

The City of Oxnard has three sources of water: United Water's OH System, Calleguas MWD, and their own City wells. Water received from Calleguas MWD is imported surface water from northern

California (Sacramento/San Joaquin Delta), and is of higher quality (lower total dissolved solids and minerals) than local water. Oxnard blends its Calleguas and local (United plus City wells) supplies at about a one-to-one ratio to deliver water of a reasonable quality and taste. In effect, the use of OH water reduces the use of water imported from northern California.

Port Hueneme Water Agency receives United's OH water and treats it with reverse osmosis and/or ultrafiltration to remove the salts and improve its quality. PHWA also receives imported surface water directly from Calleguas MWD. PHWA blends the treated OH water and Calleguas MWD water prior to distribution to its customers.

The Ocean View pipeline provides OH water primarily to agricultural customers. There are a few domestic services on the Ocean View pipeline, to farm houses and businesses. The Ocean View pipeline (a lateral to the OH pipeline formerly operated by the now-dissolved Ocean View MWD) is owned by the City of Oxnard. United Water reads the master Ocean View meter every month and bills the City of Oxnard for the water used. Operation and maintenance of the Ocean View pipeline is performed by Oxnard. The number of Ocean View customers has been declining over time due to the high cost of the water, and the future of the Ocean View pipeline is the subject of ongoing discussion.

The four mutual water companies (Dempsey Road MWC, Cypress MWC, Saviers Road MWC, and Vineyard Avenue Estates MWC) all receive and deliver United's water without blending or further treatment.

Ventura County ranks approximately13th among all United States counties in agricultural production, with over $1,000,000,000 in annual revenues, largely due to reliable, low-cost water. Ventura County is first in the nation in strawberries, lemons, and celery.

2.5 Population

Information on the local population served is shown in Table 2-1. The OH System serves a population of approximately 253,500. By 2035, the population is expected to increase to approximately 300,000. However, the water deliveries for the OH System are set by contract, and will not be affected by future population growth.

Table 2-1
Population Served By OH System

Area	2010	2015	2020	2025	2030	2035
CIBCSD (1)	7,500	7,500	7,500	7,500	7,500	7,500
NBVC (2)	20,000	20,000	20,000	20,000	20,000	20,000
Oxnard (3)	204,500	213,000	221,500	230,000	238,500	247,000
Port Hueneme (4)	21,000	22,500	23,000	23,500	24,000	24,500
Others	500	500	500	500	500	500
Total	**253,500**	**263,500**	**272,500**	**281,500**	**290,500**	**299,500**

Notes:
All values rounded up to nearest 500.
(1) Personal conversation with Jared Bouchard, CIBCSD, 18 April 2011.
(2) Personal conversation with NBVC.
(3) Data provided by Dakota Corey, City of Oxnard.
(4) Ventura Council of Governments, 2008.

2.6 Climate

The OH service area is on the Oxnard plain, which has a mild Mediterranean style climate, with cool, wet winters and mild, dry summers. Temperatures only rarely fall below freezing in the winter. Average daily maximum temperature for Oxnard is 70.1 degrees Fahrenheit (see Table 2-2). Average annual evaporation-transpiration is 46.43 inches (see Table 2-2). Average rainfall in the Oxnard area is approximately 14.8 inches per year, most of it falling from December through April (see Table 2-2). A higher quantity of rainfall falls in the mountains of the watershed, contributing to the local water supply. Historical rainfall in nearby Santa Paula is plotted in Figure 2-2. An example of a normal water year would be 1976, with an annual precipitation of 12.91 in. A single dry year is best exemplified in 1948 which only received 3.37 in. of precipitation. The driest 3-year period occurred between 1988 and 1990, when the average precipitation was only 7.56 in.

Water demands can increase in late summer and fall during brief "Santa Ana" conditions, characterized by hot, dry winds from the east (off the southern California deserts). Occasional east winds in the fall also increase irrigation water demands for a few days at a time. During the few frost days, some growers use water to prevent their crops from freezing, increasing demands in those early mornings.

Table 2-2
General Climate Data

	Jan	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**
Average Daily Max. Temperature (°F) (1)	65.4	66.3	66.2	67.8	68.8	71.2	74.0
Standard Average ETo (in.) (2)	1.83	2.20	3.42	4.49	5.25	5.67	5.86
Average Precipitation (in) (1)	3.34	3.35	2.49	1.03	0.17	0.05	0.02

	Aug	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
Average Daily Max. Temperature (°F) (1)	75.0	75.1	74.1	70.5	66.6	70.1
Standard Average ETo (in.) (2)	5.61	4.49	3.42	2.36	1.83	46.43
Average Precipitation (in) (1)	0.05	0.23	0.29	1.64	2.11	14.77

Notes:
(1) Western Regional Climate Center. Station no. 046569, Oxnard, CA.
(2) CIMIS station 156, Oxnard, CA.

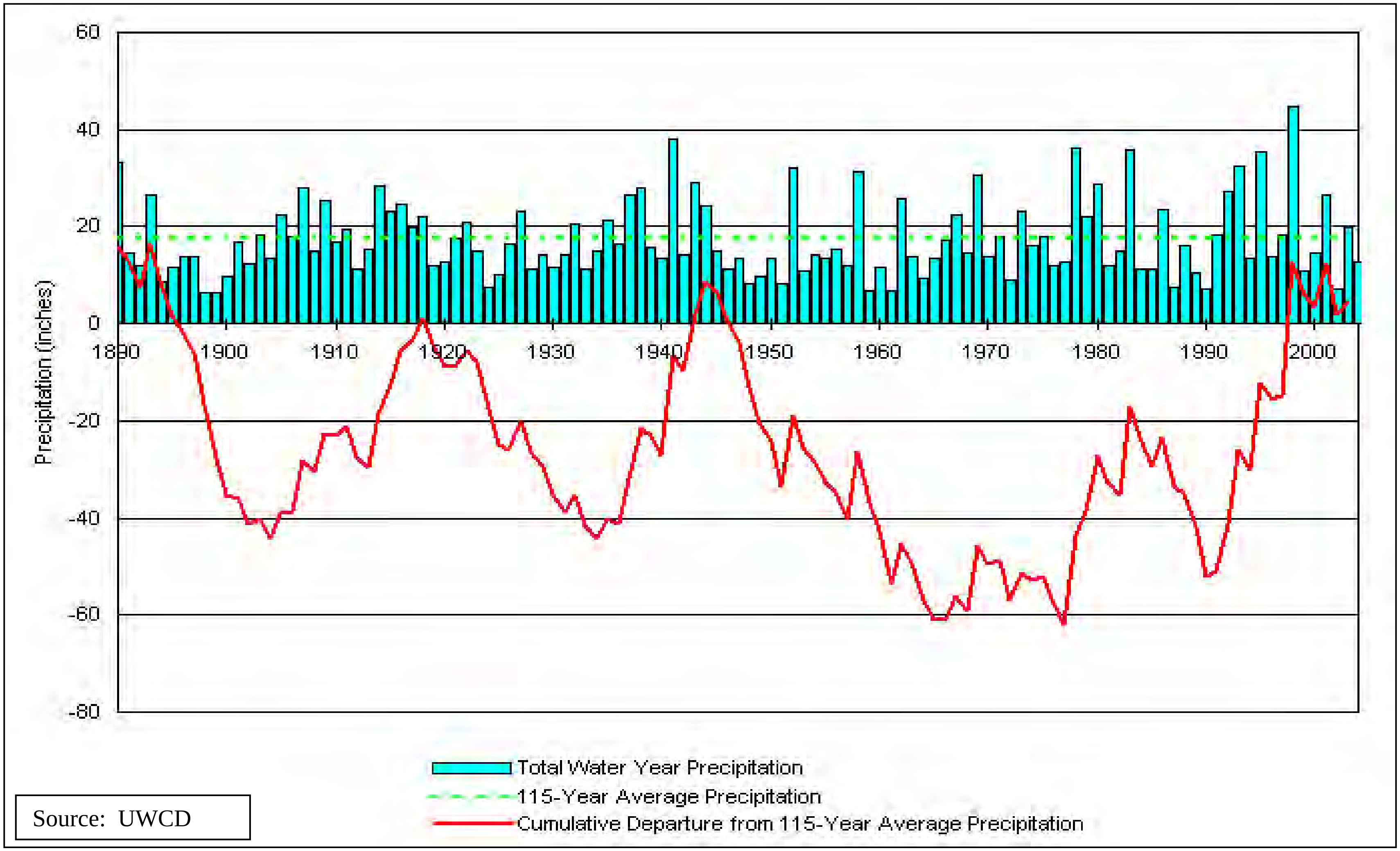


Figure 2-2
Santa Paula Annual Precipitation
United Water Conservation District
April 2011

2.7 OH Facilities

The OH System facilities supply drinking water to United's customers on the Oxnard Plain. OH facilities consist of the following: shallow wells, deep wells, El Rio Spreading Grounds, OH Plant, and OH pipeline. Each of these facilities is defined below. The OH pipeline, along with other OH facilities, is shown in Figure 2-3. A schematic of the OH facilities in El Rio is shown in Figure 2-4. Each of the primary OH system components is described below.

2.7.1 Shallow Wells

The OH system has nine shallow aquifer wells, located primarily around the perimeter of the El Rio spreading grounds. These wells include Wells Nos. 2A, 4, 5, 6, 7, 8, 11, 15, and 16. A summary of the shallow wells is provided in Table 2-3. These wells are rather old, with most constructed using cable tool methods in the 1950s. Wells 2A, 11, and 16 are newer wells. These nine wells are perforated in the higher quality, upper aquifer system, which is directly recharged by surface water diverted from the Santa Clara River. Despite their age, these wells have performed well over the last 50 years, and maintain fairly high specific capacities. The wells are maintained by periodic replacements of pumps, column piping, tubing, electric motors and other components as necessary. From time to time the well casings are "shot" with low-grade explosive charges to restore their specific capacities. There is some risk to this procedure and, in 2000, Well No. 2A partly collapsed and a section of the casing had to be relined. Acid treatment of the wells has not been successful in the past due to local water chemistry

2.7.2 El Rio Spreading Grounds

All of the OH shallow wells except Well No. 11 are located immediately adjacent to the El Rio spreading grounds. Water diverted from the Santa Clara River at the Freeman Diversion is recharged into groundwater at El Rio via those spreading grounds. Although the spreading grounds are not part of the OH system, they have a big impact on its operation. While spreading operations are underway, the well water is similar in water quality to the river water. The river water used for recharge is usually of higher quality than ambient groundwater. When spreading has stopped for a few months, well water quality can decline. Tracer studies have shown that water recharged into the spreading ponds takes just a couple of days to migrate into the well production zones.

2.7.3 Deep Wells

In addition to the shallow aquifer wells, the OH system includes three deep aquifer wells constructed in the 1980's. These are Wells Nos. 12, 13 and 14, located along Rose Avenue. A summary of the deep wells is provided in Table 2-3. These wells are perforated in the deeper aquifer, separated from the shallow aquifer by a clay layer. Due to high iron and manganese in the groundwater pumped from these wells, they are used primarily as backup wells.

These deep wells are operated under a waiver (for the high iron and manganese) provided by the California Department of Public Health. This waiver was allowed after conducting a survey of District OH customers, which must be done every seven years. The deep aquifer wells were used extensively in the 1985-1991 drought. However, they have not been used to supply OH water since 1992, except for one week during construction of the El Rio Improvements in 1997. They are maintained and tested periodically in preparation for any future drought.

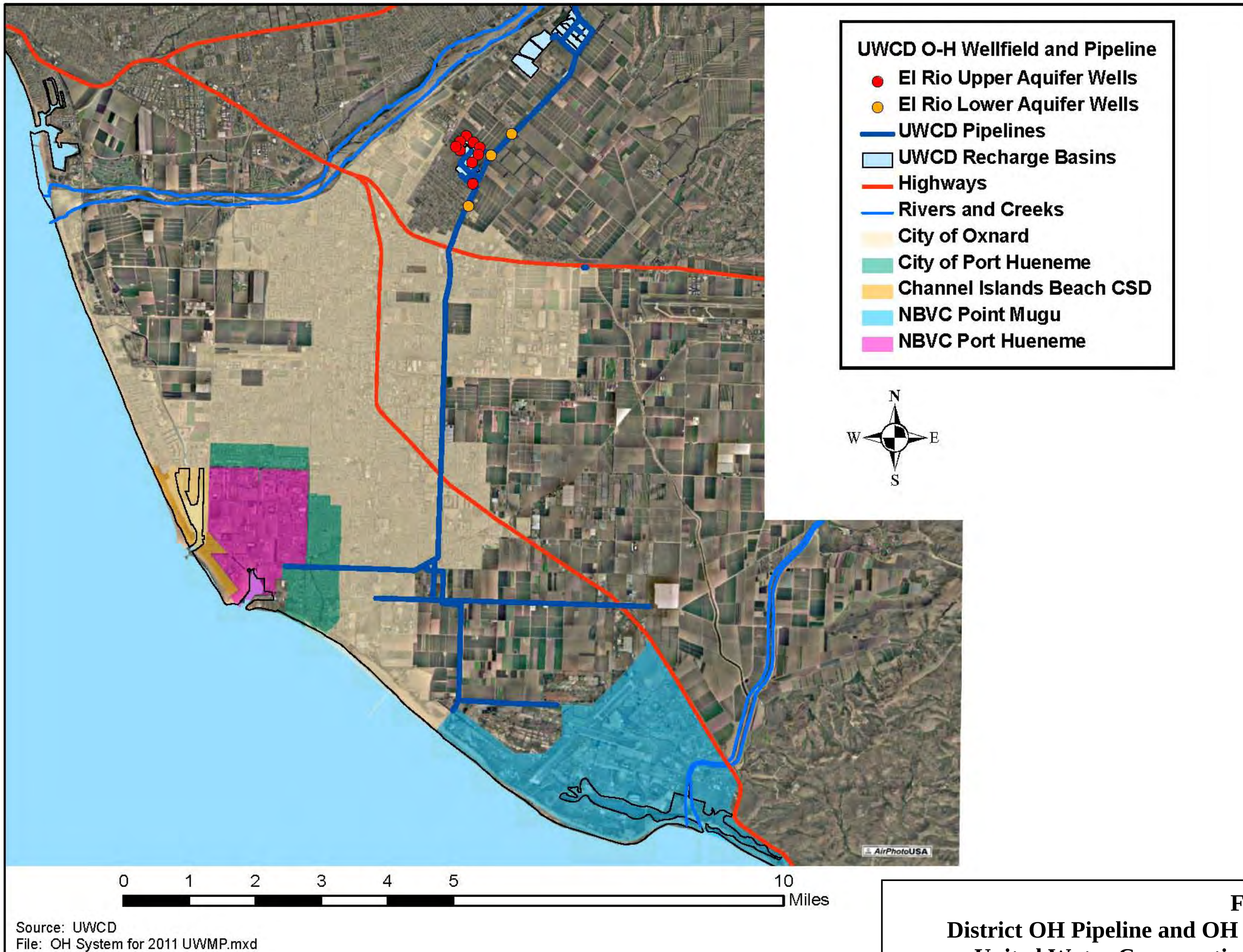


Figure 2-3
District OH Pipeline and OH Facilities
United Water Conservation District
April 2011

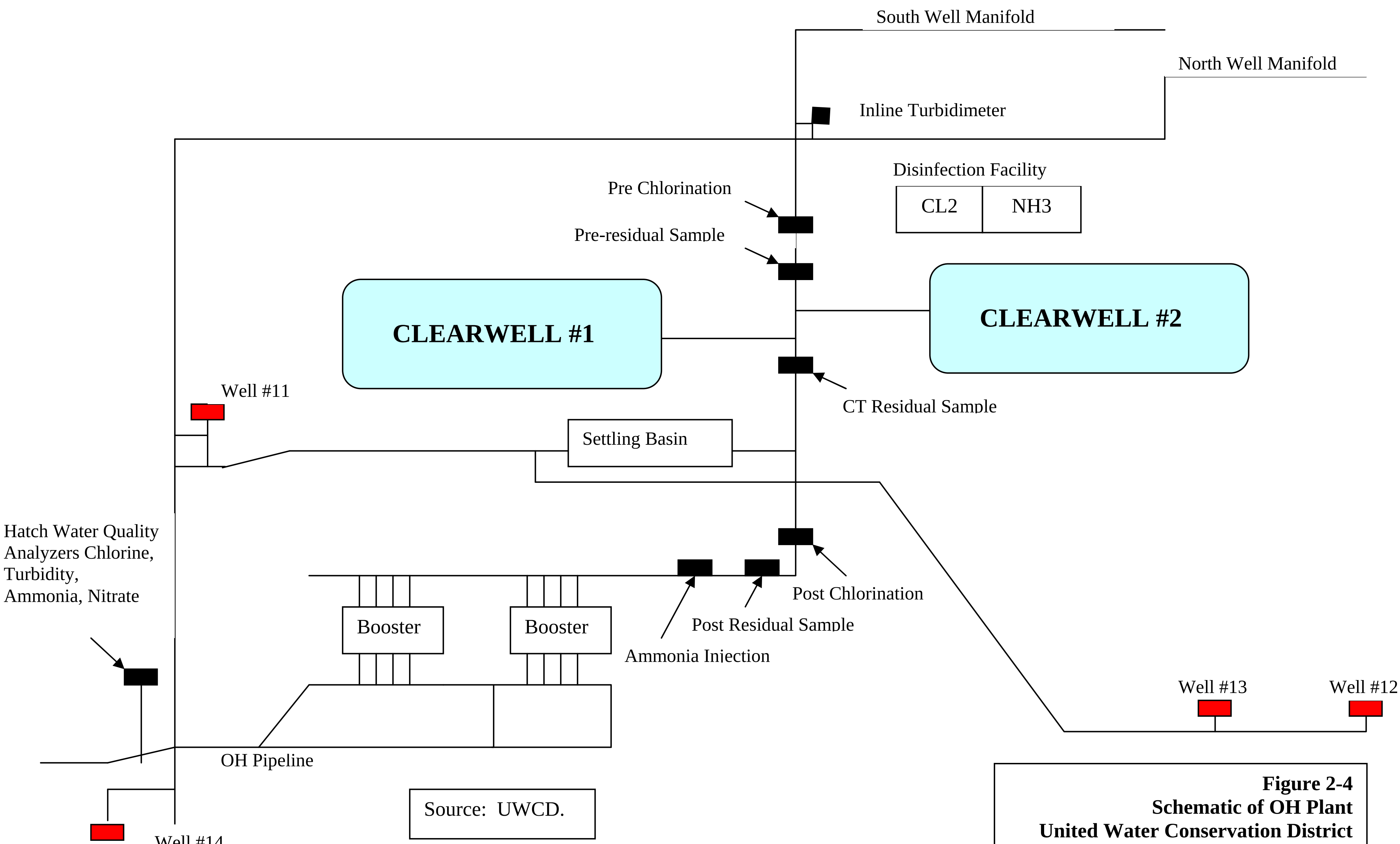


Figure 2-4
Schematic of OH Plant
United Water Conservation District
April 2011

Table 2-3
OH Active Well Characteristics

Well No.	Source Aquifer	Well Depth (feet)	Well (1) Capacity (gpm)	Pump Bowl Depth (feet)	Driver Size (HP)	Driver Type
2A	UAS	320	1,850	176	100	U.S. Electric Motor
4	UAS	303	1,836	155	100	U.S. Electric Motor
5	UAS	303	2,423	177	100	U.S. Electric Motor
6	UAS	301	1,836	187	100	U.S. Electric Motor
7	UAS	326	1,903	177	100	U.S. Electric Motor
8	UAS	314	2,292	187	100	U.S. Electric Motor
11	UAS	360	3,298	163	150	U.S. Electric Motor
12	LAS	1,112	2,854	478	400	Westinghouse Softstart
13	LAS	1,418	2,791	351	300	Westinghouse Softstart
14	LAS	1,470	3,598	387	500	Westinghouse Softstart
15	UAS	330	3,630	192	150	U.S. Motor and Allen-Bradley Softstart
16	LAS	810	2,150	790	100	U.S. Motor

Notes:
(1) Data as 2010

2.7.4 El Rio Plant

The complex consisting of the two booster plants, the chlorine building, the clearwells, and associated office and shop buildings are commonly referred to as the El Rio Plant.

2.7.5 OH Disinfection Facility

The disinfection building is a state-of-the-art facility constructed in 1998. It houses up to 8 one-ton cylinders of chlorine liquid/gas. After primary chlorination, ammonia is added, using a 19 percent aqueous ammonia solution. The disinfection residual is provided by chloramines, a combination of chlorine and ammonia. The chlorine building includes a scrubber system (caustic soda) to de-active any chlorine leaks, and backup power generation.

2.7.6 OH Clearwells

The OH system has two 8 million gallon clearwells (reservoirs), located near the disinfection building. Water pumped from the OH wells is stored in the clearwells before being repumped to customers. The clearwells are made with a plastic (polyethylene) lining and plastic floating cover. Having two clearwells provides redundancy for maintenance.

2.7.7 OH Electric Booster Plant

The OH booster plant pumps water from the OH clearwells into the OH pipeline. Water is delivered to OH customers on demand at a constant pressure (60 psi at the plant in El Rio). The pumps consist of four 400 HP electric-driven vertical turbine pumps. To accommodate rapid fluctuations in demand, the motors are driven by variable frequency drives (VFD's). One of the four pumps serves as a backup pump. In the event of a power failure (and a failure of the gas-driven pumps), water can be delivered by gravity from the clearwells into the OH pipeline.

2.7.8 OH Gas-Driven Booster Plant

Prior to construction of the electric-driven booster plant in 1997, water was pumped by natural gas driven engines. There are for 400 HP natural gas driven engines that run four centrifugal pumps, housed in a block building. The old booster plant is kept in service as a backup to the electric booster plant in case of power outages or mechanical failures. It also allows the District to participate in Demand Relief Programs, in which the electric-driven motors are turned off, upon request, during peak periods of electric power demands. The gas booster plant is operated under a permit from the Ventura County Air Pollution Control District (APCD).

2.7.9 OH Pipeline

The OH pipeline includes 12 miles of varying diameter cement-mortar lined and coated steel pipes, starting at 54-inches in diameter at the OH plant in El Rio, and tapering to 16-inches at the furthest reach. There are no individual retail customers on the OH pipeline (except for one farmhouse). Instead, large turnouts are provided to retail water agencies.

2.7.10 Backup Generator

The OH system includes a diesel powered 750 KW backup generator. In the event of a massive power failure, this generator will power the OH shallow wells for direct delivery to customers. Sufficient fuel is stored on site to supply about three days of demand.

2.7.11 SCADA System

The SCADA System (Supervisory Control and Data Acquisition) is the automated control system that monitors and operates United's facilities, including the OH System. Routine checks and adjustments are made by the SCADA system. The system includes telephone dial-out so that operators can be called 24-hours a day in the event of emergencies or alarm conditions. Alarm conditions include low chlorine residuals, mechanical failures, low system pressures, power outages, and over 500 different things that can go wrong. United’s SCADA system is based on Allen-Bradley components.

2.8 OH Design Capacities

The OH System is designed to deliver a peak flow of 53 CFS to its customers, via the OH pipeline. That capacity is based on maintaining a pressure of 60 psi at the booster plant, and providing adequate flow pressures at United customers' turnouts. In practice, the pressure provided to United customers exceeds their needs. For example, Oxnard reduces the OH line pressure at their blending stations. PHWA uses a pressure reducing valve to decrease the line pressure before treatment. A detailed hydraulic analysis has not been done to determine whether the OH deliveries could be increased within the limits of the existing pipeline pressure capacities.

The OH wellfield has a combined capacity of about 73 CFS, as detailed in Table 2-3. In general, there is surplus well capacity in the wellfield, which is needed for blending and backup purposes.

2.9 OH Wellfield Treatment

Due to the proximity between the OH shallow wells and the El Rio spreading grounds (within 25 feet in places), the shallow wells are considered to be "groundwater under the influence of surface water." This means that the requirements of the Surface Water Treatment Rule (SWTR) are applicable. Previous particulate analyses of the well water indicate that the surface water effects are largely attenuated by filtration of the surface water through the soil between the time it is spread and the time it reaches the wells. This "natural filtration" has many benefits and is used in Europe to provide filtration of surface water. Some researchers argue that natural filtration is superior to conventional filtration. For purposes of the SWTR, California DHS considers the natural filtration of the OH wellfield to be equivalent to slow sand filtration, and credits the system with 2 logs removal via filtration (equivalent to 99 percent of Giardia-size pathogens removed).

The SWTR requires surface water to be disinfected for a sufficient contact time to kill viruses and pathogens. Primary disinfection for the OH system is provided by chlorine, before the addition of ammonia. The OH clearwells include baffles to force the water to flow around a circuitous path, providing sufficient contact time in the reservoir to meet the requirements of the SWTR. The monitoring requirements of the SWTR are followed to ensure that sufficient contact time is obtained. Monthly reports on the treatment results are provided to DPH.

After the chlorinated water leaves the clearwells, ammonia is injected into the water to form chloramines, which provide a long-lasting disinfection residual. Chloramination is preferred to chorine due to the reduced tendency to form trihalomethanes and other organic decay byproducts that can cause cancer. Chloramines are also longer lasting, and are compatible with the chloraminated water used by the two largest OH customers, Oxnard and PHWA.

Water from the deep aquifer wells is high in iron and manganese. When those wells are pumped, a sequestering agent, Aqua-Mag, is added to the well water to sequester the iron and manganese. Such sequestering reduces the aesthetic impacts of water high in iron and manganese.

2.10 Groundwater Recharge Facilities

Although they are not part of the OH System, United's groundwater recharge facilities contribute to the groundwater supply pumped from the OH wells. The Freeman Diversion is a roller compacted concrete (RCC) dam on the Santa Clara River in Saticoy. Up to 375 CFS of river water is diverted there into canals, which carry the water to two spreading grounds, including the El Rio spreading grounds adjacent to the OH wellfield. After the water is filtered at a microscreen facility in Saticoy, the diverted water is conveyed to El Rio through a buried pipeline along Rose Avenue.

2.11 Operations Staff

The OH System is operated by a highly trained and competent staff. The OH system is rated by DHS as a T4/D4 system, which requires certified Grade 4 operators for the treatment system and certified Grade 4 distribution system operators. The District presently has four Grade 4 treatment operators on staff.

The OH System is monitored 24-hours a day by operations staff. Each week, one of approximately six operators is assigned "rotating shift" duty, during which they are on-call to respond to alarms and emergencies. While on call, operators carry pagers and cell phones, which are automatically called by the SCADA system with verbal notification of any alarm conditions. For example, they might receive a call with a voice message "low chlorine levels in the clearwell." Operators can query the system remotely and decide whether they need to respond to the emergency. On-call operators are generally able to respond to emergencies within a 30-minute period.

2.12 Emergency Response

The District has prepared several emergency-planning documents including, but not limited to, the following: Vulnerability Assessment, Risk Management Plan, and an Emergency Response Plan. Due to the sensitive nature of the information within these documents, the District does not make these documents available to the public.

SECTION 3: SYSTEM DEMANDS

3.1 UWMP Requirements

This section includes the following:

- Provide baseline daily per capita water use, urban water use target, interim urban water use target, and compliance daily per capita water use, along with the bases for determining those estimates, including references to supporting data. (CWC, 10608.20(e))
- *Wholesalers:* Include an assessment of present and proposed future measures, programs, and policies to help achieve the water use reductions. *Retailers:* Conduct at least one public hearing that includes general discussion of the urban retail water supplier's implementation plan for complying with the Water Conservation Bill of 2009. (CWC, 10608.36, 10608.26(a))
- Report progress in meeting urban water use targets using the standardized form. (CWC, 10608.40)
- Quantify past, current, and projected water use, identifying the uses among water use sectors, for the following: (A) single-family residential, (B) multifamily, (C) commercial, (D) industrial, (E) institutional and governmental, (F) landscape, (G) sales to other agencies, (H) saline water intrusion barriers, groundwater recharge, conjunctive use, and (I) agriculture. [past = 2005, present = 2010, and projected to be 2015, 2020, 2025, and 2030] (CWC, 10631(e)(1))
- Provide documentation that either the retail agency provided the wholesale agency with water use projections for at least 20 years, if the UWMP agency is a retail agency, OR, if a wholesale agency, it provided its urban retail customers with future planned and existing water source available to it from the wholesale agency during the required water-year types. [Average year, single dry year, multiple dry years for 2015, 2020, 2025, and 2030] (CWC, 10631(k))
- Include projected water use for single-family and multifamily residential housing needed for lower income households, as identified in the housing element of any city, county, or city and county in the service area of the supplier. (CWC, 10631.1(a))

3.2 Annual Water Demands

Annual water demands on the OH system are listed in Table 3-1, and plotted in Figure 3-1. Average annual deliveries (excluding line losses and pump to waste) for the period 1984 to 2010 were 14,330 AF. In 1995 and 1996, Oxnard took less OH water than usual due to availability of a low-cost Calleguas MWD water program.

Total annual water pumping from the upper aquifer wells and deep aquifer wells is summarized in Table 3-2. Average annual water extractions from the upper aquifer wells for the period 1984 to 2010 were 14,093 AF. Average annual water extractions from the deep aquifer wells for the period 1984 to 2010 were 293 AF. As can be seen, those wells are generally only used in drought conditions or to serve agriculture outside the OH System.

The District is a water wholesaler, therefore it does not have data to quantify past or current water demands for individual retail agencies, identifying the uses among water use sectors, for the following: (A) single-family residential, (B) multifamily, (C) commercial, (D) industrial, (E) institutional and governmental, (F) landscape, (G) sales to other agencies, (H) saline water intrusion barriers, groundwater recharge, conjunctive use. This data is available by contacting the retail agencies within the District.

Table 3-1
Annual OH Water Demand 1984 to 2010

Calendar Year	Annual OH Water Demand (AF) (1)
1984	14,588
1985	14,445
1986	13,884
1987	14,501
1988	14,270
1989	14,457
1990	14,757
1991	12,644
1992	12,699
1993	14,978
1994	13,093
1995	8,666
1996	6,881
1997	17,776
1998	16,785
1999	17,673
2000	14,122
2001	13,339
2002	14,920
2003	16,761
2004	12,075
2005	9,790
2006	9,900
2007	22,759
2008	17,297
2009	18,155
2010	15,695
Average	**14,330**

Notes:
Source – UWCD.
(1) Annual water demand values rounded up to next AF.

In recent years the demands in Table 3-1 have increased because of the availability of the Supplemental M&I Water Program, a discretionary program that can be discontinued during a drought.

3.2.1 Demands by Lower Income Households

As a wholesaler, the District has provided sufficient water to all OH customers to meet customer allocations including water necessary for lower income single-family households and multi-family households.

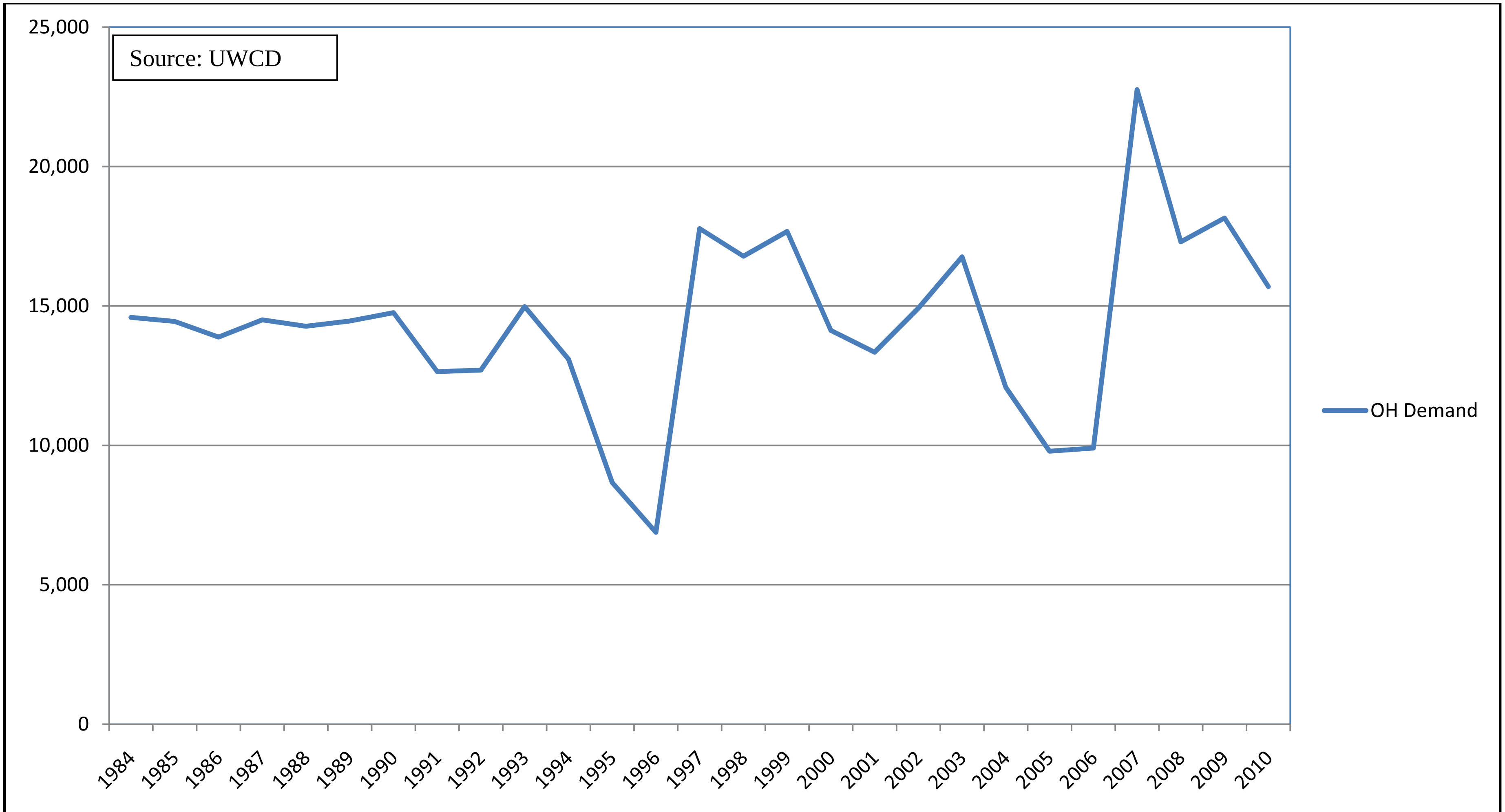


Figure 3-1
Annual OH Water Demand
United Water Conservation District
June 2011

Table 3-2
OH Well Pumping 1984-2010

Calendar Year	Upper Aquifer Pumping (UAS) (AF)	Lower Aquifer Pumping (LAS) (AF)	Total (AF)
1984	14,585.2	0	14,585.2
1985	13,901.1	0	13,901.0
1986	14,094.5	2.0	14,096.5
1987	14,764.4	564.0	15,328.4
1988	15,466.4	43.0	15,509.3
1989	13,751.1	711.0	14,462.1
1990	11,961.0	2,796.0	14,757.0
1991	11,047.0	1,597.0	12,644.0
1992	12,211.0	97.0	12,307.9
1993	14,772.9	206.0	14,978.8
1994	13,027.8	67.0	13,094.7
1995	8,637.4	28.0	8,665.3
1996	6,848.4	33.0	6,881.3
1997	17,714.8	62.0	17,776.7
1998	16,615.7	168.0	16,783.6
1999	17,659.9	12.0	17,671.9
2000	14,031.2	91.0	14,122.2
2001	13,320.1	18.0	13,338.1
2002 (1)	14,125.0	793.0	14,918.0
2003	16,749.3	10.0	16,759.3
2004 (1)	11,638.1	437.0	12,075.1
2005	9,789.2	6.9	9,796.1
2006	9,899.9	6.2	9,906.1
2007	22,758.9	4.3	22,763.2
2008	17,296.5	59.2	17,355.7
2009	18,154.4	73.6	18,228.0
2010	15,694.8	32.9	15,727.7
Average	**14,093.2**	**293.3**	**14,386.4**

Note:
(1) LAS wells were pumped to the irrigation pipeline (not part of the OH System).

The OH System is operated under an agreement between United and the OH Customers. In that agreement, each customer is assigned an annual allocation for OH water, and a maximum flow rate at which water can be received. A list of OH customers and their maximum allocation contract amounts for OH water is provided in Table 3-3. However, these allocations are subject to GMA reductions noted in Table 3-4. Thus, the current maximum OH customer allocation is reduced to 10,655 AFY as the result of GMA required pumping reductions of 25 percent. This value will be used for the OH customers future maximum allocations.

In practice, peak flows to each customer are not metered. There is no way to know whether a customer is exceeding its peak flow capacity. Fortunately, total peak flows leaving the OH plant, which are metered, have not exceeded the total design capacity of 53 CFS. In fact, peak flows have been reduced since PHWA's treatment plant has gone on-line. If problems with peak flows were to occur, it would be feasible to install peak flow meterheads and require the OH customers to remain within their limits.

Table 3-3
OH Customer Sub-allocations

OH Customer	OH Sub-Allocation (AF)
City of Oxnard	
Oxnard	6,237.78
Ocean View (now Oxnard)	2,729.55
Oxnard Subtotal	**8,967.33**
Port Hueneme Water Agency	
City of Port Hueneme	3,593.18
NBVC - Point Mugu	899.19
NBVC - Port Hueneme	120.18
Channel Islands Beach CSD	0.00
PHWA Subtotal	**4,612.55**
Mutual Water Companies	
Cypress Mutual	96.20
Dempsey Road Mutual	194.47
Saviers Road Mutual	27.57
Vineyard Avenue Estates	266.00
Mutual Subtotal	**584.24**
Other OH Customers	
Donions Recharge	5.25
Kunho (Del Norte)	9.50
Rio Del Valle Schools	26.70
Ventura Co Game Preserve	1.28
Other Customer Subtotal	**42.73**
Total Number of Accounts	**15**
Total of Suballocations	**14,206.85**

3.3 Fox Canyon Groundwater Management Agency

The Fox Canyon Groundwater Management Agency (FCGMA) is located in Ventura County and encompasses several coastal basins that underlie the cities of Oxnard, Port Hueneme, Camarillo, and Moorpark. The FCGMA was formed by Act 2750, passed by the California Legislature, to monitor and control pumping within the GMA boundaries, shown in Figure 3-2.

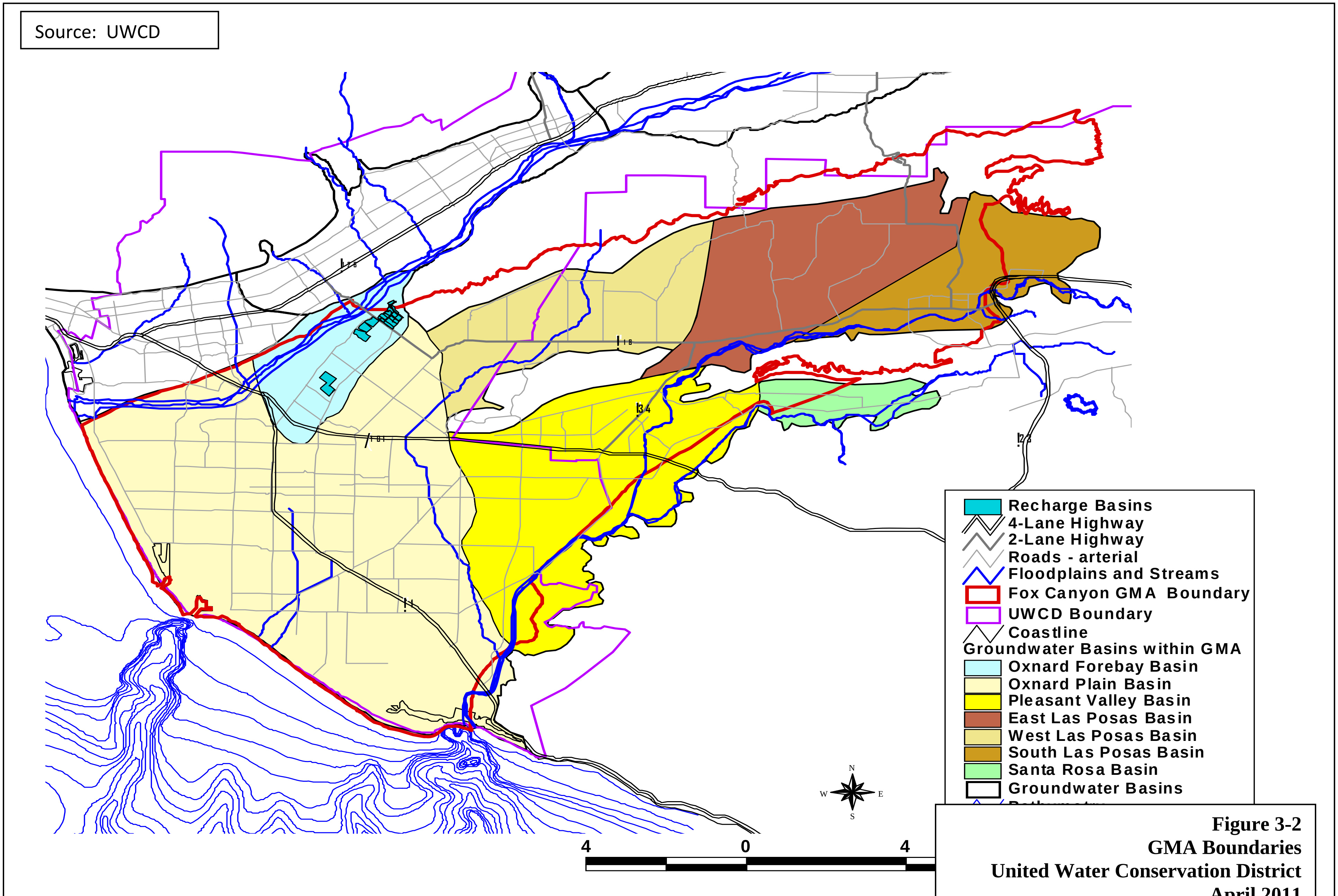


Figure 3-2
GMA Boundaries
United Water Conservation District
April 2011

The FCGMA overlies approximately 118,00 acres (185 square miles). The FCGMA was initially created to manage the groundwater in both overdrafted and potentially seawater-intruded areas within Ventura County. The prime objectives and purposes of the FCGMA are to preserve groundwater resources for agricultural, municipal, and industrial uses in the best interests of the public and for the common benefit of all water users. Protection of water quality and quantity along with maintenance of long-term water supply are included in those goals and objectives. To fund its activities, the GMA collects an annual charge (per acre-foot of pumped water) from all pumpers within its boundaries. The GMA has the authority to pass ordinances to control the pumping of groundwater in its service area. GMA Ordinance 8 controls the amount of water that can be pumped from the Oxnard Plain and Las Posas area. Each pumper is assigned a historical allocation based on their pumping from each well during 1985 to 1989. Pumping is to be cut back 5 percent every five years, up to a maximum reduction of 25 percent in 2010. The GMA cutbacks required by year are summarized in Table 3-4.

Table 3-4
GMA Pumping Reductions by Year

Years	Reduction Required	Pumping Allowed
1991	None	100%
1992-1994	5%	95%
1995-1999	10%	90%
2000-2004	15%	85%
2005-2009	20%	80%
2010 and beyond	25%	75%

The GMA cutbacks were originally intended to bring the aquifer system into balance by the year 2010. A pumper can build up GMA "credits" if he pumps less than his allocation in any given year. However, if a pumper runs out of credits and pumps in excess of their reduced annual pumping allocation, they will be assessed a GMA penalty for each AF of excess water pumped. The GMA penalty for exceeding an allocation is presently set at $1,105 to $1,855 per AF (GMA, Resolution No. 2010-07), depending on the amount, which is considered to be above or at the cost of purchasing replacement water, to provide a pumping disincentive.

The OH wellfield is subject to the same pumping limitations and GMA penalties as any other pumpers. The total available GMA allocations for the OH wellfield are summarized in Table 3-5. Total historical GMA allocations for the District's OH wellfield are 15,170 acre-feet per year. However, this number is reduced to 11,377 AFY as the result of GMA required pumping reductions of 25 percent. This value will be used for the District's future maximum allocation (see Table 3-6).

Table 3-5
OH Historical GMA Allocation

Source	Historical Allocation (AF/Yr)	Year Effective
OH Pumping 1985 – 1989	14,673.628	1991
Noble Pit allocation transfer	203.428	1994
Transfer from Vineyard Avenue Estates	266.000	1997
Transfer from Rio Del Valle Schools	26.700	1997
Total	**15,169.756**	

The GMA pumping limitations and penalties provide a very strong incentive for OH customers to reduce their pumping. Each OH customer has an allocation as listed in Table 3-3. By the terms of the OH Agreement, each customer's allocation is referred to as that customer's suballocation. If a customer pumps more than his reduced suballocation, then that customer is liable for any GMA penalties that may accrue. There are provisions in the OH Agreement for payment in advance to cover penalties for over-pumping. At an additional cost of $1,105 to $1,855 per AF, OH customers are encouraged to conserve water and use other sources that may be available.

3.4 Groundwater Management Plan

Both United Water and the GMA operate under the guidelines of a 2007 Groundwater Management Plan prepared by the GMA entitled, *2007 Update to the Fox Canyon Groundwater Management Agency Groundwater Management Plan*. A copy of the GMA Plan is provided in Appendix D. A copy of the Plan is available on the GMA website.

3.5 Assessment of Present and Future Demand Management Programs

Section 6 summarizes the District's present and proposed future measures, programs, and policies to help achieve the water use reductions.

3.6 Projected Water Demands

Projected water demands for the OH System are estimated in Table 3-6. These demands are based on customers staying within their GMA suballocation, including reductions.

The District is a water wholesaler, therefore it does not have data to quantify future water demands for individual retail agencies, identifying the uses among water use sectors, for the following: (A) single-family residential, (B) multifamily, (C) commercial, (D) industrial, (E) institutional and governmental, (F) landscape, (G) sales to other agencies, (H) saline water intrusion barriers, groundwater recharge, conjunctive use. This data is available by contacting the retail agencies within the District.

3.7 Water Conservation Act of 2009

In February 2008, Governor Arnold Schwarzenegger introduced a seven-part comprehensive plan for improving the Sacramento-San Joaquin Delta. A key component of this plan was a goal to achieve a 20 percent reduction in per capita water use statewide by the year 2020 (also known as the 20x2020 target). The Governor’s inclusion of water conservation in the Delta plan emphasizes the importance of water conservation in reducing demand on the Delta and in reducing demand on the overall California water supply. In response to Schwarzenegger’s call for statewide per capita savings, the DWR prepared a 20x2020 Water Conservation Plan (DWR, 2010). The Water Conservation Plan developed estimates of statewide and regional baseline per capita water use and outlined recommendations to the Governor on how a statewide per capita water use reduction plan could be implemented.

Table 3-6
Projected OH Water Allocation Pumping 2011-2035

Year	Maximum OH Allocation Pumping (AF) (1)	GMA Reductions
2011	11,377	75%
2012	11,377	75%
2013	11,377	75%
2014	11,377	75%
2015	11,377	75%
2016	11,377	75%
2017	11,377	75%
2018	11,377	75%
2019	11,377	75%
2020	11,377	75%
2021	11,377	75%
2022	11,377	75%
2022	11,377	75%
2023	11,377	75%
2024	11,377	75%
2025	11,377	75%
2026	11,377	75%
2027	11,377	75%
2028	11,377	75%
2029	11,377	75%
2030	11,377	75%
2031	11,377	75%
2032	11,377	75%
2033	11,377	75%
2034	11,377	75%
2035	11,377	75%

Notes:
(1) Based on allocations and does not include customer credits

In November 2009, SBX7-7, The Water Conservation Act of 2009 (CWC, 10608-10608.44) was signed into law as part of a comprehensive water legislation package. The Water Conservation Act addresses both urban and agricultural water conservation. The urban provisions reflect the approach taken in the 20x2020 Water Conservation Plan. The legislation sets a goal of achieving a 20 percent statewide reduction in urban per capita water use and directs urban retail water suppliers to set 2020 urban water use targets. This new legislation requires urban retail water suppliers to summarize the calculation of this water use target in the UWMP.

3.7.1 Baseline Water Use

Water suppliers must define a 10- year base period (or 15-year) (also known as baseline) for water use that will be used to develop their target levels of per capita water use. Water suppliers must also calculate water use for a 5-year baseline period, and use that value to determine a minimum required reduction in water use by 2020. The longer baseline period applies to a water supplier that meets at least 10 percent of its 2008-measured retail water demand through recycled water. Methodology 3: Base Daily Per Capita Water Use describes the calculations.

3.7.2 Water Use Targets

An urban retail water supplier, as defined above, must set a 2020 water use target and a 2015 interim target using one of four methods. (CWC, 10608.20(a)(1)) The 2020 water use target will be calculated using one of the following four methods:

- Method 1: Eighty percent of the water supplier's baseline per capita water use
- Method 2: Per capita daily water use estimated using the sum of performance standards applied to indoor residential use; landscaped area water use; and CII uses
- Method 3: Ninety-five percent of the applicable state hydrologic region target as stated in the 20x2020 Water Conservation Plan
- Method 4: Urban water use target is calculated by estimating the baseline per capita use and subtracting total water savings (savings from metering, indoor residential, commercial, industrial, institutional, landscape, and water loss).

The target may need to be adjusted further to achieve a minimum reduction in water use regardless of the target method (this is explained in Methodology 3). The Water Code directs that water suppliers must compare their actual water use in 2020 with their calculated targets to assess compliance. In addition, water suppliers will report interim compliance in 2015 as compared to an interim target (generally halfway between the baseline water use and the 2020 target level). The years 2015 and 2020 are referred to in the methodologies as compliance years. All baseline, target, and compliance-year water use estimates must be calculated and reported in gallons per capita per day (GPCD). Water suppliers have some flexibility in setting and revising water use targets:

- A water supplier may set its water use target and comply individually, or as part of a regional alliance (see Methodology 9: Regional Compliance).
- A water supplier may revise its water use target in its 2015 or 2020 urban water management plan or in an amended plan.
- A water supplier may change the method it uses to set its water use target and report it in a 2010 amended plan or in its 2015 urban water management plan. Urban water suppliers are not permitted to change target methods after they have submitted their 2015 UWMP.

3.7.3 Data Reporting

DWR will collect data pertaining to urban water use targets through three documents: (1) through the individual supplier UWMP; (2) through the regional UWMP; and (3) through regional alliance reports.

Water suppliers that comply individually must report the following data in their UWMP (applicable UWMP dates are included in parentheses).

- Baseline Gross Water Use and Service Area Population (2010, 2015, 2020)
- Individual 2020 Urban Water Use Target (2010, 2015, 2020) and Interim 2015 Urban Water Use Target (2010)
- Compliance Year Gross Water Use (2015 and 2020) and Service Area Population (2010, 2015, 2020)

- Adjustments to Gross Water Use in the compliance year (2015, 2020)
- Water suppliers who choose Target Method 2 also must provide Landscaped Area Water Use and Baseline CII Water Use data (2010, 2015, and 2020).
- Water Suppliers who choose Target Method 4 must provide the components of calculation as required by Target Method 4.

3.7.4 District Compliance

As previously stated, the OH System is operated under an agreement between United and the OH Customers. In that agreement, each customer is assigned an annual allocation for OH water, and a maximum flow rate at which water can be received. A list of OH customers and their contract amounts for OH water is provided in Table 3-3.

As per the requirements of the California Water Conservation Bill of 2009 (SBX7-7, enacted November 2009) each retail water agency will be required to reduce the average per capita daily water consumption by 20 percent by December 31, 2020 (also known as the 20 x 2020 Plan).

Each of the District's customers will be required to reduce their consumption by 20 percent by 2020. However, most of the District's customers have multiple sources of water to meet demand requirements. These customers may reduce their purchase of United water, or they may reduce purchase/production of other supplies. United has no control of whether the customers reduce their purchase of United water or other water sources. Therefore, United will be able to provide water to meet customers' annual allocations up to a maximum of 11,380 AF/Yr and meet requests for providing available customer groundwater credits up to a maximum of 53 CFS in the OH Pipeline.

3.7.5 Water Use Reduction Plan

As a wholesaler, the District is not required to meet the 20 percent water demand reduction as required of retailers by recent legislation SBX7-7. The District's water demand management plan is summarized in Section 6. Contact each of the District's wholesale customers for details regarding their water demand reduction programs.

SECTION 4: SYSTEM SUPPLIES

4.1 UWMP Requirements

This section includes the following:

- Identify and quantify the existing and planned sources of water available for 2015, 2020, 2025, and 2030. (CWC, 10631(b))
- Indicate whether groundwater is an existing or planned source of water available to the supplier. (CWC, 10631(b))
- Indicate whether a groundwater management plan been adopted by the water supplier or if there is any other specific authorization for groundwater management. Include a copy of the plan or authorization. (CWC, 10631(b)(1))
- Describe the groundwater basin. Indicate whether the groundwater basin is adjudicated. Include a copy of the court order or decree. Describe the amount of groundwater the urban water supplier has the legal right to pump under the order or decree. (CWC, 10631(b)(2))
- For groundwater basins that are not adjudicated, provide information as to whether DWR has identified the basin or basins as overdrafted or has projected that the basin will become overdrafted if present management conditions continue, in the most current official departmental bulletin that characterizes the condition of the groundwater basin, and a detailed description of the efforts being undertaken by the urban water supplier to eliminate the long-term overdraft condition. (CWC, 10631(b)(2))
- Provide a detailed description and analysis of the location, amount, and sufficiency of groundwater pumped by the urban water supplier for the past five years (CWC, 10631(b)(3))
- Provide a detailed description and analysis of the amount and location of groundwater that is projected to be pumped. [Provide projections for 2015, 2020, 2025, and 2030] (CWC,10631(b)(4))
- Describe the opportunities for exchanges or transfers of water on a short-term or long-term basis. 10631(d)
- Include a detailed description of all water supply projects and programs that may be undertaken by the water supplier to address water supply reliability in average, single-dry, and multiple-dry years, excluding demand management programs addressed in (f)(1). Include specific projects, describe water supply impacts, and provide a timeline for each project. (CWC, 10631(h))
- Describe desalinated water project opportunities for long-term supply, including, but not limited to, ocean water, brackish water, and groundwater. (CWC, 10631(i))
- Provide information on recycled water and its potential for use as a water source in the service area of the urban water supplier. Coordinate with local water, wastewater, groundwater, and planning agencies that operate within the supplier's service area. (CWC, 10633)
- Describe the wastewater collection and treatment systems in the supplier's service area, including a quantification of the amount of wastewater collected and treated and the methods of wastewater disposal. (CWC, 10633(a))

- Describe the quantity of treated wastewater that meets recycled water standards, is being discharged, and is otherwise available for use in a recycled water project. (CWC, 10633(b))
- Describe the recycled water currently being used in the supplier's service area, including, but not limited to, the type, place, and quantity of use. (CWC, 10633(c))
- Describe and quantify the potential uses of recycled water, including, but not limited to, agricultural irrigation, landscape irrigation, wildlife habitat enhancement, wetlands, industrial reuse, groundwater recharge, indirect potable reuse, and other appropriate uses, and a determination with regard to the technical and economic feasibility of serving those uses. (CWC, 10633(d))
- The projected use of recycled water within the supplier's service area at the end of 5, 10, 15, and 20 years, and a description of the actual use of recycled water in comparison to uses previously projected. (CWC, 10633(e))
- Describe the actions, including financial incentives, which may be taken to encourage the use of recycled water, and the projected results of these actions in terms of acre-feet of recycled water used per year. (CWC,10633(f))
- Provide a plan for optimizing the use of recycled water in the supplier's service area, including actions to facilitate the installation of dual distribution systems, to promote recirculating uses, to facilitate the increased use of treated wastewater that meets recycled water standards, and to overcome any obstacles to achieving that increased use. (CWC, 10633(g))

4.2 Groundwater

The water supply for the OH system is provided solely by local groundwater, pumped from the 12 OH wells. Details regarding the OH wells were provided in Section 2. As noted in Section 3.2, average annual water demands on the OH system for the period 1984 to 2010 were 13,967 AF. Average annual water extractions from the upper aquifer wells for the period 1984 to 2010 were 14,093 AF. Average annual water extractions from the deep aquifer wells for the period 1984 to 2010 were 293 AF. Details regarding local groundwater basins are provided below.

4.2.1 Oxnard Plain Groundwater Basins

The groundwater basins within United's boundaries, including the Oxnard Plain Basin, are shown on Figure 4-1. A generalized cross section of the aquifers is shown in Figure 4-2. There are several aquifers at varying depths in the Oxnard Plain. The OH wells are located in the part of the aquifer system called the Oxnard Forebay, or the Montalvo Basin.

Source: UWCD

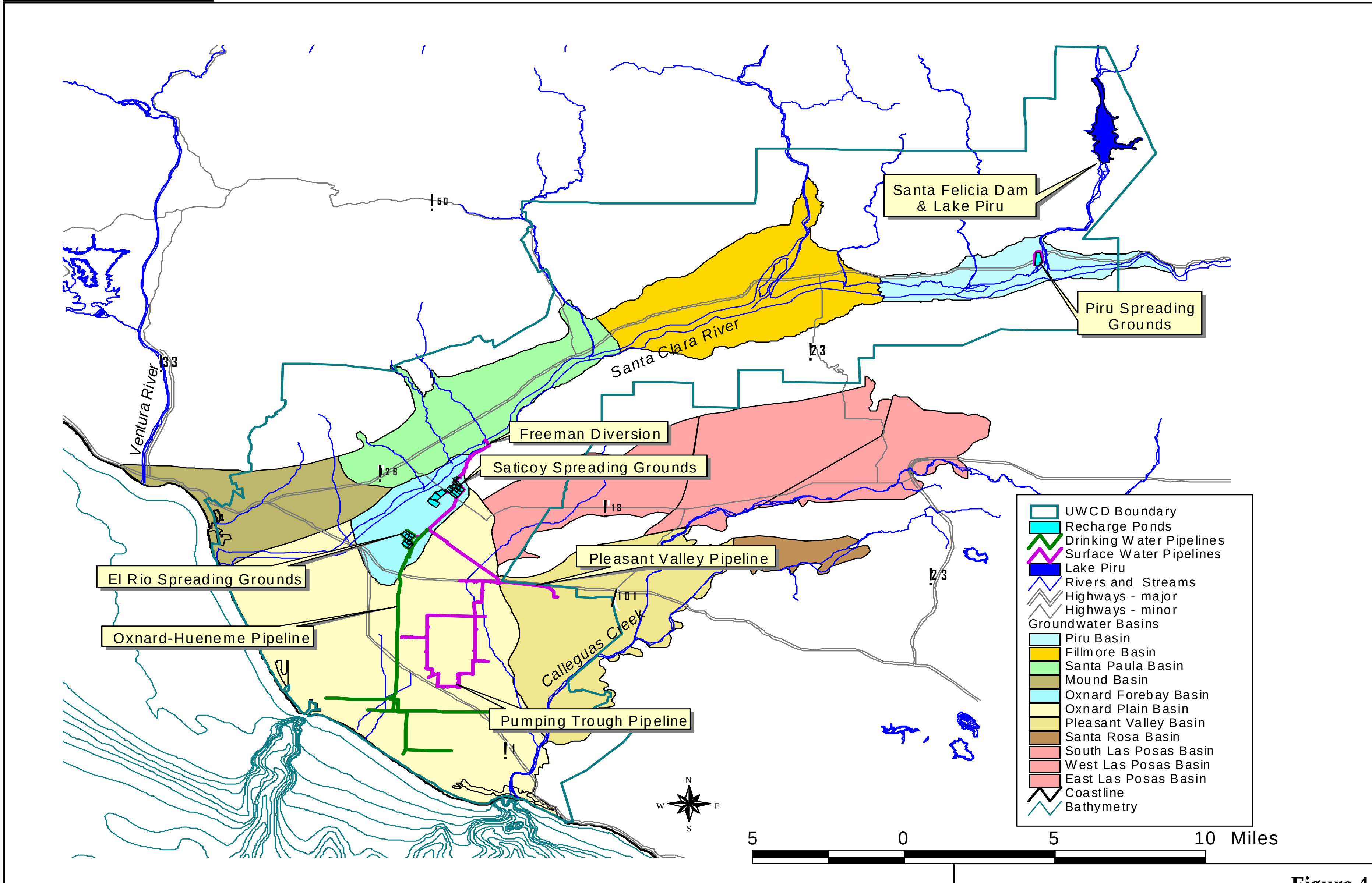


Figure 4-1
Groundwater Basins Within the District
United Water Conservation District
April 2011

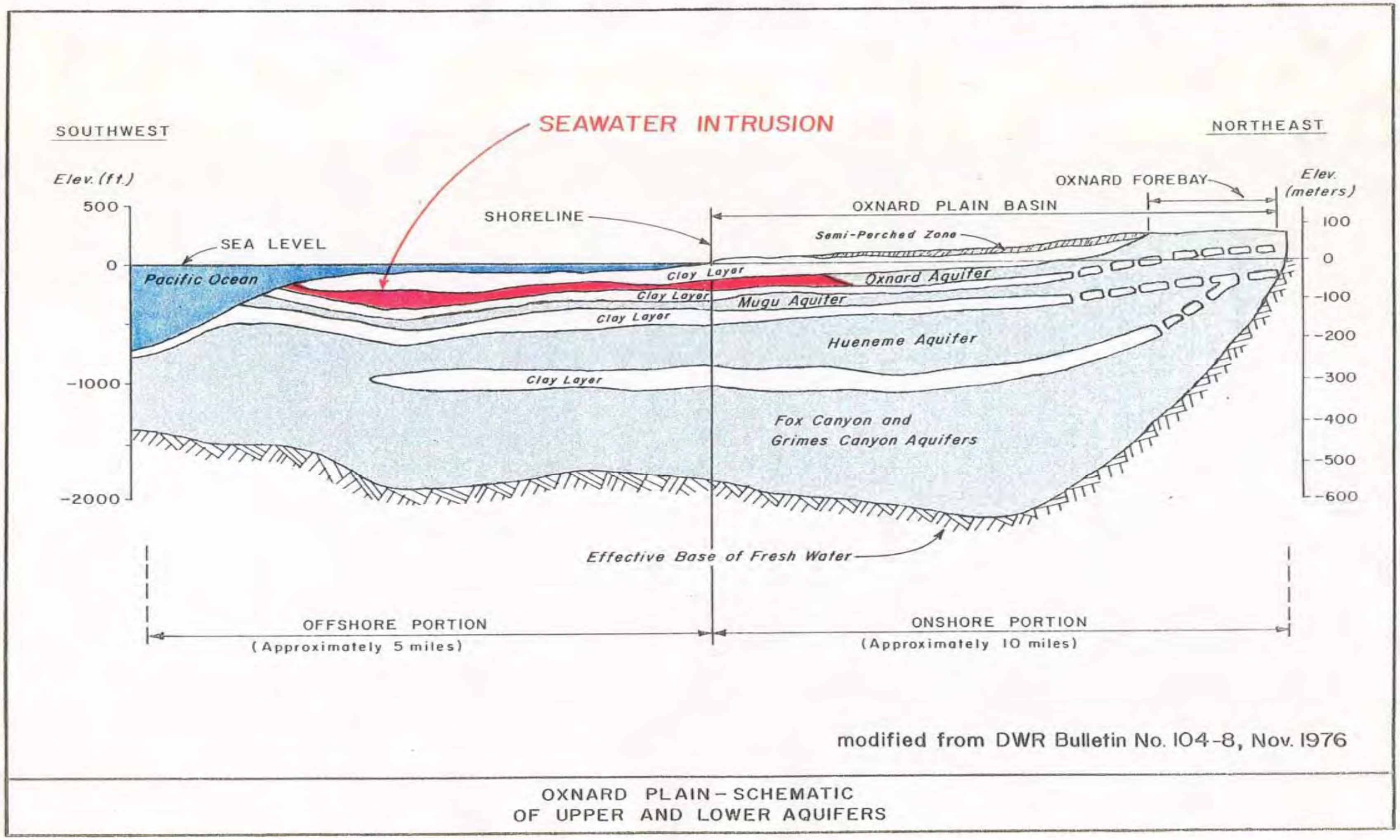


Figure 4-2
Cross-Section of the Oxnard Plain Aquifers
United Water Conservation District
April 2011

The Forebay is an important part of the Oxnard Plain aquifer system, where the aquifers are uplifted, truncated by erosion, and unconfined. The Forebay is recharged by infiltration from the Santa Clara River in its riverbed and by river water that is diverted to United's spreading basins. In areas outside the Forebay, the aquifers are covered by a confining clay layer. The Forebay is hydraulically connected to the other aquifers in the Oxnard Plain basin. Thus, the primary recharge to the Oxnard Plain basin is from underflow from the Forebay rather than from deep percolation of water from surface sources on the plain itself. In some areas of the Oxnard Plain, a semi-perched aquifer sits above the confining clay; this perched water is of poor quality and is not commonly used as a water supply. (FCGMA, 2007)

The Oxnard Forebay is the one of seven groundwater basins along the path of the Santa Clara River as it flows from the mountains of Los Angeles and Ventura Counties to the Pacific Ocean. The groundwater basins are within the more regional Ventura basin, which is an elongate east to west trending structurally complex syncline within the Transverse Range physiographic province (Yeats, et. al., 1981). Geology associated with the Transverse Range is primarily east to west trending folding and faulting that creates the elongate mountains and valleys that dominate Santa Barbara County and Ventura County. (FCGMA, 2007)

In the Oxnard Plain and Pleasant Valley areas, there exists an Upper Aquifer System (UAS) and Lower Aquifer System (LAS). The aquifers contain gravels and sands deposited along the ancestral Santa Clara River, within alluvial fans along the flanks of mountains, and in a coastal plain/delta complex at the terminus of the Santa Clara River. The aquifers are recharged by infiltration of streamflow, artificial recharge, mountain-front recharge along the flanks of the basins, direct infiltration of precipitation on the valley floor, bedrock outcrop in adjacent mountain fronts, and irrigation return flow. (FCGMA, 2007)

The Oxnard Plain basin, which is locally intruded with seawater and saline water, is almost entirely dependent on recharge in the Forebay to pressurize the UAS and LAS. Recharge in the Saticoy Spreading Facility contributes significantly to potentiometric levels of the UAS throughout the entire Oxnard Plain and Oxnard Forebay basin. The contribution of Forebay recharge to water level increases in the LAS is more restricted. Water level rise in the LAS, in response to recharge, is observed throughout the Forebay and the northern and western portions of the Oxnard Plain. Groundwater levels in the southern area have been below sea level for decades. (FCGMA, 2007)

The Upper Aquifer of the Oxnard Forebay and Oxnard Plain consists of the Mugu and Oxnard aquifers of Late Pleistocene to Holocene age. The UAS rests uncomfortably upon the LAS, with basal conglomerates in many areas of the Oxnard Plain. In the Oxnard Plain, the basal conglomerates are referred to as the Mugu Aquifer. (FCGMA, 2007)

The LAS consists of the Grimes Canyon, Fox Canyon, and Hueneme aquifers. The LAS can consist of the most upper portion of the Santa Barbara Formation as well as the San Pedro Formation. The Saugus member makes up the Upper San Pedro Formation and the Las Posas Sand member makes up the Lower San Pedro Formation. These formations were deposited during late Pliocene the late Pleistocene. The Fox Canyon aquifer is associated with the Los Posas Sand member, which was deposited during a shallow marine regression. As a result, the Fox Canyon Aquifer is extensive and is the most pumped aquifer associated with the LAS. The Grimes Canyon aquifer is a marine sand and gravel member of the Santa Barbara Formation. Beneath the Santa Barbara Formation is the Pliocene Pico Formation, a marine siltstone, sandstone, conglomerate and shale, generally considered to be non-water bearing. (Mukae and Turner, 1975) (FCGMA, 2007)

The general absence and discontinuity of prohibitively low permeability layers within the upper aquifers throughout the Forebay allows effective recharge of the basin. In the northeastern portion of the Forebay, the LAS has been uplifted and truncated where it subcrops beneath the UAS. In this area, recharge from the surface sources may enter the Upper Aquifer and subsequently into the underlying Lower Aquifer. Because of the considerably different transmissive capabilities of these two aquifer systems, recharged water preferentially recharges and remains in the Upper Aquifer. Using isotopic analysis, the U.S. Geological Survey estimated that 80 percent of recharge water enters and remains within the Upper Aquifer. (Izbicki et. al., 1995) The remaining 20 percent reportedly migrates through the upper system and recharges the Lower Aquifer. (FCGMA, 2007)

In addition to the District's recharge program, natural recharge processes are also significant. Deep percolation of water in the natural channel of the Santa Clara River is known to be prolific, and indeed this was a principal recharge mechanism sustaining the historic natural groundwater flow from the Forebay to the Oxnard Plain, before discharging to the ocean where aquifer units outcrop along the continental shelf. Much of this discharge is thought to take place in the near-shore submarine canyons that exist offshore near Port Hueneme and Point Mugu. Under low-flow conditions in the Santa Clara River, water diverted by United would otherwise recharge the Oxnard Forebay naturally by infiltrating through the alluvium of the active river channel. Other sources of natural recharge include the deep percolation of rainfall, underflow from adjacent groundwater basins, and mountain front recharge from South Mountain. (FCGMA, 2007)

The groundwater levels in the Oxnard Plain aquifers change considerably from year to year depending climatic conditions and pumping patterns. Historical groundwater elevations in key wells are shown in Figure 4-3. Current data for one of the Oxnard Forebay wells is provided in Figures 4-4 and 4-5. This data indicates that groundwater elevation in the last 80 years has been highly variable likely due to climatic conditions and groundwater pumping. However, these figures also indicate that over the last 10 years the groundwater elevation has been fairly stable, as compared to historical highs and lows, primarily due to the District's recharge program. (UWCD, 2011)

A summary of groundwater reliability in the Oxnard Forebay is provided in Section 5.5.

4.2.2 Strategy for Recharging the Oxnard Plain Aquifers

The strategy of United's groundwater recharge operation is to recharge surface water from the Santa Clara River into two spreading grounds and a mined gravel pit in the Oxnard Forebay. These grounds include the Saticoy spreading grounds northeast of Highway 118 and the El Rio Spreading grounds at the El Rio plant. Near the Saticoy spreading grounds is the Noble pit, a former gravel pit mined of its aggregate, and now converted to recharge basins. Water recharged in these facilities migrates over time into the other Oxnard Plain aquifers towards the coast. The average annual net recharge for El Rio was greater than 18,000 acre-feet for the years 1995 to 2006.

Another element in United's recharge operations is the in-lieu supply of surface water to farms in the southeastern Oxnard Plain Basin and the Pleasant Valley Basin. This surface water supply reduces pumping in a critical portion of the District where overdraft is the greatest. Direct conveyance of water to the area of demand reduces the need to pump groundwater and allows recovery of the depressed water levels.

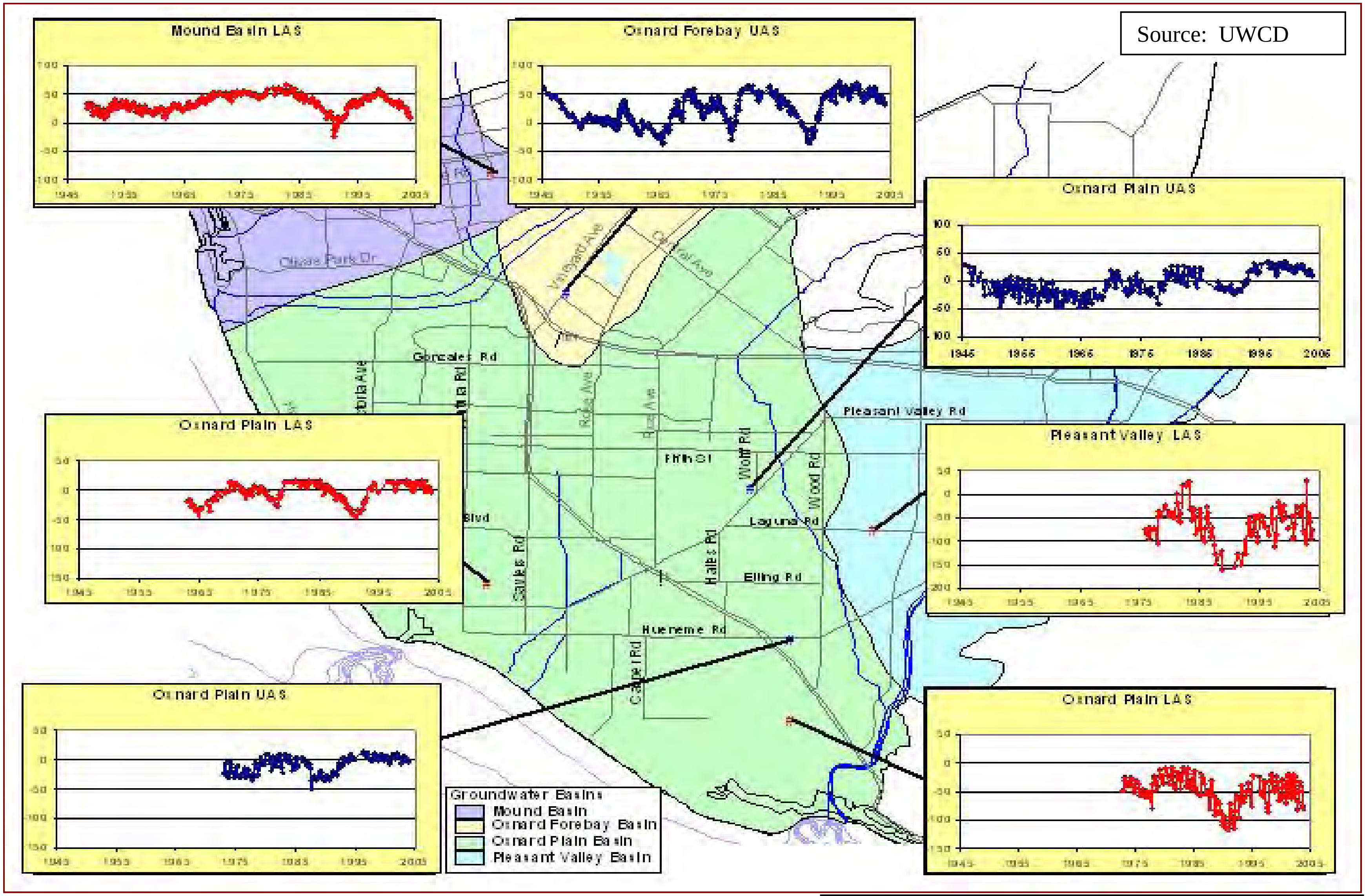
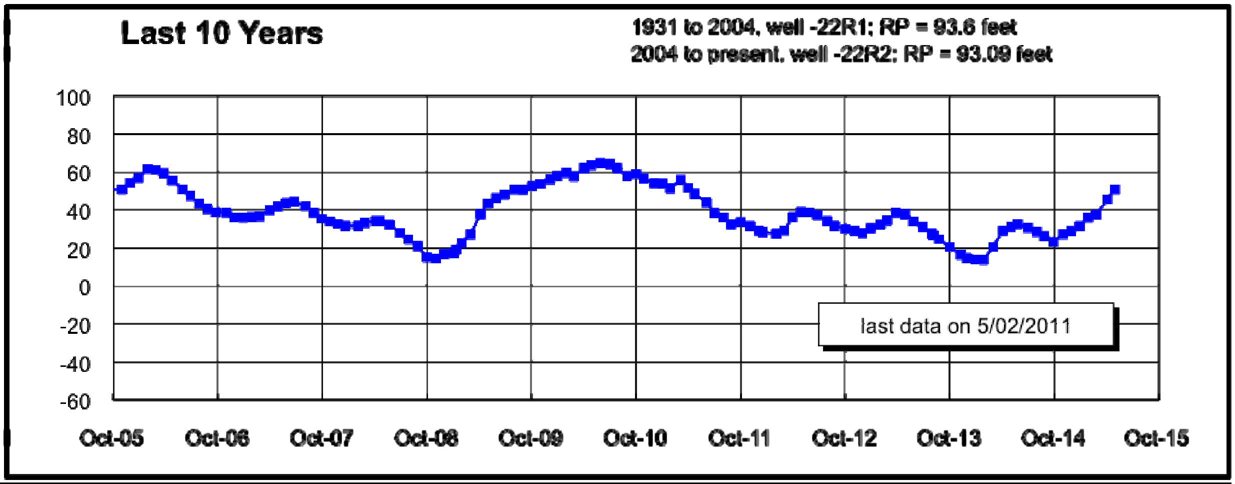


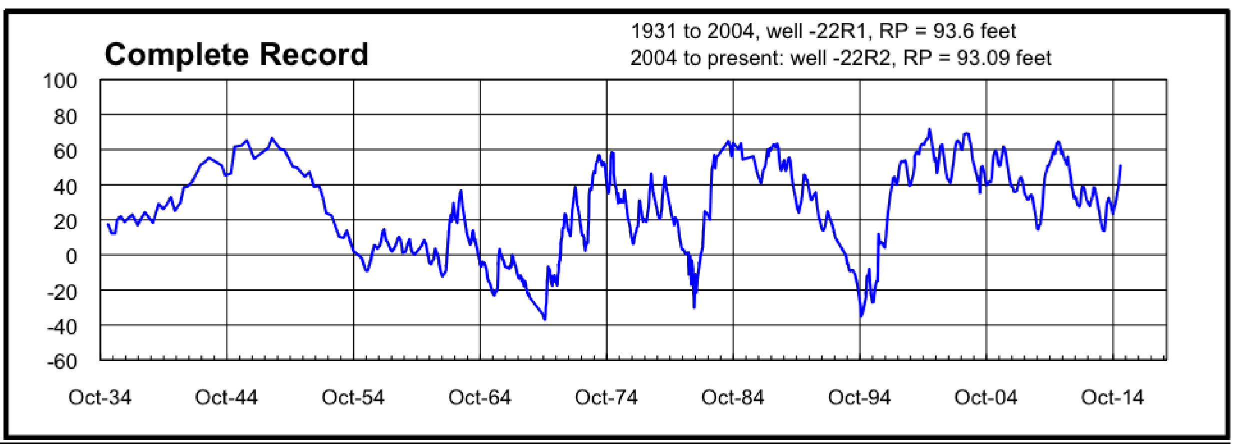
Figure 4-3
Historical Groundwater Elevations in Key Wells
United Water Conservation District
April 2011

Figure 4-4
Well 2N/22W-12R1 Groundwater Elevations vs Time 2001 to 2011



Source: UWCD, 2011.

Figure 4-5
Well 2N/22W-12R1 Groundwater Elevations vs Time 1930 to 2011



Source: UWCD, 2011.

Grant conditions provided to United by the State Water Resources Control Board also place limits on how the Oxnard Forebay groundwater basin is operated. These conditions – no longer thought to remain in effect – are provided in Appendix E. Once the groundwater level in the Oxnard Forebay falls below a preset critical level, recharge operations in the Forebay have priority over diversions for agricultural irrigation across the plain, and the deep aquifer wells must be pumped in preference to the shallow aquifer wells. This condition does not affect the OH water supply, but it does affect the quality of the water delivered. However, in a water supply emergency, water deliveries to the OH System would have a higher priority than the grant conditions, to protect human health.

4.2.3 Adjudication

As previously noted, the District pumps groundwater from the Oxnard Forebay Basin. The Oxnard Plain basins are not adjudicated.

4.2.4 Overdraft of the Oxnard Plain Aquifers

Local seawater intrusion was observed in the 1930s and 1940s along the shores of the Port Hueneme area as groundwater levels decreased and chloride levels increased in wells. This drop in groundwater levels on the Oxnard Plain basin coincided with rapid local urban development and significant expansion in agriculture. Within 20 years, seawater intrusion in the Port Hueneme area had extended as much as 3 miles inland. In some of the affected wells, chloride concentrations reached nearly 20,000 mg/L. This seawater intrusion into the Upper Aquifer System (UAS) was located adjacent to the Hueneme Submarine Canyon that is directly offshore of Port Hueneme. Seawater intrusion also occurred in the UAS near Point Mugu area adjacent to the Mugu Submarine Canyon that extends offshore from Mugu Lagoon. Figure 4-6 indicates the local areas of seawater intrusion. Groundwater levels in the Lower Aquifer System (LAS) also dropped below sea level in the late 1950s. (FCGMA, 2007)

In the Point Mugu area, chlorides have not significantly decreased over the past two decades. Instead, chloride concentrations continued to increase in the area of Mugu Lagoon, reaching concentrations almost as high as seawater in some wells. Several trends in saline intrusion are evident on the south Oxnard Plain. In the more southeastern Point Mugu lobe, concentrations of chloride are generally higher than in the past both in the LAS and UAS. (FCGMA, 2007)

Construction of the improved Freeman Diversion has helped bring the UAS into balance. Seawater intrusion has been at least partly reversed in the UAS, near the Santa Clara River. However, the LAS and UAS to the south are still being "mined." Overall extractions exceed recharge by approximately 20,000 AF/Yr. The seawater intrusion front for the deep aquifers may have advanced onshore in some areas. United's current groundwater management strategies deal with intrusion of both the UAS and LAS. Available storage within the Oxnard Forebay is estimated to be 38,000 AF.

4.2.5 Moving Pumping Inland

The primary purpose of constructing the OH System in the 1950s was to move pumping inland, away from the coast. As seawater encroached into the aquifers near the coastline, it threatened the water supply of urban areas (and all overlying land uses).

There are hydrogeological benefits to moving pumping inland, closer to the points of recharge. More water can be pumped from those locations without drawing groundwater levels below sea level, which draws seawater into the aquifers. Those hydrogeologic benefits remain valid today. It is important for the OH System to remain viable and cost-effective, so that the OH Customers will continue to use OH water instead of their own wells nearer to the coastline. The GMA pumping allocation for the OH wellfield (discussed in Section 3) provides such an incentive.

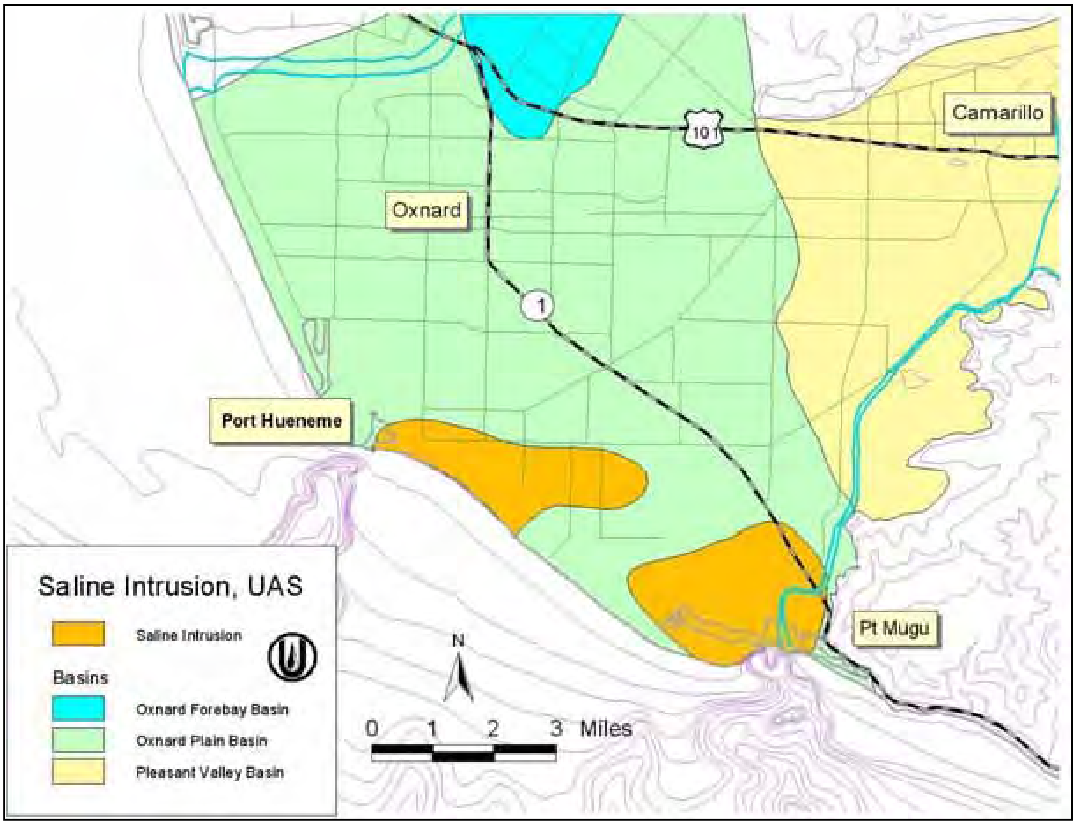


Figure 4-6
Areas of Seawater Intrusion on Oxnard Plain 2006
United Water Conservation District
April 2011

4.3 Local Surface Water

4.3.1 Availability

Closely related to the availability of groundwater is the availability of surface water in the Santa Clara River, used to recharge the Oxnard Plain and Pleasant Valley aquifers. The Santa Clara River carries high flows in most winters, but nearly stops flowing in the late summer. Peak flows in large winter storms have exceeded 140,000 CFS. By late summer, those flows usually recede to a range of 5-20 CFS. In some years, the river has dried up completely by late summer. That has not happened since the last drought, before the construction of the improved Freeman Diversion; and it remains to be seen whether the improved Freeman Diversion will dry up in droughts, given increased wastewater production upstream in the watershed.

Surface water flows can vary considerably from year to year. United's operating strategy is to spread as much water as possible in wet years. Although groundwater levels in the Oxnard Plain and Oxnard Forebay basins can respond rapidly to a wet year, the normal trend is for groundwater levels to gradually change over a multiple-year period in response to changing hydrologic conditions. As an example, after the wet year of 1998, many wells in the Oxnard Plain temporarily became artesian, flowing at the surface from aquifer pressure.

4.3.2 Lake Piru Operations

In addition to its groundwater recharge facilities, United Water owns and operates Lake Piru. Winter storm runoff is stored in the lake for later release downstream. In the late summer or early fall, water is released from Lake Piru at a high flow rate of 400 to 600 CFS. Typically, approximately 10,000 to 50,000 AF of water is released downstream each year. Average releases are approximately 27,000 AF per year. Some of that water reaches the Freeman Diversion 26 miles downstream, and is used to recharge the Oxnard Plain. Since the Oxnard Plain aquifers are in a state of overdraft, United's operating priority is to convey as much water as possible to the Freeman Diversion each year. However, the upstream groundwater basins (the Piru basin, Fillmore basin, and Santa Paula basin) naturally percolate some of the water released each year. The percentage of water reaching the Freeman Diversion from Lake Piru has varied from about 20 percent to almost 90 percent, depending on many factors.

In the past, United Water has exercised its option to perform an early release from Lake Piru when high nitrates threatened the OH wellfield. That option remains available for any future water quality emergencies in the OH wellfield

4.3.3 Supplemental M&I Water Program

The Supplemental M&I Water Program is a program that provides OH customers additional water above their reduced OH suballocation. This is a joint program between United Water and Calleguas MWD. Calleguas MWD has partially funded the Conejo Creek Diversion, which pumps surface water from Conejo Creek to Pleasant Valley County Water District, PVCWD, in the eastern part of United's service area. This program allows PVCWD to reduce groundwater pumping from the Pleasant Valley Basin, which is the most over pumped basin in United’s service area. GMA credits accumulated as a result of that reduced pumping are transferred from PVCWD to Calleguas MWD. Those credits are then transferred from Calleguas MWD to United Water, and credited to the OH wellfield. This program allows additional pumping from the OH wellfield, which supplies participating OH customers. As part of this program, participating OH customers pay a surcharge for the supplemental water received.

That surcharge is transferred to Calleguas MWD as partial compensation for their costs for the Conejo Creek project. Since 2005, five (5) OH customers have participated in the program. The surcharge paid by Calleguas customers is lower than that paid by OH customers who are not Calleguas customers. As part of this program, United's groundwater management team exercises discretion each year on how much supplemental M&I water can be used without adverse impacts to the aquifers.

United’s contract with Calleguas MWD allows for United to withdraw from the program if necessary. United is under no obligation to continue the program and delivering water to OH customers will always take precedence over the Supplemental M&I Water Program.

4.4 Imported State Project Water

The Ventura County Flood Control District (now the Watershed Protection District) is a contractor for the State Water Project, SWP, with an annual entitlement to 20,000 acre-feet per year of State water. The County in turn contracted with three local agencies to distribute that SWP water entitlement: 5,000 AF/Yr to Casitas Municipal Water District, 10,000 AF/Yr to the City of Ventura, and 5,000 AF/Yr to United Water Conservation District. United Water is the only agency of the three that has received any of its SWP water. To deliver SWP water to United Water, the California Department of Water Resources releases the water from Pyramid Lake, where it flows down Piru Creek into Lake Piru. The water can then be released downstream as part of the annual water conservation release from Lake Piru. Some of that water will arrive at the Freeman Diversion, where it can be recharged into the Oxnard plain aquifers, contributing to the OH water supply.

In 2004, United purchased some of the City of Ventura's annual entitlement to SWP water. Some 2,000 AF of the City's entitlement was delivered into Lake Piru that year. There is potential for the purchase of some or all of Ventura and Casitas' SWP water in future years for the purpose of groundwater recharge.

The purchase of SWP water is not part of the normal operation of the OH System and United has no plans to do so on a long-term basis. United purchases SWP water for the benefit of the aquifer system, on behalf of all pumpers. In practice, the SWP water is purchased with funds from United's State Water Fund, which is financed through local property taxes. However, such property tax assessments are not collected from Oxnard. Oxnard purchases SWP water from Calleguas MWD, offsetting pumping and directly benefiting the aquifers. Historically, a sharp distinction has been made between those who are annexed to Calleguas MWD and those who are not. As a policy matter, Calleguas and its parent agency, Metropolitan Water District, are normally the sole suppliers of SWP water within their service areas.

Studies on SWP reliability conducted by DWR (2010) indicate that current and future deliveries of the District's SWP allotment will be significantly affected by many factors, including substantial changes resulting from Delta pumping restrictions and climate change. These estimates indicate that projected SWP deliveries to contractors may vary between 7 percent and 60 percent (DWR 2010). The lowest minimum delivery (7 percent) is based on the driest year (1977). However, recent water supply and reliability analysis indicates that more significant reductions in SWP water delivery may occur over time. These reductions are due to one or more factors including the following: legal decisions to protect endangered species, short-term and long-term climatic factors, drought contingency, etc.

Some OH customers also receive water from Calleguas MWD. That water is imported from Northern California. To the extent that those customers utilize OH water, that amount of water does not need to be imported into Ventura County.

Currently, DWR estimates it will be able to deliver 80 percent of requested SWP water in 2011. In 2010, the SWP delivered 50 percent of a requested 4,172,126 acre-feet, up from a record-low initial projection of 5 percent due to lingering effects of the 2007 to 2009 drought. Deliveries were 60 percent of requests in 2007, 35 percent in 2008, and 40 percent in 2009. The last 100 percent allocation, difficult to achieve even in wet years due to pumping restrictions to protect threatened and endangered fish, was in 2006.

4.5 Future Water Supply Projects

United has several future water supply projects that are being studied and considered, as discussed below:

4.5.1 Ferro-Rose Recharge Project

The Freeman Diversion presently has the physical capacity to divert more water than can be put to beneficial use. In wet years, the District can divert its water rights limit of 375 CFS for up to about four weeks. After that point, the spreading ponds exhibit reduced percolation rates, and the gravel basins are nearly full. Some water that would otherwise be diverted at the Freeman Diversion must then flow to the ocean.

The Ferro-Rose Recharge Project would deliver surface water diverted at the Freemen Diversion into new gravel pits near United's existing facilities. Those new gravel pits would include the Riverpark pits, the Ferro pit, and the Rose Pit, which have been mined of their aggregate. Use of those pits would increase the yield of the Freeman Diversion, increasing the amount of water recharged into the aquifers. United acquired the Ferro and Rose basins in 2009.

The Ferro-Rose Recharge Project would be constructed in several phases. Phase 1 may start as early as 2013, and would convey up to 375 CFS of diverted water into the new gravel basins. This phase would not require a change to United's water license to divert water. The Phase 1 facilities are shown in Figure 4-7. Phase 2 would increase the diversion rate to 1,000 CFS, which would require a change to United's surface diversion water rights. Receiving a new permit from the State Water Resources Control Board to increase the diversion rate could take 10 years or more. Therefore, Phase 2 would be constructed after the year 2023. The Phase 2 facilities are shown in Figure 4-8.

The Ferro-Rose Recharge Project would improve the reliability of the OH water supply. With an increased yield of up to 10,000 AF/Yr on average, this would help bring the Oxnard Plain aquifers into long-term balance.

4.5.2 Oxnard's GREAT Program

The City of Oxnard is implementing its GREAT program, which will develop additional water supplies for the City. The GREAT program includes several elements, including advanced treatment of wastewater, potential injection of treated wastewater into the ground, potential supply of treated wastewater to agricultural users in the Oxnard plain, treatment of OH water to remove salts, and transfers of GMA credits to Oxnard and United to allow increased pumping. The GREAT program will affect the delivery of water through the OH system. Some of the additional water to be developed by Oxnard will be delivered through the OH System. In general, RO plants are operated at a steady flow. So, instead of peaking on demand, demands on the OH system should flatten. That would improve the reliability of the OH supply during peak periods.

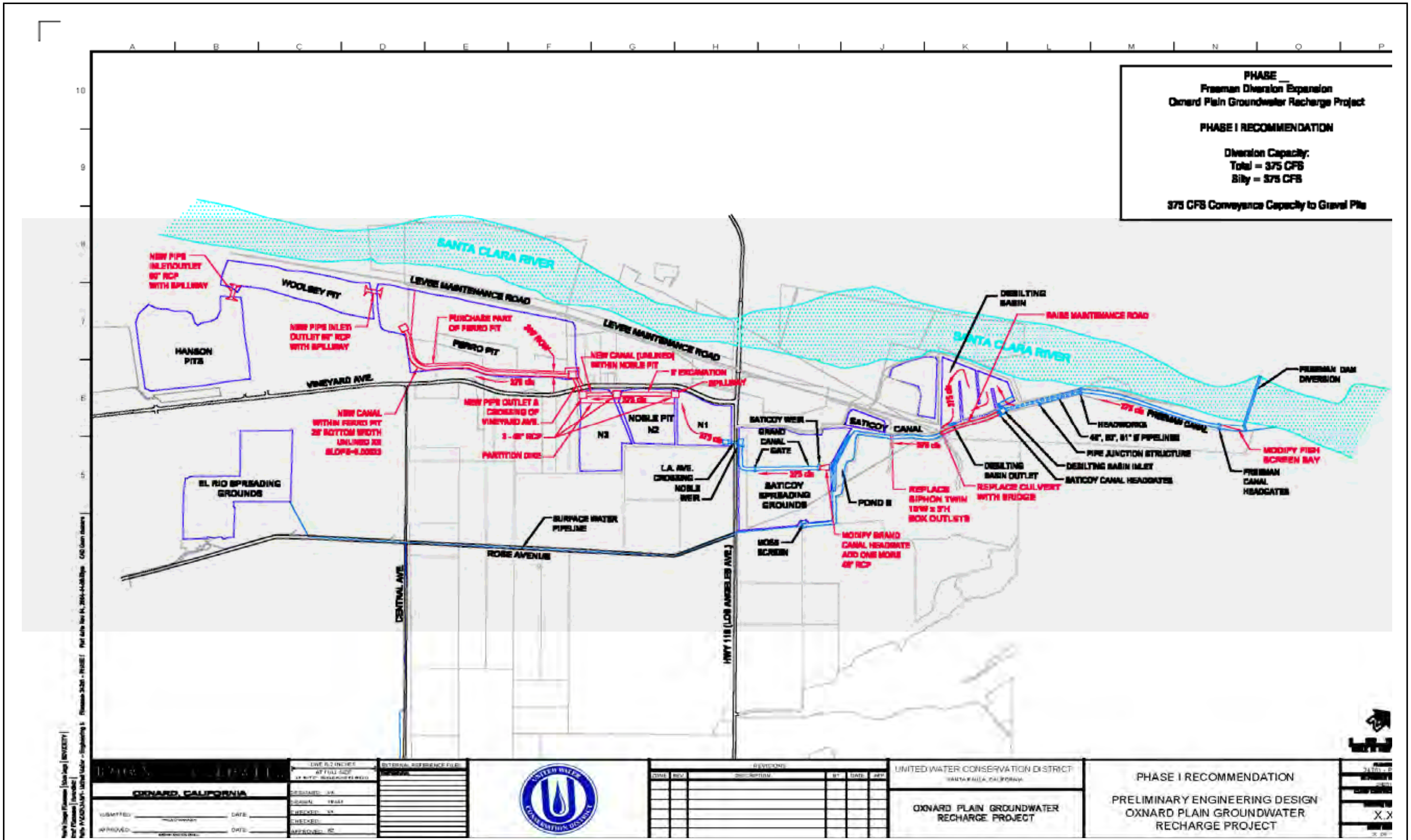


Figure 4-7
Ferro-Rose Recharge Project Phase 1
United Water Conservation District
April 2011

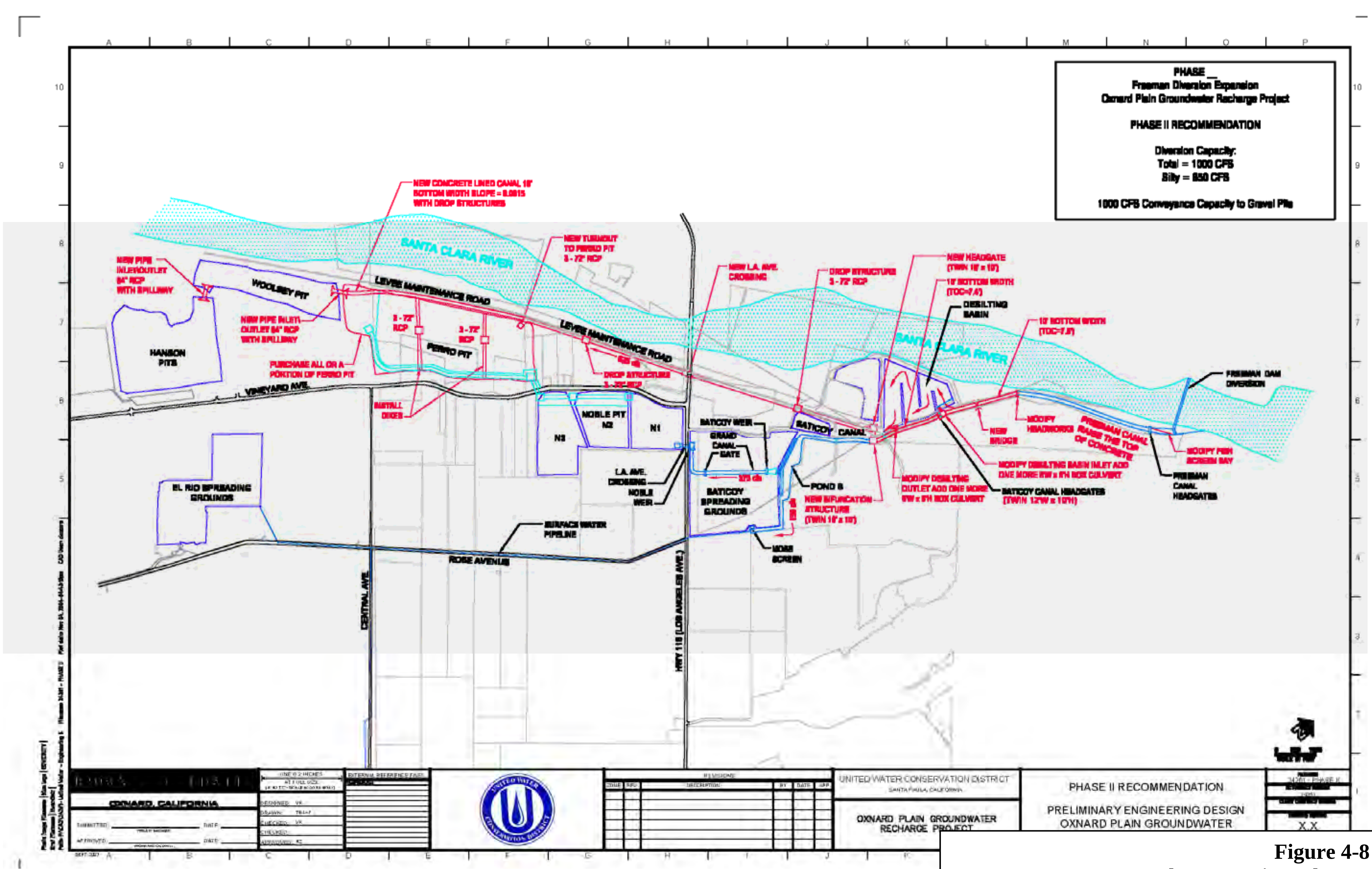


Figure 4-8
Ferro-Rose Recharge Project Phase 2
United Water Conservation District
April 2011

The GREAT program has undergone, and will continue to undergo, extensive hydrogeological evaluation to ensure that it will not harm the Oxnard Plain aquifers. Its net effect is to move pumping away from the coast and into the more easily recharged Oxnard Forebay. It is therefore assumed that the GREAT program will benefit the aquifers. Oxnard is the largest OH customer. By improving the overall reliability of Oxnard's water supply, the GREAT program will help ensure the reliability of the water supply for all OH users.

4.5.3 - Sewering El Rio

One of the most important projects to protect water quality of the OH wellfield has been the recent installation of sewers in the El Rio area, located next to, but downgradient of, the OH wellfield. That area consists primarily of residences that are served by individual septic systems. Such septic systems are a source of nitrates, which leach into the groundwater supply. Ventura County has taken the lead role on a project to connect those residences into the City of Oxnard's wastewater collection system. Project construction is nearly complete. This project will slightly reduce the groundwater supply in the Forebay.

4.5.4 - Desalination

While United has no plans to develop capabilities to deliver desalinated water, the District is continually looking for new ways to develop available resources to improve the OH system and District groundwater recharge activities.

4.5.5 - Imported State Project Water

The Ventura County Flood Control District (now the Watershed Protection District) is a contractor for the State Water Project, SWP, with an annual entitlement to 20,000 acre-feet per year of State water. The County in turn contracted with three local agencies to distribute that SWP water entitlement: 5,000 AF/Yr to Casitas Municipal Water District, 10,000 AF/Yr to the City of Ventura, and 5,000 AF/Yr to United Water Conservation District. United receives the SWP water from DWR via Pyramid Lake, where it flows down Piru Creek into Lake Piru. The water can then be released downstream as part of the annual water conservation release from Lake Piru. Some of that water will arrive at the Freeman Diversion, where it can be recharged into the Oxnard plain aquifers, contributing to the OH water supply.

The purchase of SWP water is not part of the normal operation of the OH System. In future emergencies or severe droughts, additional SWP water might become available to supply water to the El Rio spreading grounds. Institutional and contractual arrangements would need to be made, including agreements with Calleguas MWD. A draft preliminary feasibility report on the importation of additional State Water has been prepared by United Water to evaluate the option of importing some of Casitas MWD and Ventura's State Water Project water into United's service area.

Studies on SWP reliability conducted by DWR (2010) indicate that current and future deliveries of SWP water will be significantly affected by many factors, including substantial changes resulting from Delta pumping restrictions and climate change. These estimates indicate that projected SWP deliveries to contractors may vary between 7 percent and 60 percent (DWR 2010). The lowest minimum delivery (7 percent) is based on the driest year (1977). However, recent water supply and reliability analysis indicates that more significant reductions in SWP water delivery may occur over time. These reductions are due to one or more factors including the following: legal decisions to protect endangered species, short-term and long-term climatic factors, drought contingency, etc.

4.6 Recycled Water

Several sources of recycled wastewater are available in United's service area. Some of that recycled water is already being put to beneficial use, either directly or indirectly. United does not operate any wastewater recycling facilities, but many water agencies within the District service area operate treatment plants. Tables 4-1 and 4-2 summarize the local wastewater collection, treatment, and disposal. Wastewater from these facilities eventually finds its way into the United system, either directly through groundwater recharge or indirectly through stream discharges. However, these sources contribute to the water supply through the initiative of the agencies that control them. The sources of recycled water are summarized below.

United is actively encouraging the use of recycled water by farmers. United has participated in several Oxnard Plain Users Group meetings to provide information and encourage consensus that recycled water is an essential part of the future water supply for agriculture in Ventura County. Recycled water uses and projects may account for nearly 50,000 AF by 2035 (see Table 4-3 for additional details). Potential uses include use by wildlife habitat, groundwater recharge including indirect potable reuse, and agriculture irrigation. United is confident that recycled water will be used within a few years. Groundwater supply reliability for M&I use will be significantly improved once local farmers on the Oxnard Plain use recycled water. The District does not own or distribute recycled water to retail customers, therefore the District does implement incentives or methods to optimize recycled water use.

4.6.1 Los Angeles County

There are two wastewater treatment plants in Los Angeles County that discharge tertiary treated wastewater into the Santa Clara River, upstream from United's service area. A total of over 30 CFS is discharged at present. Due to growth in Los Angeles County, that flow is increasing over time. During most of the year, this recycled water flows down the Santa Clara River and percolates into the Piru groundwater basin, where it blends with local groundwater and is repumped, or it migrates underground toward the Fillmore basin. In wetter periods, when the Santa Clara River is flowing well, the wastewater blends with surface water and contributes to the surface water supply. Some of that water is diverted at the Freeman Diversion. Fortunately, in such wet periods, a great deal of blending with natural storm water occurs. Only in very wet periods, when flows at the Freeman Diversion exceed 375 CFS, does that recycled water flow to the ocean. That happens about four weeks a year on average. Thus, little of the recycled water produced in Los Angeles County goes to waste, and is used indirectly, after mixing with other water sources and being filtered underground.

4.6.2 Fillmore and Piru Wastewater Treatment Plants

The Fillmore wastewater treatment plant and the Piru wastewater treatment plant both discharge treated wastewater into percolation ponds. That water recharges the Fillmore and Piru groundwater basins, and is beneficially used via well pumping, after mixing with local groundwater supplies and being naturally-filtered underground.

Table 4-1
Wastewater Collection and Treatment (AFY)

	2005	2010	2015	2020	2025	2030	2035
Wastewater collected and treated in service area (1)	42,000	55,000	60,000	60,000	53,000	49,000	49,000
Volume that meets recycled standards (1)	0	7,000	14,000	18,000	18,000	18,000	18,000

Notes:
(1) All values rounded up to nearest 1,000 AF.

Table 4-2
Disposal of Wastewater (non-recycled) (AFY)

Method of Disposal	Treatment Level	2005	2010	2015	2020	2025	2030	2035
Percolation-Evaporation Ponds (1)	Secondary	1,400	1,600	1,800	2,000	2,000	2,000	2,000
Stream Discharges (2)	Secondary	40,403	53,078	58,153	57,403	52,703	48,003	48,003

Notes:
(1) All values rounded up to nearest 100 AF.
(2) All values rounded up to nearest 1,000 AF.

Table 4-3
Recycled Water Uses – Actual and Potential (AFY)

Recycled Water Use	Treatment Level	2010	2015	2020	2025	2030	2035
Wildlife Habitat (1)	Tertiary	8,000	8,000	8,000	8,000	8,000	8,000
Groundwater Recharge (1,2)	Secondary/ Tertiary	44,000	46,000	44,000	37,000	32,000	32,000
Agriculture (1)	Tertiary	4,000	7,000	9,000	9,000	9,000	9,000

Notes:
(1) All values rounded up to nearest 1,000 AF.
(2) Includes indirect potable reuse.

4.6.3 Santa Paula Wastewater Treatment Plant

The Santa Paula wastewater treatment plant is located about two miles upstream of the Freeman Diversion. The City of Santa Paula completed construction of a new wastewater treatment plant in early 2010. The new plant provides secondary treatment of the local wastewater. Current plant design includes an annual average daily flow of 3.4 MGD. It presently discharges approximately 2 MGD of secondary effluent into the percolation/evaporation ponds located adjacent to the plant site. New recharge ponds percolate the recycled water to the Santa Paula groundwater basin. The City may eventually use some of their recycled water for irrigation purposes. Whether or not that happens, the wastewater will continue to contribute to the local water supply one way or another.

4.6.4 Saticoy Sanitary District

Saticoy Sanitary District operates a wastewater plant about two miles downstream of the Freeman Diversion. They percolate about 130 AF/Yr of wastewater into percolation ponds north of the Santa Clara River. That water recharges the Oxnard Forebay, and indirectly contributes to the water supply for the OH system. Although that recycled water is unlikely to migrate towards the OH wellfield, it supplies other pumpers that draw from the Forebay.

4.6.5 City of Oxnard

The City of Oxnard operates a wastewater plant that discharges approximately 20,000 AF/Yr of secondary treated effluent into the ocean. That represents a significant water resource that could benefit the Oxnard plain. The City of Oxnard has investigated the beneficial use of that wastewater through further treatment, which would allow it to be used for agricultural irrigation and even direct groundwater recharge. Use of the City's recycled water is part of the City's GREAT program, previously described, which is in the early stages of implementation. The GREAT program is expected to provide approximately 1,275 AFY of recycled water treated to tertiary standards for M&I use by 2012, as well as 6,050 AFY for use by agricultural customers. This amount is expected to increase to 28,000 AFY (total) within the next 20 years. This water could be delivered directly to agricultural customers, used as part of a seawater intrusion barrier or injected directly into groundwater wells. The GREAT program will encourage use of recycled water by pricing it well below the price of non-recycled water, making more water available for groundwater recharge. United will participate in several stages of that program, in partnership with Oxnard. Thus, recycled water will become an important part of the water supply picture on the Oxnard plain.

4.6.6 City of Ventura

The City of Ventura operates a wastewater treatment plant that discharges treated water into the Santa Clara River estuary, from where it flows into the ocean. Prior to 2008, the city was required by permit to discharge at least 5.6 MGD of treated water into the estuary, to maintain habitat there. Some recycled water is pumped and used for irrigation purposes at the Buenaventura Golf Course, the Olivas Park Golf Course, and other locations within the city. However, Ventura's discharge to the estuary is under review and some environmental advocates are pushing to halt Ventura's discharges to the estuary. On the other hand, some arguments have been made that Ventura's discharges are sustaining habitat in the estuary and provide environmental benefits. The effects of the City's discharges are being studied in detail. Should Ventura be required to stop estuary discharges, which seems unlikely to happen within the next 5 years, additional recycled water could become available for use for irrigation purposes. Although uncertain, there is a chance that any additional recycled water supply could reduce the pumping on the Oxnard Plain.

4.6.7 Conejo Creek Project

At the Conejo Creek Diversion on Conejo Creek just south of the Ventura Freeway, water from the creek is pumped to irrigation customers, including Pleasant Valley County Water District on the eastern Oxnard plain. PVCWD pumps its own groundwater from the Oxnard plain aquifers and also receives river water from United Water. Thus, any Conejo Creek water received by PVCWD reduces their use of surface and groundwater. This increases the amount of water available to others. Part of the water in Conejo Creek comes from the Hill Canyon Wastewater Treatment Plant, operated by the City of Thousand Oaks. Thus, the Conejo Creek project is partly a recycled water project.

4.7 Water Quality Issues

4.7.1 Blending of OH Wells

The major water quality problem for the OH system is the occasional presence of high nitrate levels in some of the shallow aquifer wells. The OH wellfield is surrounded by strawberry fields, which are fertilized with nitrate-based fertilizer. There are also domestic septic systems in the El Rio area, both for individual residences and for institutions like Rio Mesa High School. It is thought that septic systems and agriculture contribute about equally to the nitrate problem. El Rio is located within the Oxnard Forebay, where both fertilizers and leached wastewater can percolate easily into the drinking water aquifer.

Typically, nitrates are low in the winter and spring, when surface water from the Santa Clara River is being recharged into the El Rio spreading grounds. The river water is usually low in nitrates, normally well under 10 mg/L; and that water strongly influences the wells. Normally, surface spreading stops around June of each year, due to reduced river flows. After that point, nitrate levels in some wells may increase. The increase is usually gradual, but sudden jumps in nitrate levels are frequently observed. It is not uncommon for one or more wells to exceed the Maximum Contaminant Level (MCL) for nitrate of 45 mg/L. Nitrate levels in each OH well are sampled and analyzed once a week, and nitrate levels are watched closely. All of the OH wells feed into a common manifold near the chlorine building. This allows a blending operation, which results in a delivered nitrate level within the MCL. To provide an emergency warning capability, there is a nitrate analyzer to continually monitor nitrate levels delivered from the El Rio plant. If nitrate levels approach the MCL, an alarm is sent out to the on-call operator.

During very dry periods, such as near the end of a several year drought, nitrate levels in some wells can exceed 100 mg/L or, less commonly, even 200 mg/L. Several wells can have high nitrates at one time. By that time, blending may no longer be adequate to ensure safe drinking water. At that time, a decision would be made to turn on the deep aquifer wells, which are very low in nitrates. With that additional supply, it is expected that nitrates in delivered water can be kept under the MCL.

4.7.2 MTBE Concerns

Several years ago, MTBE's from spilled gasoline were detected at the Poole Oil site along Vineyard Avenue, about 1,300 feet away from the nearest OH well (Well No. 15). United's groundwater staff were closely involved in monitoring that MTBE spill and the associated cleanup, which has been completed. The evidence indicates that the spill has been cleaned up and/or has migrated downstream from the wellfield. This problem will be monitored for several more years. In the event MTBE's are detected in any OH wells, use of those wells would be curtailed and, if necessary, the deep aquifer wells would be used.

4.7.3 Deep Aquifer Wells

The deep aquifer OH wells have not been used for production for over 10 years. They would be pumped only in extreme conditions, as follows:

- Very high nitrate levels in the shallow wells
- Low groundwater levels in the Oxnard Forebay
- Water quality or other emergency with the shallow water wells
- Failure of the shallow wellfield.

Although not used for production, the deep wells are usually run once a month to take water samples, and to test the equipment. Operating the deep aquifer wells introduces additional water quality problems. The high iron and manganese in those wells exceeds secondary MCL's. Despite the sequestering agent added, some effects on the chlorination residual can be expected. The deep wells have not been operated since the chloramination of the OH water was started in 2000.

Maintaining a balance between chlorine and ammonia is tricky at best, and adding varying blends of deep and shallow aquifer water to the mix can introduce chemical imbalances. This problem will require close operator oversight, and will have to be addressed on a trial and error basis once the deep wells come into use for the first time.

Operating the deep aquifer wells could also affect PHWA. It was United's understanding that there could be some scaling problems on the RO and ultrafiltration membranes at the PHWA treatment plant if deep well water is delivered. The OH water is normally fairly low in turbidity, and PHWA just uses bag filters to remove particulate matter. When iron and manganese react with chlorine, a precipitate can occur. The bag filters may not be heavy-duty enough to remove such fine particles. In addition, iron and manganese can cause heavy scaling just by their chemical nature. In the event the deep aquifer wells are used, United must give PHWA advance notice so that they can put anti-scaling measures into place, and weigh the option of receiving Calleguas water during such periods. They would also need to implement monitoring measures, to catch any problems early. The RO membranes are very costly and scaling presents a significant risk. United has been advised by PHWA that use of United’s deep aquifer wells would not damage their RO membranes.

Iron and manganese treatment of the OH deep aquifer well water could be considered. However, considering how seldom those wells are used, such additional treatment does not appear to be cost-effective or necessary at this time.

4.7.4 Flushing program

One typical problem with chloraminated water is the risk of nitrification in pipelines and reservoirs. With nitrification, ammonia-eating bacteria grow in the pipeline and cause the disinfection residual to drop, creating water quality problems including unpleasant odors. The OH system is fairly resistant to such nitrification because there are few dead spots where the water does not flow. The major area of concern is near the end of the OH pipeline, past the main PHWA turnout. Flows in that area can be low, causing the potential for nitrification.

To reduce the problem of nitrification, periodic flushes of the OH pipeline are conducted. These flushes can also introduce new water quality problems, particularly for PHWA. Flushes stir up sediment etc. in the pipeline, which can enter the PHWA turnout. High turbidities measured at their plant will shut it down automatically, to protect the equipment. It is necessary to notify PHWA in advance of doing a flush, so that they can shut down for a day or so. Even so, PHWA can have difficulties coming back on line, due to sediment that settles out in their pipeline.

4.7.5 Line Breaks And Repairs

After an OH line break, it is sometimes necessary to sterilize the pipeline and perform a system flush. This requires coordination with the OH customers. An emergency flush can create the same water quality problems for PHWA as a planned flush described above. One fortunate aspect of an unplanned flush is that it can delay the need for a subsequent regularly scheduled flush.

4.7.6 2010 Consumer Confidence Report

As a drinking water system, the OH System is subject to the annual reporting requirements of California and Federal regulations. An annual Consumer Confidence Report (CCR) is prepared for the OH System, and delivered to all OH customers. The larger OH customers (Oxnard and PHWA) use United's information to prepare their own CCR's. However, the smaller mutual water companies, who utilize OH water almost exclusively, use United's CCR as their own, and deliver it directly to their customers. A copy of the 2010 CCR is provided in Appendix F.

SECTION 5: WATER SUPPLY RELIABILITY AND WATER SHORTAGE CONTINGENCY PLANNING

5.1 UWMP Requirements

This section includes the following:

- Describe water management tools and options to maximize resources and minimize the need to import water from other regions. (CWC, 10620(f))

- Describe the reliability of the water supply and vulnerability to seasonal or climatic shortage and provide data for (A) an average water year, (B) a single dry water year, and (C) multiple dry water years. (CWC, 10631(c)(1))

- For any water source that may not be available at a consistent level of use - given specific legal, environmental, water quality, or climatic factors - describe plans to supplement or replace that source with alternative sources or water demand management measures, to the extent practicable. (CWC, 10631(c)(2))

- Provide an urban water shortage contingency analysis that specifies stages of action, including up to a 50-percent water supply reduction, and an outline of specific water supply conditions at each stage. (CWC, 10632(a))

- Provide an estimate of the minimum water supply available during each of the next three water years based on the driest three-year historic sequence for the agency's water supply. (CWC, 10632(b))

- Identify actions to be undertaken by the urban water supplier to prepare for, and implement during, a catastrophic interruption of water supplies including, but not limited to, a regional power outage, an earthquake, or other disaster. (CWC, 10632(c))

- Identify additional, mandatory prohibitions against specific water use practices during water shortages, including, but not limited to, prohibiting the use of potable water for street cleaning. (CWC, 10632(d))

- Specify consumption reduction methods in the most restrictive stages. Each urban water supplier may use any type of consumption reduction methods in its water shortage contingency analysis that would reduce water use, are appropriate for its area, and have the ability to achieve a water use reduction consistent with up to a 50 percent reduction in water supply. (CWC, 10632(e))

- Indicate penalties or charges for excessive use, where applicable. (CWC, 10632(f))

- Provide an analysis of the impacts of each of the actions and conditions described in subdivisions (a) to (f), inclusive, on the revenues and expenditures of the urban water supplier, and proposed measures to overcome those impacts, such as the development of reserves and rate adjustments. (CWC, 10632(g))

- Provide a draft water shortage contingency resolution or ordinance. (CWC, 10632(h))

- Indicate a mechanism for determining actual reductions in water use pursuant to the urban water shortage contingency analysis. (CWC, 10632(i))

- Provide information, to the extent practicable, relating to the quality of existing sources of water available to the supplier over the same five-year increments, and the manner in which water quality affects water management strategies and supply reliability. [For years 2010, 2015, 2020, 2025, and 2030] (CWC, 10634)

- Assess the water supply reliability during normal, dry, and multiple dry water years by comparing the total water supply sources available to the water supplier with the total projected water use over the next 20 years, in five-year increments, for a normal water year, a single dry water year, and multiple dry water years. Base the assessment on the information compiled under Section 10631, including available data from state, regional, or local agency population projections within the service area of the urban water supplier. (CWC, 10635(a))

5.2 Introduction

The reliability of the OH water supply depends on several factors discussed above: groundwater conditions, weather trends, United's management of surface and ground water, the GMA's demand management efforts, water conservation, and, perhaps most importantly, water quality limitations. The worst drought experienced by the OH System was the 1985 to 1991 seven year drought. By the end of that drought, nitrate levels in some OH wells were high, and groundwater levels had fallen below several well pump intakes. To maintain pumping capacity, several well pumps were reinstalled with deeper bowls. Deep aquifer wells were also used to help meet demand.

The last drought occurred before the improved Freeman Diversion was completed. Since the Oxnard Plain aquifer is recharged through runoff from the Santa Clara River watershed, the water diverted through the Freeman Diversion has improved United's ability to recharge groundwater. OH demand is being decreased due to the GMA pumping reductions. Water conservation by agriculture has decreased agricultural demands by as much as 25 percent. Overall, conditions are much improved since the last drought. It is projected that the OH System will be able to meet its contracted deliveries in the worst expected drought. Thus the reliability of the OH water supply is not expected to be dependent on the runoff from any given set of water years.

5.3 Analysis of Future Water Supplies and Demands: Normal Year, Single Dry Year, Multiple Dry Year

There is expected to be an adequate water supply during the worst drought conditions that have historically been experienced in the service area. Under those conditions, it would be feasible to lower the pump bowls to be able to continue deliveries, if necessary. Drought conditions result in dropping groundwater levels. Groundwater in the Oxnard plain is less susceptible to brief droughts, like a three-year drought. Longer droughts, in the range of 7 to 20 years, are more important for local groundwater supplies.

What is significant is that the OH system survived the last drought without any reductions to OH customers. This event occurred before the construction of the improved Freeman Diversion and other facilities. No institutional restrictions will limit pumping during droughts. It is concluded that the OH system will have adequate water during the foreseeable future for any single dry year and multiple dry year period.

In compliance with the Urban Water Management Planning Act, an assessment was developed to determine the District's water supply reliability. This assessment includes a comparison of the total projected water demand with the water supplies available for the following conditions:
(1) normal/average water year, (2) single dry water year, and (3) five consecutive dry years. Results for the assessment for each of these three conditions are described below.

5.3.1 Normal Water Year

Table 5-1 summarizes United's normal (average) water year supply and demand estimates. Local groundwater is anticipated to be the primary water resource through 2035. For normal water year assessment for groundwater supply, the District selected the average for the period 1970 to 2010 as the basis for the evaluation. As previously noted, the District provides water based on a maximum allocation. Each of the OH customers will secure sufficient water resources to meet increased demands through 2035. This assessment indicates a net positive supply or contingency ranging from approximately 722 AFY in 2010 through 2035. Thus, no deficit was observed during the assessment of normal water year supplies and demands.

Table 5-1
Normal Year Supplies vs Demands 2010-2035

	2010	2015	2020	2025	2030	2035
Supplies	11,377	11,377	11,377	11,377	11,377	11,377
Demands	10,655	10,655	10,655	10,655	10,655	10,655
Total	722	722	722	722	722	722

5.3.2 Single Dry Water Year

The District selected Water Year 1976-1977 as the basis for the single dry water year assessment of groundwater. Table 5-2 summarizes the reliability assessment of single dry water year supplies and demands. Local groundwater is anticipated to be the primary water resources through 2035. This assessment indicates that the District would have net surplus of approximately 722 AF in 2010 through 2035. Thus, no deficit was observed during the single dry water year assessment of supplies and demands.

Table 5-2
Single Dry Year Supplies vs Demands 2010-2035

	2010	2015	2020	2025	2030	2035
Supplies	11,377	11,377	11,377	11,377	11,377	11,377
Demands	10,655	10,655	10,655	10,655	10,655	10,655
Total	722	722	722	722	722	722

5.3.3 Multiple Dry Water Year Assessment

The District selected Water Years 1988-1992 as the basis for the multiple dry water year assessment of groundwater. Local groundwater is anticipated to be the primary water resource through 2035. Table 5-3 summarizes the reliability assessment of multiple dry water year supplies and demands for the period 2015 to 2035. This assessment indicates that the District would have a net surplus of approximately 722 AF in 2015 through 2035. Thus, no deficit was observed during this multiple dry water year assessment of supplies and demands

Table 5-3
Multiple Dry Year Supplies vs Demands 2010-2035

	2010	2015	2020	2025	2030	2035
Supplies	11,377	11,377	11,377	11,377	11,377	11,377
Demands	10,655	10,655	10,655	10,655	10,655	10,655
Total	722	722	722	722	722	722

5.4 Water Shortage Scenarios

5.4.1 Historic Three-Year Drought

Several water shortage scenarios are possible for the OH system, as discussed below:

As previously discussed, there is expected to be an adequate water supply during the worst drought conditions that have historically been experienced in the service area. Under those conditions, it would be feasible to lower the pump bowls to be able to continue deliveries, if necessary. Drought conditions result in dropping groundwater levels. Groundwater in the Oxnard plain is less susceptible to brief droughts, like a three-year drought. Longer droughts, in the range of 7 to 20 years, are more important for local groundwater supplies.

What is significant is that the OH system survived the last drought without any reductions to OH customers. This event occurred before the construction of the improved Freeman Diversion and other facilities. No institutional restrictions will limit pumping during droughts. It is concluded that the OH system will have adequate water during the worst foreseeable 3-year drought. The quality of the water is a bigger concern than its availability, as discussed below.

5.4.2 Long-Term Droughts

The highest risk to the OH water supply will occur during long-term droughts, on the order of five years or more. Under those conditions, the groundwater levels in the Oxnard Forebay will drop below the 80,000 AF storage limit, triggering the limits in the SWRCB grant conditions. That means that the deep aquifer wells will be used in preference to shallow aquifer wells. That will decrease water quality (secondary standards) of delivered water but will not affect the supply. However, the delivery of drinking water to OH customers is a higher priority than the grant conditions. Thus, during temporary emergencies during a long-term drought, such as mechanical failure of one or more deep aquifer wells, as much water would be pumped from the shallow wellfield as needed to meet OH demands.

5.4.3 High Nitrate Levels

A significant risk to the reliability of the OH supply is the potential for high nitrates during drought conditions, as described above. In severe droughts, when river water is not available, it is conceivable that many of the shallow OH wells may exceed the MCL for nitrate. Under severe conditions, it may not be possible to blend the available wells to meet the nitrate standard. Nitrate is a primary drinking water standard and must not be exceeded without stringent public notification requirements, and likely the supply of bottled water to some customers. Nitrate levels exceeding the MCL can adversely affect the health of newborn children, which is a scenario to be avoided if at all possible. In the event of a nitrate emergency, United Water, as a wholesale supplier, would work with its customers and the Department of Health to determine an appropriate response by each agency.

Nitrate contamination affects only the shallow aquifer wells. In the event of extensive nitrate contamination of the shallow wells, the deep aquifer wells would be used. Use of the deep aquifer wells would allow some blending with the better shallow wells. With half the shallow wells under the MCL for nitrate of 45 mg/L, full OH deliveries could be made.

United Water prepared a study of nitrate levels to determine their origin and to figure out how they reach drinking water wells. The July 2008 report is titled *Nitrate Observations in the Oxnard Forebay and Vicinity, 1995-2006*. Current thinking is that nitrates reside in a thin layer of water at the top of the aquifer. When dry conditions cause that layer to lie within a well's perforations, then high nitrate water is pumped by that well, raising nitrate levels. The present focus of United's nitrate studies is on the collection of data, including several wells with different sampling depths.

Based on historical data, it is United's assessment that under all foreseeable groundwater conditions, with the current wells and operation of the OH System, the District will be able to blend water to meet OH customers' demands without exceeding the MCL for nitrates.

5.4.4 Groundwater Contamination

Another potential risk to the OH water supply could develop as the result of groundwater contamination. This could be created by several sources: spillage of agricultural chemicals, runoff from industrial areas, accidents involving tanker trucks of hazardous chemicals, sewage spills and the like. The District's response to such contamination would be handled on a case-by-case basis. In the case of the recent MTBE contamination in the Forebay, United's Groundwater Department staff became closely involved in oversight of the cleanup program. The two wells closest to the spillage site were tested monthly for MTBE's. Had MTBE's been detected in those wells, they would have been shut off and pumping would have been shifted to wells farther away from the spill; more frequent sampling would also have been undertaken. It is possible that the deep aquifer wells, not as susceptible to surface water contamination, would be pumped to reduce pumping from the remaining shallow wells. Fortunately, the OH System has reserve well capacity to allow shifting of pumping to other wells. However, severe contamination, especially during a high nitrate period, could conceivably result in a reduced pumping capacity that would not meet demands.

The District has prepared a Source Water Assessment of potential sources of contamination of its groundwater supply. That assessment is available for public review at the District's offices.

5.4.5 Upstream Sewage Spills

The OH wells are located immediately adjacent to recharge ponds in El Rio. The surface water recharged there is subject to contamination by upstream sewage treatment plants. Such contamination could overwhelm the natural filtration and disinfection process, reducing the safety of the OH water for potable uses. Fortunately, it takes several days for water diverted at the Freeman Diversion to reach the El Rio spreading grounds. Several times during the last decade, there have been sewage spills into the Santa Clara River. Most of those have been small, and their effects were not measurable at the Freeman Diversion. However, one untreated wastewater spill from the Santa Paula wastewater plant caused a high spike in coliform levels at the Freeman Diversion.

In almost every case, United has received timely notice from one or more agencies of such spills. The Santa Paula wastewater plant operators, the County Environmental Health Division, the Ventura County Office of Emergency Services, and others are aware of the District's recharge operation and call us in the event of any spills or emergencies. When United receives notification of a potentially serious spill, normal practice is to stop recharging water at the El Rio spreading grounds. United will do that even for minor events, in case the initial assessment of the extent of the spill turns out to be wrong – it is better to err on the safe side. After significant events, United will begin monitoring coliform levels at the Freeman Diversion and in the desilting basin. Once United has confirmed that levels of coliform have returned to ambient levels, then staff will resume recharge operations at El Rio.

The water diverted from the Santa Clara River is raw surface water, and has natural levels of coliform in it. United's desilting basin can effectively restore coliform to ambient levels at low flows. Nevertheless, sewage contamination of river water is a potential problem that is important, and is closely monitored by District staff.

5.4.6 Upstream Petroleum Spills

There is considerable crude oil production and transportation in the Santa Clara River watershed. From time to time there have been oil spills that reached the river. There have been several such incidents over the last two decades, including a major pipeline break after the Northridge earthquake, and an oil truck that crashed into Santa Paula Creek. United has usually received good notification after such incidents. United has even received calls from concerned citizens who observed oil in the water before District staff received any official notifications. Oil spills are easy to see and they receive a good deal of press and public attention.

Normal practice is to stop diverting water altogether after the District receives word of an oil spill. United staff also takes samples of the water in the river, at the Freeman Diversion. However, United usually does not detect any measurable levels of hydrocarbons, even when United staff sees oil floating on the surface, due to the large amount of dilution that take place. Unlike sewage spills, which are harder to detect, United staff can easily see oil floating on the river water after an oil spill. Once United staff have determined the real extent of the spill, and after the oil sheen has returned to ambient levels, the District resumes water diversions. The desilting basin also provides some detention time to help any crude oil decompose, or be digested by microorganisms.

As a point of reference, there are natural oil seeps in the watershed, and even under the best of circumstances one can observe occasional swirls of oil on the surface of the river water. These natural seeps can be observed along Highway 150 near St. Thomas Aquinas College, and in Sespe Creek near the confluence with Tar Creek. In Sespe Creek, one can even observe trout living in deep pools of clear water that has an oil sheen on top. After one storm that caused flash floods near sulfur mountain, United staff found tar in the Freeman Diversion fish ladder. The presence of crude oil in the watershed is a natural phenomenon.

5.4.7 Short-Term Power Outages

The OH System is well protected against short-term power outages, lasting under 12 hours. When power is lost to the OH wellfield, the wells stop pumping into the clearwells. Fortunately, the two 8.4 MG reservoirs (clearwells) provide nearly one day's storage under average demand conditions. Thus the wellfield can be out of service for a while before the system runs out of water.

When power is lost to the OH electric booster pumps, the natural gas-driven booster pumps start automatically, and take over the pumping within a minute or so. The pressure in delivered water drops for a few seconds, and then recovers to a slightly lower level. For control reasons, the gas-driven pumps maintain a pressure of 40 psi at the OH plant, lower than the normal 60 psi maintained by the electric booster pumps. When power comes back on, the electric pumps resume pumping, and the normal 60 psi is resumed. When that happens, the control system slows down the natural-gas engines, and they idle until the operator arrives to shut them down manually.

To maintain power to United facilities during brief power outages there are several standby diesel generators at the OH plant:

1) A standby generator next to the gas-driven booster plant, which drives the SCADA system and much of the plant (but not the booster pumps).

2) A standby generator within the chlorine building which operates the disinfection facilities during power outages.

3) A standby generator near the shop building that operates the metering and post-chlorination detectors during power outages.

4) The SCADA system floats off of batteries, which power inverters. When power is lost, the SCADA system continues to function off the batteries with all of its control and data capabilities intact. During the outage, the battery charger continues to be powered by the standby generator.

All of these components have been tested many times during brief power outages. United can routinely deliver water to OH customers during power outages.

5.4.8 Natural Gas Outages

The standby gas-driven booster pumps depend on the supply of natural gas. If an emergency were to occur that resulted in the loss of natural gas alone, the OH supply would not be affected, because pumping would continue via electric power.

If an emergency caused loss of both natural gas and electric power, the OH booster pumps would not work. It would not be possible to deliver water to OH customers at a pressure of 60 psi. Fortunately, it is possible to deliver water to United customers by gravity from the clearwells. That was how the system was operated before 1967 – water flowed by gravity into the OH pipeline to the customers, who are at a lower elevation than the plant. The booster plant was built in 1967 because Oxnard wanted to be able to blend OH water with higher pressure water from Calleguas MWD without repumping. During the construction of the 1997 El Rio Improvements, a 24-inch bypass pipe and valve was constructed between the clearwell manifold and the booster pump discharge pipes. When pressure in the OH line drops below a certain point, a "fail-open" valve automatically opens to allow water to flow from the clearwells into the OH pipeline. The maximum amount of water that can flow by gravity is limited to approximately 25 CFS. But that will meet the most important water needs of the OH customers. Under low pressure conditions, less water will be used by the customers. (Less water comes out of a tap at low pressure.)

Under gravity flow conditions, the two schools in El Rio will not receive water at adequate pressure for domestic purposes. Without an alternate supply of water, the schools would need to be closed for the day. The supply to Vineyard Avenue Estates would also be at low pressure, but they have the ability to repump from their tank to attain adequate pressure. Both of these customers were added to the OH System in the 1990s, and neither had been previously served by gravity flow.

Natural gas outages are rare. Unlike electric outages, United has never experienced a loss of natural gas. Even after the 1994 Northridge earthquake, when electric power was out for 10 hours, water lines broke, and phone lines were down; there was plenty of natural gas.

5.4.9 Long-term Power Outage

A long-term power outage could be caused by a severe earthquake, sabotage, or major equipment failure in the power grid. An example is the major east coast power failure of 2003, precipitated by cascading failures in the interconnected power supply. With California power lines passing over many earthquake faults, and a single western power grid between Canada and Mexico, such a power failure is not out of the question in this area. After the 1994 Northridge earthquake, local power was out for about 10 hours.

Deregulation of the power industry has also reduced the numbers of crews available to make emergency repairs, which could delay resumption of power after any large scale emergency.

The OH System has a 750 KW diesel-powered generator for the OH wellfield. The generator is supplied by an 8,000 gallon diesel tank, which has enough fuel to last three days, more with rationing. The generator is able to supply temporary power only to the OH shallow water wells. It has enough power to run 6 or 7 of the OH wells at one time. This would allow a continued water supply to OH customers at a somewhat reduced flow.

The 750 KW gen-set does not come on automatically after major outages. Instead, operations staff must start the generator manually. As discussed above, OH water will continue to be delivered automatically after any power outage. However, the clearwells will eventually run out of water after 12 to 24 hours. A decision to start the generator would be made if there are indications that the power will be off for some time. Such indications could come from SCE, press reports, a lack of good reports, or a sense that an emergency is severe enough that power is unlikely to be restored soon.

The 750 KW generator will deliver water into the clearwells, to keep them full. If natural gas is available (or power is available at the electric booster pumps), then water would be pumped from the clearwells into the OH pipeline at pressure. If natural gas is not available, then the water would flow by gravity from the clearwells into the OH line. Under the worst case scenario, United could deliver water at a lower-than-normal pressure to OH customers as follows: wells powered by the 750 KW generator would pump water into the clearwell, which feeds the OH line by gravity, while disinfection is powered by another standby generator.

Therefore, under the worst-case power-loss scenario, United should be able to continue water deliveries to OH customers.

5.4.10 Major Equipment Failure

The OH water supply could be interrupted for any one of the following reasons:

1) Microbial contamination. Should positive coliforms be detected in violation of the Coliform Rule, United will issue a boil order notice to the public and/or the retail customers, depending on the nature of the event and on recommendation by the Department of Public Health.

2) Major Pipeline Failure. The OH pipeline is a single line, with no loops. If it fails catastrophically, the OH supply would be interrupted to any customers downstream of any isolation valve, until repairs could be made. There are not many isolation valves in the pipeline, so a break in a critical spot could interrupt the supply to all customers.

3) Failure of the Clearwells. If both clearwells were to fail, it would not be possible to deliver disinfected water from the shallow wells, since contact time is provided by the clearwells. However, it may be possible to continue delivering water to those OH customers who have no other source of supply. Oxnard, PHWA and the Ocean View pipeline would be shut off from the OH supply. Wells 11, 12, and 13, which are not under the influence of surface water, would be operated through the small settling basin. The post chlorination location would become the sole chlorine injection point. Ammonia injection would be discontinued, because of the difficulty of maintaining the right mixture. Then water could be delivered to the smaller OH customers. The settling basin does not have an overflow. So the trick will be to keep the water in the settling basin at the right level, without overtopping the basin. The booster pumps would be shut off, and water would be delivered by gravity.

4) Disinfection Building Failure. In the event of a fire or major damage to the District disinfection building, United would not be able to disinfect the OH supply. United would immediately stop pumping from the OH wells, to preserve any disinfected water already in the clearwells. All customers that have other sources of water would be shut off, including the Ocean View pipeline. United would then remove the skid-mounted hypochlorite disinfection unit from the PTP system. (The farmers can do without chlorination of their irrigation supply for a while.) The skid unit would be installed at the El Rio plant and rigged to pump into the OH system, with large amounts of flushing water. United would then chlorinate a limited amount of water for use by those OH customers who do not have other sources of supply. Contact time can be obtained in the pipeline at low flows. Once this temporary system is working, United could then open the Ocean View pipeline, after the Ocean View pipeline customers were notified that water use there must be limited to domestic purposes. This temporary setup could be operated indefinitely, until repairs could be made to the disinfection facility. However, the disinfected water would be chlorinated, but not chloraminated.

5) SCADA System Failure. If the SCADA system, including some major instrumentation components, fails completely for some reason, it could disrupt United's ability to deliver water. Once an assessment of the problem is made, adjustments could be made to United's standard operations to continue serving water. For example, wells could be turned on and off manually, chlorine dosage rates could be set manually, and the booster pump VFD's can be set to deliver water at a range of pressures. Staff would be placed on 24-hour shifts to continually operate the system. United could draw operators from other locations (Saticoy) to help keep the system running at all hours. United expects to be able to deliver water in the event of a control system failure.

5.5 Overall Assessment of the Reliability of the OH Groundwater Supply

5.5.1 Status of the Oxnard Forebay Basin

The Oxnard Forebay Basin was included within the ‘Ventura Central Basin’ declared by DWR to be in a critical state of overdraft in its 1980 Bulletin 118-80, *Ground Water Basins in California*. In its 2003 update to Bulletin 118, *California’s Groundwater*, DWR designated a portion of the Ventura Central Basin to the Santa Clara River Valley Basin with five subbasins (Piru, Fillmore, Santa Paula, Mound, and Oxnard [Plain]). The Ventura Central Basin was listed as being in a critical state of overdraft (DWR Bulletin 118-80), though DWR stated that they did not receive sufficient funding in 2003 to make a thorough evaluation of the status of the 11 critically overdrafted basins identified in Bulletin 118-80, nor did it address overdraft conditions in the Santa Clara River Valley Basin or its subbasins.

United Water publishes an annual *Groundwater Conditions Report*, which is available on United’s website at www.unitedwater.org. In that report, published to meet State reporting requirements, United estimates the annual and accumulated overdraft in the basins it manages as a whole. For example, for the purpose of estimating overdraft the Oxnard Forebay is lumped together with the other seven groundwater basins. The report concludes that two of the eight groundwater basins managed by the District are in long-term overdraft: the Oxnard Plain Basin and the Pleasant Valley Basin. The Oxnard Forebay Basin is a separate basin and is not in overdraft as a single hydrogeological unit.

5.5.2 Hydrogeologic Overview

The Oxnard Forebay, Oxnard Plain and Pleasant Valley basins are hydrologically interconnected. Of those, the Oxnard Plain Basin and the Pleasant Valley Basin are currently overdrafted. Seawater intrusion is occurring only in the Oxnard Plain Basin, though the Pleasant Valley Basin has experienced elevated chloride levels in places due to the dewatering of prehistoric marine clays and the upward migration of poor quality water.

United's groundwater experts believe that the Oxnard Forebay basin itself is not currently in a state of overdraft. It is about 5 miles from the ocean and is not directly affected by seawater intrusion. Water levels in the Oxnard Forebay generally recover to historic highs following a single wet year. Although the Forebay is important for recharging the Oxnard Plain and Pleasant Valley basins via underground flow, the Forebay by itself is not overdrafted. Nevertheless, any long-term solution to the overdraft of the other basins must include the management of the Oxnard Forebay.

The OH System draws its groundwater supply from the Oxnard Forebay Basin. United's groundwater experts believe that the Oxnard Forebay should have sufficient groundwater to allow the OH demands to be met in the worst reasonably expected drought (e.g., equivalent to the worst drought in recorded history). If some future drought occurs that is worse than previously experienced, the Oxnard Forebay would still have reserve groundwater in storage; however, some restrictions might be imposed on OH pumping from the Forebay to help protect the other two basins. Policymakers developing such restrictions should consider the public health needs of United's OH customers.

5.5.3 Regulatory Considerations

Groundwater pumping from the Oxnard Forebay Basin is managed by the Fox Canyon GMA. The Fox Canyon GMA was established by California Act 2750 *Fox Canyon Groundwater Management Agency* [Stats 1982 ch 1023]. Article 701(b) allows the GMA to control groundwater extractions by suspending extractions from extraction facilities including the Oxnard Forebay Basin. The GMA has the power to require pumpers to greatly reduce and even to stop pumping. However, in practice, the GMA has instead focused on applying a surcharge on excess pumping to discourage overpumping. That strategy has worked very well over the past 20 years, and has encouraged the construction of new facilities and use of alternate water supplies (e.g., Oxnard's GREAT program and the Conejo Creek project.) It is reasonable to expect the GMA to continue that strategy, at least for the short term. The GMA also has the legal authority to increase the extraction surcharge until safe yield is obtained.

Under <u>present</u> GMA ordinances and policies, no restrictions on pumping would be placed on the OH System during a drought, so long as the OH System did not exceed the amount of pumping allowed by ordinances. That allowable amount of pumping is the basis of the supply projections used in this UWMP, predicted to be available until the year 2036 when the OH contracts expire. Therefore, under <u>present</u> ordinances, the groundwater supply needed to meet OH contractual levels can be pumped in the future without restrictions. Under a worst case scenario, if pumping exceeds allowable limits it should only be necessary to pay the GMA groundwater extraction surcharges already discussed herein. In principle, the groundwater can be pumped if it is available, under <u>present</u> ordinances.

Although present GMA ordinances allow pumpers to extract groundwater in excess of their annual allocation if they have credits, and even to pump beyond those limits if they are willing to pay the groundwater extraction surcharge, the GMA does not consider the accumulation of credits to be equivalent to *banked* water. The concept of "banking" groundwater implies that additional supplies have been introduced to place new water in the "bank." The concept of a 'bank' also implies that there is some sort of guarantee that water deposited in one year will be available for withdrawal in a future year. However, in the case of the Oxnard Plain and Pleasant Valley basins, and to some extent the Forebay, there is no guarantee that the water will be available in long-term droughts. The GMA correctly advises that, even with present limits on pumping, there is no guarantee that enough groundwater will be available in the future throughout its service area (GMA letter to the City of Ventura dated June 3, 2011). The

GMA also correctly advises that their ordinances and the use of credits are subject to revision or expiration by the GMA board at any time.

5.5.4 Potential Changes to GMA Policies

Over the past few years, the GMA has facilitated discussions among stakeholders as to how to handle surplus GMA credits. Some ideas that have been discussed include allowing credits to have an expiration date, placing a cap on the amount of credits that can be accumulated, limiting use of credits in a single year to some percentage of allocation, treating M&I and agricultural credits differently, and other measures. None of those ideas has obtained widespread support from stakeholders. Next, the GMA Board may consider its own steps to develop limits on future accumulation and use of credits. There is no guarantee that present GMA policies will remain in place beyond the near future. The outcome of this debate could affect the future availability of water pumped from the Forebay.

5.5.5 Summary of OH Supply Reliability

In summary, United's groundwater experts predict that an adequate supply of groundwater should be available in the Oxnard Forebay to meet the anticipated future demands of the OH System. The Oxnard Forebay Basin is not in overdraft. The OH System was able to meet demands in the 1985-1991 drought, before the construction of significant new facilities that have improved reliability. The OH System has surplus well pumping capacity. In the event of a worse-than-expected drought, the pump bowls of the OH wells could be lowered. Groundwater levels in the Oxnard Forebay in June 2011 indicate that there should be sufficient water in the Forebay until at least 2014, shortly before the next UWMP update is due, even if a drought starts in 2012. We conclude that the OH System has a sufficiently reliable supply of water for the purpose of this Urban Water Management Plan.

These conclusions and their supporting arguments are relevant solely to the purpose of the District's Urban Water Management Plan and are not intended for any other use.

5.6 Mandatory Water Use Prohibitions

United two largest OH customers have other sources of water. Oxnard receives water from Calleguas MWD and City wells, and PHWA receives water from Calleguas. In the event of a fifty percent (50%) reduction in supply, United would ask those two customers to take additional water from Calleguas. Oxnard and PHWA could also pump their own wells. In a long-term emergency it may be possible, with approval of the GMA, for United to transfer some OH credits to Oxnard and/or PHWA so that they could pump their own wells without penalty. Calleguas MWD also has GMA credits, and a transfer of those credits could be considered in any unexpected County-wide emergency.

The other OH customers, including the four mutual water companies and the schools, do not have other reliable sources of water. In a water shortage emergency, preference would be given to providing OH water to such customers.

In the event that temporary or long-term reductions in water deliveries are required for the OH delivery system, usage updates would be provided to District customers more frequently than they are under normal operating conditions. Flow meters exist at all delivery points along the pipeline, and under normal conditions these meters are read and recorded on a monthly basis. If reductions in water deliveries are required, meters could be read more frequently and promptly reported to the water user. This frequent reporting of water usage, likely on a weekly basis, will assist water retailers in budgeting their reduced supply for the OH system. The frequent reading and reporting of existing meters will serve as an effective means of determining actual reductions in water usage.

Significant penalties are levied on OH customers by the Fox Canyon Groundwater Management Agency if they take delivery of water in excess of their use allocations. To date, the threat of these financial penalties has effectively discouraged the overuse of local groundwater within the boundaries of the GMA.

5.6.1 Interruption of Water Supplies

The OH water supply could be interrupted for any of the following reasons:

- Major equipment failure
- Severe earthquake
- Sabotage
- Acts of war.

In the event of such an interruption, United may shut off the OH water supply to Oxnard, PHWA, and Ocean View pipeline. United would notify the remaining customers to conserve water as much as possible. United would then try to make the water remaining in the clearwell last as long as possible.

In such an emergency, United would likely retain the ability to pump water out of its wells, using its 750 KW generator. United would be able to fill water trucks, water buffaloes, and the like at the plant. United would allow the public and other agencies to refill water containers there. Temporary connections would be made to hydrants etc. to allow that to happen. Access to United water would be provided along Rose Avenue, where there is easy access. United prepared for a similar scenario as part of the District's "Y2K" readiness program.

5.6.2 Water Shortage Ordinances

As a water wholesaler, United has no direct relationship with retail water customers. However, as noted in Section 5.5, United could implement an emergency water shortage contingency program with potential demand reductions up to 50 percent. United is currently updating District ordinances to include a water shortage contingency ordinance. United has prepared a draft resolution that the Board of Directors may adopt during periods of serious or sustained drought. The resolution contains a reference to United's UWMP. Adoption of the resolution will serve as formal notice to our wholesale customers that the potential for a water shortage on the OH system is thought to exist, and allow these customers to prepare for our planned actions should a water shortage actually develop. A copy of the District's draft resolution is provided in Appendix G.

United's two largest customers, Port Hueneme Water Agency and the City of Oxnard, sell water retail and have their own water conservation measures, including water use prohibition ordinances. During a 10 percent to 50 percent water shortage, such prohibitions can include using potable water for street washing, filling of decorative fountains, car washing or filling or refilling pools. Financial impacts are outlined in United's customers' respective UWMPs. United does not expect to receive any revenue or expenditure impacts from these measures, since the District supplies water to customers by contract. For additional details regarding specific mandatory water use prohibition ordinances for retail customers, please contact the District's customers directly.

5.6.3 Financial Impacts of Reduced Water Sales

The water rate structure of OH customers is based on a mix of fixed costs and variable costs, are designed to insulate United from potential revenue loss that might occur during periods of reduced pumping and delivery of potable water. Each year, OH customers pay a fixed cost that is based on their allocation of peak capacity. Variable costs of delivering water (including energy costs, staffing, treatment chemicals, and maintenance) are paid by customers on a monthly basis as they receive deliveries from the OH pipeline. In the event of a supply disruption, significant variable costs such as power and chemicals will be reduced, and will preserve the financial health of this enterprise fund. In addition, the OH fund maintains a cash reserve of approximately one million dollars for use in times of emergency or financial shortfall.

While the OH delivery system is operated as an enterprise fund, United receives revenue from all pumpers within the District. In times when the OH system cannot meet the City of Oxnard's demand for local water, they will likely pump their own wells on the Oxnard Plain to make up this supply component. Under this scenario, United's revenue is largely unaffected by this change in pumping locations. The Port Hueneme Water Agency is more likely to import additional State Water Project water to make up for a diminished supply from El Rio. This would result in a slight reduction in revenue for United. However, OH deliveries to PHWA represent but a small portion of the overall pumping within the District. Therefore, a short-term reduction in water deliveries is not expected to significantly impact United's budget or revenue.

5.7 Vulnerability Assessment

In 2003, United received a grant from the United States EPA to prepare a Vulnerability Assessment (VA) of its water supply. The VA, prepared by a consultant, focused on various types of threats including terrorist attacks and sabotage. Various weaknesses were investigated and steps were designed to reduce the risk of damage to the OH water supply and injuries to customers. Many of the recommendations in the VA were put into effect. In accordance with the VA, United staff are trained in how to respond to potential attacks. Because of the sensitive nature of the VA, the VA is not made available to the general public.

SECTION 6: DEMAND MANAGEMENT MEASURES

6.1 UWMP Requirements

This section includes the following:

- Describe how each water demand management measures is being implemented or scheduled for implementation. Use the list provided. [(1) Discuss each DMM, even if it is not currently or planned for implementation. Provide any appropriate schedules] (CWC, 10631(f))

- Describe the methods the supplier uses to evaluate the effectiveness of DMMs implemented or described in the UWMP. (CWC, 10631(f)(3))

- Provide an estimate, if available, of existing conservation savings on water use within the supplier's service area, and the effect of the savings on the ability to further reduce demand. (CWC, 10631(f)(4))

- Evaluate each water demand management measure that is not currently being implemented or scheduled for implementation. The evaluation should include economic and non-economic factors, cost-benefit analysis, available funding, and the water suppliers' legal authority to implement the work. (CWC, 10631(g))

- Include the annual reports submitted to meet the Section 6.2 requirements, if a member of the CUWCC and signer of the December 10, 2008 MOU. [Signers of the MOU that submit the annual reports are deemed compliant] (CWC, 10631(j))

6.2 Introduction

United is primarily a water wholesaler and does not sell directly to members of the public. Consequently, United is not directly involved with implementing many of the DMMs outlined in Water Code § 10631 (f). However, United's retail customers implement many of their own DMMs to reduce demand in their jurisdictions. For example, the City of Oxnard is currently implementing or is planning to implement all of the DMMs listed in Water Code § 10631 (f)(1). Please contact the City of Oxnard for additional details.

United periodically conducts education campaigns promoting water conservation as described below. However, these campaigns are aimed at members of the general public who are not actually direct customers of United (since United is a wholesaler). Many of United's demand management programs support the retailers programs. United does not track progress of the water conservation programs for retail agencies. Requests for information regarding retail water conservation programs should be addressed to the individual retail agencies.

As a wholesaler, United is required to implement a minimum of five (5) of the BMPs including the following: system water audits, leak detection, and repair; metering with commodity rates for all new connections and retrofit of existing connections; wholesale agency programs; conservation pricing; and water conservation coordinator. Each of these programs are summarized below.

6.3 System Water Audits, Leak Detection, and Repair

Distribution system water audits compare the total amount of water produced from wells to the total water demand as determined by meter readings (water sold). The difference between water production and water sold represents the unmetered water (also known as unaccounted-for water). Surveillance of the water system to detect leaks and leak repair is a routine operation.

United tracks potential leakage in the OH system on a monthly basis by comparing the amount of water delivered to customers to the amount of water produced from the OH wells. These water losses typically average less than 5 percent per year (see Table 6-1 for a summary of the District's current and planned program). However, losses (unmetered water) have occurred from time to time due to undetected pipeline leaks, meter failures, improper meter operation, clearwell leaks, construction activities, leaking check valves, and large amounts of flushing. A certain percentage of water loss is built into the OH Agreement, in that the OH wellfield GMA allocation exceeds the amount of water contracted to customers. However, any excessive water losses are costly to the extent that they contribute to any GMA penalties from overpumping. That provides a motivation for keeping water losses to a minimum.

Table 6-1 indicates that the District's known water losses have decreased from approximately 5 percent to 2 percent. The District is responsible for annual audits for approximately 10.7 miles of mains. Table 6-1 also indicates that precise water savings from this program are difficult to calculate. The District does not include an estimated annual water savings in Table 6-1 even though the District conducts extensive preventative maintenance programs known to reduce water losses.

Table 6-1
System Water Audits, Leak Detection and Repair

Actual	2006	2007	2008	2009	2010
Percent of unaccounted water	5	5	5	5	5
Miles of mains surveyed	10.7	10.7	10.7	10.7	10.7
Miles of lines repaired	1	0	0	0	0
Actual expenditures ($)	$9,000	0	0	0	0
Actual water savings (AFY)	569	0	0	0	0

Planned	2011	2012	2013	2014	2015
Percent of unaccounted water	2	2	2	2	2
Miles of mains surveyed	10.7	10.7	10.7	10.7	10.7
Miles of lines repaired	0	0	0	0	0
Projected expenditures ($)	0	0	0	0	0
Projected water savings (AFY)	0	0	0	0	0

Whenever water losses exceed approximately 5 percent in two consecutive months, District staff conduct a thorough review of available data to determine the cause of the water loss. When the source of the loss is determined, District staff repair the faulty line and restore normal water flow. Due to the relatively young age of United's infrastructure (District pipelines only date back to 1954), wholesale replacement of pipelines is not necessary at this point.

Heath Consultants performed the last system-wide audit of the OH system in 2001. United has not scheduled another extensive audit for the next five year period. However, United's routine monthly audit

would identify a significant discrepancy in volume pumped and volume delivered which would be indicative of a potential significant leak in the OH System.
United staff performs a yearly maintenance program of the OH system. Every year, a portion of the 53 blind flanges in the OH Pipeline, a major source of leaks, are replaced. Replacement rate is roughly 6 percent of the total number of flanges, or 3 to 4 flanges per year. This program helps to prevent major leaks and subsequent water loss, although the exact amount of water saved is not known.
Starting in 1995, all propeller meters at OH turnouts have been rotated at least once every two years. Such meters tend to slow down with age and wear. Replacement meters are in stock for almost all OH meters. When a meter is rotated, a new (or rebuilt) meter is installed and the old meter is sent to a meter shop for calibration and repairs. The rebuilt meters are then kept until they can be used for the next rotation. While there are a total of 16 meters, United only replaces the 9 existing propeller meters. The other 7 meters (mag meters) are maintained by the city of Oxnard (5) and United (2). The bi-annual cost of meter rotation averages approximately $10,000 per rotation. Precise water savings from this program are difficult to calculate, as old meters would normally fail at different rates and with differing levels of severity. However, since the District's propeller meters are designed with a plus/minus 2 percent margin of error, then the District believes that water loss from meter inaccuracy does not exceed 2 percent of total flows.

6.4 Metering with Commodity Rates

Meters are instrumental to a number of conservation efforts because they provide information on water use to consumers. The impact water meters have on consumption range from 10 to 30 percent, but reductions of as much as 50 percent have been observed due to metering and volumetric pricing. (CUWCC, 2005) All of the District's customers have meters and all of the customers are charged for the quantity of water used (commodity rates). The District's rates are defined in Section 6.6.

The District actively evaluates existing meters known to be malfunctioning or damaged to ensure that the quantity of water delivered to wholesale customers is properly accounted for. Many meters are replaced with new and improved meters, while others are recalibrated and reinstalled. There are two primary benefits of maintaining the accuracy of water meters: (1) minimizes the amount of unaccounted for water and revenue lost for malfunctioning meters, and (2) wholesale customers receive an accurate bill for water used.

Over the last few years, United's customers on the O-H pipeline replaced a number of meters. The City of Oxnard recently replaced the older inaccurate meters at the turnouts with highly accurate mag meters. This meter upgrade has significantly increased the accuracy of the meter readings. Calculated line losses have ranged from negative 3 percent (gain) to 6 percent loss, averaging 1.3 percent line loss. Calculated annual line losses totaled 189, 144, and 128 acre-feet for the years 2005, 2006 and 2007, respectively. Given the District's OH system maintenance schedules, line losses exceeding 200 acre-feet per year are not anticipated before the year 2025.

Table 6-2 indicates that the District, as a wholesaler, has 0 unmetered accounts. Table 6-2 also indicates the District spends approximately $10,000 annually on meter replacement and maintenance programs. Metering and billing with commodity rates are known to reduce retail water demands by 10 to 20 percent. However, the District is a wholesaler and does not control retail rates. Thus, the District did not include an estimated annual water savings in Table 6-2.

Table 6 -2
Metering with Commodity Rates

Actual	2006	2007	2008	2009	2010
Number of unmetered accounts	0	0	0	0	0
Number of retrofit meters installed	11	0	6	6	6
Number of accounts w/o commodity	0	0	0	0	0
Actual expenditures ($)	$10,000	$10,000	$10,000	$10,000	$10,000
Actual water savings (AFY) (1)	0	0	0	0	0

Planned	2011	2012	2013	2014	2015
Number of unmetered accounts	0	0	0	0	0
Number of retrofit meters installed	6	6	6	6	6
Number of accounts w/o commodity	0	0	0	0	0
Actual expenditures ($)	$10,000	$10,000	$10,000	$10,000	$10,000
Actual water savings (AFY) (1)	0	0	0	0	0

Notes:
(1) As a wholesaler, the District was not able to calculate water savings for this program.

All of the District's connections are metered including every turn-out, every well, and the treatment plant. Readings are monitored each month and if there are discrepancies exceeding three percent for three months in a row, an investigation is triggered. It is not clear that the AWWA Water Audit M36 standard is applicable to UWCD's wholesale operations. The District is currently in full compliance with the CUWCC coverage requirements.

6.5 Wholesale Agency Programs

As a wholesale agency, United does not directly implement many of the DMMs commonly performed by retail water agencies. However, United assists the retail customers in their efforts to conserve water and reduce demand by implementing District organized public information campaigns. Since 1997, United Water has had a Water Conservation Program (WCP) to encourage its customers to conserve water. This program is run by United's Water Conservation Coordinator. The objective of the WCP is to identify, promote, and assist in the implementation of water conservation and groundwater protection activities.

The District's WCP includes the following elements and objectives:

- **School Education:**
  - Provide classroom presentations
  - Provide educational and promotional materials (stickers, pencils, videos, etc.)
  - Attend school functions and provide materials and a booth
  - Provide tours of United's facilities

- **General Public Objectives:**
  - Develop specific programs targeting the general public in both English and Spanish
  - Provide water education/conservation and groundwater protection information via mail
  - Provide educational and promotional materials
  - Attend functions, provide material and booth (Science Fair, Farm Fest, etc.)
  - Provide tours of United's facilities

- **Urban Use Objectives:**
  - Provide landscape water conservation information for new/existing single-family homes
  - Provide information on reducing water waste
  - Provide educational and promotional materials (low flow toilets, xeriscape gardening, leak detection)
  - Provide information to landscape architects and nurseries
  - Provide tours of United's facilities.

- **Agricultural Use Objective:**
  - Provide educational and promotional materials on water education/conservation and groundwater protection
  - Provide tours of United's facilities.

- **Industrial Use Objective:**
  - Provide educational and promotional materials.

United's Water Conservation Program makes use of the following resources:

- **Groundwater Guardian Program:** A group of community and affiliate representatives for development of activities for groundwater protection and education.

- **California Water Awareness Campaign:** Provides packets of information for teachers during May – Water Awareness Month.

- **Water Education Foundation:** Provides teaching tools and materials (books, videos, etc.).

- **ACWA:** Provides teaching tools and materials.

- **DWR and MWD:** Provides teaching tools and materials.

- **UWCD:** Funds speakers, educational materials, teaching tools, and free products (cups, water bottles, pens, pencils, etc.).

United's water conservation program is well received and appreciated by its constituents. Table 6-3 indicates that the District generally produces approximately 15 public information activities annually and 12 to 15 school activities annually. These programs typically cost approximately $8,000 to $15,000 annually.

The CUWCC has not developed a coverage report so there is no official determination of United's compliance with this DMM. United has a three-pronged approach to its education programs: on-site tours at its facilities, school visits, and educational materials. United offers a variety of educational materials to meet the differing needs of residential, commercial, agricultural, and industrial customers.

United is not currently offering financial or technical support to its retailers. United will explore opportunities for providing financial and/or technical support to its retailers. United will confer with its retailers regarding the types of assistance that would be most effective, assess its resources and proceed accordingly. In general, the District is in full compliance with the CUWCC coverage requirements.

Table 6-3
Wholesale Agency Programs and Expenditures

	Number of Agencies Assisted				
Program Activities	**2006**	**2007**	**2008**	**2009**	**2010**
Public Information	15	15	15	15	15
School Education	0	15	15	12	12
Actual Expenditures	$10,000	$8,000	$7,000	$1,500	$15,000

	Number of Agencies to be Assisted				
Program Activities	**2011**	**2012**	**2013**	**2014**	**2015**
Public Information	15	15	15	15	15
School Education	12	12	12	12	12
Actual Expenditures	$8,000	$8,000	$8,000	$8,000	$8,000

6.6 Conservation Pricing

As described in Section 4, the pumping allocations for each of United's customers are being reduced from their historical levels. Water conservation is encouraged by the assessment of a surcharge of $1,105 to $1,855 for each acre-foot which is pumped beyond the reduced GMA allocation . District water rates are summarized in Table 6-4.

Table 6-4
District Fiscal Year 2010-2011 Water Rates

Pipelines	**Agriculture Rate ($ per AF)**	**Municipal and Industrial Rate ($ per AF)**
Pleasant Valley Pipeline	$72.50	--
Pumping Trough Pipeline	$166.50	--
Saticoy Well Field	$30.00	--
Oxnard Hueneme Pipeline		
OH (Variable Rate)	$155.50	$155.50
OH (Marginal Rate)	$80.85	$80.85
Fixed Well Replacement Charge	$14.08	$14.08
Annual Fixed Charge	$23,252 x UPC of each OH customer	
Supplemental M&I		
Calleguas Member Agencies	--	$159.00
Non Member Agencies	--	$241.00
Groundwater Zones		
A	$19.50	$58.50
B	$37.50	$112.50
C	$25.50	$76.50

United meters every connection and bills volumetrically for all water delivered. Typically the volumetric revenue meets or exceeds the 70 percent threshold. In 2009, the volumetric portion accounted for about 60 percent. As a wholesaler, United provides water to its customers in accordance with a long-term contract with fixed and variable costs. United will review its rate structure but it is expected that the volumetric portions will rebound to achieve threshold rates as the local economy recovers. The District anticipates full compliance with the CUWCC coverage requirements in fiscal year 2012.

United's current OH rate structure is established by an agreement between United and its OH customers that expires in 2036. As noted in Figure 3-1, some OH customers may elect not to take any OH water in some years. To provide sufficient cash flow to support the system during such low demand periods, the rate structure relies on a large fixed capacity charge. United's ability to raise sufficient revenues based on a given level of conservation pricing is somewhat limited. It is not clear that the District could change existing OH contracts. Since each customer has contracted for a fixed amount of water, and since United's water is less costly than other sources, conservation pricing would likely be of little benefit.

6.7 Water Conservation Coordinator

United has employed a Water Conservation Coordinator since 2005 to oversee the District's Water Conservation Program and promote water conservation. Prior to that year, responsibility for overseeing the District's Water Conservation Program was assigned to different staff members. Expenditures for the water conservation coordinator are reflected in Table 6-5. Currently, the Executive Coordinator of Administrative Services is managing the WCP activities. The District will evaluate the current WCP and allocate staff accordingly. The District anticipates full compliance with the CUWCC coverage requirements in fiscal year 2011.

Table 6-5
Water Conservation Coordinator Staff and Budget

Actual	2006	2007	2008	2009	2010
Number of full-time positions	1	1	1	1	1
Number of full/part-time staff	1	1	1	1	1
Actual expenditures	$15,143	$16,435	$30,557	$31,220	$10,115

Planned	2011	2012	2013	2014	2015
Number of full-time positions	1	1	1	1	1
Number of full/part-time staff	1	1	1	1	1
Projected expenditures	$5,000	$5,000	$6,000	$6,000	$6,000

6.8 AB1420 Compliance

Assembly Bill (AB) 1420 (Stats. 2007, ch. 628) amended the Urban Water Management Planning Act, Water Code Section 10610 et seq., to require, effective January 1, 2009, that the terms of, and eligibility for, any water management grant or loan made to an urban water supplier and awarded or administered by the Department of Water Resources (DWR), State Water Resources Control Board (SWRCB), or California Bay-Delta Authority (CBDA) or its successor agency (collectively referred to as "Funding Agencies"), be conditioned on the implementation of the water Demand Management Measures (DMMs) described in Water Code Section 10631(f).

Water management grants and loans include programs and projects for surface water or groundwater storage, recycling, desalination, water conservation, water supply reliability and water supply augmentation. This funding includes, but is not limited to, funds made available pursuant to Public Resources Code Section 75026 (Integrated Regional Water Management Program).

AB 1420 conditions eligibility for a water management grant or loan on implementing the DMMs listed in Water Code section 10631(f). These DMMs correspond to the fourteen Best Management Practices (BMPs) listed and described in the CUWCC MOU. Based on this, DWR has consulted with the CUWCC and appropriate funding agencies, and determined that it will equate the DMMs with the BMPs described in the CUWCC MOU for loan and grant funding eligibility purposes.

Urban water suppliers are required to complete the AB 1420 Self-Certification Statement Table 1. Table 1 provides an update of past and current BMP implementation, to demonstrate whether suppliers are implementing BMPs at the coverage level determined by the CUWCC MOU. If urban water suppliers are not implementing all BMPs at the coverage level determined by the CUWCC MOU, they may be eligible to receive grant and loan funds by providing a schedule, budget, and finance plan to implement all BMPs at the coverage level determined by the CUWCC MOU. Table 2 provides information on the schedule, budget, and finance plan to implement all BMPs, commencing during the first year of the agreement, for a project for which the urban water supplier receives funds.

The District has prepared both Table 1 and Table 2. Copies of AB 1420 Tables 1 and 2 are provided in Appendix H. As part of a Prop 84 grant application process, DWR has approved United's AB1420 forms.

SECTION 7: STATE AND LOCAL IMPACTS OF CLIMATE CHANGE

7.1 UWMP Requirements

California Department of Water Resources suggests that urban water suppliers consider, in their 2010 UWMP, potential water supply and water demand effects related to climate change.

7.2 Introduction

Current climate change projections suggest that California will continue to enjoy a Mediterranean climate with the typical seasonal pattern of relatively cool and wet winters and hot, dry summers. However, climate patterns are different now and may continue to change at an accelerated pace. Increases in global emissions of greenhouse gases are leading to serious consequences for California including, but not limited to, the following: higher air and water temperatures, rising sea levels, increased droughts and floods, decreased amount and duration of snow pack, and extreme variability in weather patterns. (CA DWR, 2009; CA NRA, 2009) These changes are anticipated to intensify over the 20-year planning horizon of this UWMP. Even if all emissions of greenhouse gases ceased today, some of these developments would be unavoidable because of the increase in greenhouse gases recorded over the last 100 years and the fact that the climate system changes slowly. (PPIC, 2011) Many of these climate changes would affect the availability, volume, and quality of California water resources.

7.3 Potential Impacts of Climate Change

Potential impacts to state and local water resources and water demands includes the following:

7.3.1 Precipitation

Rainfall variability is expected to increase, leading to more frequent droughts and floods, runoff from snowpack may be earlier and less predictable, and precipitation may fall as more rain and less snow. Computer models differ in determining where and how much rain and snowfall patterns may change under different emissions scenarios. However, the models are nearly unanimous in predicting a 12 to 35 percent decrease in northern California precipitation levels by mid-century (relative to average precipitation for 1960-1990). (CA NRA, 2009) California DWR estimates that Sierra Nevada snowpack may be reduced by 25 to 40 percent by 2050 (relative to average snowpack for mid 20th century). (CA NRA, 2009) However, average air temperature increases of 6 to 11 degrees Fahrenheit could trigger intensification of the of the El Nino Southern Oscillation (ENSO) cycles over the Pacific Ocean. (CA RNA, 2009) Intensification of the ENSO cycles could mean stormier wet years and even drier (or extended periods of) drought years. These ENSO cycles may lead to more severe coastal storms during the winter months and more erosion and coastal flooding. (CA RNA, 2009)

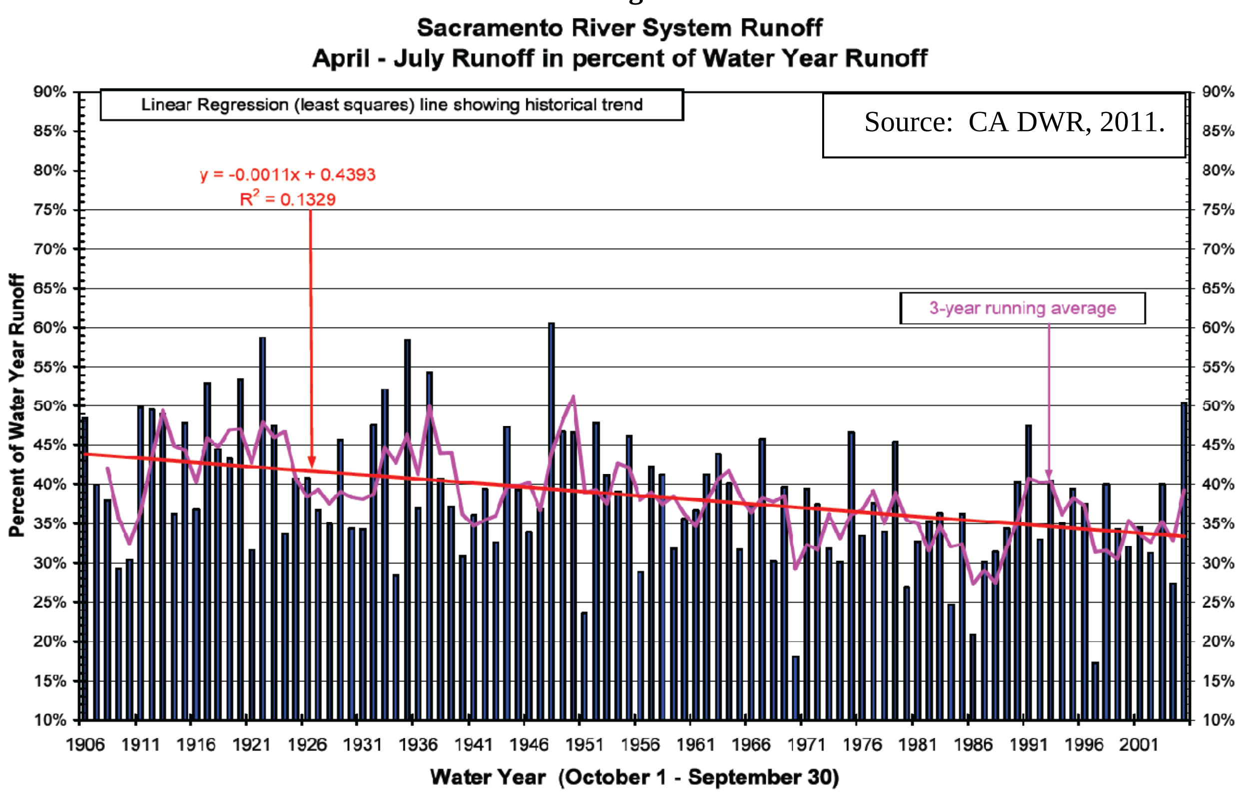
7.3.2 Air Temperature

Air temperatures in California are anticipated to increase by 2 to 9 degrees Fahrenheit by the year 2100. (CA NRA, 2009) Higher air temperatures may result in more rain and less snow, diminishing the reserves of water held in the Sierra Nevada snowpack. (CA NRA, 2009) Higher air temperatures may increase evaporation rates from reservoirs by 15 to 37 percent. (CA NRA, 2009) Regions that rely heavily upon surface water could be particularly affected as runoff becomes more variable and extended droughts occur more frequently. Change in air temperature may further stress the state’s forests, making them more vulnerable to pests, disease, fire, and changes in species composition. Higher air temperatures may also increase evapotranspiration rates and external water demands for agriculture and landscaping, both significant sources of water demand within the District.

7.3.3 Runoff

Spring runoff from snowpack is occurring earlier now than it did in the first part of the 20th century. This change in runoff could affect availability of spring and summer snowmelt from mountain areas, including State Water Project water from the Sacramento Delta and local rivers and streams. As an example, Figure 7-1 indicates the change in timing of seasonal runoff on the Sacramento River. The amount of April to July runoff (as a percent of total runoff) on the Sacramento River has decreased from nearly 45 percent to under 35 percent over the period 1906 to 2005 resulting in a loss of approximately 1.5 million AF of water (during April to July). (CA DWR, 2011) Changes is runoff timing may force water agencies to adapt to more runoff earlier in the water year which affects water storage for potable and irrigation demands, hydroelectric power production, and lake recreation, etc. Total annual exports from the Delta for State and Federal contractors may also decrease by 20 to 25 percent by the year 2100. (CCCC, 2009) Also, changes in runoff patterns may impact ground water recharge in California especially those areas prone to ground water overdraft including Ventura County.

Figure 7-1



7.3.4 Sea Level

Sea levels have risen by as much as 7 inches along the California coast over the last century. (CA NRA, 2009) According to some estimates, sea level is projected to rise an additional 2 to 5 feet by 2100. (PPIC, 2011; Pacific Institute, 2009; CA RNA, 2009; CAT, 2008) These sea level increases could significantly impact infrastructure within coastal areas and affect quantity and timing of State Water Project water exports from the Sacramento Delta. Affects of sea level rise in the Delta would be two-fold: (1) problems with weak levees protecting the low-lying land, many already below sea level; and (2) increased salinity intrusion from the ocean which could degrade fresh water transfer supplies pumped at the southern edge of the Delta or require more fresh water releases to repel ocean salinity. Estimated costs of 100-year flooding on coastal areas (4.6 feet) could reach $100 billion (2000 dollars) for replacement value of buildings and contents. (Pacific Institute, 2009) In addition, sea level rise poses threats to fragile Sacramento Delta levees, which are extremely important for the State Water Project water supply. Changes in sea level may also impact areas prone to seawater intrusion, such as Ventura County, further impacting water quantity and quality of available groundwater.

7.3.5 Flooding

Diminishing mountain snowpack reduces water storage and may increase the risk of flooding in many areas of California including Ventura County. There is some variance in the literature about whether climate change will impact the frequency and intensity of storm events in California over the next 100 years. However, as noted previously, average air temperature increases of 6 to 11 degrees Fahrenheit could trigger intensification of the of the El Nino cycles over the Pacific Ocean which may lead to stormier wet years, extended periods of drought years, more severe coastal storms during the winter months, and more erosion and coastal flooding. (CA RNA, 2009)

7.4 Mitigation and Adaptation

Responding to climate change generally takes two forms: mitigation and adaptation. Mitigation is taking steps to reduce human contribution to the causes of climate change by reducing green house gas (GHG) emissions. Adaptation is the process of responding to the effects of climate change by modifying local systems and behaviors to function in a warmer climate. (CA DWR, 2011)

In the water sector, climate change mitigation is generally achieved by reducing energy use, becoming more efficient with energy use, and/or substituting renewable energy sources in place of fossil fuel based energy sources. Because water requires energy to move, treat, use, and discharge, water conservation is also energy conservation. As each water supplier implements DMM/BMPs and determines its water conservation targets, it can also calculate conserved energy and GHGs not-emitted as a side benefit. Once a water supplier has calculated the water conserved by a BMP, it is straightforward to convert that volume to conserved energy, and GHGs not-emitted. Additionally, water suppliers may want to reconsider DMMs that conserve water but do so at a significant increase in GHG emissions. (CA DWR, 2011)

Climate change means more than hotter days. Continued warming of the climate system has considerable impact on the operation of most water districts. Snow in the Sierra Nevada provides 65 percent of California’s water supply. Predictions indicate that by 2050 the Sierra snowpack will be significantly reduced. Much of the lost snow will fall as rain, which flows quickly down the mountains during winter and much of which cannot be stored in the current water system for use during California’s hot, dry summers. The climate is also expected to become more variable, bringing more droughts and floods. Water districts will have to adapt to new, more variable conditions. (CA DWR, 2011)

Principles of climate change adaptation include the following:

- The more mitigation water agencies do now, the less adaptation they may have to do in the future, because climate impacts could be less severe.
- Mitigation is much less expensive than adaptation.
- Mitigation should happen globally.
- Adaptation must happen locally.
- Adaptation strategies should be implemented according to future conditions, regular assessment and recalibration.

- Some adaptation strategies have benefits that can be realized today.

7.5 Local Strategies

As climate change continues to unfold in the coming decades, water agencies may need to mitigate and adapt to new strategies, which may require reevaluating existing agency missions, policies, regulations, facilities, funding priorities, and other responsibilities. Examples of District mitigation and adaptation strategies include, but not limited to, the following:

- Prepare long-term facility and sustainability master plan. The District should prepare a long-term projection (such as 50-year) of facility improvements including District specific elements for climate change adaptation.
- Increase surface water diversions. The District should be prepared to utilize additional Santa Clara River runoff and flood flows.
- Increase ground water recharge. The District should be prepared to utilize additional surface water and recycled water for recharge.
- Promote use of recycled water. The District should adopt policies that promote the use of recycled water for appropriate and cost-effective uses including but not limited to ground water recharge and ground water injection.
- Promote water use efficiency. The District should aggressively support implementation of urban and agricultural best management practices.
- Increase investments in infrastructure. The District should aggressively invest in new District infrastructure that supports adaptation strategies (such as increased surface water diversion, ground water recharge, and recycled water) and existing principal facilities susceptible to impacts of climate change.

Notwithstanding the above strategies for dealing with climate change, the reality is that current environmental regulations place a very high priority on releasing additional water for fish and the environment. There will be great reluctance by regulators to acknowledge that changes to the earth’s climate may alter the ranges of sensitive species. To attempt to maintain artificial ranges that may no longer be viable, regulators will likely require even more water to be released to the environment. With powerful laws like the Endangered Species Act to support such reactions, there will be more competition for scarce water supplies between people and the environment. Resolving this conflict will be one of the biggest challenges confronting future water managers.

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The Residential Runoff Reduction Study

Municipal Water District of Orange County

Irvine Ranch Water District

July 2004

Study Participants

A & N Technical Services

CalFed Bay-Delta Progam

California Department of Pesticide Regulation

California Environmental Protection Agency

California Regional Water Quality Control Board

HydroPoint Data Systems, Inc.

Irvine Ranch Water District

Metropolitan Water District of Southern California

Montgomery Watson Labs

Municipal Water District of Orange County

National Water Research Institute

County of Orange

Southern California Coastal Water Research Project

State Water Resources Control Board

United States Department of the Interior Bureau of Reclamation

Contents

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Tables, Figures & Exhibits

Executive Summary

Study Background and Rationale

In 2001, the Irvine Ranch Water District (IRWD), the Municipal Water District of Orange County (MWDOC), and the Metropolitan Water District of Southern California (MWD) completed a small-scale study of weather-based evapotranspiration (ET) irrigation controllers. This study, known as the "Westpark Study," tested the effectiveness of ET controller technology in residential applications. After 40 such controllers were installed in the Westpark neighborhood of Irvine, California, water demand and runoff in the study area were measured. The resulting average water savings for this study were 37 gallons per day, or 7 percent of total household water use and 18 percent of irrigation water use.

Based upon the findings of the Westpark Study, IRWD and MWDOC partnered on new research, the Residential Runoff Reduction (R3) Study, in which the number of sites studied was increased, a baseline area where no changes were made was included, and an "education only" area where printed educational materials were distributed was also included. This made the R3 Study one of the first studies to attempt to quantify the effectiveness of public education alone versus a technology-based plus education approach to reducing residential irrigation water usage. Figure ES-1 presents the study participants and their respective roles within the R3 Study.

The R3 Study had four primary purposes:

1) To test the use of weather-based irrigation technology, also known as ET controllers, to manage irrigation water for residential homes and large landscape areas;
2) To evaluate the effectiveness of a targeted education program on residential homeowners;
3) To determine the correlation between proper water application in landscape irrigation and the quantity and quality of urban dry-season runoff; and
4) To gauge the acceptance of water management via the controller technology.

Study Methodology

The R3 Study area included five similar neighborhoods (Sites 1001 through 1005) in Irvine, California, each with its own single point of discharge into the urban storm drain system. The five sites are shown on Figure ES-2. At these points of discharge from each study area, the runoff volume was monitored and water quality samples were taken. The five sites were divided into three separate areas. The first area, Site 1001 (retrofit group), used ET controller technology and public education. The second area, Site 1005 (education group), received educational materials, but did not receive controllers. The third area (control group) consisted of three separate neighborhoods (Sites 1002, 1003, and 1004), which received neither ET controllers nor educational materials.

Figure ES -1
R3 Study Participants

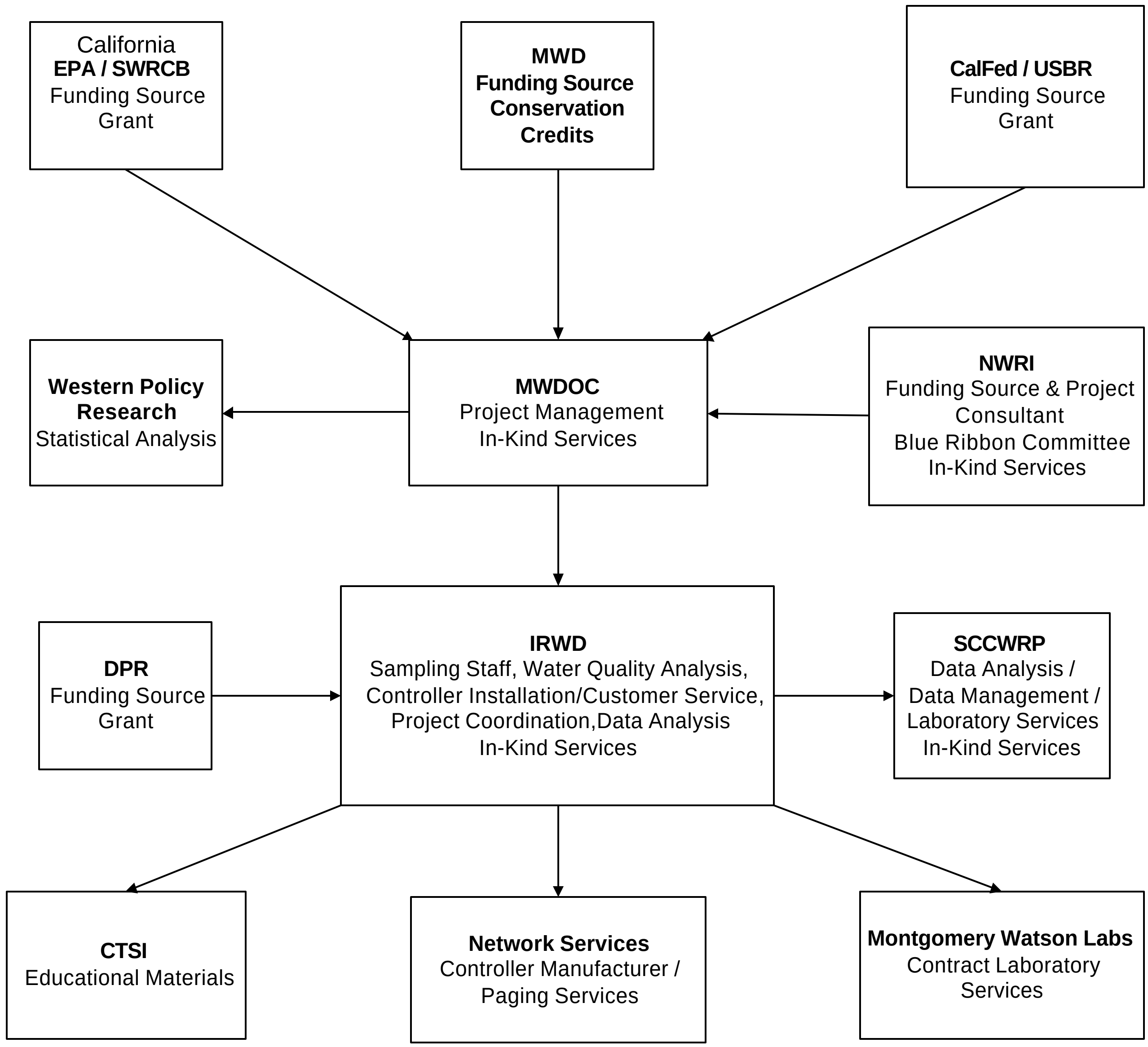
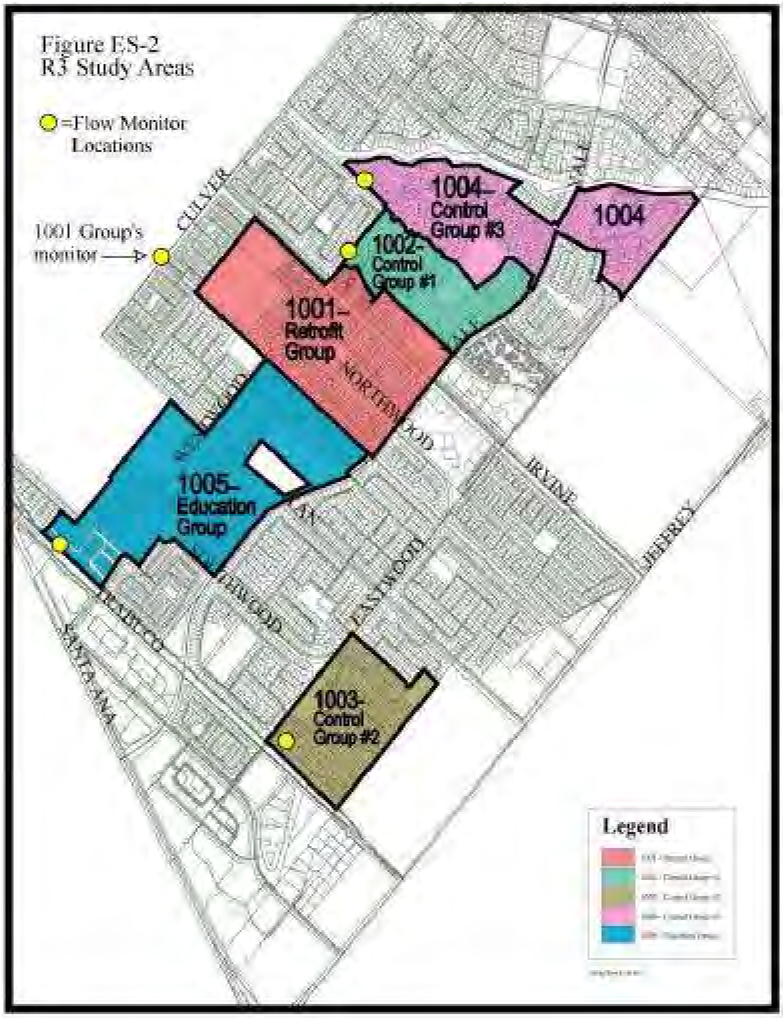


Figure ES-2
R3 Study Areas



Evaluation Results

After the initial 18-month study period was completed, the data was compiled and evaluated for water conservation savings, dry season runoff changes, and changes in the quality of the dry season runoff water. The following summarizes the results:

a) Water Conservation Savings
Water conservation savings from the typical participant in the retrofit group were 41 gpd, or approximately 10 percent of total household water use. The bulk of the savings occurred in the summer and fall (Figure ES-3. Residential Water Savings: Technology + Education). The education group residential customers saved 26 gpd, or about 6 percent of total water use. The savings from this group were more uniform throughout the year (Figure ES-4, Residential Water Savings, Education Only). The retrofit group also included 15 dedicated landscape accounts (ranging in size from 0.14 acres to 1.92 acres), which showed average water savings of 545 gpd. The net result was eight times more water savings than with the single-family residential controller, strongly indicating that the larger the landscape, the better the savings per controller.

Figure ES -3
Residential Water Savings: Technology + Education

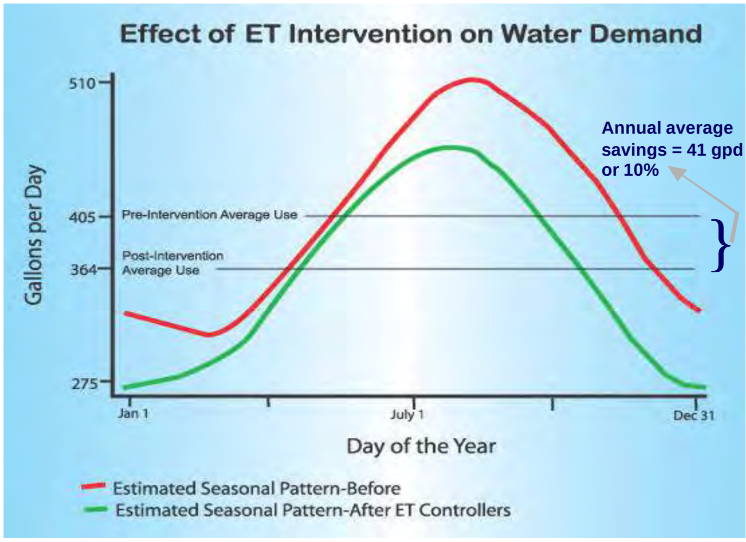


Figure ES -4
Residential Water Savings: Education Only

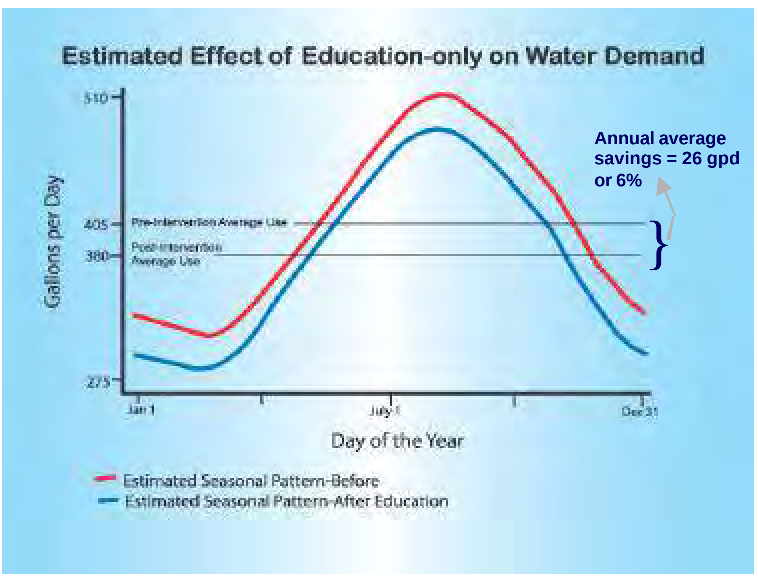


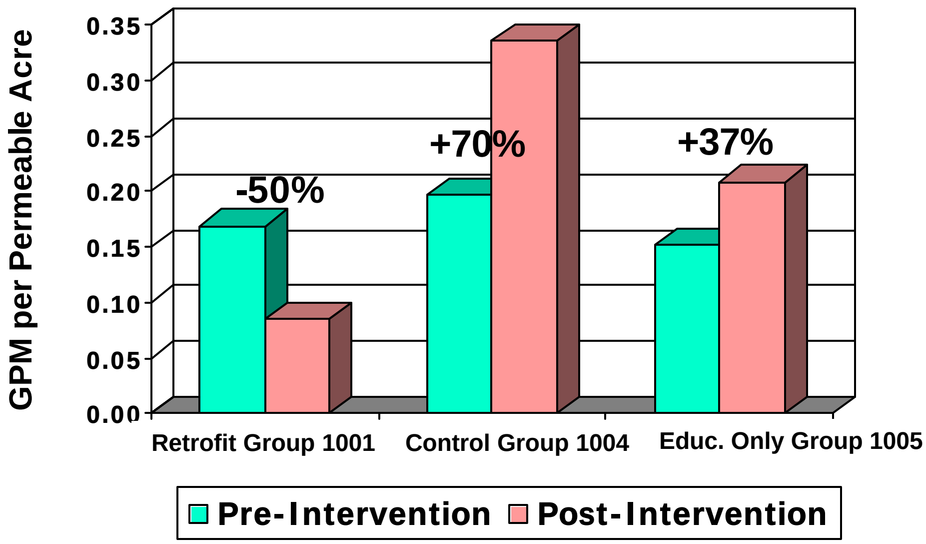
Figure ES -5
Changes in Runoff Within Each Site

b) Dry Season Runoff Changes

The retrofit group experienced a 50 percent direct reduction in water runoff (pre-intervention runoff compared to post-intervention runoff) during dry season periods. When the retrofit group is compared to the control group, the dry season runoff shows a statistical reduction of approximately 71 percent. In contrast, a comparison of direct pre-intervention and post-intervention runoff from the education group increased 37 percent, while runoff increased 70 percent within the control group. Other than the presence of an

ET controller, the primary difference between these groups is the participation of the 15 landscape accounts in the retrofit group. These accounts irrigated approximately 12 acres of landscape versus between 4 to 5 acres of total irrigated area for the 112 residential homes. Figure ES-5 presents R3 Study changes in runoff within sites.

Figure ES -5
Changes is Runoff Within Each Site



Note: It is also possible to compare post-intervention runoff *between* the study sites. These comparisons suggest a higher reduction in runoff for Site 1001 (between 64 and 71 percent) than was observed for the "within site" pre and post comparison, and a reduction in runoff of 21 percent for Site 1005. However, as described more fully in the text, these comparisons are less reliable than the "within site" pre and post comparisons shown here.

c) Changes in Runoff Water Quality

The study gathered a great deal of information on the water quality constituents present in urban runoff. In almost all cases, the data showed no changes in the concentration of these constituents in the runoff. The most significant fact to come out of the urban runoff water quality data is that the decrease in runoff volume from the retrofit group did not appear to result in an increase in the concentration of pollutants in the runoff. Thus, it is probable that a reduction in total pollutant migration could be achieved by reducing total dry season urban runoff.

d) Public Acceptance of Water Management

While there were some customer service-related issues, the retrofit group had a generally positive response to the ET controller, with 72 percent of participants indicating that they liked the controllers. The retrofit group also found that the controller irrigation either maintained or improved the appearance of the landscape. This has very positive implications. The water district customers receive a desired benefit of a healthy landscape, and the community receives several important environmental benefits from the conservation of valuable and limited water resources and the reduction in dry season urban runoff.

Findings, Conclusions, and Recommendations

The R3 Study showed that weather-based irrigation controllers, which provide proper landscape water management, resulted in water savings of 41 gpd in typical residential settings and 545 gpd for larger dedicated landscape irrigation accounts. The observed reduction in runoff from the retrofit test area was 50 percent when comparing pre-intervention and post-intervention periods and 71 percent in comparison to the control group. The education group saw reductions in water use of 28 gpd, and a reduction in runoff of 21 percent in comparison to the control group. Water quality parameters in both study areas were highly variable, and very few differences in the level of monitored constituents were detected. In terms of water savings per controller (and cost-effectiveness), the study clearly indicated that larger landscape areas (parks and street medians) should provide the initial targets for the expansion of similar programs.

Chapter 1: Introduction

1.1 Overview

Weather-based evapotranspiration (ET) irrigation control has long been a tool of large agricultural operations, maximizing crop yields through pinpoint management of crop watering. The Residential Runoff Reduction (R3) Study was conducted to evaluate the applicability of ET technology for other uses. This chapter of the study report presents the following:

- Background information on study rationale;
- Specific study goals and objectives;
- Identification of study partners and their roles/contributions to the study.

The organization of this report is also described, and commonly-used abbreviations and acronyms are listed. References used during the study are presented in Appendix A.

1.2 Background

Approximately 58 percent of residential water demand is used for outdoor purposes, primarily for home landscape irrigation (AWWARF Residential End Uses of Water, 1999). Excess irrigation results in inefficient use of valuable water supplies and increased runoff that is the transport mechanism of pollutants that enter natural waterways and, ultimately, the Pacific Ocean for areas along the west coast.

Landscape water use efficiency/water conservation and watershed management in the urban sector are linked. Water agencies throughout the state are implementing 14 Best Management Practices (BMPs) to increase the efficient use of urban water supplies including landscape irrigation efficiency. Cities and counties are also implementing National Pollutant Discharge Elimination System (NPDES) permit requirements containing BMPs for watershed management focused on runoff reduction.

Recent studies in Orange County have had promising results. In 1998-1999, Irvine Ranch Water District (IRWD), Municipal Water District of Orange County (MWDOC), and the Metropolitan Water District of Southern California (MWD) conducted a study that evaluated the use of weather-based ET irrigation control technology at 40 residential homes in the Westpark area of Irvine. The report from this research, entitled "Residential Weather-Based Irrigation Scheduling: Evidence from the Irvine 'ET Controller' Study," showed water savings that translated to 37 gallons per day (gpd), or 7 percent of total household water use/16 percent of irrigation water use.

In April 2001, water savings from the ET Controller study in Westpark were evaluated through September 2000, or the second post-retrofit year. This evaluation confirmed the persistence of water savings observed during the initial evaluation. More specifically, this evaluation concluded that ET Controllers were able to reduce total household water consumption by roughly 41 gallons per household per day, representing an 8 percent reduction in total household use, or an 18 percent reduction in estimated landscape water use.

The R3 Study represents the next phase of research associated with the new irrigation control technology linking benefits to watershed management.

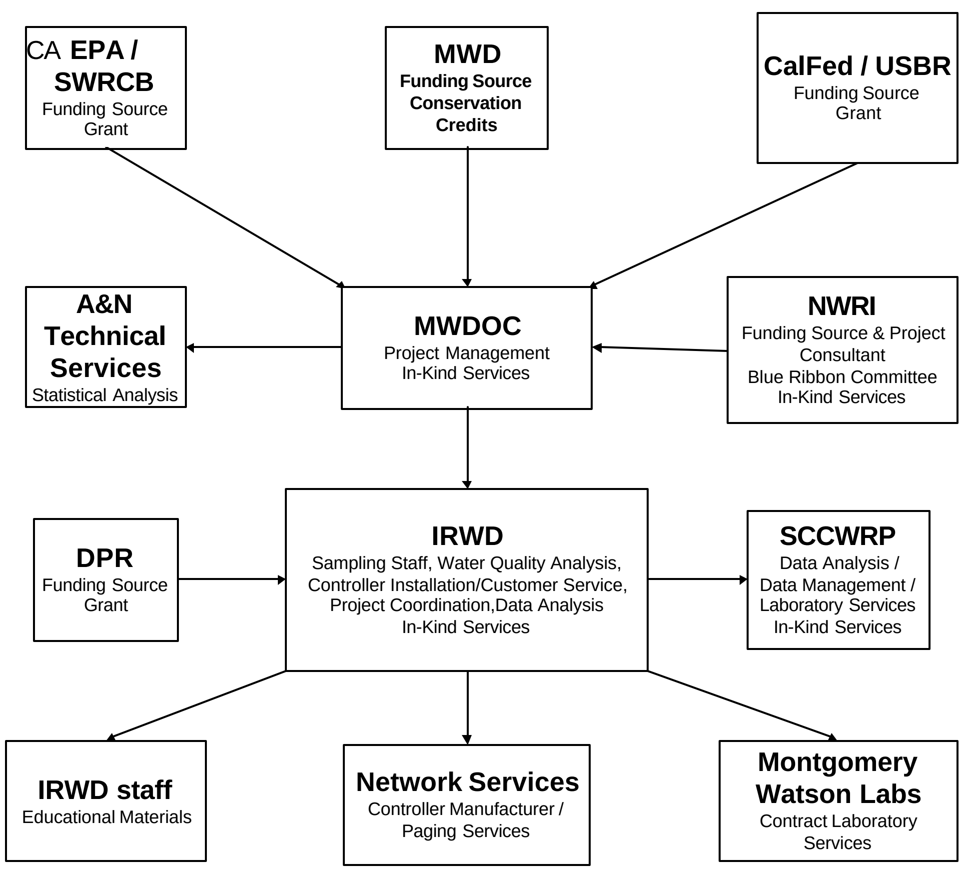
1.3 Study Goal and Objectives

The goal of the R3 Study was to quantify ET Controller savings for single-family residences and large landscape users. The study had four primary purposes: 1) to develop and expand the application and use of pager-signal (electronic controller) technology to manage irrigation water for residential homes and large landscape areas; 2) to evaluate the effectiveness of a targeted education program; 3) to determine the connection between proper water use in the landscape and the quantity and quality of dry weather runoff; and 4) to gauge the acceptance of water management via the controller technology.

1.4 Study Partners

The R3 Study was made possible through a partnership of agencies and organizations committed to improved water use efficiency and watershed management. The members of the partnership are shown on Figure 1-1. The figure also indicates the roles played by each study partner.

Figure 1-1
R3 Study Partners



As shown on Figure 1-1, the R3 Study involved a diverse mix of study participants and funding agencies bringing equally diverse interests and visions to the project. In general, the study was based on the premise that runoff from poor irrigation practices from urban areas in the San Diego Creek watershed constitutes non-point source pollution and contributes to water quality problems both in the Creek and in Newport Bay, the receiving water for the Creek. Although water quality problems in the Creek and Bay have been well documented, data on the specific sources of these pollutants is limited.

The R3 Study was intended to focus on and analyze both the quality and quantity of runoff from relatively small sub-areas of the watershed to provide insight into the sources of pollution in the Creek and Bay. In addition to providing this baseline information, the study was intended to evaluate the effectiveness of two methods of reducing runoff and improving water quality: 1) education; and 2) education combined with ET controller technology. Furthermore, since irrigation runoff is 100 percent water waste, the water agency participants were very interested in the ability of the study intervention methods to reduce customer water usage.

The R3 Study presented a good opportunity to develop valuable information about the relative effectiveness of structural (retrofit) versus non-structural (public education) controls. A technology + education (retrofit group) BMP was applied in one neighborhood, an education-only BMP was applied in a second neighborhood, and a control was established through three additional neighborhoods.

A more detailed discussion of the study participants is provided below. For purposes of simplicity, the organizations are categorized as agencies responsible for water quality, agencies responsible for water supply, and “supporting participants.” However, in many cases, these objectives are overlapping and are not mutually exclusive.

1.4.1 Agencies Responsible for Water Quality

Study participants whose major area of responsibility is water quality include the California Environmental Protection Agency (CAEPA), the State Water Resources Control Board (SWRCB), the Regional Water Quality Control Board (RWQCB), the California Department of Pesticide Regulation (DPR), the County of Orange, and the Southern California Coastal Water Research Project (SCCWRP). These agencies are charged with regulating, enforcing, implementing, or researching and monitoring federal and state laws pertaining to water quality and the control of constituents which may degrade water quality. For example, the RWQCB is responsible for establishing limits on the amount of pollutants that can be discharged to Newport Bay. These limits are defined as “Total Maximum Daily Load” (TMDL). The County of Orange, which provided indirect funding to the study through DPR, is the primary permittee on the Municipal Separate Storm Sewer System (MS4) Permit issued by the RWQCB. The County’s primary interest in the study relates to their efforts to implement a comprehensive program of BMPs to meet the TMDLs as required by the MS4 permit. In addition to providing improved baseline water quality and runoff information, these agencies focus on gauging the effectiveness of the two study intervention methods in reducing the quantity of runoff and improving the quality of the water that does run off.

l.4.2 Water Agencies

IRWD and MWDOC are water districts whose primary mission is to provide safe and reliable water service to customers within their respective service areas. The reliability of water service, in particular, is directly related to the efficiency of water use. In other words, since supplies of reasonably priced water are essentially fixed, increases in efficiency can result in additional supplies being available for storage until they are needed during periods of supply shortages.

Both IRWD and MWDOC, as well as MWDOC's "parent" agency, MWD, operate various water efficiency/conservation programs within their service areas. Some progress has been made on increasing water use efficiency from programs targeting outside use for landscape irrigation (which generally accounts for about 50 percent of total urban water use). However, water use in this sector remains closely linked to the ability and responsiveness of landscape personnel with responsibility for controlling and adjusting irrigation control timers.

Two basic issues are associated with this "people to water use efficiency" link. First, there is a wide variation in the abilities of personnel to properly set baseline irrigation schedules based on site factors (type of plant material, soil, exposure, slope, irrigation equipment, etc.). Second, for various reasons, it is believed that very few of these timers are adjusted on a sufficient frequency to promote optimum water use efficiency. Consequently, the water agencies are very interested in technologies such as the irrigation controller tested as a part of the R3 study. This technology allows irrigation schedules to be automatically adjusted based on real-time weather conditions. Equally important, the technology provides the ability to set appropriate base irrigation schedules by site conditions, particularly the soil type (infiltration capacity) and slope. This capability is critical to reducing runoff.

In addition to the potential effectiveness of the water management/irrigation controller program, IRWD and MWDOC were also very interested in determining if the focused educational and communication efforts tested in the study could yield customer water savings. This is particularly important since these efforts can be a very cost-effective way to achieve water savings.

In addition to water conservation, water agencies are becoming increasingly aware of their role as providers of water which, if not used efficiently, may ultimately become a nuisance or source/carrier of non-point source pollution. Consistent with its vision to optimize the use of resources as demonstrated by its globally-recognized recycled water reuse program, IRWD in particular has taken a leadership role in addressing irrigation runoff/non-point source pollution within its service area, which covers a majority of the San Diego Creek watershed. In addition to the current study focusing on potential source control measures, IRWD has prepared a master plan outlining a system of constructed wetlands which will capture and treat runoff and improve water quality in the watershed and Newport Bay.

1.4.3 Supporting Participants

The remaining study participants provided vital support for various aspects of the study. Network Services Corporation (now HydroPoint Data Systems, Inc.) manufactured the ET controllers used in the study and was responsible for compiling weather data and transmitting this information to the controllers. The National Water Research Institute (NWRI) provided input on the study design and evaluation, and A&N Technical Services prepared the detailed analysis of water savings and runoff reduction under a contract. Similarly, a portion of the water quality analysis was conducted under a contract by Montgomery Watson.

1.5 Report Organization

The R3 Study report is organized into two main parts: a body, consisting of seven chapters, followed by eight Appendices containing references and the analyses prepared by the study partners and presented in their entirety.

The first two sections of this report (Chapters 1 and 2) present general information about study goals and methodology. Chapter 1 presents study rationale, goals and objectives, and participating organizations. Chapter 2 describes how the study area was developed and presents the methodology used to develop information on the four main study areas: water conservation savings, dry season runoff/reduction savings, water quality impacts, and customer acceptance/public education.

Chapters 3 through 6 present the evaluations for the four main study areas, respectively, water conservation, dry season runoff, water quality, and customer acceptance. Each chapter provides an overview, summarizes the evaluation approach, presents results, and summarizes major conclusions. More detailed information on the evaluations is presented in the Appendices.

The final section of this report (Chapters 7) integrates study results and describes relevance for future planning and policy. Key findings, conclusions, and recommendations are presented.

The Appendices to this report contain eight sections. Appendix A, References, lists reports, articles, and other documents utilized during the R3 Study. Appendix B, Study Design, provides support information for Chapter 2, Study Methodology, and provides details on the techniques and methods used for data collection, sampling, and analysis. Appendix C, Water Conservation, presents the detailed water conservation evaluation conducted by A&N Technical Services, Inc., and includes detailed information on data models developed for the analysis. Appendix D1, Statistical Analysis of Urban Runoff Reduction, and Appendix D2, 2003 Runoff Data, present the detailed statistical analysis of runoff reduction. These analyses were also prepared by A&N Technical Services, Inc., and include detailed information on the data collection and analysis approach. Appendix E1 and E2 present Water Quality information. E1 was prepared by SCCWRP, and E2 was prepared by GeoSyntec Consultants. Finally, Appendix F, Public Education, presents information on customer acceptance and public involvement.

1.6 Abbreviations and Acronyms

The following abbreviations and acronyms are used in this report:

ADP	antecedent dry period
ANOVA	analysis of variance between groups
AWWA	American Water Works Association
AWWARF	American Water Works Association Research Foundation
BACI	before-after control impact
BMPs	Best Management Practices
CAEPA	California Environmental Protection Agency
Calfed	consortium of state and federal agencies who address California and San Francisco Bay-Delta water issues
cfs	cubic feet per second
CIMIS	California Irrigation Management Information System
CTR	California Toxic Rule
DPR	California Department of Pesticide Regulation
ET	evapotranspiration
fps	feet per second
GIS	geographic information system
gpd	gallons per day
HOA	homeowners association
IRWD	Irvine Ranch Water District
K-W	Kruskal-Wallis
mgd	million gallons per day
mg/acre/day	milligrams per acre per day
mg/L	milligrams per liter
mL	milliliters
MPN	most probable number
MS4	Multiple Separate Storm Sewer System
MWD	Metropolitan Water District of Southern California
MWDOC	Municipal Water District of Orange County
NPDES	National Pollutant Discharge Elimination System
NWRI	National Water Research Institute
OCPFRD	Orange County Public Facilities and Resources Department
OP	organophosphorus
ng/L	nanograms per liter
PCF	pressure control facility
R3	Residential Runoff Reduction Study
RWQCB	Regional Water Quality Control Board
SCCWRP	Southern California Coastal Water Research Project
SWRCB	State Water Resources Control Board
TIN	total inorganic nitrogen
TKN	total Kjeldahl nitrogen
TMDL	total maximum daily load
TN	total nitrogen

TP	total phosphorous
ug/L	micrograms per liter
USBR	United States Bureau of Reclamation
USEPA	Untied States Environmental Protection Agency

Chapter 2: Study Methodology

2.1 Overview

Historically, water agencies have utilized educational programs and in some cases allocation-based rate structures to achieve improved irrigation efficiency in urban landscapes. With the introduction of "smart" weather-based irrigation controller technology, which in early studies generated quantifiable and reliable irrigation water savings over time, water agencies may now have a new and effective management tool to introduce to residential and other customers. The R3 Study compared, in a controlled setting, water savings and watershed management benefits of a remote, weather-based "ET" automated irrigation controller technology. This chapter of the report presents information on the methodology used in the following areas:

- Study design, including study area development, flow monitoring and water quality sampling procedures, and determination of a viable ET irrigation controller operation and selection process.
- Evaluation of water conservation savings.
- Quantification of dry season runoff reduction savings.
- Assessment of water quality impacts.
- Approach to public acceptance/public education.

More information on study design is presented in Appendix B. Evaluation-specific information on study design, data collection/analysis, and results is presented in Chapters 3 through 6 for water conservation, dry season runoff reduction, water quality, and public education, respectively. Additional details are provided in Appendices C through F.

2.2 Study Design

Study design included developing a viable study area, which provided for accurate data collection and comparison. Identifying appropriate flow monitoring equipment and determining an effective ET irrigation controller operation and selection were also important.

The goal of this study is to compare the effectiveness of technological BMPs versus public education for reducing the volume, concentrations, and mass emissions of potential pollutants in dry weather runoff from irrigated landscapes. The technological BMP consisted of ET controllers that communicate with irrigation systems of individual households and selected large landscapes, such as street medians, parks, etc. This technology is designed to optimize watering times for landscaped areas, hence reducing over-watering and resultant runoff. (See Section 2.2.3.) The public education campaign focused both on appropriate watering times and on the correct application of pesticides, herbicides, and fertilizers. (See Section 2.3.4.) These two types of BMPs were tested in residential neighborhoods, typically the most common land use in urban watersheds (Wong et al.1997). The goal was to determine if technology or education provides more pollutant reduction so that urban runoff managers can select optimal runoff pollutant minimization strategies.

2.2.1 Development of the Study Area

When developing the R3 Study area, the study partners focused on identifying watersheds with similar characteristics that would enable them to confirm water savings identified in the previous "Westpark" study, a water conservation evaluation (IRWD, MWDOC and MWD, 200l). Because a parallel purpose was to expand upon the findings of the Westpark study by measuring changes in dry weather volume (dry season runoff evaluation) and pollutant content of residential runoff (water quality evaluation) associated with improved irrigation management practices, both single-family residences and medium-size landscapes were considered. The R3 Study area is located within IRWD's service area as shown on Figure 2-1.

The R3 Study involved data collection and evaluation not previously attempted at such a large scale. In order to ensure reliable and accurate results, the study team sought to minimize the effects of outside variables that might produce "skewed" results. The team designated a study area that included five similar neighborhoods in Irvine, California. The study area was configured so that meaningful data could be provided for the water conservation, dry weather runoff reduction, and water quality evaluations. Runoff from each of the neighborhoods could be isolated and sampled at a single point from within the municipal sewer system, enabling each neighborhood to be treated individually. At these points of drainage, the runoff volume was monitored, and water quality samples were taken. The five neighborhoods are summarized in Table 2-1 and depicted graphically on Figure 2-2.

Table 2-1
Summary of Neighborhoods

Name	Description/Purpose	Comments
Site 1001 Retrofit Group	The homes in this group were retrofitted with an ET controller and also received education information.	The Retrofit Group area consisted of: • 112 residential landscapes • 12 City of Irvine streets • 2 condominium associations • 1 homeowners association
Sites 1002 – 1004 Control Groups	The homes in this group were monitored as experimental control groups and received no ET controller and no public education materials.	The Control Group area had evaluation-specific variations in size and configuration. In addition, some evaluations assessed "matched" and "unmatched" controls from within and outside of the study area.
Site 1005 Education Group	The homes in this group received information materials only (the same education information as supplied to the Retrofit Group).	The Education Group consisted of 225 homes identified by visual selection. This area also included one large school site.

Figure 2-1
Location of R3 Study Area Within Southern California

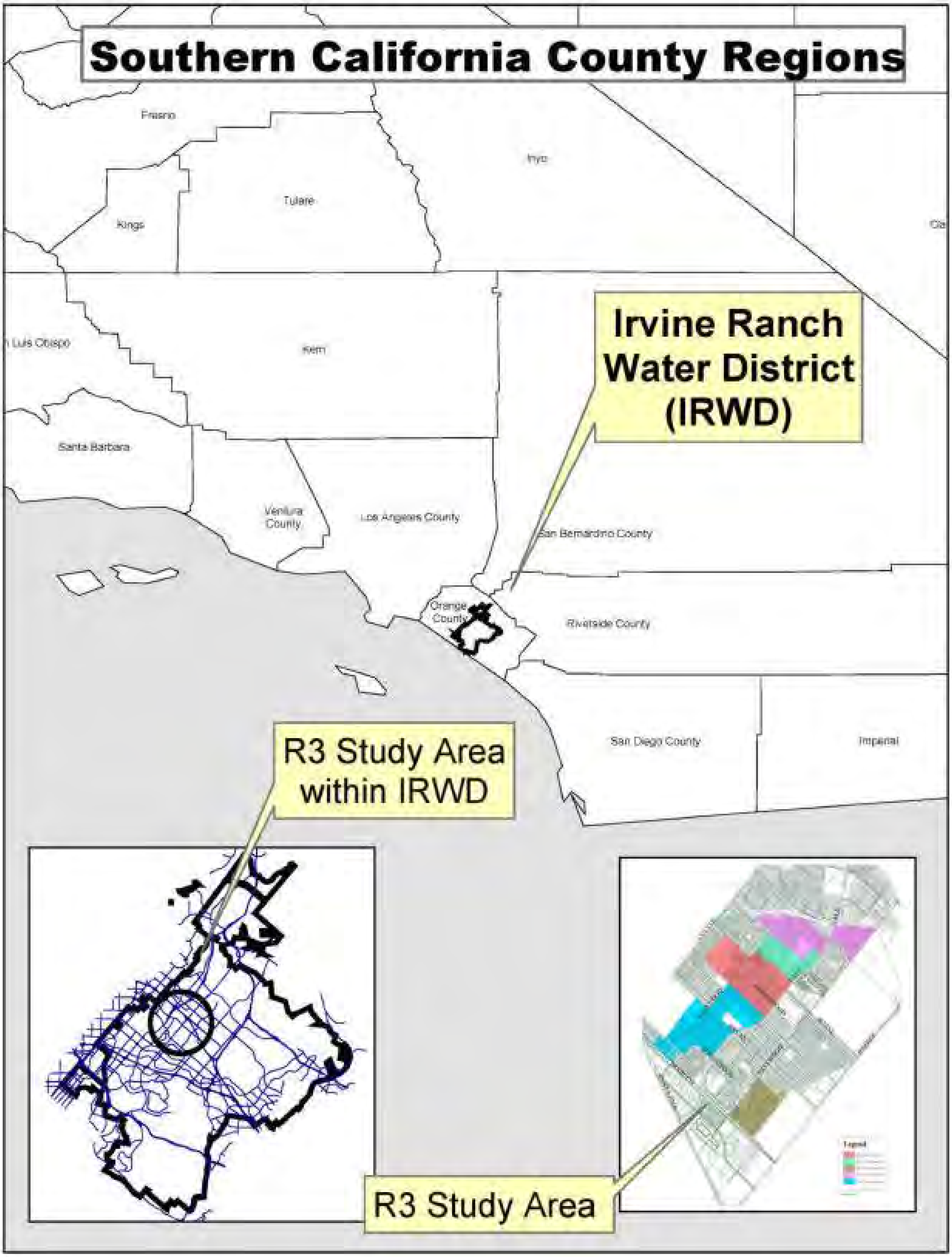
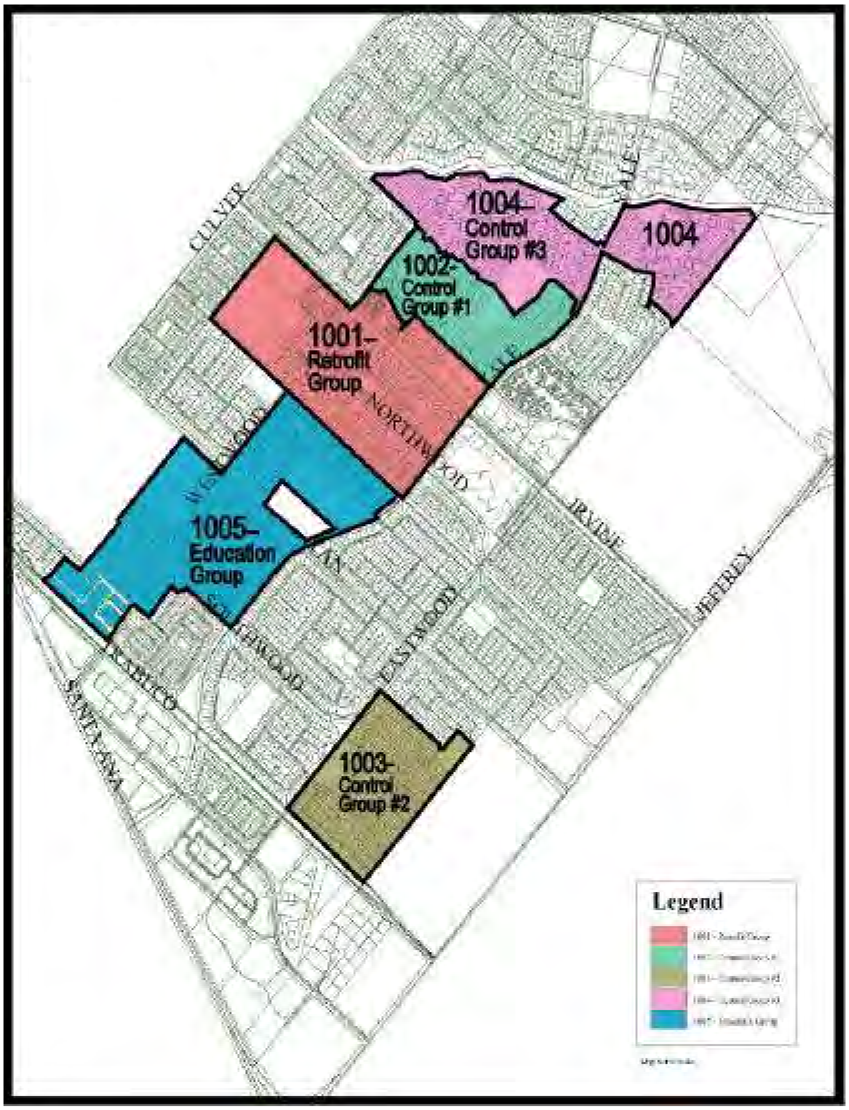


Figure 2-2
R3 Study Neighborhood Areas



In the first of the neighborhoods (Site 1001 or retrofit group), participating homes received a site evaluation and installation of an ET controller to automatically adjust irrigation schedules. Additionally, the residents at these homes received information regarding environmentally-sensitive landscape maintenance practices. The controllers were installed in 112 residential homes, 12 city street landscapes in the City of Irvine, two condominium associations' landscapes, and one homeowners association (HOA) landscape. The HOA landscape had three distinctive sites: 1) pool/park/tennis courts, 2) park, and 3) streetscapes.

The second neighborhood (Site 1005, or education group) received the same environmentally-sensitive landscape maintenance information as the first group, as well as a suggested irrigation schedule.

The three remaining neighborhoods (Sites 1002 – 1004, or control group) did not receive ET controllers and were not provided educational materials. Residents in the control groups had no knowledge of the study and were used only for comparison purposes. The make-up of the control group varied depending upon the evaluation. In the water conservation evaluation, "matched controls" were used in addition to the control group sites. In the water conservation and the dry weather runoff evaluations, only data from Site 1004 was used, as discussed in Sections 2.3.1 and 2.3.2. Data from all three sites was used in the water quality evaluation.

The five neighborhoods were selected based on the following criteria: 1) isolation from other neighborhood watersheds, 2) climate, 3) land use, 4) development age, and 5) irrigation water management techniques. These parameters are described in greater detail in Appendix B.

2.2.2 Flow Monitoring / Water Quality Sampling

This section summarizes the approach to flow monitoring and water quality sampling.

2.2.2.1 Flow Monitoring

Two main criteria were established for the study's flow monitoring equipment. First, the monitor could not alter the pipe or channel. Second, the monitoring had to be sufficiently accurate to distinguish seasonal flow changes and any flow change that resulted from the two study treatments (retrofit and education). Because the storm drain systems used for flow monitoring are designed to convey peak storm flows, and the focus of the R3 study was on changes in dry season (low flow) runoff associated with the treatments, the flow monitors had to be able to detect relatively small differences in low volume flows in large diameter storm drains. This situation was exacerbated by the fact that only a portion of each tributary neighborhood received the study treatments. Two flow monitoring technologies were determined to meet these criteria:

- Manning's equation plus a level sensor
- Velocity sensor and level monitor (area-velocity)

The area-velocity method was chosen due to lack of slope information for the storm drain system. The selected equipment was an American Sigma 950, which is battery-operated and can record data every minute. The equipment has an ultrasonic transmitter and a velocity sensor, both of which were installed in the storm drain. The ultrasonic transmitter establishes the water surface level and area, while the velocity sensor determines the velocity of the water in the pipe. Flow is calculated by the equation:

- Flow = Area x Velocity

Because four of the five monitoring locations were in a pipe, several variations on the ultrasonic transmitter / velocity sensor were tested before the combination of sonic and velocity wafer were finalized.

The accuracy of the flow monitoring equipment was tested at all study sites. This was accomplished by metering flow (at three different levels) from a fire hydrant within each tributary watershed and comparing these metered flows to flows measured at the flow monitoring locations. As expected, the accuracy of the flow monitors varied from site to site depending on the nature and condition of each storm drain. For example, some settling of the storm drain was noted near the flow monitor for Site 1002, resulting in an accumulation of sediment. This physical "anomaly" altered the hydraulic characteristics of the pipe and affected the accuracy of flow measurements. However, based on the flow test results, it was believed that these issues were manageable. The subsequent analysis of flow data as presented in Chapter 4 of this report suggests that this belief was partially correct; although flow monitoring problems required data from two of the three control sites to be discarded, the data from the other three sites (two treatments and one control) was sufficiently accurate to allow for the determination of meaningful statistical results.

2.2.2.2 Water Quality Sampling

The water quality sampling program quantified constituents found in residential runoff flows. This program consisted of two phases: 1) pre-study and 2) dry weather sampling. More information about water quality sampling and analysis is provided in Section 2.3.3, Chapter 5 and Appendices B and E.

2.2.3 ET Irrigation Controller Operation and Selection Process

The technology-based BMP consisted of an ET controller + education. The ET controller selected was similar to most automatic sprinkler timers available at home improvement stores and nurseries, but with the capacity to receive radio signals that will alter sprinkler timing based on current weather conditions. If the weather is hot and dry, the radio signal calls for longer or more frequent irrigation. If the weather is cool and moist, such as recent precipitation, the radio signals call for shorter or less frequent irrigation. For the R3 Study, the existing sprinkler timers that are set manually by the homeowner were replaced with the radio-controlled ET controller systems. Trained technicians were used to ensure successful installation because the ET controller requires programming for each valve including area (size of yard or planter per valve), soil type (clay, sand, etc.), and landscape type (turfgrass, shrubbery, etc.). The remaining irrigation system was unchanged, including piping and sprinkler head configuration.

Since residential areas include landscapes other than the homeowners, these "common area" and streetscape landscape areas ("medium-size" landscapes) were included in the water management component of the R3 Study. As shown in Table 2-2, the medium-size landscapes accounted for an estimated 70 percent of the total landscape area treated in the retrofit group (Site 1001). The installation process for both residential and medium-size landscapes is described in Appendix B.

2.2.3.1 Controller Installation

The study evaluated the performance of the engineering of irrigation management techniques to reduce the consumption and residential runoff while maintaining the quality of the landscape. A typical irrigation controller is difficult to program and limited in the scope of the scheduling ability. Proper scheduling requires calculations based on real time ET data, landscape topography, and plant type, which are beyond the capabilities of typical controllers. The landscaper in the field is left to guess or rely on past experience as to the correct amount of water, the correct runtime to prevent runoff, and the correct number of days of the week to water.

The controllers were installed following the general principle that an ET controller is a water management tool and that professional operation should result in conservation and reduction of runoff. A picture of the controller is shown on Figure 2-3. More information is provided in Appendix B.

Figure 2-3
ET Controller

2.2.3.2 ET Controller Operation

The operation of the ET controller in this study was optimized by proper irrigation scheduling. As discussed further in Chapter 4 and Appendices B, D1 and D2, the ET controller must meet three key criteria: cost, ease of operation, and ability to conserve water and reduce runoff.

2.3 Study Evaluations

This section summarizes the water conservation evaluation, the quantification of changes in dry season runoff reduction savings, the analysis of water quality impacts, and the approach to customer acceptance / public education.

Table 2-2
Study Sites Land Use and Treatment Summary

Site 1001

Land Use	No. of Lots	Acres	Treatment Sites	Treatment Acreage*	No. of Controllers
SFR	565	66.8	112	6.6	112
Condo	109	10.3	2	1.9	8
HOA	4	5.9	1	0.9	3
School	2	4.6			
Landscape	10	19.4	12	11.2	15
Street	97	49.7			
Unmetered	64	11.5			
Total	**851**	**168.1**	**127**	**20.5**	**138**

***Note: All acreage except SFR were considered "medium-size" landscapes.**

Site 1002

Land Use	No. of Lots	Acres	Treatment Sites	Treatment Acreage	No. of Controllers
SFR	-	-	control	control	control
Condo	-	-	control	control	control
HOA	-	-	control	control	control
School	-	-	control	control	control
Landscape	-	-	control	control	control
Street	-	-	control	control	control
Unmetered	-	-	control	control	control
Total	**-**	**-**			

Table 2-2 (continued)
Study Sites Land Use and Treatment Summary

Site 1003

Land Use	No. of Lots	Acres	Treatment Sites	Treatment Acreage	No. of Controllers
SFR	-	-	control	control	control
Condo	-	-	control	control	control
HOA	-	-	control	control	control
School	-	-	control	control	control
Landscape	-	-	control	control	control
Street	-	-	control	control	control
Unmetered	-	-	control	control	control
Total	**-**	**-**			

Site 1004

Land Use	No. of Lots	Acres	Treatment Sites	Treatment Acreage	No. of Controllers
SFR	417	47.8	control	control	control
Condo	-	-	control	control	control
HOA	1	0.9	control	control	control
School	1	8.0	control	control	control
Landscape	2	0.0	control	control	control
Street	42	25.0	control	control	control
Unmetered	61	7.1	control	control	control
Total	**524**	**88.8**			

Site 1005

Land Use	No. of Lots	Acres	Treatment Sites	Treatment Acreage	No. of Controllers
SFR	559	67.9	225	13.0	n/a
Condo	-	-	-	-	n/a
HOA	1	1.5	-	-	n/a
School	2	12.1	-	-	n/a
Landscape	2	0.0	-	-	n/a
Street	45	0.0	-	-	n/a
Unmetered	8	2.7	-	-	n/a
Total	**617**	**84.2**	**225**	**13.0**	**0**

2.3.1 Water Conservation Evaluation

The water conservation evaluation was conducted by A&N Technical Services, Inc. The firm performed a statistical analysis of historical water consumption records from, roughly, July 1997 to August 2002. Two main types of water use were reviewed: single-family residences and medium-size landscapes. For the single-family residences, data was compared among the retrofit group, the education group, and the control group. For the medium-size landscape accounts, a slightly different approach was used. Accounts within the study area were compared to "matched" and "unmatched" controls in the City of Irvine, both within and outside of the study area. Matched controls were similar in sun exposure, irrigation type, soil type, etc. Unmatched controls were areas not similar enough to be used for direct comparison but areas that could be used for weather normalization. A detailed description of the methods used to evaluate water savings for the single-family residence and medium-size landscape sites is provided in Chapter 3 and Appendix C of this report.

2.3.2 Dry Season Runoff Reduction Savings Quantification

In addition to the water conservation evaluation, A&N Technical Services, Inc., performed a statistical analysis of the reduction of runoff induced by ET controller and irrigation education. With the assistance of IRWD staff, who collected runoff data, A&N developed regression models to estimate mean runoff by site.

Two of the control sites (1002 and 1003) had recurring measurements issues that produced generally unreliable data. Site 1002 was found to have a physical hydraulic jump, which caused sediments to build in such a way that flows avoided the monitor. At Site 1003, there was an occurrence of illegal dumping of cement into the storm drain. This event reshaped the monitoring area, led to continuous collection of debris, and caused the monitor to perform erratically. Thus, it was only possible to use data from Site 1004. More details are provided in Chapter 4 and Appendices D1 and D2.

2.3.3 Water Quality Impacts Assessment

As described in Section 2.2.2.2, the water quality sampling program quantified constituents found in residential runoff flows. Two independent reviews of the water quality data were performed. The initial review, conducted by SCCWRP, used parametric statistical techniques (t-test; analysis of variance [ANOVA]), which provide a good descriptive review of the study. However, these techniques are generally considered to have less power for detecting differences in data than other statistical tests. A subsequent statistical overview was performed by Geosyntec Consultants to review alternative and possibly more "robust" data analysis techniques. This work, which included the review of only a portion of the data set, focused on additional descriptive techniques (time series plots; box plots; probability distributions) and the use of non-parametric statistical techniques (rank-sum test; Kruskal-Wallis [K-W]). The SCCWRP and Geosyntec Consultants reports are presented in Appendix E-1 and E-2, respectively.

2.3.4 Public Acceptance / Public Education Approach

The public acceptance evaluation was conducted to compare the effectiveness of proposed BMPs for ET controller technology + education and education only. The participating ET technology retrofit group homes received a site evaluation and installation of an ET controller to manage the irrigation system. Additionally, the residents of these homes received information regarding environmentally-sensitive landscape practices. The education-only group received an initial informational packet containing three items: an introductory letter, an informational booklet, and a soil probe to measure the water content of landscaped soils.

In addition to the initial packet, monthly reminders were mailed to each homeowner that included tips for maintaining the irrigation system. Suggested sprinkler run times (for the non-ET controller neighborhood) and tips on fertilizer or pesticide application usage, including non-toxic alternatives, were also provided in the monthly newsletter. A telephone log was kept to monitor incoming customer calls relating to the R3 Study, and a pre- and post-program survey was developed to measure customer impact of the study. More details are provided in Chapter 6 and Appendix F.

Chapter 3: Water Conservation

3.1 Overview

This chapter describes the statistical analysis of water savings (water conservation) among customers who installed ET controllers and customers given irrigation education in the study area. Specific information includes:

- A summary of study methods and evaluation approach.
- Evaluation results for large landscape customers and for single-family residences.
- Effect of ET controllers on seasonal peak demand.

More detailed information is provided in Appendix C.

3.2 Evaluation Approach

This section summarizes the overall evaluation approach, the records, review process, and data assessment techniques.

3.2.1 Overall Evaluation Approach

Historical water consumption records for a sample of participants and for a sample of nonparticipating customers were examined statistically. The hypothesis was that installation of new irrigation technology or better management of existing equipment would reduce the observed water consumption of customers participating in this program. This study empirically estimates the water savings that resulted from two types of "interventions"—1) customers receiving both ET controllers and follow-up education and 2) customers receiving an education-only intervention. Both single-family residences and medium-size landscapes were evaluated. (See Tables 3-1 and 3-2.)

Table 3-1
Summary of Water Conservation Evaluation Approach for Single-family Residences

Site	Number of Usable Accounts	
Site 1001 Retrofit Group	Retrofit Non Participants	97* 213
Site 1004 Control Group		264
Site 1005 Education Group	Education Non Participants .	192* 346

*Note: These sample numbers are smaller than the total number of original participants in each group due to changes in tenants, anomalous data, and other data quality issues.

Table 3-2
Summary of Water Conservation Approach for Medium-size Landscapes

Type	Number of Usable Accounts	Average Acres Per Account
Participating Landscapes	15*	0.93
Matched Controls	76	0.92
Unmatched Controls	895	0.96

Note: This sample number is smaller than the total number of original study participants due anomalous data, and other data quality issues.

Since installation of ET controllers required the voluntary agreement of the customer to participate, this sample of customers can be termed "self-selected." Customers in the education–only group were initially approached by mail about their interest in participating in the study. 137 customers initially expressing interest were included in the study group. However, because sufficient interest in the study was not generated through this mailing to meet the study saturation goals for this group, the remaining 112 participants self selected. While this analysis does quantitatively estimate the reduction of participant's water consumption, one may not directly extrapolate this finding to nonparticipants. This is because self-selected participants can differ from customers who decided not to participate.

The explanatory variables in these models include:

- Deterministic functions of calendar time, including
    - the seasonal shape of demand
- Weather conditions
    - measures of air temperature
    - measures of precipitation, contemporaneous and lagged
- Customer-specific mean water consumption
- "Intervention" measures of the date of participation and the type of intervention

3.2.2 Records Review Process

Consumption records were compiled from IRWD's customer billing system for customers in the study areas. Billing histories were obtained from meter reads between July 1997 and August 2002. It is important to note that a meter read on August 1 will largely represent water consumption in July. Since the ET controllers were installed in May and June of 2001, the derived sample contained slightly more than one year of data for each participant. More information is presented in Appendix C.

The landscape-only customers (15 accounts) were handled separately. Two control groups were developed for these irrigation accounts: A matched control group was selected by IRWD staff by visual inspection, finding three-to-five similar control sites for each participating site. Similarity was judged by irrigated area and type of use (HOA, median, park, or streetscape). Since the City of Irvine was improving irrigation efficiency on the City-owned sites during the post-intervention period, this matched control group also had potential water savings. A second control group was developed where the selection was done solely based on geographic area. In this way, the statistical models could separately estimate the water savings effects for each group. (See Appendix C.)

3.2.3 Data Assessment Techniques

The first major issue with using meter-read consumption data is the level and magnitude of noise in the data. The second major issue is that records of metered water consumption can also embed non-ignorable meter mis-measurement. To keep either type of data inconsistencies from corrupting statistical estimates of model parameters, the modeling effort employed a sophisticated range of outlier-detection methods and models. These are described in Appendix C.

Daily weather measurements—daily precipitation, maximum air temperature, and evapotranspiration—were collected from the California Irrigation Management Information System (CIMIS) weather station located in Irvine. Daily weather histories were collected as far back as were available (January 1, 1948) to provide the best possible estimates for "normal" weather through the year. Thus, 54 observations were available upon which to judge "normal" rainfall and temperature for January 1^{rst} of any given year.

Robust regression techniques were used to detect which observations were potentially data quality errors. This methodology determines the relative level of inconsistency of each observation with a given model form. A measure is constructed to depict the level of inconsistency between zero and one; this measure is then used as a weight in subsequent regressions. Less consistent observations are down-weighted. Other model-based outlier diagnostics were also employed to screen the data for any egregious data quality issues.

3.3 Evaluation Results

This section presents evaluation results for single-family residences and landscape-only customers. The effect of ET controllers on peak demand is also discussed.

3.3.1 Estimated Single-family Residential Water Demand

Table 3-3 presents the estimation results for the model of single-family water demand in the R3 study sites. Twenty-one variables are listed. This sample represents water consumption among 1,525 single-family households between June 1997 and July 2002. This sample contains 97 ET controller/education participants (in Site 1001) and 192 education-only participants (in Site 1005). This sample is smaller than the total number of participants in each group due to changes in tenants and anomalous data.

The constant term (1) describes the mean intercept for this equation. (A separate intercept is estimated for each of the 1,525 households, but these are not displayed in Table 3-3 for reasons of brevity.) The independent variables 2 to 8—made up of the sines and cosines of the Fourier series described in Appendix C (Equation 2)—are used to depict the seasonal shape of water demand.

Table 3-3
Single-family Residential Water Demand Model

Dependent Variable: Average Daily Metered Water Consumption in gallons per day (gpd)		
Independent Variable	**Coefficient**	**Std. Error**
1. Constant (Mean intercept)	405.6593	3.1660
2. First Sine harmonic, 12 month (annual) frequency	-45.4215	0.9636
3. First Cosine harmonic, 12 month (annual) frequency	-89.1494	0.9629
4. Second Sine harmonic, 6 month (semi-annual) frequency	3.6549	0.6798
5. Second Cosine harmonic, 6 month (semi-annual) frequency	1.0709	0.6733
6. Third Cosine harmonic, 4 month frequency	1.7312	0.7151
7. Fourth Sine harmonic, 3 month (quarterly) frequency	4.4016	0.7403
8. Fourth Cosine harmonic, 3 month (quarterly) frequency	3.3491	0.7865
9. Interaction of contemporaneous temperature with annual sine harmonic	48.7897	17.1559
10. Interaction of contemporaneous temperature with annual cosine harmonic	-72.4672	22.3626
11. Deviation from logarithm of 31 or 61 day moving average of maximum daily air temperature	284.7163	13.542
12. Interaction of contemporaneous rain with annual sine harmonic	10.1102	1.8546
13. Interaction of contemporaneous rain with annual cosine harmonic	5.9969	2.6904
14. Deviation from logarithm of 31 or 61 day moving sum of rainfall	-34.0117	1.8931
15. Monthly lag from rain deviation	-13.3173	1.0549
16. Average Effect of ET controller/Education (97 participants)	**-41.2266**	**4.0772**
17. Interaction of ET intervention with annual sine harmonic	38.9989	5.3327
18. Interaction of ET intervention with annual cosine harmonic	-6.3723	4.8980
19. Average Effect of Education-only intervention (192 participants)	**-25.5878**	**2.8081**
20. Interaction of Ed.-only intervention with annual sine harmonic	6.0357	3.5870
21. Interaction of Ed.-only intervention with annual cosine harmonic	-3.0703	3.3826
Number of observations	94,655	
Number of customer accounts	1,525	
Standard Error of Individual Constant Terms		120.85
Standard Error of White Noise Error		129.81
Time period of Consumption	June 1997 - July 2002	

The predicted seasonal effect is the shape of demand in a normal weather year. This seasonal shape is important because it represents the point of departure for the estimated weather effects (expressed as departure from normal). The effect of the landscape interventions on this seasonal shape was also tested.

The estimated weather effect is specified in "departure-from-normal" form. Variable 11 is the departure of monthly temperature from the average temperature for that month in the season. (Average seasonal temperature is derived from a regression of daily temperature on the seasonal harmonics.) Rainfall is treated in an analogous fashion (Variable 14). One month lagged rainfall deviation is also included in the model (Variable 15). It is also noted that the contemporaneous weather effect is interacted with the harmonics to capture any seasonal shape to both the rainfall (Variables 12 and 13) and the temperature (Variables 9 and 10) elasticities. Thus, departures of temperature from normal produce the largest percentage effect in the spring growing season. Similarly, an inch of rainfall produces a larger effect upon demand in the summer than in the winter.

The effect of the landscape conservation program interventions is captured in the following rows. The parameter on the indicator for ET controllers/education (Variable16) suggests that the mean change in water consumption is 41.2 gpd (reduction) while the education only participants (Variable 19) saved approximately 25.6 gpd. Because residential meters serve both outdoor and indoor demand, the model cannot say whether education-only participants saved this water through improved irrigation management or by also reducing indoor water consumption. Since the sample includes only one year of post-intervention data, the model cannot say how persistent either effect will be in future years.

3.3.2 Estimated Landscape Customer Water Demand

Table 3-4 presents the estimation results for the model of medium-size landscape (irrigation-only) customer water demand in the R3 study sites. Seventeen variables are listed. This sample represents water consumption among 992 accounts between June 1997 and August 2002 and contains 21 ET controller accounts, 76 matched control accounts, and 895 unmatched control accounts.

The constant term (1) describes the intercept for this equation. The independent variables 2 to 9—made up of the sines and cosines of the Fourier series described in Appendix C (Equation 2)—are used to depict the seasonal shape of water demand. The estimated weather effect is specified in "departure-from-normal" form. Variable 10 is the departure of monthly temperature from the average temperature for that month in the season. (Average seasonal temperature is derived from a regression of daily temperature on the seasonal harmonics.) Rainfall is treated similarly (Variable 11). One month lagged rainfall deviation is also included in the model (Variable 12). The next variable accounts for the amount of irrigated acreage on the site. (Note that while measured acreage is available for all irrigation-only accounts, this is not true for single-family accounts.)

The effect of the landscape conservation program interventions is captured in the following rows. The parameter on the indicator for ET controllers (Variable 14) suggests that the mean change in water consumption is 545 gpd (reduction), approximately 21 percent of the pre-intervention water use. The matched control group (Variable 16) did experience water savings, approximately 241 gpd or 8.7 percent of their pre-intervention water use. As noted previously, this group included City of Irvine landscape accounts for which a parallel water efficiency program was conducted. The variables testing for differences in pre-intervention use cannot distinguish any differences between the different types of accounts.

Table 3-4
Landscape Customer Water Demand Model

Dependent Variable: Average Daily Metered Water Consumption (in gallons per day)		
Independent Variable	**Coefficient**	**Std. Error**
1 Constant (Mean intercept)	2624.0890	235.5602
2. First Sine harmonic, 12 month (annual) frequency	-810.6712	26.4690
3. First Cosine harmonic, 12 month (annual) frequency	-1979.1650	26.1149
4. Second Sine harmonic, 6 month (semi-annual) frequency	103.7890	26.7195
5. Second Cosine harmonic, 6 month (semi-annual) frequency	-18.6126	27.1067
6. Third Sine harmonic, 4 month frequency	-123.5511	28.2926
7. Third Cosine harmonic, 4 month frequency	106.4412	28.6328
8. Fourth Sine harmonic, 3 month (quarterly) frequency	38.3819	30.6999
9. Fourth Cosine harmonic, 3 month (quarterly) frequency	-61.4848	30.9128
10. Deviation from logarithm of 31 or 61 day moving average of maximum daily air temperature	6293.6890	565.6084
11. Deviation from logarithm of 31 or 61 day moving sum of rainfall	-748.2235	52.1792
12. Monthly lag from rain deviation	-209.9027	46.5477
13. Irrigated Acreage (in acres)	485.1284	140.1746
14. ET controller sites, test for difference in pre-intervention use	-327.6321	1511.6870
15. Average Effect of ET controller (21 accounts)	-545.3841	330.3669
16. Matched accounts, test for difference in pre-intervention use	-166.6455	693.9447
17. Average Effect of city efficiency improvements (76 accounts)	-240.4067	148.4015
Number of observations		56666
Number of customer accounts		977
Standard Error of Individual Constant Terms		5766.8
Standard Error of White Noise Error		4189.5
Time period of Consumption	June 1997 - July 2002	

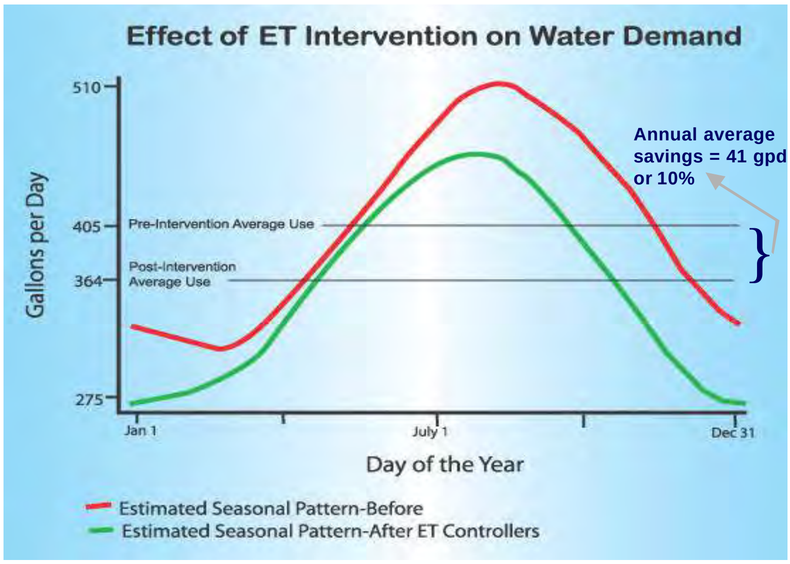
3.3.3 Effect of ET Controllers on Seasonal Peak Demand (Single-family Residential)

The question of how these programs affected the seasonal shape of water demand can be interpreted from the remaining interactive effects—the indicators interacted with the first sine and cosine harmonics.

When the pre / post seasonal patterns are combined with their pre / post mean water consumption, the following before and after picture can be seen throughout the year.

On Figure 3-1, several observations should be made. First, the difference between the two horizontal lines corresponds to the estimated mean reduction of approximately 41 gpd. Second, the assumption of a constant 41 gpd effect does not hold true throughout the year. The reduction is barely noticeable in the spring growing season and is much larger in the fall.

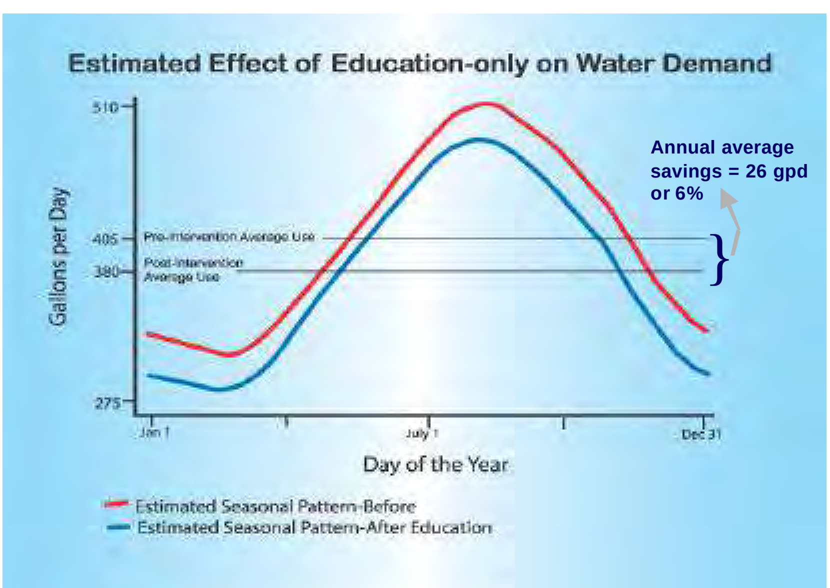
Figure 3-1
Effect of ET Intervention on Seasonal Water Demand for Single-family Residential



The reduction in peak demand—though dependent upon how the seasonal peak is defined—is greater than the average reduction. The estimated peak day demand, occurring on August 8, is reduced by approximately 51 gallons. This "load-shaping" effect of the ET controller intervention can translate into an additional benefit to water agencies. The benefits from peak reduction derive from the avoided costs of those water system costs driven by peak load and not average load—the costs for new treatment, conveyance, and distribution all contain cost components driven by peak capacity requirements

Figure 3-2 plots the corresponding estimates for the education-only intervention. The reduction in average demand is less—approximately 25 gpd. The effect upon the estimated seasonal shape of demand is much more muted. In fact, the change to the estimated seasonal shape of demand induced by the education-only intervention is not significantly different from zero at classical levels of significance.

Figure 3-2
Estimated Effect of Education-only on Seasonal Water Demand for Single-family Residential



3.4 Conclusions

This modeling effort focused on developing the best depiction of net changes in water consumption due to the landscape interventions of ET controllers and / or education. Much of the modeling effort was expended on data cleaning, diagnosis, and validation. The most serious data issues were identified and appropriately handled. To the extent that future data quality can be improved, future work could provide several statistical refinements in model specification. These are described in Appendix C.

The documentation provided in this report describes the shape of water savings achieved by the landscape interventions of ET controllers and / or education. Households participating in these programs saved significant amounts of water. Savings for the education-only program were less than for the retrofit group, but were still significant. The ET controller / education program changed both the level and shape of water demand.

Chapter 4: Runoff

4.1 Overview

This chapter presents the statistical analysis of the reduction of runoff induced by ET controllers and irrigation education. Specific information includes:

- Description of flow meters used and the data collection approach
- Discussion of the runoff analysis and analytical methods
- Presentation of evaluation results

More detailed information is provided in Appendices D1 and D2.

4.2. Evaluation Approach

The evaluation approach is summarized in Table 4-1 and discussed in more detail below.

Table 4-1
Summary of Dry Weather Runoff Evaluation Approach

Site	Description/Purpose	Controllers	Measuring Points
Site 1001 Retrofit Group	The study site contained 565 single-family residences. Of these, 112 participated in the ET/education program. In addition, 15 medium-size landscape sites also received ET controllers.	The accounts listed in Table 2-1 were allocated controllers as follows: • 112 for residential landscapes • 15 for 12 City of Irvine streets • 8 for the condominium associations • 3 for the HOA	1
Sites 1004 Control Group	This site contained 417 single-family residences and 44 large landscapes.	Not Applicable	1
Site 1005 Education Group	At this site, 225 residential customers participated in the irrigation education program.	Not Applicable	1

4.2.1 Data Collection

To measure dry weather runoff, flow monitors were installed at the five locations shown on Figure 4-1. The study used Sigma 950 flow monitors manufactured by Hach. The flow monitor applies an area-velocity calculation. The basic formula for flow is: flow (Q) equals the velocity (V) of the water multiplied by the area (A) of the water (Q=VA).

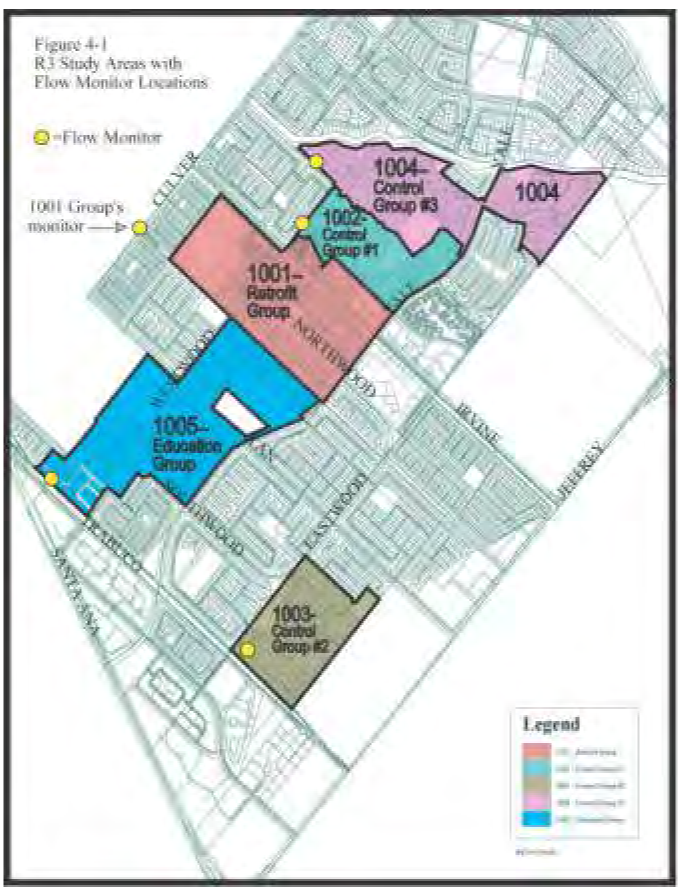
The first variable in the equation, velocity, was measured by velocity wafers placed below the surface of the runoff stream to measure the velocity of the water. These electronic devices were attached to metal plates positioned at the bottom of the concrete pipes that carried runoff. Each velocity wafer was centered to the width of the water flowing in the pipe. Once it is correctly positioned, the wafer measures the velocity of the water by measuring the speed of the particles in the water. This information is then transmitted via cable to the Sigma 950.

The second variable in the water flow equation, the area of the water, also referred to as the cross sectional area, was obtained by multiplying the depth of the water by its width. This calculation is based on geometry, the diameter of the pipe, and the depth of the water. Since the geometry of the area is the arc of a circular pipe of known diameter, the Sigma 950 was able to internally calculate this measurement using data from a sonic sensor. The sonic sensor measures the depth of the water by hanging above the water surface and sending out a sonic pulse that reflects off the surface of the water.

The Sigma 950 contains a central processing unit that recorded the time, water depth, water velocity, and flow every five minutes.

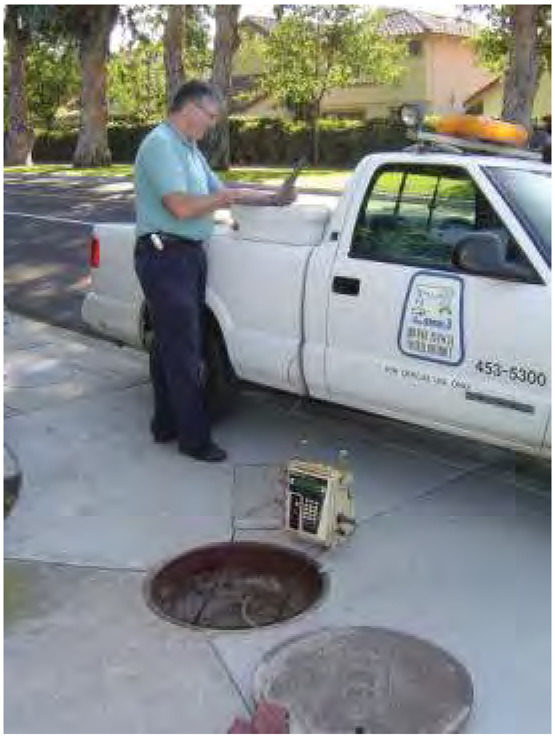
Maintaining the flow monitors in good working order required an R3 Study field staff member to visit each of the five data collection locations twice per week. At each site, staff would open the manhole and lift out the monitor. Then, the storm drainpipe would be inspected for any obstruction or interference with the flow or with the devices (velocity wafer and sonic sensor) used to measure flow.

Figure 4-1
Flow Monitor Locations



Next, staff would measure the depth of the water with a tape measure and recalibrate the flow monitor to this measurement. The velocity wafers could not be calibrated. They were adjusted for accuracy, however, during low flow and low velocity periods. To accomplish this, staff would observe an object on the surface of the water. As the object moved with the flow, staff would estimate its speed as feet per second (fps). This speed was compared to the value simultaneously registered on the flow monitor. If the observed velocity was much slower than that recorded by the monitor, staff would disconnect the velocity wafer. This action would usually reset the velocity wafer. If the problem persisted, the wafer would be replaced.

Figure 4-2:
Downloading Data from Sigma 950 Flow Monitor to Laptop



4.2.2 Ranking Collected Data

Twice per week during each site visit, data was downloaded from the flow monitor to a laptop computer. This process is depicted on the adjacent figure (Figure 4-2). When staff returned to IRWD's operations building, the data was downloaded to the District's central computer. Here the data was transferred from a text file to an excel file. At this point, staff would rank the data for each download of each site. After observing the site, recalibrating the flow monitor, and reviewing the data graphs, staff would add ranking to each site's data. The following process assigned these ranks: a) if staff observed nothing unusual and had no reason to suspect any data collection problems, the flow, depth and velocity received a ranking of "zero," b) if one of these factors was suspect or the data graph had an unusual jump in value, the rank indicator was a "one," c) if staff noted a problem which may have affected the data and changed its values beyond the tolerances of the equipment, the data was ranked with a "two."

4.2.2 Data Methods

Robust regressions techniques were used to detect which observations were potentially data quality errors. This methodology determines the relative level of inconsistency of each observation with a given model form. A measure is constructed to depict the level of inconsistency between zero and one; this measure is then used as a weight in subsequent regressions. Less consistent observations are down-weighted. Other model-based outlier diagnostics (Cook's distance, DFBETA statistics, and residual diagnostics) were also employed to screen the data for any egregious data quality issues

After screening for the known data quality problems, using the "rank" indicator, all raw meter reads were first converted to average hourly values. These were then aggregated by date to convert to daily runoff, available in both mean hourly flow and total daily volume.

Precipitation taken from the Irvine weather station was matched to the daily data and used to separate wet from dry days. It should be noted that wet weather flows were monitored and evaluated in a parallel study that assessed pesticide contributors from residential land use during dry and wet weather (SCCWRP, 2003). However, the focus of the R3 study was runoff reduction during the peak irrigation season (i.e., dry weather).

Wet weather storm flow can be a more complicated phenomenon to predict, as it depends on the timing and magnitude of the rainfall event, the moisture deficit of soils, and other factors. The relative lack of large storm events in the post-intervention period precluded examination of these more complicated forces and the effect that the landscape interventions might have on wet day runoff.

Area-standardized measures of site runoff were also created for dry/wet days, where total daily volume was divided by the estimated permeable/total area. Estimates of area for the study sites were derived from the IRWD geographic information system (GIS) system. The GIS system was queried to produce estimates of the number of lots and total area for the different land use classifications (single family residence, condo, HOA, school, landscape, street, and unknown). The GIS system also provided an estimate of the number of buildings, and building area. The area taken up by buildings is treated as impermeable. The remaining area was separated into permeable and impermeable area using a land use classification-specific assumption of impermeability. Table 4-2 provides the raw data used to construct the estimated site area. (Due to lack of usable flow measures, Sites 1002 and 1003 are not separately reported.) Table 4-3 aggregates the data by site.

Table 4-2
Estimated Area of Study Sites by Land Use

R3 GROUP	#Lots	Classification	Total Area in square feet. (sq. ft.)	Building Area in sq. ft.	Assumed Impermeable Coefficient %	Estimated Impermeable Area in sq. ft.	Estimated Permeable Area in sq. ft.
1001	64	Unmetered	499885		0	0	499885
1001	565	SFR	2911227	976574	0.5	1943900	967326
1001	109	Condo	447096	189721	0.9	421358	25738
1001	4	HOA	255208		0.75	191406	63802
1001	2	School	198676		0.9	178808	19868
1001	10	Landscape	845529		0	0	845529
1001	97	Street	2163105		1	2163104	0
1004	61	Unmetered	307556		0.0	0	307556
1004	417	SFR	2081636	719485	0.5	1400560	681076
1004	1	HOA	40165		0.8	30123	10041
1004	1	School	348739		0.9	313865	34874
1004	2	Landscape	1136		0.0	0	1136
1004	42	Street	1089143		1.0	1089143	0
1005	8	Unmetered	118370		0.0	0	118370
1005	559	SFR	2957363	1033197	0.5	1995280	962083
1005	1	HOA	66421		0.8	49816	16605
1005	1	School	264236		0.9	237812	26424
1005	1	School	261089		0.9	234980	26109
1005	2	Landscape	773206		0.0	0	773206
1005	45	Street	1736098		1.0	1736098	0

Table 4-3 **Estimated Area of Study Sites**						
R3 Group	**Estimated Impermeable Area**		**Estimated Permeable Area**		**Total Area**	
	sq.ft.	**acres**	**sq. ft.**	**acres**	**sq. ft.**	**acres**
1001	4,898,578	112.5	2,422,148	55.6	7,320,724	168.1
1004	2,833,691	65.1	1,034,683	23.8	3,868,374	88.9
1005	4,253,986	97.7	1,194,553	44.1	6,176,783	141.8

4.3 Evaluation Results

Table 4-4 presents the robust regression estimation results for the model of dry day runoff in R3 study Site 1001 (containing some customers receiving the ET controller/education intervention), Site 1004 (whose customers received no treatment), and Site 1005 (containing some customers receiving the education-only treatment). This sample represents metered dry day runoff, standardized by estimated site permeable area, between February 2001 and June 2002.

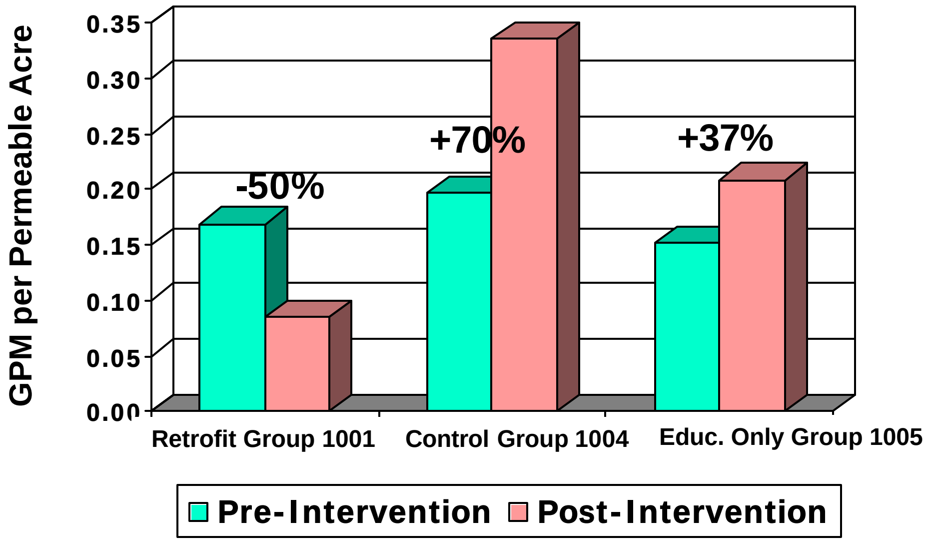
The changes in runoff estimated during the R3 study are summarized on Figure 4-3 and described in more detail below. Additional descriptions of the regression models are presented in Appendices D1 and D2.

Table 4-4
Robust Regression Estimates of Mean Dry Day Runoff

Dependent Variable: Dry Day Runoff Height (in hundredths inches per unit area) (Height=Runoff Volume/Site Area)

Variable	**Coefficient**	**Std. Error**	**t**	**Prob.>|t|**
Mean Runoff: Feb-May 2001				
1. Intercept (1001 mean runoff)	0.898563	0.120838	7.44	0
2. Difference of Site1004 in pre-period	0.143721	0.157245	0.91	0.361
3. Difference of Site1005 in pre-period	-0.092260	0.151479	-0.61	0.543
Change in Runoff: June 2001-June2002				
4. Change of Site 1001 in post-period	-0.445390	0.134540	-3.31	0.001
5. Change of Site 1004 in post period	0.878089	0.113737	7.72	0
6. Change of Site 1005 in post period	0.202553	0.106973	1.89	0.059
Number of observations	950			
F (5, 944)	74.92			
Prob. > F	0			
Quasi-R-Squared	0.35			

Figure 4-3
R3 Study's Changes in Runoff (Within Sites)



4.3.1 Pre-intervention Period

The constant term (Variable 1) in Table 4-4 defines the intercept for the model equation and can be interpreted as the mean daily runoff in Site 1001—about 0.898 hundredths of an inch per permeable acre (equal to 0.00898 inches). Variables 2 and 3, the indicators for Sites 1004 and 1005 in the pre-period, suggest that estimated difference in mean runoff is not statistically distinguishable from zero (standard error > coefficient). The estimated pre-period site mean runoff for these sites can also be inferred from these coefficients:

$$m_{4,\mathrm{Pre}} \equiv m_1 + d_{4,\mathrm{Pre}} \approx 0.899 + 0.144 = 1.042 \text{ hundredths of an inch and}$$

$$m_{5,\mathrm{Pre}} \equiv m_1 + d_{5,\mathrm{Pre}} \approx 0.899 - 0.092 = 0.806 \text{ (See Table 4-5.)}$$

Table 4-5
Study Site Comparisons of Pre Period Flow vs. Post Period Flow

	1001 Pre	1001 Post	1004 Pre	1004 Post	1005 Pre	1005 Post
Permeable Square feet	2,422,148	2,422,148	1,034,683	1,034,683	1,922,797	1,922,797
Permeable Acres (Table 4-3)	55.6	55.6	23.8	23.8	44.1	44.1
Coefficient from Table 4-4 (Hundredths of in/day/perm acre)	0.899	-0.445	0.144	0.878	-0.092	0.203

Table 4-5 (continued)

	1001 Pre	1001 Post	1004 Pre	1004 Post	1005 Pre	1005 Post
Hundredths of in/day/perm acre flow	0.899	0.453	1.042	1.777	0.806	1.101
in/day/perm acre flow	0.0090	0.0045	0.0104	0.0178	0.0081	0.0110
feet/day	0.04164	0.02063	0.0081	0.0178	0.0081	0.0110
Raw GPM	9.42	4.75	4.67	7.96	6.71	9.71
GPM/perm acre	0.169	0.085	0.197	0.335	0.152	0.208
Percent change in flow (Pre to Post)	**-50%**		**+70%**		**+37%**	

4.3.2 Post-intervention Period

The formal test for the change in runoff in the post-intervention period (June 2001-June 2002) can be found in the following three terms: variables 4, 5 and 6 as shown in Table 4-4. The estimated change in dry day runoff for Site 1001 (Variable 4 in Table 4-4), is -0.44 hundredths of an inch. In relative terms, this works out to approximately a 50 percent reduction. The implied mean post-intervention dry day runoff for Site 1001, is 0.89-0.44˜0.45 hundredths of an inch. This reduction in runoff is statistically distinguishable from zero at classical levels of confidence.

It should be noted that the pre- and post- periods are not comparable. The post-intervention period, June 2001 to June 2002, includes 13 months, but would be fairly close to an annual average. The period of time covered by the pre-intervention period for all sites, February to May 2001, includes at most four months. For Site 1001, the pre-intervention period only includes the months of April and May in 2001 because the flow meter produced enough invalid reads in February and March to necessitate its relocation to a new site in April. Since these are not the highest months for urban runoff, it would be reasonable to expect runoff in the post-intervention period to increase. For this reason, the reduction of 50 percent from the pre-intervention period would be a lower bound on the true estimate of runoff reduction. An examination of the other two valid sites would provide insight into how much runoff would have increased in the post-intervention period.

The estimated change in dry day runoff for Site 1004 (Variable 5 in Table 4-4) is +0.88 hundredths of an inch. This increase in runoff is statistically distinguishable from zero at classical levels of confidence. The implied mean post-intervention dry day runoff for Site 1004, is (0.89+0.88˜) 1.77 hundredths of an inch. In relative terms, this works out to a fairly large (1-{1.77-1.03}/1.03˜) 70 percent increase in the post-intervention period.

The estimated change in dry day runoff for Site 1005 (Variable 6 in Table 4-4) is +0.20 hundredths of an inch. This increase in runoff is statistically distinguishable from zero at close to classical levels of confidence. The implied mean post-intervention dry day runoff for Site 1005, is (0.89+0.20˜) 1.09 hundredths of an inch. In relative terms, this works out to a more modest (1-{1.09-0.80}/0.80=) 37 percent increase in the post-intervention period.

4.3.3 Comparison Across Sites

The last and potentially most vulnerable inference compares the time change in runoff across sites. If Site 1001 had experienced the same change in runoff as its neighbor sites 1005 or 1004, then dry day runoff would have increased from 37 to 70 percent in the post-intervention period. In absolute terms, this would imply a prediction of non-intervention runoff of 1.24 to 1.53 hundredths of inches per acre. Compared to the realized 0.45 hundredths of inches of runoff in the post-intervention period, this reduction would translate to reduction in runoff from 64 to 71 percent.

A similar counterfactual exercise for Site 1005 would require assuming that Site 1004 is a good matched control site. Then dry weather runoff in Site 1005 would have increased by 72 percent in the post-intervention period, a level of 1.38 hundredths of inches per acre. Compared to the realized 1.09 hundredths of inches of runoff in the post-intervention period, the reduction would translate into a modest but non-ignorable 21 percent decrease in runoff.

Both of these exercises require use of Site 1004 as a control site. While the unadjusted flow measures for Sites 1001 and 1005 are fairly close in the pre-intervention period, the same cannot be said for the flow measures from Site 1004. There are uncertainties as to which of the three estimates of reduction runoff for Site 1001 should be used. The direct within-site estimate of a 50 percent runoff reduction is likely biased low; runoff in the post-intervention period should have increased. The estimate of 64 percent, based on Site 1005 as a control site, may also be biased on the low side. Though Site 1005 did have pre-intervention runoff that reasonably matched Site 1001, Site 1005 also contained more than 200 homes that participated in the education-only intervention with monthly follow-up. These homes did have quantified water savings, some of which is likely to have resulted from reduced runoff. Site 1004 did not receive any treatment, but did have measurement issues. Thus, the estimate of a 71 percent reduction, using Site 1004 as a control site, has an unknown bias.

The bigger inferential uncertainties lie in how these conservation interventions will work as they are scaled in a larger program or in how implementations of these programs would work in other areas.

4.4 Conclusions

The difficulties encountered in calibrating custom configured equipment to measure dry season / low flow runoff limited the amount of pre-intervention data. This in turn precluded simple before and after comparisons of mean runoff flow. Nonetheless, a sufficient length of baseline data was collected to allow quantitative estimates of runoff reduction. If additional flow data can be collected, additional analysis would be possible: 1) the runoff reduction under wet conditions could be examined, and 2) an estimate of the seasonal shape of runoff could be included in the models to improve the precision of the estimated runoff reduction.

Because the runoff measurement is not at a customer level, it was not possible to distinguish the relative contribution of different customers to urban runoff reduction. Thus, for Site 1001, it was not possible to determine how much the single-family ET controller/education contributed relative to the ET controller intervention with medium-size landscape customers.

However, because the medium-size landscapes accounted for an estimated 70 percent of the area "treated" with ET controllers (Table 2-2), on strictly a proportional basis it is likely that the medium-size landscapes contributed to the majority of the observed runoff reduction for Site 1001.

Chapter 5 Water Quality and Watershed Implications

5.1 Overview

This chapter describes the water quality evaluations conducted as a part of the R3 Study and outlines the potential implications of these evaluations on the San Diego Creek Watershed. Specific information includes:

- A discussion of two approaches to the evaluation of water quality
- A summary of the study methods relating to water quality
- Development of "before and after" assessments of water quality to evaluate the effectiveness of ET technology and public education
- Detailed discussions of the evaluation approaches and findings based on these approaches
- A discussion of the implications of the findings for water quality in the San Diego Creek Watershed, focusing on TMDL constituents

More detailed information is provided in Appendices E1 and E2.

5.2 Introduction

Two independent reviews of water quality measurements were conducted as a part of this study. The initial review was conducted by SCCWRP as a part of its participation in the R3 Study and is included in its entirety as Appendix E1. This review used parametric statistical techniques (t-test; ANOVA), which provide a good descriptive review of the study data, but are generally considered to have less statistical power for detecting differences in data than other statistical tests. In general, because of the variability of the data and limitations in sample quantities, this review concluded that there was virtually no difference in either the concentration or "flux" (concentration times flow) of pollutants over time or between study treatments.

A subsequent statistical overview by Geosyntec Consultants was commissioned by IRWD to review alternative and possibly more "robust" data analysis techniques that might identify differences in study data not uncovered during the initial review. This work, which included the review of only a portion of the data set, focused on additional descriptive techniques (time series plots; box plots; probability distributions) and the use of non-parametric statistical techniques (rank-sum test; K-W). For some of the parameters reviewed, these techniques suggest that differences in measured water quality did occur across time and between study treatments. The entire Geosyntec report is provided in Appendix E2.

As noted above, both of the completed statistical reviews of the study data are included in the Appendices of this report. The remainder of this chapter of the report discusses the key findings of each review.

5.3 SCCWRP Water Quality Review

This section describes the SCCWRP evaluation approach, sampling and laboratory analysis, data analysis, and interpretations of the results. Watershed implications are also discussed.

5.3.1 Evaluation Approach

A before-after, control-impact (BACI) design was used to evaluate the effectiveness of both the sprinkler technology and public education. Each neighborhood was sampled every other week between December 2000 and June 2001. In June 2001, homes in one of the neighborhoods were outfitted with the ET controllers. Since homeowners with the retrofitted ET controllers were simultaneously being educated, a well-defined public education campaign was also begun with these homeowners. To ascertain the difference between education and ET technology, homeowners in a second neighborhood were targeted with an identical public education campaign, but without effect of the ET retrofit technology. There was no education or technology intervention in the remaining three neighborhoods, which served as control neighborhoods to document the effect of no treatment. Sampling at the five neighborhoods continued every other week from June 2001 to June 2002.

5.3.2 Sampling and Laboratory Analysis

Each neighborhood was hydrologically self-contained and drained to a single underground pipe. At each of these five locations, samples were collected for flow and water quality. Stage (water depth) and velocity were recorded at 5-minute intervals using an ultrasonic height sensor mounted at the pipe invert and a velocity sensor mounted on the floor of the pipe. Flow was calculated as the product of velocity and wetted cross-sectional area as defined by the stage and pipe circumference. Despite the relatively continuous measurement of flow, many of the flow measurements were excluded due to faulty readings. Synoptic flow and water quality measurements were only available for two sites over the course of the entire study (i.e. before and after intervention), including the ET controller + education and education only sites. Flow measurements at the time of water quality sampling for the three control sites were considered faulty and discarded.

Grab samples for water quality were collected just downstream of the flow sensors in the early morning using peristaltic pumps and pre-cleaned Teflon tubing. Samples were placed in individual pre-cleaned jars, placed on ice, and transported to the laboratory within one hour. Each sample was analyzed for 19 target analytes, five microbiological parameters, and four toxicity endpoints (Table 5-1). Target analytes included trace metals, nutrients, and organophosphorus (OP) pesticides. Microbiological parameters included fecal indicator bacteria and bacteriophage. Toxicity was evaluated using two marine species, the purple sea urchin *Strongylocentrotus purpuratus* and the mysid *Americamysis bahia*. All of the laboratory methodologies followed standard protocols developed by the USEPA or Standard Methods.

5.3.3 Data Analysis

Data analysis consisted of five steps: 1) comparison of water quality among the five neighborhoods prior to intervention; 2) comparison of water quality concentrations over time by neighborhood; 3) comparison of water quality concentrations before and after intervention by treatment type; 4) comparison of pollutant flux before and after intervention by treatment type; and 5) correlation of toxicity measures with potential toxicants in dry weather runoff.

Comparison of water quality concentrations among the five neighborhoods prior to intervention was conducted to assess if there were inherent differences among treatment sites for each

Table 5-1
Reporting Level and Method for Target Parameters

	Reporting Level	Method
Metals (ug/L)		
Antimony	0.2	EPA 200.8
Arsenic	1.5	EPA 200.8
Barium	0.2	EPA 200.8
Cadmium	0.2	EPA 200.8
Chromium	0.3	EPA 200.8
Cobalt	0.1	EPA 200.8
Copper	1.5	EPA 200.8
Lead	0.3	EPA 200.8
Nickel	0.2	EPA 200.8
Selenium	5.0	EPA 200.8
Silver	0.4	EPA 200.8
Zinc	5.0	EPA 200.8
Nutrients (mg/L)		
Ammonia as N	5.0	EPA 350.1
Nitrate/Nitrite as N	5.0	EPA 353.2
Total Kjeldahl Nitrogen	10.0	EPA 351.2
Ortho-Phosphate as P	0.5	EPA 365.1
Total Phosphorus	1.0	EPA 365.4
OP Pesticides (ng/L)		
Chlorpyrifos	20.0	IonTrap GCMS
Diazinon	20.0	IonTrap GCMS
Microbiology		
Enterococcus (MPN/100 mL)	2	SM9230B
Fecal Coliform (MPN/100 mL)	2	SM9221B
Total Coliform (MPN/100 mL)	2	SM9221B
MS2 Phage (PFU/100 mL)	2	EPA 1602
Somatic Phage (PFU/100 mL)	2	EPA 1602
Toxicity (% effluent)		
Sea Urching Fertilization EC50	NA	EPA 1995
Sea Urching Fertilization NOEC	NA	EPA 1995
Mysid EC50	NA	EPA 1993
Mysid NOEC	NA	EPA 1993

Note: ug/L = micrograms per liter; MPN/100 mL=most probable number per 100 milliliters; PFU/100mL=plaque forming units per 100 milliliters; mg/L=milligrams per liter; ng/L=nanograms per liter.

constituent. This analysis was conducted using ANOVA using Tukey's post hoc test for identifying the significantly different neighborhoods. All data was tested for normality and homogeneous variance prior to testing. Only the microbiological data was determined to be non-normally distributed, so these results were log transformed prior to data analysis.

Comparison of water quality concentrations over time was accomplished by creating temporal plots of monthly mean concentration. Comparisons of water quality concentration before and after intervention by treatment type were accomplished using a standard t-test of the mean concentration before versus mean concentration after intervention. The mean concentrations for ET controller + education, education only, and ET controller + education – education only for each sampling event were normalized by the grand mean of the control sites for the same sampling event.

Pollutant flux estimates were calculated by the product of the concentration and volume at the time of sampling and then normalized to the area of the sampled neighborhood. Pollutant flux before and after treatment was compared somewhat differently since the lack of flow data at the control sites did not permit an estimate of flux for these neighborhoods. Mean pollutant flux before and after intervention was compared using standard t-tests at the ET controller + education and education only neighborhoods without normalization to control values.

Correlation of toxicity with toxicant concentrations was accomplished using a Pearson product moment correlation. These correlations are inferential only and do not presume resulting correlations automatically identify the responsible toxicants. In order to help identify potential causative toxic agents, concentrations of the correlated constituents were compared to concentrations known to induce toxicity in the respective test organisms.

5.3.4 Evaluation Results

There were significant differences in water quality among sites prior to intervention (Appendix E1, Table WQ3). Site 1004, the control site, had the greatest mean concentrations for 15 of the 24 constituents evaluated prior to the ET controller intervention. In particular, all of the mean nutrient concentrations were greater at Site 1004 than the other sites. On the other hand, Sites 1001 and 1002 generally had the lowest average concentrations prior to the ET controller intervention. Cumulatively, these sites had the lowest mean concentrations for 17 of the 24 constituents evaluated. Site 1002 also had the least toxicity, on average, of all five sites. Finally, Site 1003 had an intermediate status. Mean concentrations of enterococcus and fecal coliforms at this site were greater than any other site (fecal coliforms significantly greater than Sites 1001 and 1002), but the mean concentrations of five trace metals (chromium, copper, cobalt, nickel, selenium) were lowest at this site.

Water quality concentrations and toxicity were highly variable over time during the study period. Temporal plots of concentrations and toxicity for each site demonstrated that there was no seasonal trend and no overall trend with time. There were, however, occasional spikes in concentrations for many constituents that appeared to fall into one of two categories. The first category was recurring spikes in concentration that were unpredictable in timing and location. The second category of concentration spike was single or infrequent peaks. Occasionally these spikes would occur across multiple sites, without commensurate changes in concentration at the treatment sites (1001 or 1005). More often, infrequent spikes were isolated to a single site. For example, concentrations of chlorpyrifos climbed to over 10,000 ng/L in July 2001, but averaged near 50 ng/L the remainder of the year at site 1005. Similarly, concentrations of ammonia and total phosphorus spiked 10 and 25-fold prior to June 2001 at the control site (1004) with less variability and overall lower concentrations the remainder of the study.

There were few significant differences that resulted from the intervention of education, ET controller + education, or ET controller + education – education only, relative to control sites (Table 5-2). Only six of the 24 constituents evaluated showed a significant difference between pre and post-intervention concentrations after normalizing to mean control values. These significant differences were a net increase in concentrations of ammonia, nitrate/nitrite, total phosphorus, chlorpyrifos, diazinon, and fecal coliforms. These statistical analyses were the result of one of two circumstances. In the first circumstance, there were individual large spikes in concentration at treatment sites, but not at control sites following intervention. Therefore, the net difference in concentrations between controls and treatments increased following the intervention. In these cases, removal of the outlier samples resulted in no significant difference among treatment effects relative to controls before intervention compared to after intervention. In the second circumstance, there were large spikes in concentrations at control site(s) prior to the intervention that later subsided, while treatment site concentrations and variability remained steady. Therefore, the difference between treatments and controls changed following interventions, although it was not a result of the education or technology.

Although there were no significant differences in pollutant flux as a result of the intervention, significant differences were noted in pollutant flux among sites prior to intervention. Site 1001, the ET controller + education site, had the greatest mean flux for 22 of the 24 constituents evaluated prior to the ET controller intervention. The mean flux for 20 of these 22 constituents was significantly greater at Site 1001 than the mean flux at Site 1005 (t-test, $p<0.05$). Site 1005 had greater mean fluxes only for MS2 phage and ammonia. The differences among the fluxes prior to (and after) intervention were the result of two factors: greater flow and, at times, greater concentrations at Site 1001 compared to Site 1005. Mean dry weather flow at the time of water quality sampling was nearly three times greater at Site 1001 than Site 1005.

Toxicity was inconsistently found at all five of the sampling sites, and there was no change in toxicity as a result of the intervention (Table 5-3). The two species tested did not respond similarly either among sites, among treatments, or over time. Correlation of toxicity with constituent concentrations yielded few significant relationships for either species (Table 5-3). Mysid toxicity was correlated with diazinon and several trace metals, but the strongest relationship was with diazinon concentration. Moreover, the concentrations of diazinon were well above the levels known to cause adverse effects in mysid, while trace metals were not. Sea urchin fertilization toxicity was only correlated with concentrations of zinc. The concentrations of zinc were well above the level known to induce adverse effects in this species.

Table 5-2
Significance of ANOVA Results for the Effect of ET Controller + Education, Education Alone, and the Difference Between ET Controller + Education and Education Alone Relative to Control Concentrations. (No data indicates $p > 0.05$)

	Effect of ET Controller + Education	Effect of Education Alone	Difference Between ET Controller + Education and Education Alone
Metals			
Antimony			
Arsenic			
Barium			
Cadmium			
Chromium			
Cobalt			
Copper			
Lead			
Nickel			
Selenium			
Silver			
Zinc			
Nutrients			
Ammonia as N	0.03	0.02	
Nitrate/Nitrite as N	0.02		
Total Kjeldahl Nitrogen			
Ortho-Phosphate as P			
Total Phosphorus		0.03	
OP Pesticides			
Chlorpyrifos	<0.01	<0.01	<0.01
Diazinon		<0.01	
Microbiology			
Enterococcus			
Fecal Coliform	0.04		
Total Coliform			
MS2 Phage			
Somatic Phage			
Toxicity			
Fertilization EC50			
Fertilization NOEC			
Mysid EC50			
Mysid NOEC			

Table 5-3
Correlation Coefficients (and p value) of Constituent Concentrations with Toxicity Endpoints (No Observed Effect Concentration, NOEC and Median Effect Concentration, EC50) in Dry Weather Discharges from Residential Neighborhoods in Orange County, CA. (No data indicates p > 0.05)

	Sea Urchin Fertilization NOEC	Mysid Survival NOEC	Sea Urchin Fertilization EC50	Mysid Survival EC50
Antimony		-0.273 (0.009)		
Arsenic		-0.3396 (0.001)		
Barium				
Cadmium				
Chromium		-0.244 (0.021)		-0.219 (0.044)
Cobalt		-0.330 (0.002)		-0.279 (0.010)
Copper				
Lead		-0.215 (0.042)		
Nickel				
Silver		-0.260 (0.013)		-0.229 (0.035)
Zinc	-0.277 (0.005)		-0.274 (0.006)	
Chlorpyrifos				
Diazinon		-0.426 (0.001)		-0.468 (0.001)
Ammonia				

5.3.5 Interpretation of Results

The evaluation was unable to find large, significant reductions in concentration or pollutant flux as a result of education and/or ET controller retrofit technology. This may indicate that the technology and/or education are inefficient for improvements in water quality. Equally as important, however, was the absence of meaningful increases in concentrations. Of the small number of concentrations that showed significant increases, most could be explained by highly variable spikes in concentrations reminiscent of isolated entries to the storm drain system, as opposed to ongoing chronic inputs or the effects of best management practices evaluated in this study.

If significant changes did occur, the evaluation design may not have detected these changes due to two factors. First, the variability in concentrations within and between sites is naturally high and the evaluation simply collected too few samples. After taking into account the variability and relative differences in mean concentrations, zinc was used as an example constituent to determine what sample sizes would be required to detect meaningful differences. Assuming that the sampling yielded the true mean and variance structure that actually existed at the five sites, power analysis indicated that a minimum sample size of no less than five-fold would have been required to detect the differences observed in zinc concentrations during this study.

The second factor that could have hindered the ability to detect meaningful differences in water quality is that the technology and education treatments were applied at the spatial scale of individual homes, while the evaluation design sampled at the neighborhood scale. This problem was exacerbated because only a fraction (approximately one-third) of the homes within the neighborhoods sampled had the technological or educational treatments. Therefore, the treatments were effectively diluted, decreasing the ability to detect differences in water quality.

5.3.6 Watershed Implications

It appears that residential dry weather flows measured in the R3 Study may contribute significant proportions of some constituents to overall watershed discharges. The study sites were located within the San Diego Creek watershed, the largest tributary to Newport Bay. The Orange County Public Facilities and Resources Department (OCPFRD) publishes monitoring data on San Diego Creek to provide environmental managers the information they need to properly manage the Bay (OCPFRD 2002). The dry weather monitoring data was compiled at the mouth of San Diego Creek from OCPFRD during 2001-2002 and compared the concentrations to our results from residential neighborhoods (Table 5-4). Mean concentrations of chlorpyrifos, diazinon, copper and zinc were much higher in upstream residential neighborhoods than concentrations measured at the mouth of San Diego Creek. These residential dry weather contributions were amplified by the fact that the San Diego Creek watershed is primarily composed of residential land uses. In contrast, concentrations of selenium, arsenic, and total phosphorus in the residential dry weather discharges were much lower than the cumulative dry weather discharges from San Diego Creek, indicating that residential areas may not be the primary source of these constituents.

Table 5-4
Comparison of Mean Concentrations (95% Confidence Intervals) in Residential Dry Weather Discharges from this Study Compared to Concentrations in Dry Weather Discharges from San Diego Creek at Campus Drive During 2001-2002. (Data from OCPFRD)

	San Diego Creek	Residential
Parameter	**Mean (95% CI)**	**Mean (95% CI)**
Nitrate	5.16 (0.72)	4.76 (1.96)
Phosphate	1.98 (0.07)	1.16 (0.20)
Diazinon	0.13 (0.07)	1.52 (0.52)
Chlorpyrifos	0.05 (0.01)	0.35 (0.44)
Copper	11.59 (2.83)	23.59 (5.65)
Arsenic	6.58 (0.40)	2.68 (0.26)
Selenium	21.22 (2.65)	2.46 (0.03)
Zinc	22.08 (2.75)	60.09 (8.26)

5.4 Geosyntec Water Quality Review

This section presents examples of alternative approaches to data analysis, data analysis methods, example results, and watershed implications.

5.4.1 Examples of Alternative Approaches to Data Analysis

These example analyses focus on TMDL constituents: nutrients (total nitrogen [TN] and total phosphorus [TP]), metals (copper, lead, zinc, cadmium), pesticides, and pathogens (fecal coliform). The analyses also focus on dry weather flows, as reduction of these flows was a major objective of the R3 Study.

5.4.2 Data Analysis Methods

Exploratory Data Analysis

Visual inspection of data and exploration of factors that could potentially influence data (e.g. seasonal trends, rain events)

1. Divide data into pre and post- intervention groups.
2. Construct time series plots to visually inspect data and visually examine for seasonal trends. Overlay storm event markers to identify any relation to rainfall volume or antecedent dry period (ADP).
3. Investigate normality or log normality of data sets. Select appropriate statistical tests.
4. Construct probability plots for pre-intervention and post-intervention periods.
5. Prepare quantile plots.
6. Prepare side-by-side box plots.
7. Calculate descriptive statistics

Hypothesis Testing

Test data for skewness, normality, and statistically significant differences. Skewness and normality tests are only needed if parametric approaches are conducted. Use of non-parametric approaches is recommended for consistency because normality will not be met in all cases. Nonetheless, examples are provided to show that several of the data sets do not come from a normal distribution.

1. Skewness hypothesis test for symmetry.
2. Shipiro-Wilkes normality test.
3. Mann-Whitney rank-sum test.
4. For the data sets that have greater than 50 percent censored data (i.e., data only known to be less than the detection limit), hypothesis tests for differences in proportions.

5.4.3 Example Results

The first step in the data analysis was to construct individual time-series plots for each site to identify seasonal periodicity, step-trends, and monotonic trends. Plotting each site individually reveals more information than plotting all sites together. Also, by overlaying storm events, the role of rainfall volumes and the ADP may be more apparent and may indicate whether additional analyses are warranted (e.g., correlating ADP with concentration). Figure 5-1 is an example time-series plot with storm event markers overlain for TP for Site 1001. As shown on the figure, the pre-intervention period had much more rainfall, which likely added to the variability in runoff concentrations and fluxes. However, it is apparent that the winter and spring concentrations appear to be lower and less variable during the post-intervention period. The irrigation controllers may have had an effect on the runoff concentrations by reducing the amount of irrigation during moister weather conditions (i.e., high soil moisture). A similar effect for TN is shown on Figure 5-2. Additional time-series plots are provided in Appendix E2.

Figure 5-1
Example Time-series Plot of Total Phosphorus with Storm Event Markers.

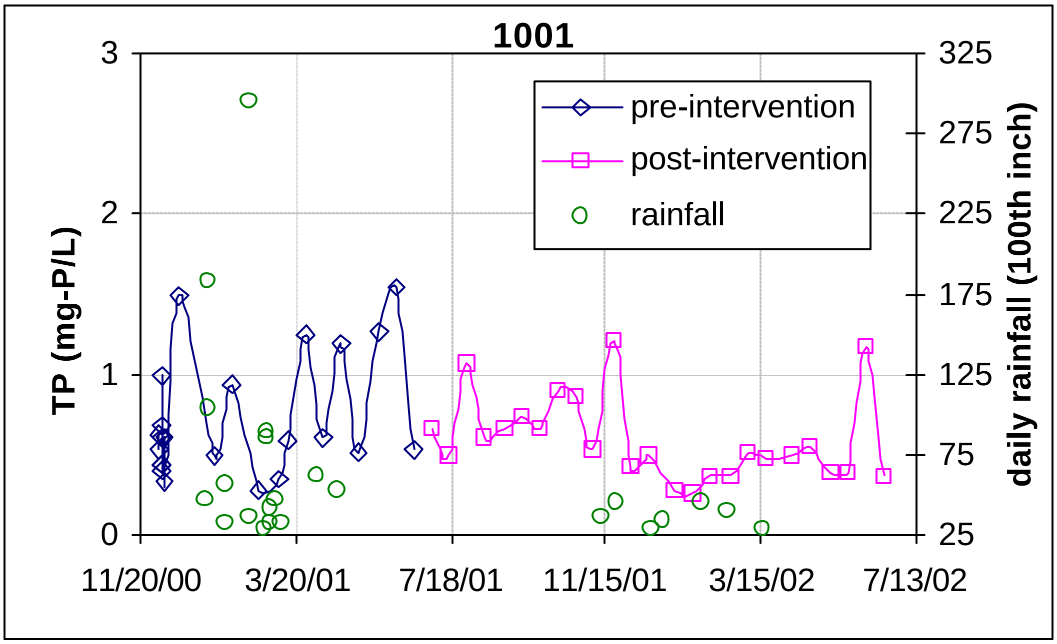
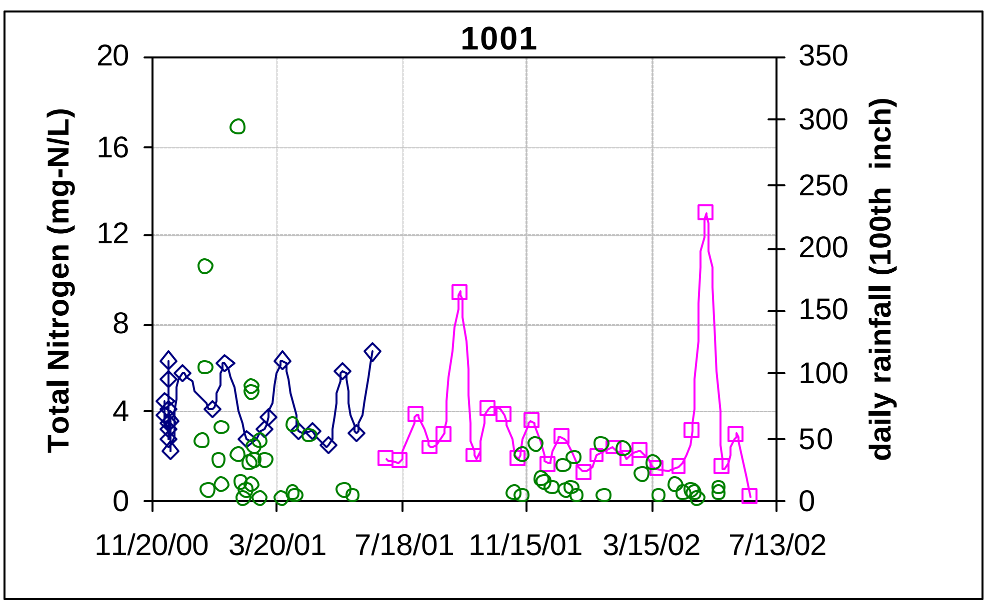


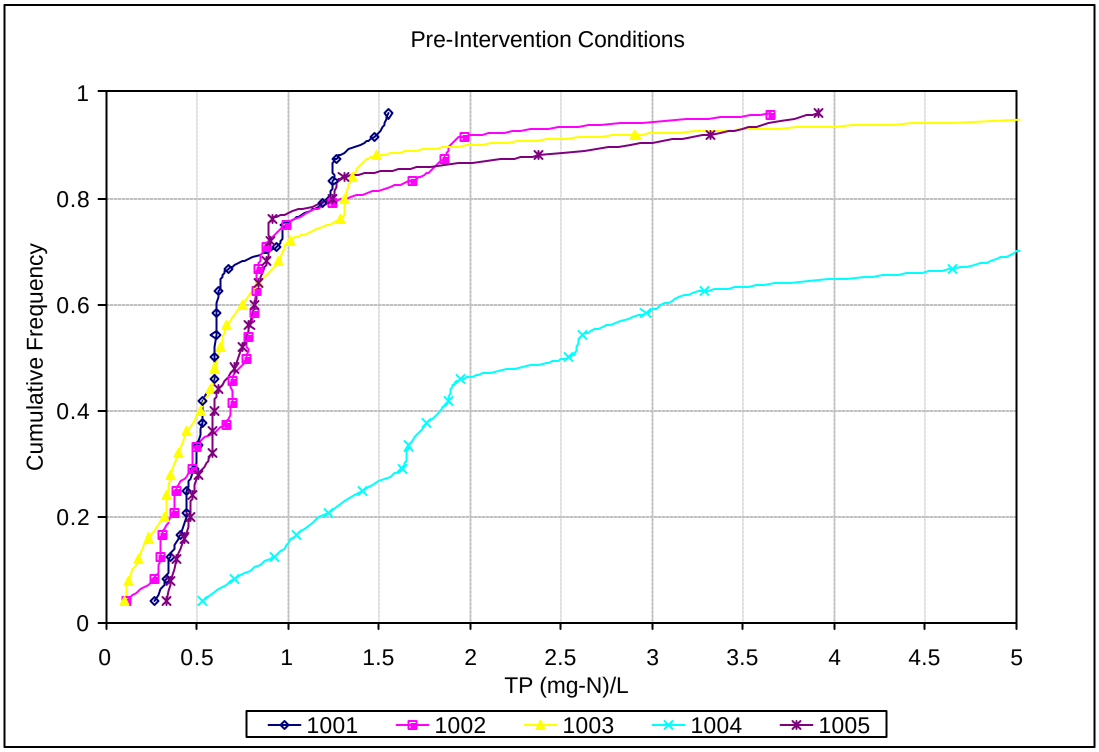
Figure 5-2
Example Time-series Plot of Total Nitrogen with Storm Event Markers.



5.4.3.1 Comparison of Water Quality Data Prior to Intervention

To visually investigate whether the test sites have similar runoff characteristics, probability plots were constructed. Figure 5-3 is an example of a probability plot for TP for all of the test sites. The figure shows that all of the sites have a similar distribution except for Site 1004.

Figure 5-3
Example Probability Plot of Total Phosphorus for All Sites Prior to Intervention.



The next step in the data analysis was to calculate parametric and non-parametric descriptive statistics. Table 5-5 is an example table of descriptive statistics for TN for all sites for both the pre- and post-intervention periods. (Additional descriptive statistics are included in Appendix E2). Table 5-5 includes the number of data points (n), the detection percent (%>MDL/RL), the mean, median, 25 percent trimmed mean, min, max, 25^{th} percentile, 75^{th} percentile, standard deviation, interquartile range (IQR), and the coefficient of skewness (g_s). Also included in the table are critical skewness coefficients (g_{cr}), which are readily available in statistics texts. If the coefficients of skewness are less than these critical values, then the data is symmetric. It should be noted that the measures of central tendency (mean and median) and variability (standard deviation) of the sites during the pre-intervention period are quite different, indicating the data arises from different distributions. The median values are consistently smaller than the mean (in some cases substantially smaller), demonstrating the influence of the outliers on the measure of central tendency. Only three pre-intervention data sets are symmetric, and none of the post-intervention data sets are. Failure to pass the symmetry test indicates the data is not normal. However, passing the symmetry test does not indicate the data is normal; this requires a normality test. The symmetry test, which is easier to conduct than normality tests, serves as an initial screen for normality to reduce the number of data sets needing further investigation.

Table 5-5
Example Table of Descriptive Statistics for Total Nitrogen for Each Site for Pre- and Post-intervention.

		1001		1002		1003		1004		1005	
Parameter	**Statistic**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
TN (calculated)	**n**	23	25	23	25	23	25	23	25	23	25
(mg-N/L)	**% > MDL/RL**	100%	80%	98%	90%	98%	96%	98%	96%	100%	98%
	Mean	4.24	3.09	5.31	3.44	3.66	4.42	48.00	10.18	6.89	7.74
	Median	3.84	2.27	3.95	2.55	2.66	2.50	19.01	5.57	5.06	4.36
	Trimmed mean	3.94	2.40	4.53	2.76	2.93	3.01	33.11	6.47	5.08	4.42
	min	2.30	0.30	1.50	0.78	1.46	0.45	3.28	0.74	2.48	1.07
	max	6.76	12.99	13.83	11.40	12.12	19.91	141.06	40.80	20.41	67.12
	25th percentile	3.20	1.79	2.27	2.10	2.11	2.04	9.05	2.71	3.52	3.47
	75th percentile	5.68	3.13	8.02	4.36	4.81	5.17	94.79	19.18	7.07	5.62
	St Dev	1.41	2.67	3.56	2.51	2.48	4.39	49.17	10.73	5.29	12.85
	IQR	2.48	1.34	5.75	2.26	2.70	3.13	85.74	16.47	3.55	2.15
	Skewness, g_s	0.55	2.82	0.84	1.87	2.13	2.27	0.74	1.37	1.88	4.46
	g_{cr}	0.96	0.92	0.96	0.92	0.94	0.92	0.96	0.92	0.94	0.92
	Symmetric ($g_s < g_{cr}$)?	Y	N	Y	N	N	N	Y	N	N	N

The non-parametric equivalent to the ANOVA test is the K-W test, which tests for a difference between the medians of independent data groups. The K-W test will also test whether the datasets are derived from the same distribution.

Comparison of the mean ranks in Table 5-6 provides an indication of whether the data groups are derived from the same distribution. A p values < 0.05 indicates that two or more of the data groups have different distributions. Examination of the mean ranks in Table 5-6 shows that Sites 1001, 1002, and 1005 have somewhat similar mean ranks, and Sites 1003 and 1004 have somewhat different mean ranks. This suggests that Sites 1003 and 1004 have a different distribution than the other sites. Thus, the K-W test was performed on just Sites 1001, 1002, and 1005. These results are shown in Table 5-7. The p-value is now greater than 0.05, so the distributions of the TN data are not significantly different. Based on this analysis, Site 1002 was determined to be the only control site for comparison of TN data. Furthermore, it is clear that Site 1004 should not be considered as a control site for TN, and Site 1003 should be used with caution.

Table 5-6
Example of Kruskal-Wallis Test Results for Total Nitrogen at the Test Sites Prior to Intervention.

Test:	**Kruskal-Wallis ANOVA**		
Comparison:	**Total Nitrogen: 1001, 1002, 1003, 1004, 1005**		
Performed by:	**GeoSyntec Consultants**		
n	115		
Total Nitrogen	**n**	**Rank sum**	**Mean rank**
1001	23	1128.0	49.04
1002	23	1162.0	50.52
1003	23	774.0	33.65
1004	23	2150.0	93.48
1005	23	1456.0	63.30
Kruskal-Wallis statistic	41.71		
p	<0.0001	(chisqr approximation)	

Table 5-7
Example of Kruskal-Wallis Test Results for Total Nitrogen at Sites 1001, 1002, and 1005 Prior to Intervention.

Test:	**Kruskal-Wallis ANOVA**		
Comparison:	**Total Nitrogen: 1001, 1002, 1005**		
Performed by:	**GeoSyntec Consultants**		
n	69		
Total Nitrogen	**n**	**Rank sum**	**Mean rank**
1001	23	710.0	30.87
1002	23	761.0	33.09
1005	23	944.0	41.04
Kruskal-Wallis statistic	3.27		
p	0.1948	(chisqr approximation)	

5.4.3.2 Comparison of Water Quality Data Before and After Intervention

Side-by-side box plots and probability plot comparisons of pre-intervention and post-intervention were constructed to identify any apparent differences in the central tendency and concentration distributions between the two data sets. Figure 5-4 shows side-by-side box plots of total nitrogen at all of the test sites. Site 1004 was omitted due to its high variability. The figure shows that Site 1001 has a distinct decrease in TN while the other sites do not. However, other sites do show a decreasing trend in median concentration and inter-quartile ranges.

Figure 5-4
Side-by-side Box Plots of Pre- versus Post-Intervention for Total Nitrogen at All Sites.

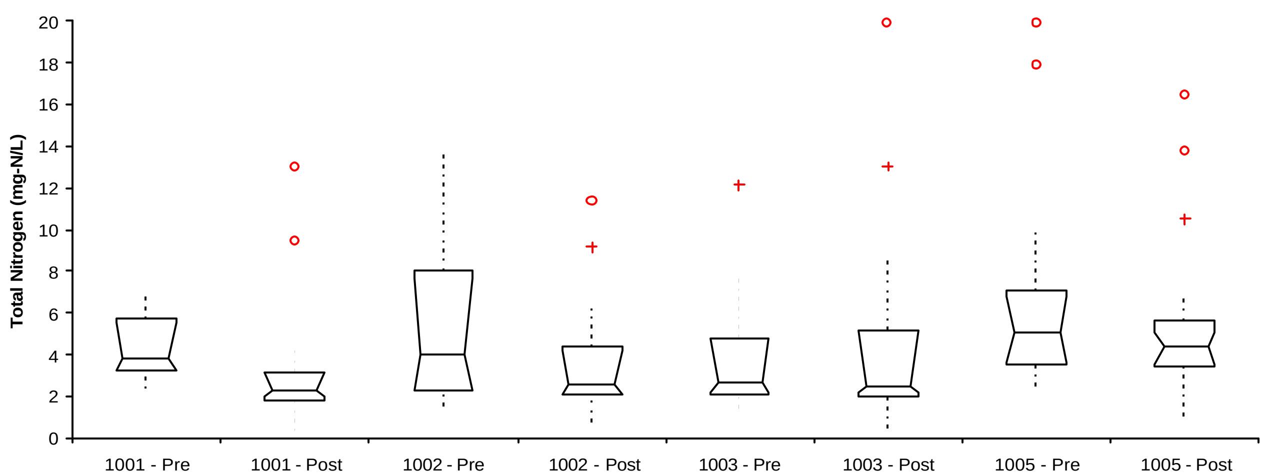
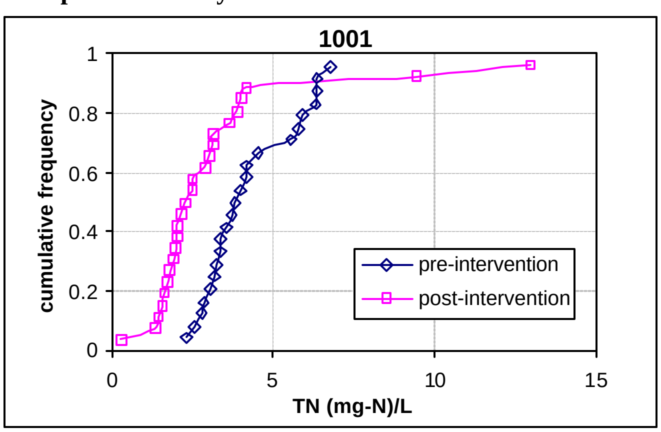


Figure 5-5 is a probability plot of TN for Site 1001 before and after intervention. (Additional probability plot comparisons are included in Appendix E2.) This figure shows a distinct reduction in TN at the site. However, since the data is from different time-periods, this difference could be related to temporal variability.

Figure 5-5
Example Probability Plot of Pre- versus Post-intervention for Total Nitrogen at Site 1001.



To evaluate if temporal variability caused by the different monitoring periods has anything to do with the difference in TN concentrations, the probability plots of the pre- and post-intervention period for Site 1001 were plotted with those for Site 1002 and Site 1005 (as these were determined to be the only valid control sites). These comparison plots are shown on Figure 5-6 and Figure 5-7. For pre-intervention, the distribution of Site 1001 more closely follows the distribution of Site 1005 than that of Site 1002, and for post-intervention the opposite is true. This indicates that the year-to-year variability alone cannot explain the reduction in TN at Site 1001.

Figure 5-6
Example Probability Plot for Total Nitrogen of Site 1001 versus Site 1002 for the Pre- and Post-Intervention Periods.

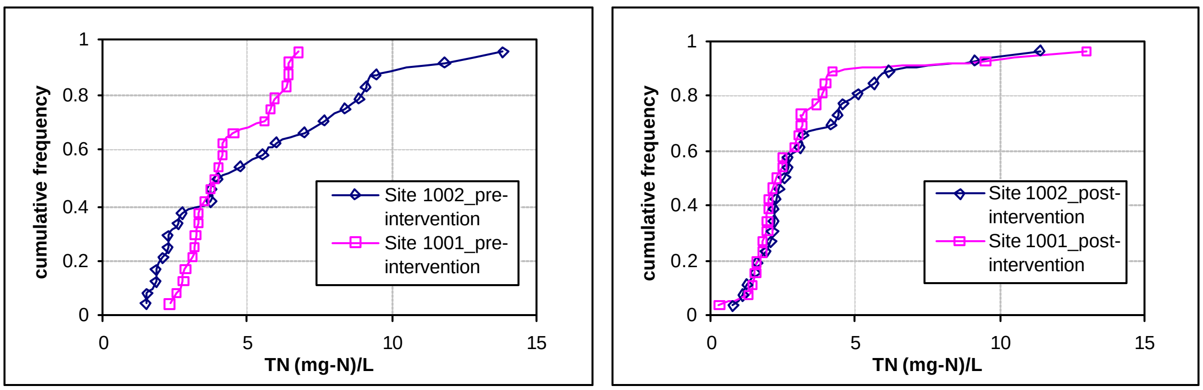
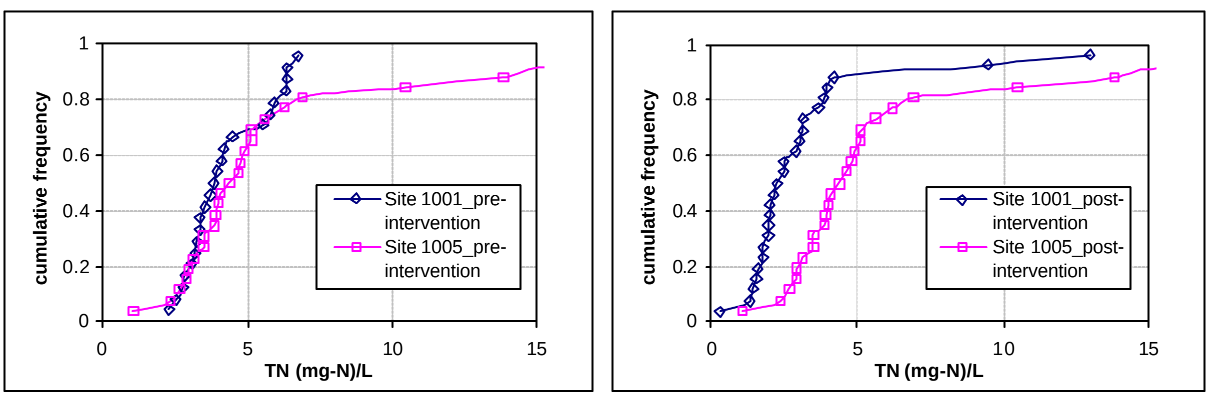


Figure 5-7
Example Probability Plot for Total Nitrogen of Site 1001 versus Site 1005 for the Pre- and Post-Intervention Periods.



The Mann-Whitney test (rank-sum) was used to determine if there is a statistical difference in the median values of two independent data sets (by rejecting the hypothesis that they are the same). Tables 5-8 through 5-10 show the output of the Mann-Whitney tests on Sites 1001, 1002, and 1005, respectively. The tables show a statistically significant difference ($p<0.05$) in the medians between the pre- versus post-intervention TN data at both Sites 1001 and 1002, but not at Site 1005. Furthermore, the difference in the medians at Site 1001 is at a higher level of confidence (more statistically significant) than the difference at Site 1002 (i.e., greater than 99 percent significant compared to about 96 percent significant). The magnitudes of these differences (Hodges-Lehmann estimator) are about 1.5 and 1.3 milligrams of nitrogen per liter (mg-N/L) for Sites 1001 and 1002, respectively. These tests indicate that the difference in the TN medians at Site 1001 from pre-intervention to post-intervention cannot be explained by the year-to-year variation alone (e.g., the intervention appears to have had an effect). It also indicates that the public education applied to Site 1005 did not appear to make a significant difference.

Table 5-8
Example Mann-Whitney Test for Difference in Medians for Total Nitrogen at Site 1001 from Pre- Versus Post-intervention.

Test :	**Mann-Whitney test**			
Alternative hypothesis	**1001: Pre versus Post**			
Performed by:	**GeoSyntec Consultants**			
n	48			
1001	**n**	**Rank sum**	**Mean rank**	**U**
Pre	23	736.0	32.00	115.0
Post	25	440.0	17.60	460.0
Difference between medians	1.497			
95.2% CI	0.883	to +?	(normal approximation)	
Mann-Whitney U statistic	115			
1-tailed p	0.0002	(normal approximation)		

Table 5-9
Example Mann-Whitney Test for Difference in Medians for Total Nitrogen at Site 1002 from Pre- Versus Post-Intervention.

Test:	**Mann-Whitney test**			
Alternative hypothesis:	**1002: Pre versus Post**			
Performed by:	**GeoSyntec Consultants**			
n	48			
1002	**n**	**Rank sum**	**Mean rank**	**U**
Pre	23	651.0	28.30	200.0
Post	25	525.0	21.00	375.0
Difference between medians	1.289			
95.2% CI	0.065	to +?	(normal approximation)	
Mann-Whitney U statistic	200			
1-tailed p	0.0355	(normal approximation)		

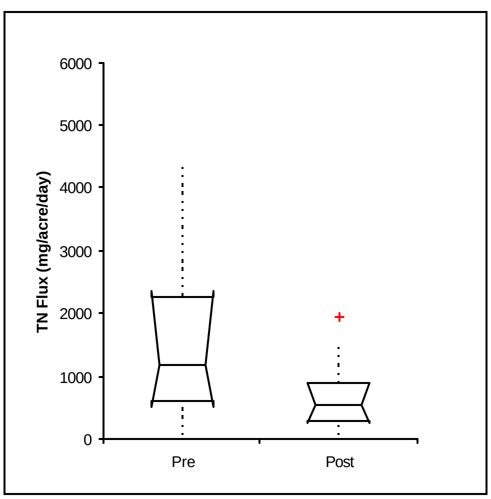
Table 5-10
Example Mann-Whitney Test for Difference in Medians for Total Nitrogen at Site 1005 from Pre- Versus Post-intervention.

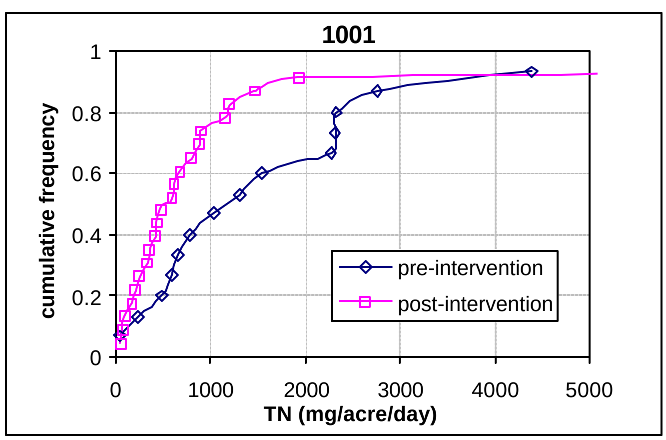
Test:	**Mann-Whitney test**			
Alternative hypothesis:	**1005: Pre versus Post**			
Performed by:	**GeoSyntec Consultants**			
n	48			
1005	**n**	**Rank sum**	**Mean rank**	**U**
Pre	23	610.0	26.52	241.0
Post	25	566.0	22.64	334.0
Difference between medians	0.530			
95.2% CI	-0.446	to +?	(normal approximation)	
Mann-Whitney U statistic	241			
1-tailed p	0.1686	(normal approximation, corrected for ties)		

5.4.3.3 Comparison of Constituent Fluxes Before and After Intervention

The statistical procedures applied to the concentrations examples above were also applied to the constituent fluxes (mass loadings). For completeness, an abridged example analysis is provided here. Figure 5-8 includes side-by-side box plots and probability plots of total nitrogen flux data milligrams per acre per day (mg/acre/day) for Site 1001 at pre- and post-intervention. There appears to be a significant decrease in the median, as well as an overall reduction in the distribution of values.

Figure 5-8
Side-by-side Box Plot and Probability Plots of Pre- Versus Post-Intervention for Total Nitrogen Flues at Site 1001.





Table

Table 5-11 shows the results of the Mann-Whitney test (rank-sum) for the total nitrogen flux at Site 1001. The medians from pre- to post-intervention are statistically significantly different at the 95 percent confidence level ($p<0.05$). The magnitude of the difference (the Hodges-Lehmann estimator) is approximately 530 mg/acre/day, indicating a relatively large reduction in total nitrogen loads from the neighborhood. However, as discussed below, the extent to which the ET controllers contributed to this reduction is unclear.

The nitrogen fluxes used in this analysis were computed as the product of the measured concentration and the average daily flow. Therefore, the reduction in TN flux could be due to a reduction in flow, a reduction in concentration, or a combination of both. Analyses presented earlier showed a statistically significant reduction in median TN concentration at Site 1001 between the pre- and post-intervention periods. Similarly, analyses discussed elsewhere in this report indicate that there was a statistically significant reduction in flow at Site 1001 between the pre- to post-intervention periods; however, it was cautioned that the pre- and post-intervention periods are not comparable due to seasonal differences in the data collection period. Thus, observed reductions in flow in 1001 could be influenced by seasonal factors. Therefore, the extent to which the ET controllers contributed to a reduction in flow is unknown. Consequently, reductions in TN flux could be attributed to a combination of TN reduction, flow reduction, and/or seasonal factors.

Table 5-11
Example Mann-Whitney Test for Difference in Medians for Total Nitrogen Flux at Site 1001 from Pre-Versus Post-intervention.

Test :	**Mann-Whitney test**			
Alternative hypothesis	**1001 flux (mg/acre/day): Pre vs. Post**			
Performed by:	**GeoSyntec Consultants**			
n	36			
1001_flux (mg/acre/day)	**n**	**Rank sum**	**Mean rank**	**U**
Pre	14	320.0	22.86	93.0
Post	22	346.0	15.73	215.0
Difference between medians	529.389			
95.1% CI	115.985	to +?	(normal approximation)	
Mann-Whitney U statistic	93			
1-tailed p	0.0239	(normal approximation)		

The above results suggest that it would be valuable to complete a more robust statistical evaluation of the data because some significant management implications could be determined.

5.4.4 Watershed Implications

The water quality evaluation results were examined in the context of existing TMDLs in the San Diego Watershed. Most of the existing TMDLs are reviewed below, and possible inferences and implications of the R3 Study data for TMDL compliance are discussed. The sediment and organophosphorus pesticide TMDLs were not reviewed because sediment data was not collected (the vast majority of sediments are transported by storm flows) and because Schiff and Tiefenthaler (SCCWRP, 2003) have previously conducted an extensive analysis of the OP pesticide data.

5.4.4.1 Comparisons with Regulatory Requirements

Mean dry-season concentrations for nutrients, toxics, metals, and pathogens at the R3 Study Sites were compared with regulatory objectives including TMDL's, California Toxics Rule (CTR) criteria, and Basin Plan objectives in Tables 5-12 and 5-13. These comparisons are strictly descriptive and provide a rough sense of dry-season residential water quality in comparison to regional water quality objectives. This comparison shows substantial variability between neighborhoods and among constituents.

Table 5-12
Comparison of Dry Season Concentrations of Nutrients and Toxics at R3 Study Sites with Regulatory Objectives

Parameter/Location	Objective	Site 1001	Site 1002	Site 1003	Site 1004	Site 1005
TIN (San Diego Creek Reach 1 / Reach 2)	13 mg/L / 5 mg/L (RWQCB-TMDL)	4.079 mg/L	0.464 mg/L	2.18 mg/L	18.16 mg/L	4 mg/L
		Percent of Samples above Toxics TMDL				
		Site 1001	**Site 1002**	**Site 1003**	**Site 1004**	**Site 1005**
Chlorpyriphos -Acute (San Diego Creek Reach 1)	18 ug/L (RWQCB-TMDL)	36.59	N/A	N/A	22.76	43.9
Chlorpyriphos - Chronic- (San Diego Creek Reach 1)	12.6 ug/L (RWQCB-TMDL)	46.34	N/A	N/A	26.02	49.59
Diazinon - Acute- (San Diego Creek Reach 1)	72 ug/L (RWQCB-TMDL)	70.73	N/A	N/A	69.11	73.17
Diazinon - Chronic- (San Diego Creek Reach 1)	45 ug/L (RWQCB-TMDL)	74.80	N/A	N/A	75.61	77.24

Table 5-13
Comparison of Dry Season Concentrations of Metals and Pathogens at R3 Study Sites with Regulatory Objectives

		Percent of Samples above CTR Criteria				
Parameter	**Objective**	**Site 1001**	**Site 1002**	**Site 1003**	**Site 1004**	**Site 1005**
Copper -Acute	13 ug/L (CTR Criteria for Metal Toxicity*)	43.59	43.59	46.14	46.15	71.79
Copper - Chronic	9 ug/L (CTR Criteria for Metal Toxicity*)	74.36	56.41	76.92	74.36	87.18
Lead -Acute	65 ug/L (CTR Criteria for Metal Toxicity*)	0	0	0	0	0
Lead -Chronic	2.5 ug/L (CTR Criteria for Metal Toxicity*)	10.26	28.21	10.26	12.82	28.21
Zinc -Acute	120 ug/L (CTR Criteria for Metal Toxicity*)	0	7.69	5.13	7.69	15.38
Zinc -Chronic	120 ug/L (CTR Criteria for Metal Toxicity*)	0	7.69	5.13	7.69	15.38
		Median Dry Season Fecal Coliform				
Parameter	**Objective**	**Site 1001**	**Site 1002**	**Site 1003**	**Site 1004**	**Site 1005**
Fecal Coliform	200 MPN/100 mL (RWQCB Basin Plan)	1400 MPN/100 mL	3000 MPN/100 mL	5000 MPN/100 mL	13000 MPN/100 mL	65000 MPN/100 mL

5.4.4.2 Nitrogen

Nitrogen Water Quality Objectives and TMDLs **–** The Basin Plan water quality objectives for nitrogen in San Diego Creek are 13 milligrams per liter (mg/L) Total Inorganic Nitrogen (TIN) in Reach 1, and 5 mg/L TIN in Reach 2 (RWQCB, 1995). Reach 1 extends from Newport Bay to Jeffrey Road, and Reach 2 extends from Jeffrey Road to the headwaters. There is no numeric standard for nitrogen in Upper Newport Bay in the Basin Plan.

The nitrogen TMDL for Upper Newport Bay is based on the general goal of reducing nutrient loads to Newport Bay by 50 percent, to levels observed in the early 1970s (USEPA, 1998b). The nitrogen TMDL sets phase-in limits on TN loads to Newport Bay (see Table 5-14). Separate loads are established for the dry and wet seasons (dry season is from April 1 to September 30). In addition, the winter load is exclusive of storm flows with an average daily flow greater than 50 cubic feet per second (cfs) in San Diego Creek at Campus Drive.

There is no TMDL for nitrogen loads in San Diego Creek, Reach 1 because it was reasoned that attainment of the 50 percent reduction in nitrogen loads to Newport Bay would result in compliance with the Basin Plan in-stream water quality standard for Reach 1 (13 mg/L TIN). However, for Reach 2, it was determined that the average in-stream nitrogen concentrations would likely remain close to or above the Basin Plan in-stream water quality standard (5 mg/L TIN), even with attainment of the Newport Bay TMDLs. Therefore a TMDL of 14 lbs/day TN was established for Reach 2 (see Table 5-14) and is applicable for all flows exclusive of storm flows greater than an average daily flow of 25 cfs in San Diego Creek at Culver Drive.

Table 5-14
Summary of Nutrient TMDLs for Upper Newport Bay and San Diego Creek

TMDL	Dec 31, 2002	Dec 31, 2007	Dec 31, 2012
Newport Bay Watershed, TN – Summer load (4/1 to 9/30)	200,097 lbs	153,861 lbs	
Newport Bay Watershed, TN – Winter load (10/1 to 3/31; non-storm)			144,364 lbs
Newport Bay Watershed, Total Phosphorus – Annual Load	86,912 lbs	62,080 lbs	
San Diego Creek, Reach 2, daily load			14 lbs/day
Urban Runoff Allocation for the Newport Bay Watershed Summer load Winter load	 22,963	 11,481	 38,283

Study Data Comparison with Nitrogen Water Quality Objective – The Basin Plan water quality objectives are expressed in terms of TIN, which is comprised of nitrate/nitrite nitrogen and ammonia. By far the majority of the TIN in San Diego Creek is comprised of nitrate/nitrite nitrogen, as measured ammonia concentrations were typically quite low with a majority below the detection limit. For this reason, only the nitrate/nitrate concentration data is compared to the Basin Plan objectives in this report.

Table 5-15 shows the mean and median nitrate/nitrite concentrations measured in the five study sites. The mean and median nitrate/nitrite concentration of all sites except 1004 was below the Reach 2 Basin Plan objective of 5 mg/L TIN. As discussed previously, Site 1004 may not be a representative control site because the underlying distribution of pre-intervention nitrogen data appears to be different from the other sites. Similar arguments may also be true for Site 1003. With the exception of Site 1004, mean nitrate/nitrite concentrations suggest that, on average, residential runoff from these sites does not contribute to the exceedance of Basin Plan standards for TIN in receiving waters in San Diego Creek, Reach 1 and 2. The Reach 2 water quality objective was occasionally exceeded in all sites, except for the post intervention conditions in 1001 and 1002.

Table 5-15
Mean and Median Nitrate/Nitrite Concentration (mg/l) by Site (all data).

	1001		1002		1003		1004		1005	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
n	23	25	23	25	24	25	23	25	24	25
Mean	2.56	1.47	2.57	1.07	2.13	1.71	36.50	6.61	2.61	4.13
Median	2.32	1.38	1.56	0.93	1.68	0.94	16.88	2.29	2.45	1.48
n>5 mg/L	1	0	4	0	1	2	18	8	2	1
n>13 mgL	0	0	0	0	0	0	12	4	0	1

The mean and median nitrate/nitrate concentrations in Sites 1004 and 1005 exhibit exceedances of the 5 mg/L standard during pre- and/or post intervention conditions. Site 1004, in particular, had high levels of measured nitrate/nitrite concentrations, especially during the pre-intervention period. A number of these high readings exceed the Reach 1 water quality objective of 13 mg/L TIN. The results from Site 1004 are not consistent with those from the other four study sites, and the source of the high readings is unknown. Localized conditions involving excessive fertilizer usage by a few users could possibly be a factor in these elevated readings. In particular, the R3 Study mentions an unknown connection to a neighboring watershed, which could explain the source of elevated nutrient levels.

The Mann-Whitney (rank-sum) test was performed to compare the statistical difference between median concentrations during pre- and post-intervention periods. The median nitrate/nitrite in the post-intervention period was lower at all sites, and the difference was statistically significant at the 0.05 confidence level. As the control stations exhibited this trend, the data (i.e. entire data sets with unequal seasonal coverage) cannot be used to ascertain if the structural and educational BMPs were effective in reducing the runoff concentrations of nitrate/nitrite.

Clearly another factor is contributing to reduced concentrations in the post-intervention period. One possibility that was investigated is differences in seasons, year-to-year variability, and sampling times of the pre- and post-intervention data. Table 5-16 presents mean and median concentrations for comparable seasons and sampling times. The table shows that there are still noticeable reductions in all of the median concentrations, except Site 1005. Applying the Mann-Whitney (rank-sum) test to the data, it was found that statistically significant differences between median nitrate/nitrite concentrations in the pre- and post-intervention periods occurred only at Sites 1001 and 1004, as compared to all sites when all data is considered. These results indicate that seasonal effects are present in the data and should be considered in the study evaluation. It may be inferred from these results that there were significant reductions in the nitrate/nitrite concentration in the intervention site during the wet season that may, in part, be attributable to the structural BMPs. It is unknown whether similar reductions would occur in dry weather runoff during the dry season because such data was not collected during the pre-intervention period.

Table 5-16
Mean and Median Nitrate/Nitrite Concentration (mg/l) by Site for Comparable Seasons and Sampling Times[1]

	1001		**1002**		**1003**		**1004**		**1005**	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
n	18	14	18	14	19	14	18	14	19	14
Mean	2.38	1.43	1.95	0.95	2.17	1.66	26.24	6.57	2.24	6.27
Median	2.22	1.48	1.16	0.96	1.50	1.02	8.94	2.06	2.03	1.96
n>5 mg/L	0	0	2	0	1	1	13	4	1	1
n>13 mg/L	0	0	0	0	0	0	7	3	0	1

1 – evening samples were deleted from the pre-intervention data. The post-intervention data include only those data collected in months identical to the pre-intervention period.

Study Data Comparison with Nitrogen TMDLs - The nitrogen TMDL is expressed in terms of total nitrogen TN loads. TN concentrations were calculated from the monitoring data as the sum of the nitrate/nitrite nitrogen and total Kjeldahl nitrogen (TKN) nitrogen. Table 5-17 shows the mean and median TN concentrations measured in the five study sites. The mean and median TN concentration in dry weather runoff are generally in the range of 2 to 5 mg/L, with the exception of Site 1004 where substantially higher concentrations were measured. The rank sum tests indicated that median TN concentrations were significantly lower (in a statistical sense) in the post-intervention period in Site 1001 (structural BMPs, see Table 5-8), and at Site 1002 (control, see Table 5-9). Based on the probability plots in Appendix E2, Site 1004 is expected to as well. However, Sites 1003 and 1005 did not show statistically significant reductions. These results did not change when only subsets of the data were used to consider possible effects stemming from the sampling time and sampling months.

Table 5-17
Mean and Median TN Concentration (mg/l) by Site

	1001		**1002**		**1003**		**1004**		**1005**	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
All Data										
n	23	25	23	25	23	25	23	25	23	25
Mean	4.24	3.09	5.31	3.44	3.66	4.42	48.00	10.18	6.89	7.74
Median	3.84	2.27	3.95	2.55	2.66	2.50	19.01	5.57	5.06	4.36
Subsets[1]										
n	18	14	18	14	18	14	18	14	18	14
Mean	4.18	2.78	4.51	2.63	3.71	3.71	33.99	8.91	6.98	9.91
Median	3.62	2.02	3.22	2.21	2.51	2.47	12.14	3.74	4.17	3.96

1 – Data subsets with comparable sampling time and seasons. Evening samples were deleted from the pre-intervention data. The post-intervention data include only those data collected in months identical to the pre-intervention period.

TN flux estimates were calculated for Sites 1001 and 1005 (Table 5-18). The flow measurements at Sites 1002 to1004 are not reliable. Therefore, flux estimates were not calculated for these sites. Flux estimates were calculated as the product of the constituent concentration and the average daily flow occurring on the day of the sample collection. The flux estimates were found to be quite variable as they depend on both flow and concentration measurements. Table 5-18 shows that median TN flux estimates decreased from the pre- to post-intervention periods for both sites. Mann-Whitney (rank sum) tests show the reductions to be statistically significant (Table 5-11). Because comparable data is not available for the control sites, it is not possible to infer whether these reductions are influenced by the ET controllers in the intervention site (1001). Also, as previously discussed, the reduction in TN flux may be attributable to a reduction in flow, a reduction in concentration, seasonal factors, or a combination of these.

Table 5-18
Mean and Median TN Flux (mg-N/acre/day) by Site

	1001		1005	
	Pre	**Post**	**Pre**	**Post**
All data				
n	14	22	10	21
Mean	1476	1667	2104	6537
Median	1164	530	1568	1177
Subset[1]				
n	12	14	10*	8
Mean	1384	587	2104	1716
Median	902	497	1568	960

1 – Data subsets with comparable sampling time and seasons. Evening samples were deleted from the pre-intervention data. The post-intervention data include only those data collected in months identical to the pre-intervention period.
* – Same as the all data case

Although the flux estimates in Table 5-18 are limited in number, duration, and location, they can be used to speculate about the magnitude of the urban area contribution of TN loads to Newport Bay and the potential reduction in loads from structural and nonstructural BMPs. Based on the limited flux data, the annual TN load to Newport Bay in dry weather runoff from urban areas in the San Diego Creek Watershed is estimated to range between 37,000 to 50,000 lbs per year under existing land-use conditions (see Table 5-19). This is for the most part below the 2012 urban runoff allocation of 49,764 lbs. The annual TN load is estimated to increase to 50,000-67,000 lbs per year under build-out conditions.

According to the 2001 report on the nutrient TMDL (OCPFRD, 2001), the average daily TN load in San Diego Creek at Campus Drive was 540 lbs/day between July 2000 and June 2001. This converts to an annual load of about 197,000 lbs, which is below the 2007 TMDL (note: San Diego Creek is the majority but not sole contributor of TN loads to Newport Bay). Estimates in Table 5-19 suggest that dry weather runoff from urban areas account for about 20 to 25 percent of the annual TN in the San Diego Creek Watershed. If it is assumed that flux reductions observed in the post intervention period are attributable to the structural and nonstructural BMPs, and if similar interventions could hypothetically be implemented on a watershed-wide basis, then the potential reduction in annual dry weather TN loads is estimated to range between 12,500-20,000 lbs. This would represent a reduction of about 6-10 percent of the current TN loads and about 30-40 percent of the estimated current dry weather urban loads. These estimates are based on few data collected in a limited area and should therefore be considered preliminary in nature.

Table 5-19
Estimated Annual TN Loads in Dry Weather Runoff from Urban Areas in the San Diego Creek Watershed

	TN flux (mg-N/acre/d)	**Annual TN Load to Newport Bay (lbs) Existing land-use[1]**	**Annual TN Load to Newport Bay (lbs) Built-out land-use[2]**
Pre-intervention conditions	1160 – 1560	37,300 – 50,500	50,000 – 67,000
Post-intervention conditions	530 – 1180	17,000 – 38,000	23,000 – 51,000
Potential reduction		~12,500 – 20,000	~16,000 – 27,000

1 –Used 40000 acres or about 53% of the San Diego Creek Watershed area (IRWD, 2003). For comparison, urban land use in 1999 use was estimated at 35,500 acres of the watershed area at Campus Drive (Tetra-Tech, 2000).
2 – Used 53500 acres or about 71% of the San Diego Creek Watershed area (IRWD, 2003).

The following conclusion can be made based on the analyses above:

- Average and median nitrate/nitrite concentrations in dry weather runoff are below the Reach 2 water quality objective (5 mg/L), for most but not all study sites.
- Occasional exceedance of the Reach 2 water quality objective occurred in all study sites.
- The majority of measured nitrate/nitrite concentrations at Site 1004 during the pre-intervention period were greater than the Reach 2 water quality objective of 5 mg/L. The data is not consistent with those from the other sites. The cause is unknown, but could possibly be related to the unknown connection to the neighboring nursery discussed in the R3 report.
- Sampling periods (months) and sampling time (morning versus evening) were found to affect the statistical significance of differences between pre- and post- intervention median nitrate/nitrate concentration in some of the sites. The sampling period and sampling time did not affect the statistical significance of differences between pre- and post-intervention median TN concentrations.
- Median TN fluxes at Sites 1001 and 1005 were statistically smaller in the post-intervention period. The extent to which the structural and nonstructural BMPs contributed to these reductions cannot be determined due to the lack of reliable flow data in the control sites.
- Preliminary estimates of annual TN loads to Newport Bay in dry weather runoff from urban sources range between 37,000 to 50,000 lbs per year, or about 20 to 25 percent of the current TN loads.
- The potential reductions in annual dry weather TN loads due to implementation of BMPs on a watershed basis is estimated to range between 12,500-20,000 pounds per year. This would represent a reduction of about 6-10 percent of the current TN loads and 30-40 percent of the urban loads.

5.4.4.3 Phosphorus

The majority of the annual TP load in the San Diego Creek Watershed occurs in the wet season, and has been correlated with sediment loads generated by storm events (USEPA, 1998b). This correlation suggests that a majority of phosphorus occurs in particulate form attached to sediments. The main sources of the TP are in Peters Canyon Wash and San Diego Creek above Culver Drive (USEPA, 1998b).

Phosphorus TMDL – There is no numeric objective for phosphorus for San Diego Creek in the Basin Plan. Because measured TP and sediment loads are correlated, it was determined in the TMDL that a 50 percent reduction in TP loads would be achieved through compliance with the sediment TMDL (USEPA, 1998a). Accordingly, the TMDL for TP was based on a 50 percent reduction of average annual load estimated at 124,160 lbs (USEPA, 1998b). The TMDLs are applicable for all flow conditions. The target compliance date was set for December 31, 2007.

The annual TP load allocation for urban areas is 4102 lbs by 2002, reducing to 2960 lbs by 2007. According to the USEPA (1998b), the TP is allocated in the same proportion as sediments. The annual urban area (stabilized vs. construction) sediment allocation for the Newport Bay Watershed is 50 tons distributed over 95.3 square miles (see Table 5 in USEPA, 1998a). This is a very small allocation over a large area. By contrast, the annual construction allocation is 6500 tons distributed over the assumed 3.0 square miles under construction in any one year. Using the same proportions of sediment load allocations, the TP load rate based on the 2007 urban allocation is 2960 lbs/95.3 square miles = 0.0485 lbs/acre/yr. If the construction and urban allocations are combined, the TP load rate based on the combined 2007 urban and construction allocations is (2960+12810) lbs/(95.3+3.0) square miles = 0.251 lbs/acre/yr.

Study Data Comparison with TMDLs – Similar to the nitrogen TMDL, the phosphorus TMDL is expressed in terms of total annual TP loads. Table 5-20 shows the mean and median TP concentrations measured in the five study sites. The mean and median TP concentrations in dry weather runoff are below 1.2 mg/L in all sites, with the exception of Site 1004, where substantially higher concentrations were measured. Comparison of the pre- and post-intervention median TP concentrations in all data (Table 5-20) reveals an increase in the median TP concentration during the post-intervention period for all sites except the intervention Site 1001 and Site 1004. In contrast, when subsets of the data with similar seasons and sampling times are considered (Table 5-20), there is a decrease in the median TP concentration at all sites except 1005. This indicates that there are seasonal influences in the data, which presumably are related to rainfall. Unfortunately, no data is available to permit comparison of pre- and post-intervention concentrations for dry weather flows during the dry season.

Table 5-20 Mean and Median TP Concentration (mg/l) by Site

	1001		**1002**		**1003**		**1004**		**1005**	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
All Data										
n	23	25	23	25	24	25	23	24	24	25
Mean	0.73	0.60	0.92	0.84	0.98	1.21	3.33	1.50	1.01	1.19
Median	0.60	0.51	0.77	0.82	0.62	0.67	2.54	1.05	0.73	0.85
Subsets[1]										
n	18	14	18	14	19	14	18	13	19	14
Mean	0.78	0.47	0.91	0.67	1.13	0.57	2.62	1.33	0.93	1.24
Median	0.61	0.41	0.73	0.56	0.75	0.58	1.82	1.07	0.75	0.83

1 – Data subsets with comparable sampling time and seasons. Evening samples were deleted from the pre-intervention data. The post-intervention data include only those data collected in months identical to the pre-intervention period.

TP flux estimates were calculated for Sites 1001 and 1005 using the approach discussed in the nitrogen section above. Table 5-21 shows that median TP flux estimates decrease from the pre- to post-intervention periods at the intervention site (1001), but not in the education only site (1005). Mean fluxes increased at both sites. However, as discussed earlier, the mean values are strongly influenced by outliers and do not provide a good measure of central tendency for the data. Application of the Mann-Whitney (rank sum) test shows the reduction in median TP flux at Site 1001 is statistically significant. This suggests that the structural BMPs had a positive influence in reducing the TP fluxes. However, because comparable data is not available for the control sites, it is not possible to ascertain the extent to which the ET controllers contributed to these reductions. Also, as discussed previously, reductions in flux could be influenced by several factors: reduction in concentration, reduction in flow, and/or seasonal variability.

Table 5-21
Mean and Median TP Flux (mg-P/acre/day) by Site (all data)

	1001		**1005**	
	Pre	**Post**	**Pre**	**Post**
All data				
n	14	22	10	21
Mean	265	370	473	1327
Median	164	109	219	219

Similar to the previous analyses of TN loads, the TP flux estimates in Table 5-21 can be used to speculate about the magnitude of the urban area contribution of TP loads to Newport Bay and the potential reduction in loads from structural BMPs. Based on the limited flux data, the annual TP load to Newport Bay in dry weather runoff from urban areas in the Newport Bay Watershed is estimated to range between about 5,000 to 11,000 lbs per year (see Table 5-22), assuming a total urban area of 95.3 square miles obtained from Table 5 of the sediment TMDL (USEPA, 1998a). These estimated annual TP loads are greater than the urban allocation (for both dry and wet weather) and are less than the combined urban and construction allocations (Table 5-22). However, these estimates are based on dry weather data only, and it is expected that a major portion of the TP loads will occur in runoff from winter storms. Therefore, actual annual TP loads would be expected to be greater. If it is hypothesized that flux reductions observed at the intervention site (1001) could be realized over the entire watershed, then the potential reduction in annual dry weather TP loads from urban areas is estimated at 2700 lbs. As stated previously, these estimates are based on few data collected in a limited area and should therefore be considered preliminary in nature.

Table 5-22
Estimated Annual TP Loads in Dry Weather Runoff from Urban Areas in the San Diego Creek Watershed

	TP flux (mg-P/acre/d)	**Annual TP Load Rate to Newport Bay (lbs/acre/year)**[1]	**Annual TP Load to Newport Bay (lbs/year)**
2007 Urban Area Allocation for Newport Bay		0.0485	2960
2007 Combined Urban and Construction Area Allocation for Newport Bay		0.251	15770
Pre-intervention conditions (median fluxes)	164 – 219	0.132 – 0.176	8049 – 10748
Post-intervention conditions (median fluxes)	109 – 219	0.088 – 0.176	5350 – 10748
Potential reduction			2700

1 - urban area is 95.3 square miles and the construction area is 3.0 square miles based on Table 5 in USEPA,1998a

5.4.4.4 Metals

***Metals TMDLs* –** The USEPA (June 2002) determined that TMDLs are required for dissolved copper, lead, and zinc in San Diego Creek, Upper Newport Bay, and Lower Newport Bay, and that TMDLs are required for cadmium in San Diego Creek and the Upper Newport Bay. The TMDLs for San Diego Creek are expressed as concentration limits, based on the California Toxic Rule (CTR) criteria at various hardness values that are associated with different flow regimes (Table 5-23). The flow regimes are based on 19 years of flow measurements in San Diego Creek at Campus Drive. The concentration-based TMDLs apply to all freshwater discharges to San Diego Creek, including discharges from agricultural, urban, and residential lands, and storm flow discharges. The applicable flow regime at any location in the entire watershed is determined on the basis of discharge at Campus Drive.

Table 5-23
Summary of Dissolved Metal TMDLs for San Diego Creek

Dissolved Metal (?g/l)	**Base flow (0–20 cfs) hardness @ 400 mg/L**		**Small flows (21-181 cfs) hardness @ 322 mg/L**		**Medium flows (182-814 cfs) hardness @ 236 mg/L**		**Large flows (>814 cfs) hardness @ 197 mg/L**
	Acute	**Chronic**	**Acute**	**Chronic**	**Acute**	**Chronic**	**Acute**
Cadmium	19.1	6.2	15.1	5.3	10.8	4.2	8.9
Copper	50	29.3	40	24.3	30.2	18.7	25.5
Lead	281	10.9	224	8.8	162	6.3	134
Zinc	379	382	316	318	243	244	208

Metals Sources **–** The USEPA (June 2002) conducted a source analysis as part of the TMDL preparation. Surface runoff is the largest contributor of metals loads in the San Diego Creek watershed, which includes natural and man made sources (USEPA, June 2002). Much of the metals loads are from natural sources. The estimated anthropogenic contributions are metal specific and range from about 33 percent for zinc to 63 percent for cadmium (USEPA, June 2002). A primary anthropogenic source of heavy metals is runoff from urban roads, which contributes to sources of cadmium (tire wear), copper (brakes, tires), lead (brakes, tires, fuels and oils), and zinc (tires, brakes, galvanized metals). Use of copper sulfate by nurseries may also be a minor source of copper loads. Other copper and zinc uses in building materials (roofing and roof drains) may be another source.

The USEPA found that metal inputs were heavily influenced by rainfall and stream flow rates. Monitoring results were reported to be highly variable due to different rainfall amounts and flows during each water year. The USEPA estimated that base flows account for 25 percent of the total metal loadings, with the remainder from low, medium and large flows caused by storms.

The USEPA's preliminary analyses suggest that: 1) a primary source of metals in dry weather runoff in the study watershed is from roads (i.e. wash off of metals in driveways, parking lots, streets, gutters, etc.); 2) the runoff concentrations will be influenced by rainfall which result in wash off of accumulated metals; and 3) the concentrations can be variable depending on the amount of rainfall.

Study Data Comparison with Base Flow TMDLs **–** The metals TMDLs for base flow conditions are based on meeting the CTR criteria at a total hardness of 400 mg/L. The CTR criteria express maximum allowable concentrations in receiving waters for acute (short term) and chronic (4-day) exposure periods. The acute and chronic criteria are expressed as values that cannot be exceeded more that once in three years. Although the criteria are applicable in the receiving waters and not in the urban runoff per se (i.e. the measured dry weather discharge), exceedance of the CTR in the urban discharge would suggest a potential for the discharge to contribute to an exceedance in the receiving waters.

Table 5-24 shows the mean and median heavy metal concentrations in the five study sites. With the exception of mean copper concentrations in some of the sites, all mean and median concentrations were below the chronic and acute CTR criteria. Copper, lead, and zinc concentrations occasionally exceeded the chronic CTR criteria, and copper and zinc concentrations occasionally exceeded the acute criteria. These exceedances suggest that the dry weather runoff can potentially contribute to an exceedance in the receiving waters. However, if intervention is determined to be effective in reducing runoff flows, then the BMPs would help to reduce impacts of these potential exceedances by allowing for greater dilution with the in-stream flows.

Table 5-24
Mean and Median Metal Concentrations (mg/L) by Site (all data)

	1001		1002		1003		1004		1005	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
Cadmium										
n	23	25	23	25	24	25	23	25	24	25
Mean	0.26	0.14	0.47	0.44	0.27	0.17	0.64	0.22	0.21	0.29
Median	0.27	0.10	0.24	0.10	0.10	0.10	0.36	0.10	0.10	0.10
n>6.2 ? g/l	0	0	0	0	0	0	0	0	0	0
n>19.1 ? g/l	0	0	0	0	0	0	0	0	0	0
Copper										
n	23	25	23	25	24	25	23	25	24	25
Mean	13.5	16.9	27.3	30.3	11.5	26.6	21.8	17.7	32.1	30.8
Median	11.5	11.4	10.9	14.0	11.1	14.3	12.7	11.4	12.3	20.4
n>29.3 ? g/l	2	2	3	7	0	2	5	4	3	5
n>50 ? g/l	0	1	3	3	0	2	2	3	3	2
Lead										
n	23	25	23	25	24	25	23	25	24	25
Mean	0.8	1.6	5.9	4.7	0.8	1.6	3.5	1.5	1.0	3.2
Median	0.6	0.6	0.9	1.2	0.6	0.8	0.7	0.7	0.7	1.3
n>10.9 ? g/l	2	1	2	3	0	0	2	0	0	1
n>281 ? g/l	0	0	0	0	0	0	0	0	0	0
Zinc										
n	23	25	23	25	24	25	23	25	24	25
Mean	58.7	37.2	115.2	86.3	56.3	56.8	83.6	40.9	74.0	75.0
Median	56.0	50.2	53.4	57.2	50.7	53.9	50.8	43.8	52.4	54.5
n>382 ? g/l	0	0	1	2	0	0	1	0	0	0
n>379 ? g/l	0	0	1	2	0	0	1	0	0	0

Dry weather metals monitoring information in the Central Irvine Channel, the immediate receiving water of the study watersheds, was unavailable. OCPFRD dry weather monitoring data is available in San Diego Creek at Campus Drive, which is quite a way downstream from the study sites. Data collected between December 2001 and June 2002 (Table 5-25) shows that average dry weather concentrations at Campus Drive are well below mean and median concentrations measured in dry weather runoff from the study watershed. Similar comparisons cannot be made for lead and cadmium because the method detection limits in the OCPFRD data are greater than those in the R3 data. None of the OCPFRD dry weather data exceeded the chronic or acute criteria.

Table 5-25
Summary of OCPFRD Dry Weather Monitoring Data of San Diego Creek at Campus Drive (12/01 to 6/02)

	Cadmium	**Copper**	**Lead**	**Zinc**
Sample number	24	24	24	24
Range	All < 1 ?g/l	<2 – 16 ?g/l	<2-2.4 ?g/l	<10-16
Mean		7.4 ?g/l	most <2 ?g/l	most <10
Median-		6.8?g/l		

These comparisons suggest that metal loads in dry weather runoff from the study (urban) watersheds could be a contributing factor to dry weather copper and zinc loads measured at Campus Drive. These dry weather discharges do not result in non-compliance of the base flow metal TMDL at Campus (based on the reviewed data only). It is unknown if the elevated concentrations measured in the dry weather urban runoff result in exceedance of the CTR criteria in the immediate receiving waters. If flow reductions observed in the intervention watershed are attributable to the ET controllers, then these controllers would help to reduce impacts from any potential exceedances of the TMDL because the discharges would be subject to greater dilution by the in-stream flows.

5.4.4.5 Pathogens

Pathogens are agents or organisms that can cause diseases or illnesses, such as bacteria and viruses. Fecal coliform bacteria are typically used as an indicator organism because direct monitoring of human pathogens is generally not practical. Fecal coliform are a group of bacteria that are present in large numbers in the feces and intestinal tracts of humans and animals, and can enter water bodies from human and animal waste. The presence of fecal coliform bacteria implies the water body is potentially contaminated with human and/or animal waste, suggesting the potential presence of associated pathogenic organisms.

Fecal Coliform TMDL **–** The RWQCB has adopted phased TMDL criteria for pathogens, with the initial focus on additional monitoring and assessment to address areas of uncertainty. The goal of the Newport Bay TMDL is compliance with water contact recreational standards by 2014:

- Fecal coliform concentration of not less than five samples per 30 days shall have a geometric mean less than 200 MPN/100 ml, and not more than 10 percent of the samples shall exceed 400 MPN/100ml for any 30-day period.

A second goal is to achieve the shellfish harvesting standards by 2020:

- The monthly median fecal coliform concentration shall be less than 14 MPN/100 ml, and not more than 10 percent of the samples shall exceed 43 MPN/100 ml.

The TMDLs are applicable for all flow regimes.

Study Data Comparison with Fecal Coliform TMDLs **–** Table 5-26 shows the mean and median fecal coliform concentrations measured in the five study watersheds. From 70 percent to 100 percent of all fecal coliform measurements were greater than 400 MPN/ml in all study watersheds. This level of exceedance is substantially greater than the allowable 10 percent. The mean and median fecal coliform concentrations also exceed the 400 MPN/100ml criterion in all study watersheds. There was insufficient data to calculate the 30-day geometric mean (a minimum of 5 samples per 30 days needed). However, the TMDL criterion (30-day geometric < 200 MPN/100 ml) would likely be exceeded, assuming that any additional data would be of the same magnitude as those collected. Exceedance of the TMDL criteria in all study watersheds suggests that urban dry weather runoff is likely a contributing factor to any dry weather exceedance of the TMDL in the receiving waters.

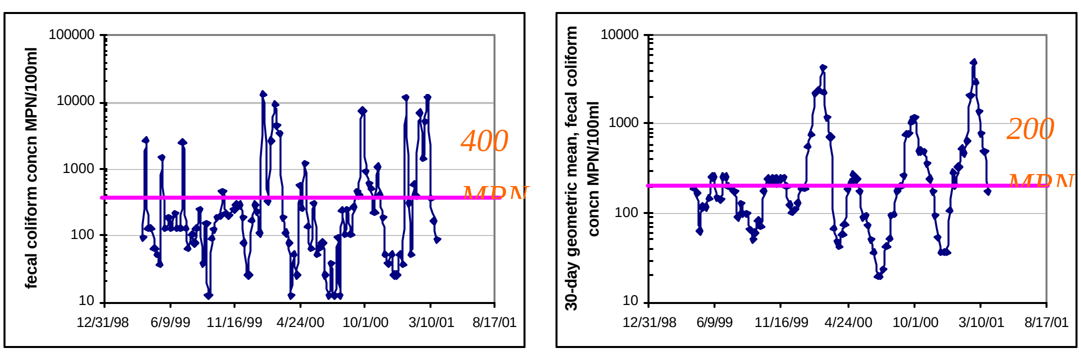
Table 5-26
Mean and Median Fecal Coliform Concentration (MPN/100ml) by Site

	1001		1002		1003		1004		1005	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
All Data										
n	22	24	21	24	23	24	21	24	23	24
Mean	4921	3003	5582	128193	34526	28980	28205	34185	17976	10326
Median	2300	1400	1700	3000	13000	4000	13000	13000	8000	8000
% > 400 MPN/100ml	82%	67%	86%	79%	100%	88%	95%	83%	92%	93%
Subsets[1]										
n	17	14	17	14	18	14	17	14	18	14
Mean	2545	3054	3090	5074	13783	37479	23312	20166	8524	6109
Median	2200	950	1400	1400	8000	2650	8000	6500	4000	2900
% > 400 MPN/100ml	100%	71%	82%	79%	100%	86%	94%	79%	100%	93%

1 – Data subsets with comparable sampling time and seasons. Evening samples were deleted from the pre-intervention data. The post-intervention data include only those data collected in months identical to the pre-intervention period.

Dry weather coliform monitoring information in the Central Irvine Channel was not available. Therefore, it is unknown if elevated fecal coliform concentrations measured in the study watershed contribute to an exceedance of the TMDL in the immediate receiving waters. The OCPFRD has collected dry and wet weather *E. coli* monitoring information in San Diego Creek at Campus Drive (OCPFRD, September 2001), which is considerably downstream from the study watersheds. A plot of the equivalent fecal coliform concentration (assuming an 80 percent *E. coli* content) shows exceedance of the TMDL occurs primarily during the wet season, although dry season exceedances are also evident (see Figure 5-9). This suggests that dry weather urban runoff is potentially a contributing factor to exceedance of the TMDL in dry weather flows at Campus Drive. The ET controllers would reduce the impacts from these potential exceedances if they were determined to be effective in reducing the dry weather runoff volumes.

Figure 5-9
Time Series of Fecal Coliform Levels of San Diego Creek at Campus Drive (converted from measured E. *coli* concentrations)



Median fecal coliform concentrations presented in Table 5-26 may be used to evaluate the influence of the structural and non-structural BMPs. When all monitoring data sets are considered, the median fecal coliform concentrations are equivalent or increase from pre- to post- intervention conditions in all sites except the 1001 (intervention site) and 1003 (a control site). Based on the Mann-Whitney (rank-sum) test, the reduction in median concentrations at Site 1001 and 1003 is significant at the 95 percent confidence level. Thus the site with the irrigation controllers corresponded to a significant reduction in median fecal coliform concentrations, in comparison to two of the three control sites, while the education only watershed exhibited no discernable reduction in median concentrations.

When subsets of the data with similar seasons and sampling times are considered (Table 5-26), there is a decrease in the median fecal coliform concentration at all sites except 1002. However, because of the smaller sample sizes, the decrease is median concentration is statistically significant only at Site 1003. This suggests that there could be seasonal influences in the monitoring data, but the data is not sufficient to determine if there are statistically significant differences in the median concentrations.

5.5 Conclusions

The initial review of water quality data from the study found virtually no difference in concentrations or pollutant flux over time. The technological and education treatments provided essentially no detectable increase or decrease in water quality following the intervention.

The follow-up review utilizing more robust statistical methods on a sample of study data suggests that the interventions did result in changes in water quality. TN levels in the retrofit neighborhood following intervention were found to be significantly lower than levels before intervention, whereas no detectable differences were noted before and after intervention in the education neighborhood. Relatively large observed reductions in TN flux in the retrofit neighborhood could be influenced by seasonal factors, and the extent to which the ET controller contributed to the reduction is unknown. Similarly, although reductions in TP flux were observed in the retrofit neighborhood, the effect of the ET controllers cannot be determined.

Chapter 6: Public Education

6.1 Overview

This chapter discusses issues pertaining to public acceptance of water conservation and runoff reduction measures. Specific information is provided on:

- Evaluation approach, including development of ET controller + education and education-only BMPs
- Customer interaction
- Evaluation results, as measured through responses to pre- and post-intervention customer surveys

More detailed information is provided in Appendix F.

6.2 Evaluation Approach

The public acceptance evaluation was conducted to compare the effectiveness of proposed BMPs for ET controller technology + education and education only. There were three groups of R3 Study participants: 1) participants who had their home irrigation controllers replaced with an ET controller and who received educational materials, 2) participants who received educational materials only, and 3) control groups, who received no interventions. The retrofit participants were selected through random "cold knocking" and through letter solicitations that explained the study. The education group was self and randomly selected. Some of the education group participants voluntarily chose to participate in the study by replying to a letter. However, the majority was randomly selected through a door-to-door campaign.

6.2.1 ET Technology + Education (Retrofit Group)

For the R3 Study, existing sprinkler timers that are set manually by the homeowner were replaced with the radio controlled ET controller systems. Trained technicians were used to ensure successful installation because ET controllers require programming for each valve including area (size of yard or planter per valve), soil type (clay, sand, etc.), and landscape type (turfgrass, shrubbery, etc.). The remaining irrigation system was unchanged, including piping and sprinkler head configuration.

The participating ET technology retrofit group homes received a site evaluation and installation of an ET controller to manage the irrigation system. Additionally, the residents of these homes received information regarding environmentally sensitive landscape practices. The controllers were installed in 112 residential homes, two condominium associations' landscapes, two HOA landscapes, one pool/park setting, and 12 city street landscapes.

Public education materials were also provided, as described in Section 6.2.2.

6.2.2 Education Only

Educational materials were provided to both the retrofit and education-only groups. Public education consisted of an initial informational packet containing three items. The first item was an introductory letter that described the purpose of the packet. The second item was a booklet with irrigation, fertilization, and weed and pest control information. The centerfold of the booklet was a month-by-month guide to irrigating, fertilizing, and pesticide application suitable for posting near the sprinkler timer. Third, each homeowner was supplied a soil probe for measuring the water content of the landscaped soils. In addition to the initial packet, monthly reminders were mailed to each homeowner including landscape maintenance tips about irrigation system, watering schedule, fertilizing, and weed and insect control. Suggested sprinkler run times (for the non-ET sprinkler neighborhood) and fertilizer or pesticide application usage, including non-toxic alternatives, were also provided in the monthly newsletter. A representative collection of the public information tools used for the R3 Study is provided in Exhibits A through D at the end of this section.

6.2.3 Customer Interaction

Home residents were advised that if they had any problems with the controller or if the controller required any adjustments, they should call the water district for assistance. IRWD's customer service department telephone number was left on a sticker on the ET controller. All calls related to the ET controller were logged in separately and routed to the appropriate staff member for assistance. Table 6-1 shows the number of calls that were received from residential residents during the R3 study period.

Table 6-1
Calls from Residential Customers in R3 Study

April 2001	1	August 2001	13	December 2001	1	April 2002	2
May 2001	12	September 2001	4	January 2002	4	May 2002	3
June 2001	7	October 2001	5	February 2002	9	June 2002	6
July 2001	13	November 2001	3	March 2002	4	July 2002	2

Generally, there were four common types of calls: 1) customer misunderstanding the way the ET controllers were supposed to operate, 2) installation-related issues, 3) maintenance or system design issues, and 4) ET controller malfunctioning. These issues were addressed and resolved. (See Appendix F.)

.

6.3 Customer Surveys

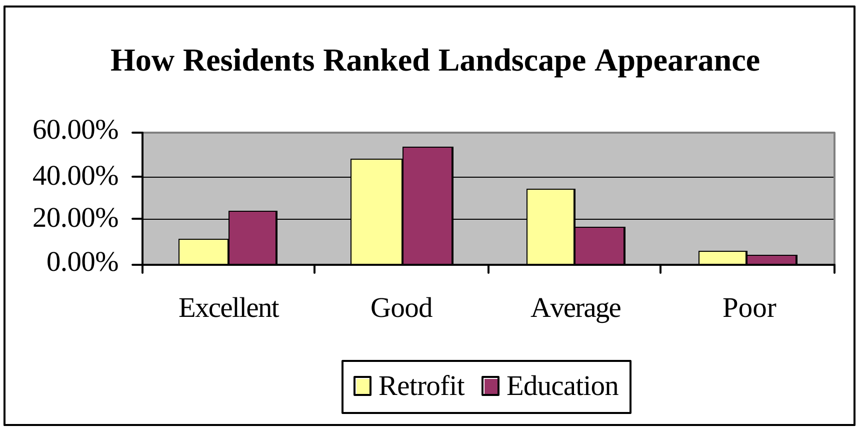
This section describes pre-and post-intervention surveys developed to measure public acceptance.

6.3.1 Pre-survey

The purpose of the pre-survey was to determine if the retrofit group and the education group had similar irrigation practices and attitudes. The pre-survey was distributed to the retrofit group while installation of the controller was taking place. Retrofit study participants were asked to fill out the survey while staff was installing the controller. The education group received their survey as part of the initial educational packet that was randomly distributed to residents. Education group participants were provided a stamped addressed envelope to return their survey to the IRWD. Ninety-seven percent (109/112) of those that received a survey from the retrofit group mailed the survey back. Twenty-four percent (53/225) of residents in the education group mailed back a survey. Pre-survey results are tabulated in Appendix F and summarized below.

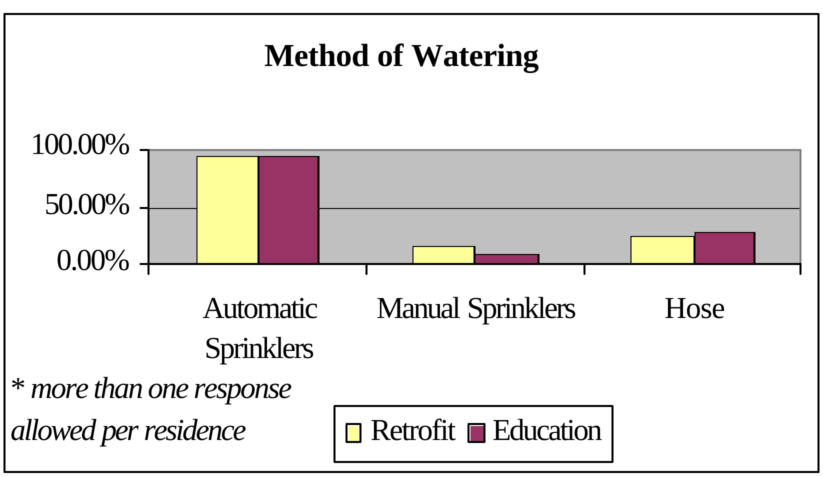
Figure 6-1 shows the responses of both of the groups. Similar responses were given. A majority of the residents in both groups believed that the appearance of the yard is average to good. It should be noted that the "excellent" response was selected by more of the education group than the retrofit group. One possible explanation for this response is that the staff was on-site while people were filling out their survey in the retrofit group.

Figure 6-1



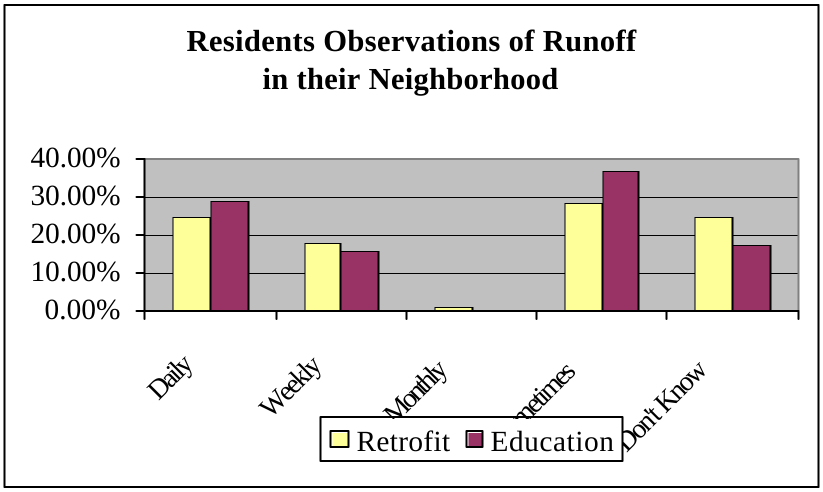
When residents were asked how they watered their lawn, the responses across groups were very similar. The percentage of people in the retrofit and education group that use automatic sprinklers, manual sprinklers, or a hose are similar. The survey shows that the retrofit and education groups have similar watering behaviors. As shown on Figure 6-2, the majority of the participants used automatic sprinklers. This is important because the R3 Study focuses on retrofitting the automatic irrigation controllers as a water management tool.

Figure 6-2



Residents were asked how often they observed runoff in their neighborhood. As presented on Figure 6-3, the data shows that residents in both groups have similar attitudes and views of urban runoff.

Figure 6-3



Residents were asked if they used fertilizers in their landscape, and chemicals to control pests or weeds. As shown on Figure 6-4, fertilizer use in both groups is almost the same. Results for chemical use were also similar for both groups. (See Figure 6-5.)

Figure 6-4

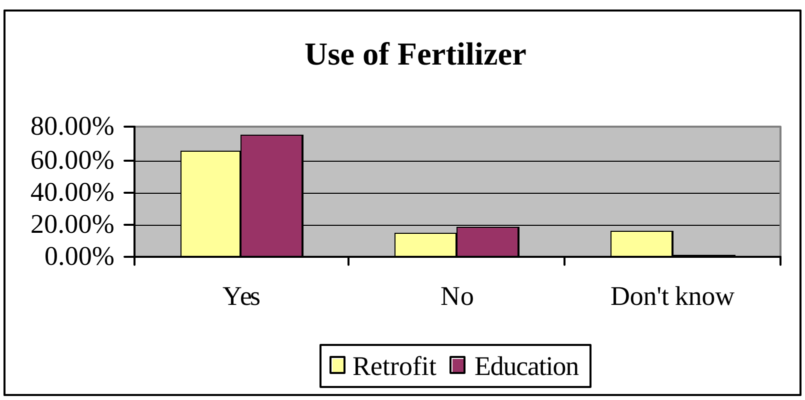
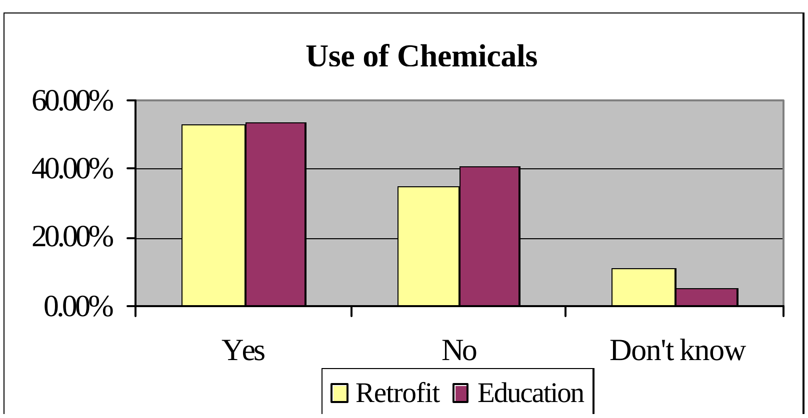


Figure 6-5



The purpose of the post-survey was to determine the attitudes of the study participants towards the ET controller and to determine if the education material had an impact on modifying behavior of the recipients. The post-survey was distributed to both of the groups through the mail. Twenty-three percent (52/225) of the education group participants responded to the survey, and forty-five percent (50/112) of the retrofit group participants responded. Post survey results are tabulated in Appendix F and summarized in the tables and text below.

6.3.2 Post-survey

Table 6-1 summarizes responses of the retrofit group compared to responses from the education group. The majority of the retrofit households acknowledged their satisfaction with the ET controller's performance and agreed that they would recommend the ET controller to their friends. It appears that the residents liked the controller and did not mind having someone else manage their irrigation-watering schedule. Data shows that households accepted the controller as a method of saving water, reducing runoff, and watering their landscapes. The survey shows that twice the number of retrofit households observed a decrease in their water bill than the education households did. A majority of the education households did not observe a change in their water bills. Data appears to show that the appearances of the retrofit landscapes were ranked equally with those landscapes that were part of the education group. It can therefore be concluded that the survey showed that the lower use of water did not create landscapes that were inferior to the education group. The customer's perception of a lower bill is important for the success of any long-term conservation program.

The retrofit and education group were asked if they were willing to pay for an ET controller signal. A majority of the households in both of the groups would not be willing to pay for an ET signal. The ET controller costs approximately $150.00 and the signal fee is $48 per year. The ET controller would be able to save less than 2 ccfs per month, which is a savings of about $14 per year. It appears that the savings in water use per year is not large enough for the water customer to pay for an ET signal.

Table 6-2
ET Controller Selected Responses

Responses to select survey questions	Retrofit group	Education group
Were satisfied with the ET controller	72 percent	n/a
Would recommend use of the ET controller to others	70 percent	n/a
Ranked the appearance of their yard as good to excellent	70 percent	69 percent
Not willing to pay for an ET signal	58 percent	69 percent
Saw decrease in water bills	44 percent	23 percent
Saw water bills unchanged	38 percent	63 percent

6.3.3 Education Only and Retrofit Group Responses

Table 6-3 summarizes the responses to the educational material by the retrofit group compared to the responses by the education group. Samples of these educational materials provided for participants in the R3 Study are presented on the following pages as Exhibit A through Exhibit D. Only half of the education households acknowledged that they sometimes or most of the time would change the settings on their controller according to ET via the monthly letter's (Exhibits A and B) suggested schedule. Monthly mailings also provided monthly landscape maintenance tips (Exhibits C and D). Here, the majority of the households in both of the groups liked the tips on the irrigation checks and fertilization sections. Although most people read these sections, a vast majority (80 percent) of households in both of the groups did not change their use of pesticides, herbicides, or fertilizers.

In addition to the education materials, a soil probe was given to both groups at the beginning of the study. A soil probe is a tool that takes a soil sample and enables the user to see the amount of moisture available to the plants and its depth. This allows the user of the soil probe to determine if the plants require more or less irrigation. More than half of the households in both groups only used the soil probe once or not at all. The majority of the people never used the soil probe at all. From a program point of view, people enjoy the education materials, but they appear to have little effect on modifying behavior.

Table 6-3
Education Material Selected Responses

Responses to select survey questions	Retrofit group	Education group
Have not changed their use of pesticides and herbicides	82 percent	81 percent
Have not changed their use of fertilizers	80 percent	73 percent
Did not use the soil probe or used it only once	76 percent	62 percent
Believed fertilization checks (part of monthly tips) were helpful	58 percent	44 percent
Believed irrigation checks (part of monthly tips) were helpful	42 percent	58 percent

6.4 Conclusions

While there were some customer service-related issues, the response to the ET controller was generally positive with 72 percent of participants indicating that they liked the controllers. This group also found that the controller irrigation either maintained or improved the appearance of their landscape. This is a classic win-win situation. The water district customers receive a desired benefit of a healthy landscape, and the community receives several important environmental benefits from the conservation of valuable and limited water resources and the reduction in dry season urban runoff.

Exhibit A
Monthly Landscape Maintenance Tips Letter Sent to "retrofit" customers in group 1001

May Landscape Maintenance Tips

The weather is getting warmer, the days are longer, and most of your plants are well into their growth stage. This is also the season for weeds and garden pests.

Irrigation System

- Watch for grass or plant growth that blocks sprinkler heads.
- Look for overspray onto streets and sidewalks and realign the sprinkler head.
- Look for dry spots and find the sprinkler problem to fix, such as a clogged head.
- Look for wet spots and potential sprinkler problems, such as a broken head.

Watering Schedule

- The Run-off Study Controller will adjust watering times as the weather changes.

Fertilizing

- Time to apply a slow release Nitrogen fertilizer to turf (apply only as directed on the bag or container).
- Keep fertilizer off of sidewalks, patio and streets.
- Do not wash fertilizer into drains or gutters.

Weed and Insect Control

- Watch for aphids and whiteflies. Wash insects off of leaves with a hard spray of water or spray with diluted soap solution.
- Apply mulch to control weeds, improve moisture retention and restore nutrients to the soil.
- Pick weeds now while they're still small.
- Use weed and insect chemicals only as directed on the containers.

This is a guide only. This guide does not hold public agencies responsible for the health and appearance of your home landscape.

Exhibit B
Monthly Landscape Maintenance Tips Letter (Sent to "education only" customers in group 1005)

May Landscape Maintenance Tips

The weather is getting warmer, the days are longer, and most of your plants are well into their growth stage. This is also the season for weeds and garden pests.

Irrigation System

- Watch for grass or plant growth that blocks sprinkler heads.
- Look for overspray onto streets and sidewalks and realign the sprinkler head.
- Look for dry spots and find the sprinkler problem to fix, such as a clogged head.
- Look for wet spots and potential sprinkler problems, such as a broken head.

Watering Schedule

- Start with this suggested schedule:
  Turf: 3 days per week, 3 cycles* of 3 minutes
  Shrubs and groundcover: 2 days per week, 3 cycles* of 3 minutes
- Reduce this amount in shaded areas.
- Use the soil probe to check the level of moisture beneath the surface before you water. If the soil is still moist 2 or more inches below the surface, wait another day to water.

Fertilizing

- Time to apply a slow release Nitrogen fertilizer to turf (apply only as directed on the bag or container).
- Keep fertilizer off of sidewalks, patio and streets.
- Do not wash fertilizer into drains or gutters.

Weed and Insect Control

- Watch for aphids and whiteflies. Wash insects off of leaves with a hard spray of water or spray with diluted soap solution.
- Apply mulch to control weeds, improve moisture retention and restore nutrients to the soil.
- Pick weeds now while they're still small.
- Use weed and insect chemicals only as directed on the containers.

This is a guide only. This guide does not hold public agencies responsible for the health and appearance of your home landscape.

*By "cycling" your irrigation timer to turn on for the suggested number of minutes about an hour apart, you reduce runoff and gain deeper watering and healthier root growth.

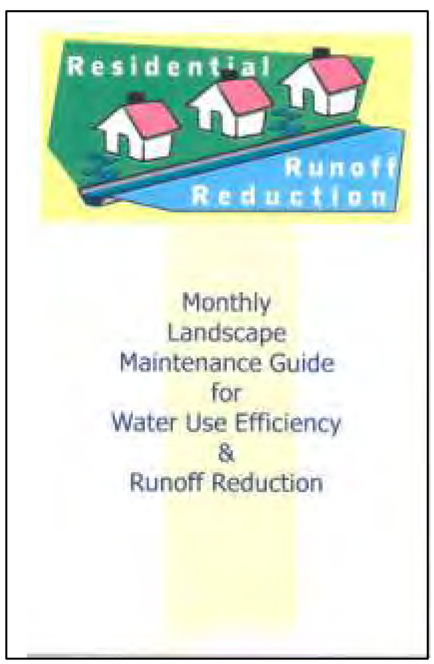
Exhibit C
Monthly Landscape Maintenance Calendar (Provided for “retrofit” and “education only” customers)
(Actual size: 8.5 in. x 11in.)

Residential Runoff Reduction

Monthly Landscape Maintenance Guide for Water Use Efficiency & Runoff Reduction

Seasons	Fall		Winter			Early Spring		Late Spring		Summer		
Month	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**
Irrigation System												
Check for: Runoff, from broken, blocked, clogged heads or overspray	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Check for Misting	✓				✓		✓		✓		✓	
Check for Dry Spots	✓							✓	✓	✓	✓	✓
Watering Schedule If two numbers are shown (i.e. 3 ▶ 2) adjust the number of days as indicated sometime during the month.												
Turf (grass) or Annuals Days to water per week	3 ▶ 2	2 ▶ 1	1	1	1 ▶ 2	2 ▶ 3	3	3	4	4 ▶ 5	4	4 ▶ 3
Trees, Shrubs Groundcovers	2 ▶ 1	1	1	1	1	1 ▶ 2	2	2	2	2	2	2
Deep Watering (trees) ●									●	●	●	●
Root zone watering: Use the soil probe any time you think there is too much or too little water in the yard. If soil is moist in the plant root zone, irrigation level is OK. If the soil is very wet, reduce your watering.												
Rain potential: Turn controllers to "rain pause" or off. Use a soil probe to determine when to turn controllers back on.	✓	✓	✓	✓	✓	✓	✓					
Fertilizing (specialty plants like roses or annuals may have different fertilizer requirements)												
Turf	Balanced ✓ slow release					Nitrogen slow ✓ release		Nitrogen slow ✓ Release			Nitrogen slow ✓ release	
Groundcovers	Balanced ✓ slow release					Balanced ✓ slow release			Balanced ✓ slow release			
Shrubs							Balanced ✓ slow release					Balanced ✓ slow release
Trees						Balanced ✓ slow release						Balanced ✓ slow release
Weed/Insect Control												
Mulch	✓							✓				
Pesticides (insects)						✓	✓		✓			✓
Herbicides (weeds)					✓		✓				✓ Optional	

Exhibit D
Monthly Landscape Maintenance Guide Provided for “retrofit” and “education only” customers
(Actual size 5.5 in. x 8.5 in)



Chapter 7: Findings, Conclusions, and Recommendations

7.1 Overview

The previous chapters of this report evaluate changes in water usage, dry weather runoff, water quality, and customer attitudes and awareness related to irrigation practices associated with the R3 Study. The intent of this chapter is to "integrate" these findings and outline their context as they relate to the interests and goals of the study participants and provide guidance for future efforts to improve water quality in the San Diego Creek watershed and in other areas of the county and state. Information is provided on:

- Findings and conclusions related to study methods for the water conservation, runoff reduction, water quality, and customer acceptance evaluations
- Findings and conclusions related to key results from the four study evaluations
- Recommendations related to future planning and policy

7.2 Study Methods

As noted in Chapters 3 through 6 of this report, study assumptions and methods demonstrated varying degrees of success. This section presents findings and conclusions regarding the degree of reliability of certain evaluation approaches and provides a foundation for future studies to build upon.

7.2.1 Water Conservation

Findings and conclusions regarding the study method for the water conservation evaluation portion of the R3 Study focused on three major areas.

First, the empirical effort used in the study quantified the change in mean water consumption and the shift in seasonal consumption. The models were not extended to document how water savings vary across households, for example, how savings are decreased/increased among lower/higher water use households. Such information could be useful in future studies.

Second, the study evaluated only about one year of post installation data. Thus, the statistical models can say little about the persistence of water savings. Additional follow-up quantification of water savings in subsequent years would be desirable.

Third, the modeling effort did not estimate the effect of self-selection by the participants in the education-only group. Thus, no attempt was made to extend the inference from the existing sample of participants to: 1) the rest of the service area; or 2) other service areas. The error component of the estimated models could be improved by specifying a function form to explain the variance. This should only be attempted after all major data issues have been resolved.

7.2.2 Runoff Reduction

As discussed in Chapters 2 and 4, significant measurement and data quality issues were associated with the enacted real-time measurement of urban runoff. The technology employed involved custom configurations and numerous needed calibration adjustments. Debris build-up was an early, ongoing, and possibly unavoidable issue that interfered with the calibration of the flow meters. Some of the original locations selected were more prone to this type of problem, and the flow meters were necessarily relocated. Although flow-monitoring problems required data from two of the three control sites to be discarded, the data from the other three sites (two treatments and one control) was sufficiently accurate to allow for the determination of meaningful statistical results.

To minimize the data collection issues experienced during the R3 Study, it would be helpful to install a V-notch weir in the storm drain. (See figure 7-1.) This would enable low flows to be captured and measured more precisely. It should be noted, however, that installation in an underground drain (as opposed to the surface drain shown on the figure) would require protective gear to be worn by the data collectors. Full gear (breathing apparatus) could become cost prohibitive for an aggressive (bi-weekly) monitoring program.

Figure 7-1
Detail of Diversion V-notch Design of Weir Installed in Large Drainage Pipe
(Note: Black sonic sensor hanging directly over V-notch to measure water flow levels.)

7.2.3 Water Quality

As discussed in Chapter 5, two independent reviews of water quality measurements were conducted as part of the R3 Study. Because of the variability of the data and limitations in sample quantities, the first review, which used parametric statistical techniques, provided less definitive results that the second review, which used more robust data analysis techniques. For some of the parameters reviewed, the robust analytical techniques were able to identify and measure differences in water quality across time and between study treatments.

7.2.4 Public Acceptance

As discussed in Chapter 6, pre- and post- intervention surveys were given to both the retrofit group and the education group. The pre-intervention survey was given to assess and document the prevailing landscape maintenance attitudes and behaviors of both participating groups. The post- intervention survey was given to determine 1) whether or not there was an acceptance of the ET controller as a way of managing landscape irrigation and 2) if exposure to the educational materials and monthly landscape maintenance tips had led to a change in irrigation practices and landscape management behaviors in either study group.

The survey responses indicate that, while 82 to 90 percent of the retrofit and education-only group reported to have read the educational materials, reading these materials did not cause their landscape maintenance habits to change. These responses suggest that future surveys should be designed to capture a measurement of the changes in the study subjects' consumer attitudes and behaviors in greater detail.

Future projects could benefit from using a marketing research firm specializing in the use of polls and surveys to measure residential consumers' attitudes and behaviors. The wording of each pre- and post- intervention survey question can be very carefully crafted in order to target, capture, and quantify each specific pre- and post- intervention behavioral change that is being measured. Identical or one-to-one correspondence between the pre- and post- survey questions is another effective marketing research technique. By documenting customers' changing responses, over time, to identical questions, behavioral shifts can be tracked and quantified.

7.3 Study Results

Key results of the four R3 Study evaluations are summarized below. Because the water conservation and runoff reduction evaluations were interrelated, the results from these evaluations are discussed together below.

7.3.1 Water Conservation and Runoff Reduction

As discussed in Chapter 3, water consumption by residential customers in the retrofit group was reduced by 41.2 gallons per day per household, with a reduction for the education group of 25.6 gallons per day per household. In contrast, whereas the runoff flows for the retrofit group were reduced during the study, flows in the education group increased (Chapter 4). There are three related explanations for this dichotomy: 1) the inclusion of small to medium size "common area" landscapes in the retrofit group and the exclusion of this group from the education group; 2) differences in irrigation scheduling between the residential homes in the two groups; and 3) proximity and relative flow volumes of the landscapes to the storm drain system.

7.3.1.1 Dedicated Landscapes

The retrofit group common areas averaged 0.8 acres in size and encompassed 15 sites/irrigation controllers including city landscape medians, HOA greenbelts, and a park. It is estimated that these sites account for more than 75 percent of the total area under treatment in the Site 1001 area. More specifically, these 15 sites totaled about 12 acres. The remaining 112 irrigation controllers installed on single-family residential lots are estimated to encompass 3.5 to 4 acres. The proportion of residences receiving educational materials including irrigation scheduling information was chosen to match the number receiving retrofit treatment. However, the total treated acres for the two groups varied considerably.

As was the protocol for all retrofit sites, irrigation schedules for these sites were established based on valve-by-valve evaluations of plant, soil, and irrigation system parameters. These schedules resulted in significantly more start times and shorter run times than that observed in these areas prior to the study.

More specifically, prior to installation of the retrofit treatment, each valve was turned on for two minutes to determine the flow. In this brief period, runoff was observed for many of the valves. This relates to the predominant clay soils, where runoff can exceed 90 percent of applied water after short periods due to the low infiltration rates. It is believed that the more frequent, short duration irrigation schedules developed by the treatment irrigation technology is the primary mechanism to reduce runoff from irrigation sites. In addition, these sites were closely monitored and incorporated suggested BMPs such as weekly meter readings. These sites were also used to develop the protocol for the midweek scheduling changes for all of the retrofit area and when to terminate a rain pause for the region.

In contrast to the retrofit group, the controllers on comparable common area landscapes in the education group are assumed to have continued with typical irrigation schedules that likely result in higher levels of runoff. If this is the case, and the common areas account for a similar percentage of irrigated area, this could explain the observed differences in runoff between the retrofit and education groups.

7.3.1.2 Differences in Irrigation Schedules

In addition to the runoff differences likely stemming from the inclusion of the nonresidential landscapes in the retrofit group, irrigation scheduling differences also existed for the residential homes between the retrofit and education groups. The education group households received a suggested irrigation schedule that provided the number of days per week to run the irrigation system, the number of minutes per cycle (start time), and a maximum of three start times. As noted above, short run times and multiple start times are believed to be the key element in reducing irrigation runoff.

Although the post-study survey indicated that about 60 percent of those in the education group changed their controller's irrigation schedule at least "sometimes," it is not clear how closely they followed the suggested schedule, including the recommendation on start times. Inasmuch as programming many controllers for multiple start times can be challenging, it is possible these instructions were generally overlooked. In contrast, the weather-based irrigation controller used on the retrofit homes automatically reduced the run time for slope, soil, and sprinkler precipitation rate. This will likely reduce runoff even in the absence of direct water savings. This difference may also be a consideration in the dissimilar runoff results in the two treatment sites.

7.3.1.3 Proximity to Storm Drains and Flow Volumes

The final consideration is the location and relative flow volumes of the common area landscapes relative to location and flow volumes of the residences. The common area landscapes were typically located closer to storm drain catch basins (and the study flow monitors) than most residential lots and also had much higher flow volumes on the individual irrigation valves. Runoff from most residential lots had to travel a signficant distance through surface street gutters before reaching catch basins and were subject to both evaporation and seepage in route. In addition, the limited drainage associated with many residential back yards could have further reduced the quantity of water reaching the storm drain from these areas in both the retrofit and education groups. Consequently, the reduction in runoff from treated retrofit common area landscapes and the presumed lack of similar reductions for the education group common areas, combined with the high valve flow volumes, likely explain the differences in observed runoff for the two treatment groups.

7.3.2 Water Quality

As described in Chapter 5, water quality samples were taken twice per month, resulting in a total of 39 samples over an 18-month period. One of the simplest and most straightforward methods to review these samples is to compare them to established water quality objectives for the San Diego Creek watershed. The subsections below address water quality and flow, and runoff water quality.

7.3.2.1 Water Quality and Flow

Chapter 5 of this report also describes issues with the reliability of study flow data during certain study periods and with certain monitoring locations. Because of the temporal relationship of these issues, integrating the water quality and flow data to determine changes in the mass loading of water quality constituents is difficult from a statistical standpoint. However, certainly, the water quality and flow data from the study provide some useful qualitative insight into the impacts of the interventions and may be instructive for future water quality improvement efforts.

7.3.2.2 Runoff Water Quality

Analyses utilizing ore robust statistical methods suggest that the intervention did result in changes in water quality. TN levels in the retrofit neighborhood following intervention were found to be significantly lower than levels before intervention, whereas no detectable differences were noted before and after intervention in the education neighborhood. Relatively large observed reduction in TN flux in the retrofit neighborhood could be influenced by seasonal factors, and the extent to which the ET controller contributed to the reduction is unknown.

7.3.3 Public Education

Data issues discussed previously make it difficult to quantify the impact of public education on reduced water usage and reduced dry season runoff. However, pre- and post-surveys of the retrofit + education and education only groups showed a positive response to the concepts of the irrigation tips. More than 70 percent of the retrofit group participants indicated that they liked the ET controllers, and the group also found that controller irrigation either maintained or improved the landscape. However, it appears that the savings in water use per year is not large enough for the water customers to be willing to pay for an ET signal.

7.4 Recommendations

The application of data from this study will influence future programs and efforts to improve water quality. The application of the irrigation management program focusing on using automatic real-time weather-based irrigation scheduling not only resulted in reductions in onsite/customer water use, but also reduced runoff. With the quality of runoff essentially unchanged, this reduction in runoff should result in a decrease in the total mass of non-point source pollutant loading to the watershed. The relative cost-effectiveness of this program should be evaluated in comparison to other existing or proposed BMPs to improve watershed water quality.

Although not directly determined from the study, the results suggest that the common area landscape sites will provide the most cost-effective application of the water management program. Additional empirical verification of this relative cost-effectiveness supposition is likely warranted.

An additional issue related to the water management program is the availability and viability of the irrigation controllers tested as a part of the study. Although the tested controllers operated reasonably well, occasionally glitches occurred, which necessitated either telephone or onsite intervention by study personnel. For the number of controllers installed for the study, these maintenance issues were manageable. However, the wide-scale use of these controllers would require a significant commitment from the water purveyor or the controller manufacturer to address maintenance issues. At this time, it is not believed that the controller manufacturer has established infrastructure to support a large number of controllers. In addition, the viability of the tested water management program is completely dependent on the regular transmission of data signals from the controller manufacturer to adjust irrigation schedules. Assurances on the long-term viability of signal transmission are imperative to the expansion of the tested program.

In contrast to the water management program, the educational program implemented as a part of the R3 Study reduced customer water use, but did not reduce measured runoff from the study area. Consequently, again assuming no change in runoff quality, this treatment would not appear to provide pollutant mass loading benefits to the watershed. However, the relationship between the observed water savings for the treated portion of the study area and increased runoff for the entire study area is unclear. Because of the clear relative cost advantages of educational programs, additional and more focused studies should be conducted to more fully understand this relationship and determine the viability of educational programs in reducing non-point source pollution.

Appendix A: References

The Residential Runoff Reduction Study

Appendix A: References

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Appendix B:
Study Design

The
Residential
Runoff Reduction
Study

Appendix B: Study Design

Introduction

In 1999, the Municipal Water District of Orange County (MWDOC) and Irvine Ranch Water District (IRWD), in partnership with other national, state, and local agencies and organizations began developing a project to accomplish two goals:

1) Measure changes in the dry weather volume and pollutant content of residential runoff associated with improved irrigation management practices.
2) Confirm residential irrigation water savings identified in a previous study evaluating an automated residential irrigation controller system (the "Westpark Study").

This Appendix presents detailed information on the general study design framework described in Chapter 2. Subjects discussed include watershed selection, flow monitoring, water quality sampling, ET controller operation and selection process, and controller installation and operation.

Watershed Selection

Five watersheds were selected for the study area, based on five criteria: 1) Isolation from other watersheds, 2) climate, 3) land use, 4) development age, 5) irrigation water management techniques.

Isolation from Other Watersheds:

A watershed consists of a region of land, which drains through a single point. The five study watersheds were located in the Northwood Village subdivision in the IRWD service area. Each watershed drains through a single point and is isolated from other sources of runoff. This enabled the runoff flow and water quality to be free of interference from other sources.

Climate

While most of Southern California and Northwood Village have a similar climate, the five watersheds share the same ET zone. They are located within 5 miles of CIMIS station #75, which provides local ET_o information. The ET_o (reference evapotranspiration, the amount of water utilized by plants and lost to evaporation) is the same throughout the Northwood region and most of the central section of the IRWD service area. The plant water requirements of ET_g, which is the standard of turfgrass for cool season turfgrass and is often referred to as simply ET, are the same for all five watersheds.

Due to the close proximity of the all the homes and the lack of any physical or geographical separation of the five watersheds, the study team relied on the CIMIS station #75 for ET_o data.

Land Use

The Northwood section of IRWD's service area was selected because the predominant land use is single-family residence. There are also local parks, common city streetscapes, two condominium associations and one homeowners association (HOA). Several of the watersheds contained townhouses, apartments or condominiums. However, these types of multi-family units were limited in each of the watersheds; no single watershed had a large number of multi-family units.

Development Age

Northwood's neighborhoods were created during two distinct periods of home development. The first phase of development began in the late 1970s and finished in the early 1980s. The second phase started in 2000 and continues to the present. The study excluded the newer section of Northwood for two reasons. First, the newer homes and their HOA are not typical of Southern California. Second, IRWD has monthly water bill information dating back to the late 1980s on homes in the older section of Northwood.

Irrigation Water Management Factors

In addition to ET_o, other basic factors of irrigation water management are precipitation rate, soil type, and plant type. This study implemented real time ET scheduling through a commercially-available signal and distributed educational material to improve water management. Other water management factors are described below.

Precipitation rates vary from irrigation valve to irrigation valve, and most of the homes applied the water with spray heads operating off the pressure provided by IRWD. The individual homeowners installed most of the irrigation systems after the purchase of their houses. The technology used in these irrigation systems was of the same approximate age and featured similar types of equipment. The irrigation systems installed in the study area were also representative of a common irrigation set-up presently in use in Southern California. .

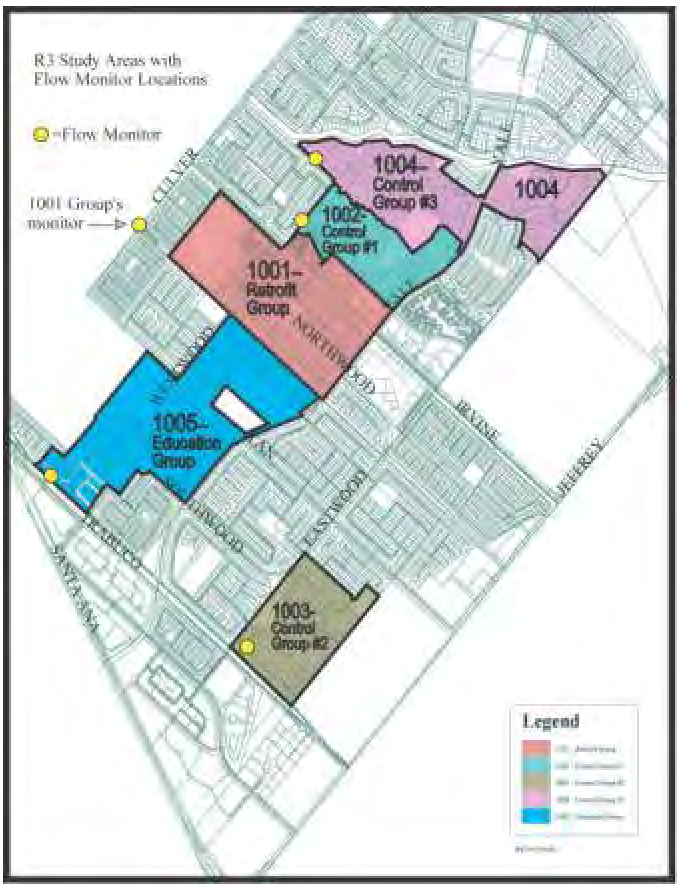
The soil type in the study area is not typical of Southern California and consists of heavy clay. Clay has the lowest infiltration rate and requires the highest level of water management.

The landscapes have sufficiently similar plant material. Although there was no data available to perform a numerical comparison, the study team field surveyed each of the potential watersheds. The majority of landscaping of all homes in the study area consisted of turfgrass. To varying extent, the outside edges, fence, building and walkways areas were lined with shrubs and plant materials other than turfgrass. The best estimate of the ratio of turfgrass to other landscaping is approximately 70 percent. While some of the homes in each of the watersheds may not have followed this construct, the vast majority of landscapes were laid out in this fashion, which allowed the study team to determine which plant materials were mostly consistently found throughout the five watersheds.

Results

After determining that large sections of Northwood were similar and after locating safe monitoring sites, the study team traced the storm drains. The selection of the monitoring site determined the shape and contents of the watershed. The study was able to isolate five watersheds with similar characteristics. The areas of the five watersheds are outlined and labeled in Figure B-1 below.

Figure B-1
Five watershed areas and their corresponding Control groups



Flow Monitoring

The two main criteria for the study's flow monitoring equipment were: 1) the monitor could not alter the pipe or channel and 2) the monitoring must be able to distinguish the seasonal flow changes and any flow change that resulted from the three different treatments (i.e., retrofit group treatment, education-only group treatment, and control group treatment).

Two technologies were suitable for this application: Manning's equation plus a level sensor, or velocity sensor and level monitor (area-velocity). The area-velocity method was chosen due to lack of slope information for the storm drain system. The selected equipment was a Sigma 950, manufactured by Hach. The equipment was battery operated, could record data every minute, and included an ultrasonic transmitter and a velocity sensor located in the storm drain. The ultrasonic transmitter established the water surface level and area, while the velocity sensor determined the velocity of the water in the pipe.

Flow was calculated by the equation: Flow = Area x Velocity. Because four of the five monitoring locations (see Figure B-1 above) were located in pipes, several variations on the ultrasonic transmitter / velocity sensor were tested before the combination of sonic and velocity wafer were selected.

Water Quality Sampling

The water quality sampling program quantified constituents found in residential runoff flows. Because a typical residential neighbor includes more than single-family lots, the concept of water management through an ET signal technology expanded to include common area landscapes.

The water quality sampling program consisted of two phases: 1) pre-study and 2) dry weather sampling.

Pre-study

Based on water level elevation provided by the flow monitors, the study team developed a plan for sampling water quality during dry weather runoff periods. In the early evening (7 to 10 pm) and again in the early morning (3 to 6 am), the water level would rise, indicating an increase in runoff flow. While the amount of change varied by location and date, the pattern was common to all of the watersheds.

The study team performed a weeklong test to determine the most representative sampling time. The team sampled all five study areas every day at 4 am and 7 pm. The constituents sampled were fecal coliform, nutrients, and trace metals.

The test results showed neither differences nor patterns in concentrations between sites, days, and sample times.

Dry Weather Sampling Duration

The final sampling program consisted of bi-weekly sampling of all five sites. During sampling weeks, all five sites were sampled for all analyses listed in Table B-1 on Tuesday, and three sites were sampled for pesticides two additional days. Toxicity samples were collected once per month at all five sites.

Table B-1
Routine Water Quality Analysis Responsibilities

Responsible Lab	Water Quality Parameter	Bottle Type
IRWD	NO_2, NO_3, NH_3, T-PO_4, TKN, O-PO_4, EC, pH, Trace Metals, Total / Fecal Coliform	(2) 1-L Cubitainer (1) 250 ml Sterile
SCCWRP	Toxicity (Sea Urchin Fertilization)	
SCCWRP	Pesticides	
MWL	MS-2 Phage	(1) 1-L (from MWL)
MWL	Enterococcus	(1) 250 mL (from MWL)

The study team collected the biweekly Tuesday samples beginning in January of 2001 and continuing through the next 18 months. The first months of sampling occurred before or during the installation of the ET controllers in the residences and the common landscape. The last 12 months, starting in July 2001 and finishing in June 2002, became the post retrofit samplings. The pesticide sampling continued for an additional six months through December 2002. Table B-2 provides outlines the water quality and data collection schedule for each group in the study.

Table B-2. Water Quality and Data Collection Schedule					
Sample Site	**Site ID**	**Cross Streets**	**Atlas Page**	**Parameter**	**Frequency**
Group A Education Site Control Site	1005 1003	Shadwell/Westmoreland Carver/Carver	84w – C1 105w – A1	Flow WQ	Weekly Bi-weekly
Group B Control Site Control Site Retrofit Site	1004 1002 1001	Hicks Canyon/Park Place La Paloma/Park Place Culver/Florence	83w – D2 83w - D1 84n – A3	Flow WQ	Weekly Bi-weekly

ET Irrigation Controller Operation and Selection Process

To meet the R3 Study objectives, it was necessary to install as many ET controllers as possible in the retrofit group. Providing the fullest coverage of the watershed with proper irrigation water management generated the best chance of changing the runoff flows. Since residential areas include landscapes other than those of the homeowners, these landscape areas were included in the water management component of the R3 Study. This represents a 3 to 1 ratio of medium-size landscapes to residential landscapes. A description of the installation process for both residential and medium-size landscapes follows:

Residential Landscapes

The IRWD staff attempted to reach as many of the 334 residences in the retrofit watershed as possible. These targeted residents received three letters which informed them of the following:

1) If selected to participate in the study, they would receive a free controller that would automatically adjust the landscape watering.
2) Their participation would be part of an environmental study aimed at preventing runoff from reaching the ocean.
3) They would be saving water without having to program an irrigation controller.
4) They were provided instructions for participating in the study along with a phone number to call to sign-up, as well as a form with a stamped and addressed envelope (for returning the form).

Additionally, IRWD staff hosted a function for the HOA in which staff demonstrated the ET controller to the residents and helped them to complete the sign-up form. Lastly, IRWD staff walked the Northwood neighborhood and hung flyers on the study candidates' front doors. These flyers contained statements from the homeowners in Westpark that had participated in the original ET Controller study. The flyers also described the ET controllers' overall customer satisfaction and ease with which the irrigation system worked.

In all, 137 residents responded to the various communication efforts by agreeing to participate in the study and installing the ET controller on their property. Of the 137 positive responses, 112 homes were equipped with proper automatic valves.

The installation of controllers began in April 2001 and continued through June 2001. A full team of IRWD staff worked weekdays, Saturdays and evenings to complete the installations. Additionally, educational materials were distributed to the retrofit group during installations.

Medium-size Landscapes

In addition to the single-family residences, the retrofit watershed contains 2 condominium complexes, and one HOA with three distinct land use types. The area also contained 12 city streetscapes. The City of Irvine agreed to change out the existing manual controllers with the ET controllers. All of the HOAs agreed to change out their controllers for the ET controllers.

The only major landscape not replacing its existing controller with an ET controller was the park-playground area of the school. The school landscape area consisted of a single meter with two separate controllers and more than 50 valves. This would require at least six ET controllers. Given the limitation in the controller and the high number of cycles that would be required to correctly irrigate the school site, IRWD was not confident that the ET controllers could be programmed in a manner that would avoid conflicting runtimes.

Controller Installation and Operation

The study evaluated the performance of the engineering of irrigation management techniques to reduce the consumption and residential runoff while maintaining the quality of the landscape. A typical irrigation controller is difficult to program and limited in the scope of the scheduling ability. Proper scheduling requires calculations based on real time ET data, landscape topography, and plant type, which are beyond the capabilities of typical controllers. The landscaper in the field is left to guess or rely on past experience as to the correct amount of water, the correct runtime to prevent runoff, and the correct days of the week to water.

The operation of the ET controller in this study was optimized by: 1) weekly maintenance, and 2) proper irrigation scheduling. IRWD staff programmed the controllers, which were operated by a combination of IRWD staff and HydroPoint consultants. (HydroPoint Data Systems, also known as HydroPoint, developed and supplied the ET controllers used in the R3 Study.)

During the prior study in Westpark, the programming was calculated based on a design precipitation rate suggested for spray heads. That study received numerous complaints that too much water was being applied and an effort was undertaken to conduct an area/flow measurement to determine the actual precipitation rate. These measurements indicated an average precipitation rate of 3.98 inches per hour while the design precipitation rate for the spray heads was 1.80 inches per hour. The measured rates varied from as low as 1.4 inches per hour to as high as 9 inches per hour. This suggested that standard settings in which a homeowner would program the controller are unlikely to efficiently run the irrigation. Because of this and other important factors, trained staff preformed the installations

Appendix C: Statistical Analysis of Water Savings

The Residential Runoff Reduction Study

Appendix C - Statistical Analysis of Water Savings

Prepared for
Municipal Water District of Orange County and
The Irvine Ranch Water District

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Summary

Findings

- $ **Single Family Residences:** Households receiving an evapotranspiration (ET) controller and education were found to save approximately 41.2 gallons per day on average (33.2 gpd – 49.2 gpd is the 95 percent confidence level). Households receiving the education treatment alone were found to save approximately 25.6 gallons per day on average (20.1 gpd – 31.1 gpd is the 95 percent confidence level). This sample compared 93 ET controller/education participants and 192 education-only participants to 1236 nonparticipating single family customers.

  A secondary finding in this sample related to seasonal shape in this average savings effect. For the one year of post-intervention consumption data within our sample, the water savings was not constant. The ET controller/education intervention, in particular, saved more water in the autumn and less in the spring growing season.

- $ **Landscape-Only Accounts:** Among a smaller sample of 21 landscape-only accounts, significant water savings (16 percent) were obtained from the use of ET controllers. A sample of 76 matched sites (similar in landscaped area and type of use) also showed the effects of City water efficiency improvements. Since both of these samples contain a large number of medians and streetscapes, it is possible that each gallon saved from irrigation-only sites contributes more to runoff reduction than a gallon saved at a single family site. Since the runoff reduction was not measured by customer account, this study will not be able to confirm or deny this hypothesis.

Introduction

The purpose of this work is a statistical analysis of water savings among customers who installed evapotranspiration (ET) controllers and customers given irrigation education in the Irvine Ranch Water District. This report documents a careful statistical analysis of historical water consumption data to derive estimates of the net water savings from these interventions.

Approach

Historical water consumption records (July 1997 to August 2002) for a sample of participants and for a sample of nonparticipating customers were examined statistically. The hypothesis was that installation of new irrigation technology or better management of existing equipment would reduce the observed water consumption of customers participating in this program. This study empirically estimates the water savings that resulted from both types of interventions—(1) customers receiving both ET controllers and follow-up education and (2) customers receiving an education-only intervention.

Since installation of ET controllers required the voluntary agreement of the customer to participate, this sample of customers can be termed "self-selected." Customers were randomly chosen to receive the education-only treatment. While this analysis does quantitatively estimate the reduction of participant's water consumption, one may not directly extrapolate this finding to nonparticipants. This is because self-selected participant can differ from customers that decided not to participate.

The explanatory variables in these models include

- Deterministic functions of calendar time, including
    - The seasonal shape of demand
- Weather conditions
    - measures of air temperature
    - measures of precipitation, contemporaneous and lagged
- Customer-specific mean water consumption
- "Intervention" measures of the date of participation and the type of intervention

Data and Methods

Consumption records were compiled from the IRWD customer billing system for customers in the study areas. Billing histories were obtained from meter reads between July 1997 and August 2002. It is important to note that a meter read on August 1 will largely represent water consumption in July. Since the ET controllers were installed in May and June of 2001, the derived sample will only contain slightly more than one year of data for each participant. Table 1 presents descriptive statistics on the sample.

Table 1: Single Family Residential Sample Descriptive Statistics

	Site 1001		Site 1004	Site 1005	
	ET Controller Participant	Non-Participant	Control	Education Participant	Non-Participant
Number of Usable Accounts	97	213	264	196	346
Pre-period: July 1997-May 2001					
Mean Use (gpd)	375	371	405	390	418
No. of observations	4,504	9,860	12,452	9,251	16,364
Post-period: June 2001-August2002					
Mean Use (gpd)	366	379	427	395	421
No. of observations	1,358	2,982	3,694	2,744	4,856

The landscape-only customers (21 accounts) were handled separately. Two control groups were developed for these irrigation accounts: A matched control group was selected by IRWD staff by visual inspection, finding 3-5 similar control sites for each participating site. Similarity was judged by irrigated area and type of use (Home Owner Association, Median, Park, or Streetscape). Since the City of Irvine was improving irrigation efficiency on the City-owned sites during the post-intervention period, this matched control group also had potential water savings. A second control group was developed where the selection was done solely located by geographic area. In this way, the statistical models can separately estimate the water savings effects for each group.

Table 2: Landscape Accounts
Descriptive Statistics

	Participant	**Matched Control**	**Unmatched Control**
Number of Usable Accounts	21	76	895
Acres per Account	0.93	0.92	0.96
Type of Account (if known)			
HOA	3	13	
Median	3	11	
Park	1	6	
Streetscape	14	47	
Pre-period: July 1997-June 2001			
Mean Use (gpd)	2,948	2,768	3,042
Mean Use per Acre (inches/day)	0.11702	0.11823	0.12893
No. of observations	967	3,503	39,352
Post-period: July 2001-August2002			
Mean Use (gpd)	2,845	2,990	3,271
Mean Use per Acre (inches/day)	0.10813	0.12012	0.13013
No. of observations	293	1,052	12,121

The first major issue with using meter-read consumption data is the level and magnitude of noise in the data. The second major issue is that records of metered water consumption can also embed non-ignorable meter mis-measurement. To keep either type of data inconsistencies from corrupting statistical estimates of model parameters, this modeling effort employed a sophisticated range of outlier-detection methods and models. These are described in the next section.

Daily weather measurements—daily precipitation, maximum air temperature, and evapotranspiration—were collected from the CIMIS weather station located in Irvine. The daily weather histories were collected as far back as were available (January 1, 1948) to provide the best possible estimates for "normal" weather through the year. Thus we have at least 54 observations upon which to judge what "normal" rainfall and temperature for January 1^{rst} of any given year.

Robust regression techniques were used to detect which observations are potentially data quality errors. This methodology determines the relative level of inconsistency of each observation with a given model form. A measure is constructed to depict the level of inconsistency between zero and one; this measure is then used as a weight in subsequent regressions. Less consistent observations are down-weighted. Other model-based outlier diagnostics were also employed to screen the data for any egregious data quality issues.

Specification

A Model of Water Demand

The model for customer water demand seeks to separate several important driving forces. In the short run, changes in weather can make demand increase or decrease in a given year. These models are estimated at a household level and, as such, should be interpreted as a condensation of many types of relationships—meteorological, physical, behavioral, managerial, legal, and chronological. Nonetheless, these models depict key short-run and long-run relationships and should serve as a solid point of departure for improved quantification of these linkages.

Systematic Effects

This section specifies a water demand function that has several unique features. First, it models seasonal and climatic effects as continuous (as opposed to discrete monthly, semi-annual, or annual) function of time. Thus, the seasonal component in the water demand model can be specified on a continuous basis, then aggregated to a level comparable to measured water use (e.g. monthly). Second, the climatic component is specified in different form as a similar continuous function of time. The weather measures are thereby made independent of the seasonal component. Third, the model permits interactions of the seasonal component and the climatic component. Thus, the season-specific response of water demand can be specific to the season of the year.

The general form of the model is:

Equation 1

$$Use = m_i + S_t + W_t + E_{i,t}$$

where ***Use*** is the quantity of water demand within time *t*, the parameter $\boldsymbol{\mu_i}$ represents mean water consumption per meter *i*, $\boldsymbol{S_t}$ is a seasonal component, $\boldsymbol{W_t}$ is the weather component, $\boldsymbol{E_{i,t}}$ is the effect the landscape interventions for meter *i* at time period *t*. Each of these components is described below.

Seasonal Component : A monthly seasonal component can be formed using monthly dummy variables to represent a seasonal step function. Equivalently, one may form a combination of sine and cosine terms in a Fourier series to define the seasonal component as a continuous function of time.[1] The following harmonics are defined for a given day *T*, ignoring the slight complication of leap years:

Equation 2

$$S_t \equiv \sum_{1}^{6}\left[b_{i,j} \cdot \sin\left(\frac{2p \cdot jT}{365}\right) + b_{i,j} \cdot \cos\left(\frac{2p \cdot jT}{365}\right)\right] = Z \cdot b_S$$

[1] The use of a harmonic representation for a seasonal component in a regression context dates back to *Hannan* [1960]. *Jorgenson* [1964] extended these results to include least squares estimation of both trend and seasonal components.

where T = (1,...365) and j represents the frequency of each harmonic.[2] Because the lower frequencies tend to explain most of the seasonal fluctuation, the higher frequencies can often be omitted with little predictive loss.

To compute the seasonal component one simply sums the multiplication of the seasonal coefficient with its respective value. This number will explain how demand changes due to seasonal fluctuation.

Weather Component: The model incorporates two types of weather measures into the weather component–maximum daily air temperature and rainfall.[3] The measures of temperature and rainfall are then logarithmically transformed to yield:

Equation 3

$$R_t \equiv \ln\left[1+\sum_{t=T}^{T_d} Rain_t\right], A_t \equiv \ln\left[\sum_{t=T}^{T_d} \frac{AirTemp_t}{d}\right]$$

where d is the number of days in the time period. For monthly aggregations, d takes on the values 31, 30, or 28, ignoring leap years; for daily models, d takes on the value of one. Because weather exhibits strong seasonal patterns, climatic measures are strongly correlated with the seasonal measures. In addition, the occurrence of rainfall can reduce expected air temperatures. To obtain valid estimates of a constant seasonal effect, the seasonal component is removed from the weather measures by construction.

[2] If measures of water demand are available on a daily basis, the harmonics defined by Equation 2 can be directly applied. When measures of water demand are only observed on a monthly basis, two steps must be taken to ensure comparability. First, water demand should be divided by the number of days in the month to give a measure of average daily use. Otherwise, the estimated seasonal component will be distorted by the differing number of days in a month. The comparable measures of the seasonal component are given by averaging each harmonic measure for the number of days in a given time period.

[3] Specifically it uses the maximum daily air temperature and the total daily precipitation at the Irvine weather station. This station was selected due to its proximity to the study area.

Specifically, the weather measures are constructed as a departure from their "normal" or expected value at a given time of the year. The expected value for rainfall during the year, for example, is derived from regression against the seasonal harmonics. The expected value of the weather measures ($\hat{\boldsymbol{A}} = \boldsymbol{Z} \bullet$) is subtracted from the original weather measures:

Equation 4

$$W_t \equiv (R_t - \widehat{R}_t) \cdot b_R + (A_t - \widehat{A}_t) \cdot b_A$$

The weather measures in this deviation-from-mean form are thereby separated from the constant seasonal effect. Thus, the seasonal component of the model captures all constant seasonal effects, as it should, even if these constant effects are due to normal weather conditions. The remaining weather measures capture the effect of weather departing from its normal pattern.

The model can also specify a richer texture in the temporal effect of weather than the usual fixed contemporaneous effect. Seasonally-varying weather effects can be created by interacting the weather measures with the harmonic terms. In addition, the measures can be constructed to detect lagged effects of weather, such as the effect of rainfall one month ago on this month's water demand.

Effect of Landscape Interventions: Information was compiled on the timing and location of each ET controller installation and education-only customer participation. The account numbers from these data were matched to meter consumption histories going back to 1997. All raw meter reads were converted to average daily consumption by dividing by the number of days in the read cycle. Using these data, relatively simple "intervention analysis" models[4] were statistically estimated where, in this case, the intervention is ET controller installation and/or participation in the landscape education program. The form of the intervention is:

Equation 5

$$E_{i,t} \equiv I_{ET} \cdot b_{ET} + I_{Ed} \cdot b_{Ed}$$

The indicator variable I_{ET} takes on the value one to indicate the presence of a working ET controller and is zero otherwise. The indicator variable I_{Ed} takes on the value one if a household agreed to participate in the education program and is zero otherwise.

The parameter $\hat{b}_{ET}$ represents the mean effect of installing an ET controller and is expected to be negative (installing an ET controller reduces water consumption.) The parameter $\hat{b}_{Ed}$ has a similar interpretation for the education-only participants.

This formulation also permits formal testing of the hypothesis that landscape interventions can affect the seasonal shape of water consumption within the year. Since numerous studies have identified a tendency of customers to irrigate more than ET requirements in the fall and somewhat less in the spring, it will be informative to examine the effect of ET controllers designed to irrigate in accord with ET requirements. The formal test is enacted by interacting the participation indicators with the sine and cosine harmonics.

[4] See Box and Tiao, "Intervention Analysis with Applications to Economic and Environmental Problems" *Journal of the American Statistical Association*, Vol 70,No. 349, March 1975, pp. 70-70.

Stochastic Effects

To complete the model, we must account for the fact that not every data point will lie on the plane defined by **Equation 1**. This fundamental characteristic of all systematic models can impose large inferential costs if ignored. Misspecification of this "error component" can lead to inefficient estimation of the coefficients defining the systematic forces, incorrect estimates of coefficient standard errors, and an invalid basis for inference about forecast uncertainty. The specification of the error component involves defining what departures from pure randomness are allowed. What is the functional form of model error? Just as the model of systematic forces can be thought of as an estimate of a function for the "mean" or expected value, so too can a model be developed to explain departures from the mean—i.e., a "variance function" If the vertical distance from any observation to the plane defined by **Equation 1** is the quantity **e**, then the error component is added to **Equation 1**:

Equation 6

$$Use = \mathbf{f}\left(\mathbf{S}_t, \mathbf{C}_t, \mathbf{T}_t\right) + e$$

The error structure is assumed to be of the form:

Equation 7

$$\begin{aligned} &e_{it} = m_i + x_{it} \\ &where \\ &m_i \sim N(0, s_m^2) \\ &x_{it} \sim N(0, s_x^2) \end{aligned}$$

The *X* and *?* are assumed to be independent of each other and of *μ*. The individual component *μ* represents the effects of unmeasured household characteristics on household water use. An example of such an unmeasured characteristic might be the water use behavior of household members. This effect is assumed to persist over the estimation period. The second component *?* represents random error. Because *μ* and *?* are independent, the error variance can be decomposed into two components:

Equation 8

$$s_e^2 = T \cdot s_m^2 + s_x^2$$

This model specification is accordingly called an error components or variance components model. The model was estimated using maximum likelihood methods.

Estimation Results

Estimated Landscape Customer Water Demand Model

Table 3 presents the estimation results for the model of landscape (irrigation-only) customer water demand in the R3 study sites. This sample represents water consumption among 992 accounts between June 1997 and August 2002. This sample contains 21 ET controller accounts, 76 matched control accounts, and 895 unmatched control accounts.

The constant term (1) describes the intercept for this equation. The independent variables 2 to 9—made up of the sines and cosines of the Fourier series described in Equation 2—are used to depict the seasonal shape of water demand. The estimated weather effect is specified in "departure-from-normal" form. Variable 10 is the departure of monthly temperature from the average temperature for that month in the season. (Average seasonal temperature is derived from a regression of daily temperature on the seasonal harmonics.) Rainfall is treated similarly (Variable 11). One month lagged rainfall deviation is also included in the model (Variables 12). The next variable accounts for the amount of irrigated acreage on the site. (Note that while measured acreage is available for all irrigation-only accounts, this is not true for single family accounts.)

The effect of the landscape conservation program interventions is captured in the following rows. The parameter on the indicator for ET controllers (15) suggests that the mean change in water consumption is 472 gallons per day, approximately 16 percent of the pre-intervention water use. The matched control group (17) did experience water savings, approximately 241 gallons per day or 8.7 percent of their pre-intervention water use. The variables testing for differences in pre-intervention use cannot distinguish any differences between the different types of accounts.

Table 3: Landscape Customer Water Demand Model **Dependent Variable: Average Daily Metered Water Consumption (in gallons per day)**		
Independent Variable	**Coefficient**	**Std. Error**
1. Constant (Mean intercept)	2619.0670	234.8112
2. First Sine harmonic, 12 month (annual) frequency	-811.6864	26.3271
3. First Cosine harmonic, 12 month (annual) frequency	-1984.6310	25.9776
4. Second Sine harmonic, 6 month (semi-annual) frequency	104.1141	26.5769
5. Second Cosine harmonic, 6 month (semi-annual) frequency	-18.5088	26.9614
6. Third Sine harmonic, 4 month frequency	-124.1069	28.1396
7. Third Cosine harmonic, 4 month frequency	107.1129	28.4812
8. Fourth Sine harmonic, 3 month (quarterly) frequency	39.5420	30.5372
9. Fourth Cosine harmonic, 3 month (quarterly) frequency	-62.1012	30.7453
10. Deviation from logarithm of 31 or 61 day moving average of maximum daily air temperature	6306.4130	562.5547
11. Deviation from logarithm of 31 or 61 day moving sum of rainfall	-747.0860	51.9108
12. Monthly lag from rain deviation	-209.8997	46.2994
13. Irrigated Acreage (in acres)	490.5891	139.6673
14. ET controller sites, test for difference in pre-intervention use	-46.2624	1278.0470
15. Average Effect of ET controller (21 accounts)	-472.1763	279.4630
16. Matched accounts, test for difference in pre-intervention use	-166.3042	691.8883
17. Average Effect of city efficiency improvements (76 accounts)	-240.9208	148.0551
Number of observations		57017
Number of customer accounts		983
Standard Error of Individual Constant Terms		5749.64
Standard Error of White Noise Error		4179.81
Time period of Consumption	June 1997- July 2002	

Estimated Single Family Residential Water Demand Model

Table 4 presents the estimation results for the model of single family water demand in the R3 study sites. This sample represents water consumption among 1,525 single family households between June 1997 and July 2002. This sample contains 97 ET controller/education participants (in Site 1001) and 192 education-only participants (in Site 1005).

The constant term (1) describes the mean intercept for this equation. (A separate intercept is estimated for each of the 1,525 households but these are not displayed in Table 4 for reasons of brevity.) The independent variables 2 to 8—made up of the sines and cosines of the Fourier series described in Equation 2—are used to depict the seasonal shape of water demand. The predicted seasonal effect (that is, $Z \cdot \widehat{b}_S$) is the shape of demand in a normal weather year. This seasonal shape is important in that it represents the point of departure for the estimated weather effects (expressed as departure from normal). We will also test to see if the landscape interventions have any effect on this seasonal shape.

The estimated weather effect is specified in "departure-from-normal" form. Variable 11 is the departure of monthly temperature from the average temperature for that month in the season. (Average seasonal temperature is derived from a regression of daily temperature on the seasonal harmonics.) Rainfall is treated in an analogous fashion (Variable 14). One month lagged rainfall deviation is also included in the model (Variables 15). The reader should also note that the contemporaneous weather effect is interacted with the harmonics to capture any seasonal shape to both the rainfall (Variables 12 and 13) and the temperature (Variables 9 and 10) elasticities. Thus, departures of temperature from normal produce the largest percentage effect in the spring growing season. Similarly, an inch of rainfall produces a larger effect upon demand in the summer than in the winter.

The effect of the landscape conservation program interventions is captured in the following rows. The parameter on the indicator for ET controllers/education (16) suggests that the mean change in water consumption is 41.2 gallons per day while the education only participants (19) saved approximately 25.6 gallons per day. The model cannot say whether education-only participants saved this water through improved irrigation management or by also reducing indoor water consumption. Since the sample includes only one year of post-intervention date, the model cannot say how persistent either effect will be in future years.

Table 4: Single Family Residential Water Demand Model

Dependent Variable: Average Daily Metered Water Consumption (in gallons per day)

Independent Variable	Coefficient	Std. Error
1. Constant (Mean intercept)	405.6593	3.1660
2. First Sine harmonic, 12 month (annual) frequency	-45.4215	0.9636
3. First Cosine harmonic, 12 month (annual) frequency	-89.1494	0.9629
4. Second Sine harmonic, 6 month (semi-annual) frequency	3.6549	0.6798
5. Second Cosine harmonic, 6 month (semi-annual) frequency	1.0709	0.6733
6. Third Cosine harmonic, 4 month frequency	1.7312	0.7151
7. Fourth Sine harmonic, 3 month (quarterly) frequency	4.4016	0.7403
8. Fourth Cosine harmonic, 3 month (quarterly) frequency	3.3491	0.7865
9. Interaction of contemporaneous temperature with annual sine harmonic	48.7897	17.1559
10. Interaction of contemporaneous temperature with annual cosine harmonic	-72.4672	22.3626
11. Deviation from logarithm of 31 or 61 day moving average of maximum daily air temperature	284.7163	13.542
12. Interaction of contemporaneous rain with annual sine harmonic	10.1102	1.8546
13. Interaction of contemporaneous rain with annual cosine harmonic	5.9969	2.6904
14. Deviation from logarithm of 31 or 61 day moving sum of rainfall	-34.0117	1.8931
15. Monthly lag from rain deviation	-13.3173	1.0549
16. Average Effect of ET controller/Education (97 participants)	-41.2266	4.0772
17. Interaction of ET intervention with annual sine harmonic	38.9989	5.3327
18. Interaction of ET intervention with annual cosine harmonic	-6.3723	4.8980
19. Average Effect of Education-only intervention (192 participants)	-25.5878	2.8081
20. Interaction of Ed.-only intervention with annual sine harmonic	6.0357	3.5870
21. Interaction of Ed.-only intervention with annual cosine harmonic	-3.0703	3.3826
Number of observations	94,655	
Number of customer accounts	1,525	
Standard Error of Individual Constant Terms		120.85
Standard Error of White Noise Error		129.81
Time period of Consumption	June 1997- July 2002	

How ET Controllers Affect Peak Demand

The question of how these programs affected the seasonal shape of water demand can be interpreted from the remaining interactive effects—the indicators interacted with the first sine and cosine harmonics. For example, the seasonal shape of demand can be derived before and after ET controller/education participation:

$$\text{Pre\_Intervention}: S_t = Z \cdot \hat{b}_S \approx -45.4 \cdot \sin_1 - 89.1 \cdot \cos_1 + 3.6 \cdot \sin_2 + 1.1 \cdot \cos_2 + \ldots + 3.4\cos_4$$

$$\text{Post\_ETIntervention}: S_t' \approx Z \cdot \hat{b}_S + 39 \cdot I_{ET} \cdot \sin_1 - 6.4 \cdot I_{ET} \cdot \cos_1$$

When the pre/post seasonal patterns are combined with their pre/post mean water consumption, the following before and after picture can be seen throughout the year.

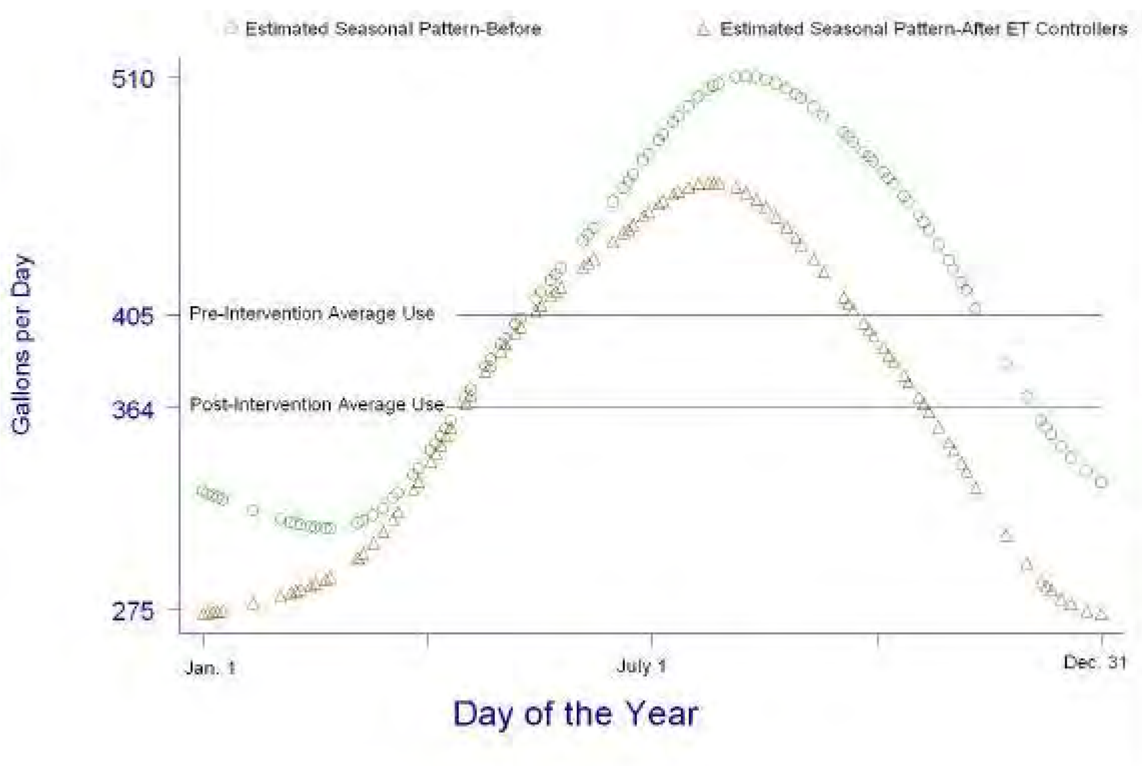

Figure 1-Effect of ET intervention on Water Demand

In Figure 1, several observations should be made. First, the difference between the two horizontal lines corresponds to the estimated mean reduction of approximately 41 gallons per day. Second, the assumption of a constant 41 gallon per day effect does not hold true throughout the year. The reduction is barely noticeable in the spring growing season and is much larger in the fall.

The reduction in peak demand—though dependent upon how the seasonal peak is defined[5]—is greater than the average reduction. The estimated peak day demand, occurring on August 8, is reduced by approximately 51 gallons. This "load-shaping" effect of the ET controller intervention can translate into an additional benefit to water agencies. The benefits from peak reduction derive from the avoided costs of those water system costs driven by peak load and not average load—the costs for new treatment, conveyance, and distribution all contain cost components driven by peak capacity requirements.

Figure 2 plots the corresponding estimates for the Education-only intervention. The reduction in average demand is less—approximately 25 gallons per day. The effect upon the estimated seasonal shape of demand is much more muted. In fact, the change to the estimated seasonal shape of demand induced by the education-only intervention is not significantly different from zero at classical levels of significance.

[5] This is the issues of "coincident" versus "noncoincident" peak demand: the extent to which the peak load of a customer coincides with the system peak. Water systems by their nature have a strong and predictable tendency to peak seasonally—for Southern California, this occurs in the summer. Given the predictability of system peaks, and the attendant costs, the empirical case for the contribution of ET controller load shaping to the reduction of systems cost is relatively straightforward. The additional value of peak reduction--over and beyond reductions in average consumption--require careful specification of the additional incremental costs necessitated by peak flow requirements.

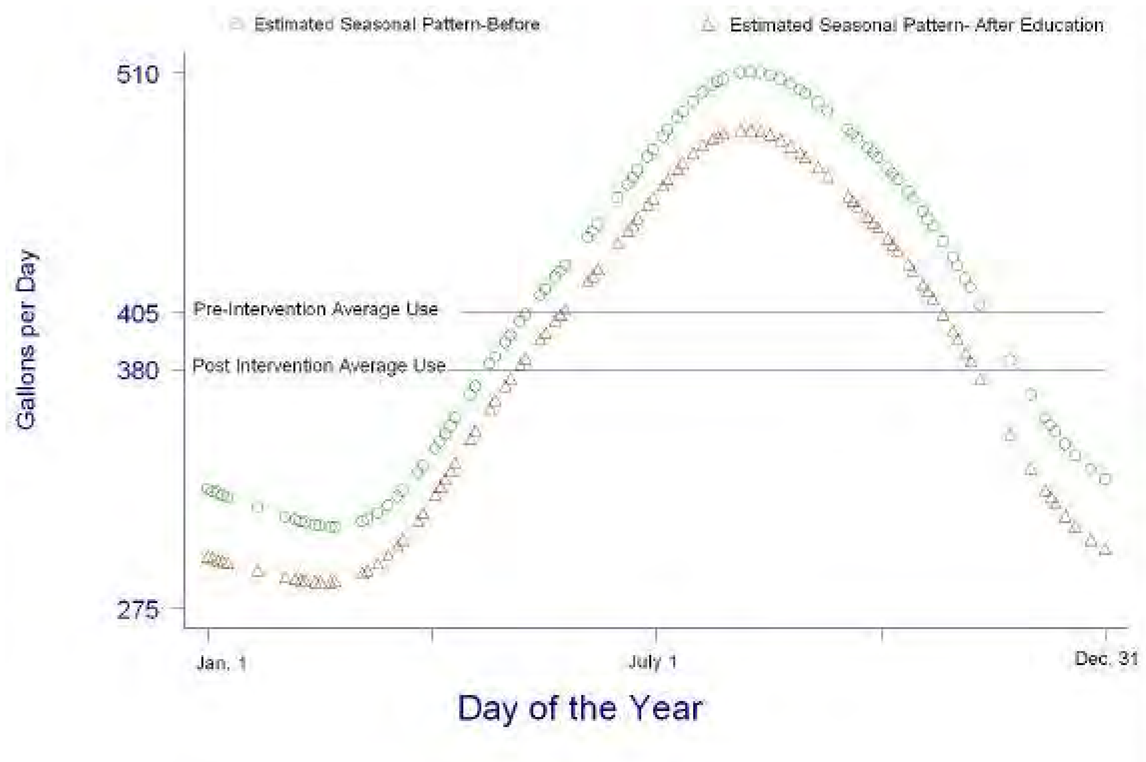

Figure 2-Estimated Effect of Education-only on Water Demand

Caveats and Additional Work

This modeling effort focused on developing the best depiction of net changes in water consumption due to the landscape interventions of ET controllers and/or education. Much of the modeling effort was expended on data cleaning, diagnosis, and validation. We believe that the most serious data issues were identified and appropriately handled. To the extent that future data quality can be improved, future work could provide several statistical refinements in model specification:

- The empirical effort has quantified the change in mean water consumption and the shift in seasonal consumption. The models have not been extended to document how water savings vary across households—how are savings decreased/increased among lower/higher water use households?
- Since the sample only contains about one year of post installation data, the statistical models can say little about the persistence of water savings. Additional follow-up quantification of water savings in subsequent years is required.
- The modeling effort to date has *not* attempted to estimate the effect of self-selection. Thus, we make no attempt to extend the inference from the existing sample of participants to (1) the rest of the service area or (2) to other service areas.
- The error component of the estimated models could be improved by specifying a function form to explain the variance. This should only be attempted after all major data issues have been resolved.

Conclusion

This report documents the shape of water savings achieved by the landscape interventions of ET controllers and/or education. Households participating in these programs saved significant amounts of water. The education-only program showed less water savings than the ET controller/education program, but were still significant. The ET controller/education program changed both the level and shape of water demand.

Appendix D1: Statistical Analysis of Urban Runoff Reduction

The Residential Runoff Reduction Study

Appendix D1 - Statistical Analysis of Urban Runoff Reduction

Prepared for
Municipal Water District of Orange County and
The Irvine Ranch Water District

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Summary

$ **Data Reliability and Validity:** There were significant measurement and data quality issues with the enacted real-time measurement of urban runoff. The technology employed involved custom configurations and numerous needed calibration adjustments. Debris build-up was an early, ongoing, and possibly unavoidable issue that interfered with the calibration of the flow meters. Some of the original locations selected were more prone to this type of problem and the flow meters were necessarily relocated. Careful attention was paid to documenting data quality issues in ways that did allow for quantitative evaluation of runoff. Nonetheless, the intrinsic data reliability constrains the inference that can be drawn.

$ **Control Study Sites 1002 and 1003:** The measured runoff for the study sites 1002 and 1003—potential control sites—had recurring measurement issues that produced generally unreliable runoff data. We were unable to use the runoff data from either of these sites to serve as a match to either of the sites receiving landscape interventions (ET controllers and/or education).

$ **Control Site (1004):** The unadjusted runoff flow at Site 1004 contained some elevated and likely invalid flow recordings in the pre-intervention period; that is prior to May 2001. Using robust statistical modeling methods, the spurious flow observations were identified and "quarantined." It is possible that these high flow measures were completely accurate measures of real runoff within Site 1004; perhaps one or more customers experienced undetected leaks. If this is the case, then Site 1004 could not serve as a good “matched” control site. The runoff in the post-intervention period for the Control Site 1004 increased 63 percent from the pre-intervention period.

$ **Effect of Education-only Intervention (Site 1005):** Study site 1005 contained approximately 565 single-family residences. Of these, 225 residential customers agreed to participate in the irrigation education program. Study site 1005 was found to have post-intervention runoff (after May 2001) that was 36 percent higher than pre-intervention runoff (May 2001 and before). The question of how much higher runoff might have been without the education intervention necessitates comparisons to comparable sites that did not receive any intervention.

Comparison across sites can, in theory, control for time-varying covariance in runoff. That is, measured runoff from a matched control group could be used to estimate how runoff increases in the summer period. Comparing across sites, however, will also require standardizing for the different areas across sites and testing for how well matched the sites are in the pre-intervention period. These results are presented in the body of this chapter. If one is willing to accept the Control Site as a matched control, Site 1005’s post-intervention runoff is 21 percent less than expected.

$ **Effect of Evapotranspiration Controller/Education Intervention:** Study site 1001 contained 565 single-family residences. Of these, 114 agreed to participate in the evapotranspiration (ET) controller/education program. In addition, approximately 26 landscape sites (HOA, City median, parks, and school sites) also received ET controllers.

Study site 1001 was found to have post-intervention runoff (after May 2001) that was approximately 49 percent less than pre-intervention runoff (May 2001 and before). These two time periods are not equivalent as valid pre-intervention measures include less than four months of data. Since urban runoff derives from outdoor water use, it generally increases in the spring and summer and declines in the autumn and winter. Hence, the 49 percent runoff reduction is likely to be an underestimate of the level of runoff reduction that would be estimated on comparable time periods.

Using either Site 1005 or 1004 as matched controls implies that the observed post-intervention runoff was 64 to 71 percent less than expected.

Introduction

The purpose of this work is a statistical analysis of the reduction of runoff induced by Evapotranspiration (ET) controllers and irrigation education in the Irvine Ranch Water District. This report documents a careful statistical analysis of measured runoff in residential areas to derive estimates of the runoff reduction from these interventions.

Methods

Robust regressions techniques were used to detect which observations are potentially data quality errors. This methodology determines the relative level of inconsistency of each observation with a given model form. A measure is constructed to depict the level of inconsistency between zero and one; this measure is then used as a weight in subsequent regressions. Less consistent observations are down-weighted. Other model-based outlier diagnostics (Cook's distance, DFBETA statistics, and residual diagnostics) were also employed to screen the data for any egregious data quality issues.

Results

Descriptive Statistics

Raw flow rates

After screening for the known data quality problems, using the "rank" indicator, all raw meter reads were first converted to average hourly values. These were then aggregated by date to convert to daily runoff—the runoff measures are available in both mean hourly flow and total daily volume. Precipitation taken from the Irvine weather station was matched to the daily data and used to separate wet from dry days. Wet weather storm flow can be a more complicated phenomenon to predict, as it depends on the timing and magnitude of the rainfall event, the moisture deficit of soils, and other factors. The relative lack of large storm events in the post-intervention period precluded examination of these more complicated forces and the effect that the landscape interventions might have on wet day runoff.

Standardizing for area

Area-standardized measures of site runoff were also created for dry/wet days, where total daily volume was divided by the estimated permeable/total area. Estimates of area for the study sites were derived from the IRWD GIS system. The GIS system was queried to produce estimates of the number of lots and total area for the different land use classifications (single family residence, condo, HOA, school, landscape, street, and unknown). The GIS system also provided an estimate of the number of buildings, and building area. The area taken up by buildings is treated as impermeable. The remaining area was separated into permeable and impermeable area using a land use classification-specific assumption of impermeability. Table 1 provides the raw data used to construct the estimated site area. (Due to lack of usable flow measures, Sites 1002 and 1003 are not separately reported.) Table 2 aggregates these data by site.

Table 1: Estimated Area of Study Sites by Land Use

R3 GROUP	#Lots	Classification	Total Area	Building Area	Assumed Impermeable Coefficient	Estimated Impermeable Area	Estimated Permeable Area
1001	64	?	499885		0	0	499885
1001	565	SFR	2911227	976574	0.5	1943900	967326
1001	109	Condo	447096	189721	0.9	421358	25738
1001	4	HOA	255208		0.75	191406	63802
1001	2	School	198676		0.9	178808	19868
1001	10	Landscape	845529		0	0	845529
1001	97	Street	2163105		1	2163104	0
1004	61	?	307556		0.0	0	307556
1004	417	SFR	2081636	719485	0.5	1400560	681076
1004	1	HOA	40165		0.8	30123	10041
1004	1	School	348739		0.9	313865	34874
1004	2	Landscape	1136		0.0	0	1136
1004	42	Street	1089143		1.0	1089143	0
1005	8	?	118370		0.0	0	118370
1005	559	SFR	2957363	1033197	0.5	1995280	962083
1005	1	HOA	66421		0.8	49816	16605
1005	1	School	264236		0.9	237812	26424
1005	1	School	261089		0.9	234980	26109
1005	2	Landscape	773206		0.0	0	773206
1005	45	Street	1736098		1.0	1736098	0

Table 2: Estimated Area of Study Sites (in sq. ft.)

R3 Group	Estimated Impermeable Area	Estimated Permeable Area	Total Area
1001	4,898,578	4,246,905	7,320,726
1004	2,833,692	572,686	3,868,375
1005	4,253,986	1,194,553	6,176,782

Robust Analysis of Runoff

Form of the Model

Using the runoff flow data, regression models were used to estimate mean runoff by site. A regression framework allows for (1) hypothesis testing within or across sites and (2) use of robust modeling techniques to identify and minimize the influence of spurious or outlying observations. Sites 1002 and 1003 contained too few valid observations to be included in this analysis. The form of the model is specified to have a single pre-intervention mean (μ_1) and to allow for tests of changes in this mean over time and across sites:

Equation 1

$$\frac{RunoffVolume_{i,t}}{SiteArea_i} \equiv m_1 + I_{4,\mathrm{Pre}} \cdot d_{4,\mathrm{Pre}} + I_{5,\mathrm{Pre}} \cdot d_{5,\mathrm{Pre}} + I_{1,Post} \cdot d_{1,Post} + I_{4,Post} \cdot d_{4,Post} + I_{5,Post} \cdot d_{5,Post}$$

The indicator variable $I_{i,\,t}$ takes on the value one to indicate that an observation comes from site *i* and the time period *t* (pre/post). Thus, the indicator variable $I_{4,Pre}$ takes on the value one for Site 1004 in the pre-period (Feb.2001-May 2001) and is zero otherwise. The parameter $d_{4,\mathrm{Pre}}$ is the estimate of how runoff in Site 1004 differs from the common mean μ_1 in the pre-period. The parameter $d_{5,\mathrm{Pre}}$ has a similar interpretation for Site 1005. The common intercept will, by construction, pick up the estimate of Site 1001 pre-period mean runoff, since the parameters $d_{4,\mathrm{Pre}}$ and $d_{5,\mathrm{Pre}}$ absorb any differences in the other sites.[1] The indicator variable $I_{,1Post}$ takes on the value one for Site 1001 in the post-period (June 2001 -June 2002); its parameter is interpreted as the estimated change to the pre-period mean runoff. The parameters $d_{4,Post}$ and $d_{5,Post}$ have similar interpretations for Site 1004 and Site 1005.

Table 3: Robust Regression Estimates of Mean Dry Day Runoff

Dependent Variable: Dry Day Runoff Height (in inches per unit area) (Height=Runoff Volume/Site Area)

Variable	Coefficient	Std. Error	t	Prob.>|t|
Mean Runoff: Feb-May 2001				
1. Intercept (1001 mean runoff)	0.898563	0.120838	7.44	0
2. Difference of Site1004 in pre-period	0.143721	0.157245	0.91	0.361
3. Difference of Site1005 in pre-period	-0.092260	0.151479	-0.61	0.543
Change in Runoff: June 2001-June2002				
4. Change of Site 1001 in post-period	-0.445390	0.134540	-3.31	0.001
5. Change of Site 1004 in post period	0.878089	0.113737	7.72	0
6. Change of Site 1005 in post period	0.202553	0.106973	1.89	0.059
Number of observations	950			
F (5, 944)	74.92			
Prob. > F	0			
Quasi-R-Squared	0.35			

Robust Regression Results

Table 2 presents the robust regression estimation results for the model of dry day runoff in R3 study Site 1001 (containing some customers receiving the ET controller/education intervention), Site 1004 (whose customers received no treatment), and Site 1005 (containing some customers receiving the education-only treatment). This sample represents metered dry day runoff, standardized by estimated site permeable area, between Feb. 2001 and June 2002.

[1] The choice of Site 1001 as the reference site—implied by excluding a Site 1001 change indicator—is not required. Choosing another site would generate an essentially equivalent model that is one that generates identical predictions, but would change the interpretation of the coefficients.

Differences among Sites in the Pre-Intervention Period. The constant term (1) defines the intercept for this equation and can be interpreted as the mean daily runoff in Site 1001—about 0.898 hundredths of an inch per permeable acre. The following two variables (2) and (3), the indicators for Sites 1004 and 1005 in the pre-period, suggest that estimated difference in mean runoff is not statistically distinguishable from zero; The standard errors of the estimated coefficients are larger than the estimated coefficients. The estimated pre-period site mean runoff for these sites can also be inferred from these coefficients: $m_{4,\text{Pre}} \equiv m_1 + d_{4,\text{Pre}} \approx 0.89 + 0.14 = 1.03$ hundredths of an inch and $m_{5,\text{Pre}} \equiv m_1 + d_{5,\text{Pre}} \approx 0.89 - 0.09 = 0.80$.

Change in Runoff in the Post-Intervention Period: The formal test for the change in runoff in the post-intervention period (June 2001-June 2002) can be found in the following three site-specific terms: variables 4, 5 and 6 as shown in Table 3. The estimated change in dry day runoff for Site 1001 (4) is -0.44 hundredths of an inch. In relative terms, this works out to approximately a 49 percent reduction. The implied mean post-intervention dry day runoff for Site 1001 is 0.89-0.44˜0.45 hundredths of an inch. This reduction in runoff is statistically distinguishable from zero at classical levels of confidence.

The reader should be careful in interpreting this result as the pre- and post- periods are not comparable. The post-intervention period, June 2001 to June 2002, includes 13 months but would be fairly close to an annual average. The period of time covered by the pre-intervention period for all sites, February to May 2001, includes at most 4 months. For Site 1001, the pre-intervention period only includes the months of April and May in 2001, because the flow meter produced enough invalid reads in February and March to necessitate its relocation to a new site in April. Since these are not the highest months for urban runoff, it would be reasonable to expect runoff in the post-intervention period to increase. For this reason, the reduction of 49 percent from the pre-intervention period would be a lower bound on the true estimate of runoff reduction. We can examine the other two valid sites for insight into how much runoff would have increased in the post-intervention period.

The estimated change in dry day runoff for Site 1004 (5) is +0.88 hundredths of an inch. This increase in runoff is statistically distinguishable from zero at classical levels of confidence. The implied mean post-intervention dry day runoff for Site 1004, is (0.89+0.88˜) 1.77 hundredths of an inch. In relative terms, this works out to a fairly large (1-{1.77-1.03}/1.03=) 72 percent increase in the post-intervention period.

The estimated change in dry day runoff for Site 1005 (6) is +0.20 hundredths of an inch. This increase in runoff is statistically distinguishable from zero at close to classical levels of confidence. The implied mean post-intervention dry day runoff for Site 1005, is (0.89+0.20˜) 1.09 hundredths of an inch. In relative terms, this works out to a more modest (1-{1.09-0.80}/0.80=) 36 percent increase in the post-intervention period.

Comparing Post-Intervention Change in Runoff across Sites. The last and potentially most vulnerable inference compares the time change in runoff across sites. If Site 1001 had experienced the same change in runoff as its neighbor sites 1005 or 1004, then dry day runoff would have increased from 36 to 72 percent in the post-intervention period. In absolute terms, this would imply a prediction of non-intervention runoff of 1.24 to 1.53 inches per acre. Compared to the realized 0.45 inches of runoff in the post-intervention period, this reduction would translate to 64 to 71 percent reduction in runoff.

A similar counterfactual exercise for Site 1005 would require assuming that Site 1004 is a good matched control site. Then dry weather runoff in Site 1005 would have increased by 72 percent in the post-intervention period, a level of 1.38 inches per acre. Compared to the realized 01.09 inches of runoff in the post-intervention period, the reduction would translate into a modest but non-ignorable 21 percent decrease in runoff.

Both of these exercises require use of Site 1004 as a control site. While the unadjusted flow measures for Sites 1001 and 1005 are fairly close in the pre-intervention period, the same cannot be said for the flow measures from Site 1004. Perhaps the question would be best put, "Given the three estimates of reduction runoff for Site 1001, which should be used?" The direct within-site estimate of a 49 percent runoff reduction is likely biased low; runoff in the post-intervention period should have increased. The estimate of 64 percent, based on Site 1005 as a control site, may also be biased on the low side. Though Site 1005 did have pre-intervention runoff that reasonably matched Site 1001, Site 1005 also contained more than 200 homes that participated in the education-only intervention with monthly follow-up. These homes did have quantified water savings, some of which is likely to have resulted from reduced runoff. Site 1004 did not receive any treatment but did have measurement issues. Thus the estimate of a 71 percent reduction, using Site 1004 as a control site, has an unknown bias.

The bigger inferential uncertainties lie in how these conservation interventions will work as they are scaled in a larger program or in how other implementations of these programs would work in other areas.

Caveats and Additional Work

- The difficulties encountered in calibrating custom configured equipment to measure runoff limited the amount of pre-intervention data. This in turn precluded simple before and after comparisons of mean runoff flow. Nonetheless, a sufficient length of baseline data was collected to allow quantitative estimates of runoff reduction. If additional flow data can be collected, additional analysis would be possible: (1) the runoff reduction under wet conditions could be examined and (2) an estimate of the seasonal shape of runoff could be included in the models to improve the precision of the estimated runoff reduction.

- Because the runoff measurement is not at a customer level, we cannot distinguish the relative contribution of different customers to urban runoff reduction. Thus, for Site 1001, we cannot state how much the single family ET controller/education contributed relative to the ET controller intervention with landscape customers.

Appendix D2: Residential Runoff Reduction Study Update – 2003 Runoff Data

The Residential Runoff Reduction Study

Memorandum

To: Dick Diamond, IRWD

From: Thomas W. Chesnutt, Ph.D.

Date: August 31, 2004

Re: Residential Runoff Reduction Study Update – 2003 Runoff Data

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Finding

The 2003 measures of runoff from the Residential Runoff Reduction Sites 1001, 1004, 1005 support the findings of the earlier data: Site 1001 has a consistently lower mean level of urban runoff *and* a smaller variation in runoff.

Approach

A & N Technical Services performed data manipulation, collation, and validation on 2003 flow data collected in the R3 Study. The raw flow measures were provided in spreadsheet form. First, the spreadsheets of flow data from three study sites were incorporated into database form. This entailed the writing of a program for each site to convert the spreadsheets that also accounted for variations of form. Second, we performed validation checks on the estimated flow rates to check for consistency problems. Where correctable, revisions will be performed to the flow estimates. Last, these raw data exhibit an inconsistent time step, varying from 5-30 minutes. The raw data for each site was converted into their consistent daily basis—mean flow and total daily volume. The consistent time series version of flow data in the three study sites was then combined into a single consistent database with a consistent time series across sites. A consistent time-step, in term, allows valid comparisons across sites.

An attached spreadsheet contains the raw estimated daily runoff data–mean daily flow, total daily volume, and an indicator measure of data quality. As was experienced with the earlier data, there were considerable measurement issues that the IRWD team had to overcome to obtain consistent measures of flow. The project team coded a data quality indicator ("rank") for each subcomponent of the flow measure—instantaneous velocity and flow height. A combined indicator was also developed. The data quality indictor was set to 2 for measures that were known to be bad (rank=2). The data quality indictor was set to 1 for measures of questionable data quality (rank=1). Thus, the data quality indicator rank would take on the value 222 if all three measures (velocity, height, and estimated flow) were known to be bad and would take on the value 111 if all three were of questionable data quality. A value of zero was assigned to measures having no known or suspected data quality issues.

The data are summarized in two ways. First, the descriptive statistics of the mean daily flow volume (adjusted by site area) at each of the three sites in this post-installation period are examined. The estimated mean daily runoff flow is expressed in inches per acre. Second, a graph of 2003 runoff data is developed for each site that displays the raw data and a lowess-smoothed line of central tendency. (Lowess smoothers are a robust data analytic technique that can convey a sense of the level of runoff.)

Table 1 provides the descriptive statistics of mean dry day runoff height at the three sites. (Note that the number of observations per site are reduced due to the exclusion of flow measures on wet days and exclusion of flow measures due to data quality concerns.) The 2003 flow data were also graphed for the three sites. These figures follow. Site 1001 that received the ET controller and education intervention consistently displays both lower levels of runoff and lower variability in runoff. Site 1004 displays very large variability in runoff; this level of variability is the norm rather than the exception. The months of May and June in 2003 did experience wetter than normal (May) and cooler than normal (June) weather patterns.

Table 1: Estimated Mean Dry Day Runoff Height

January 2003 – August 2003

(in inches per unit area)

(Height=Runoff Volume/Site Permeable Area)

Site	Obs	Mean	Std. Dev.	Min	Max
Site 1001 (ET controllers +ed.) Runoff Height	136	1.03	0.72	0	3.90
Site 1005 (Education only) Runoff Height	160	1.79	2.75	0	27.29
Site 1004 ("Control") Runoff Height	136	2.29	2.83	0	14.25

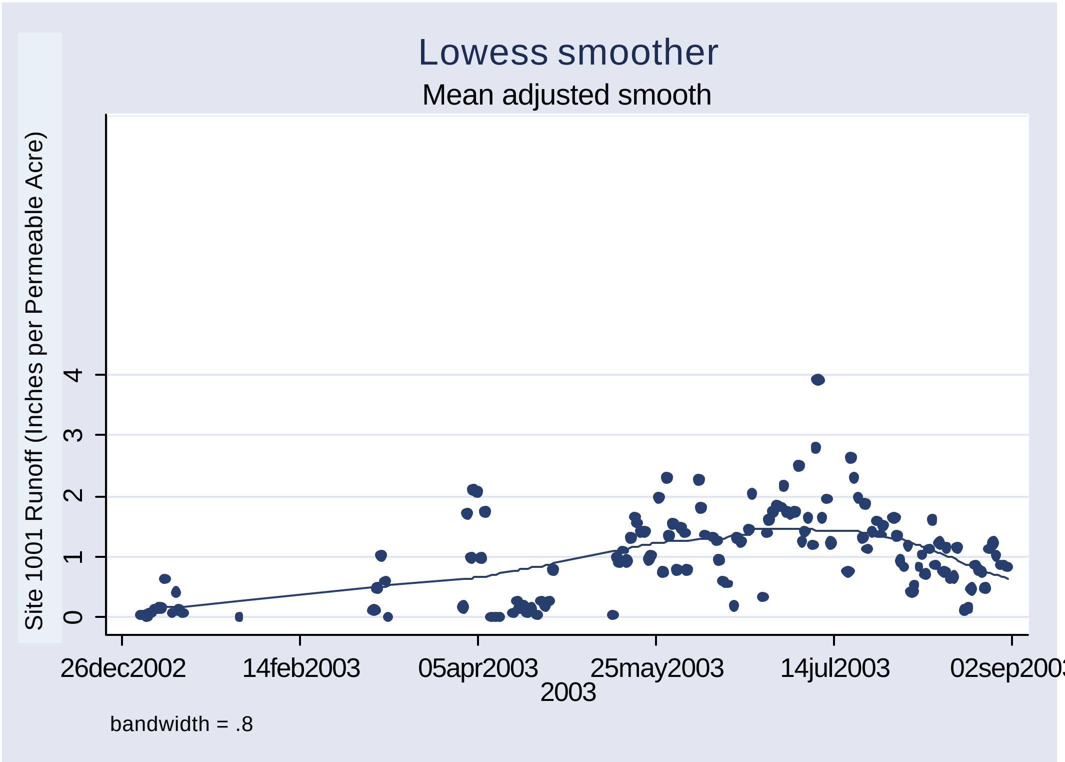

Figure 1: Site 1001 ET Control and Education Intervention

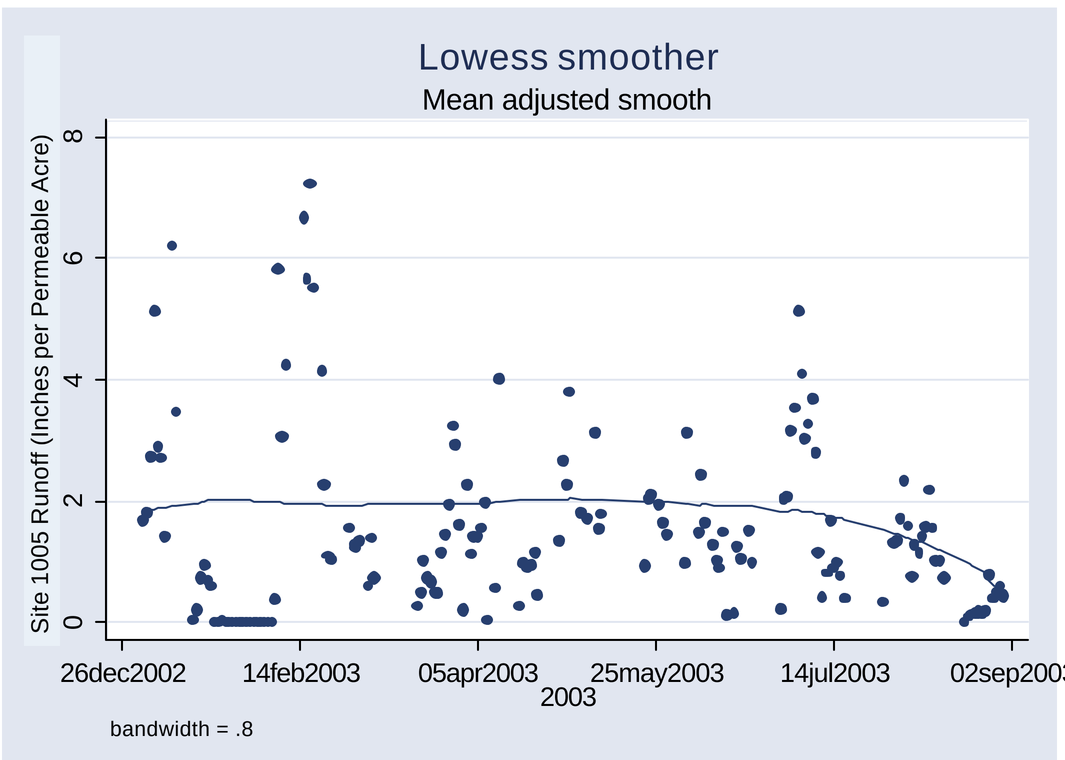

Figure 2: Site 1005 Education Only Site

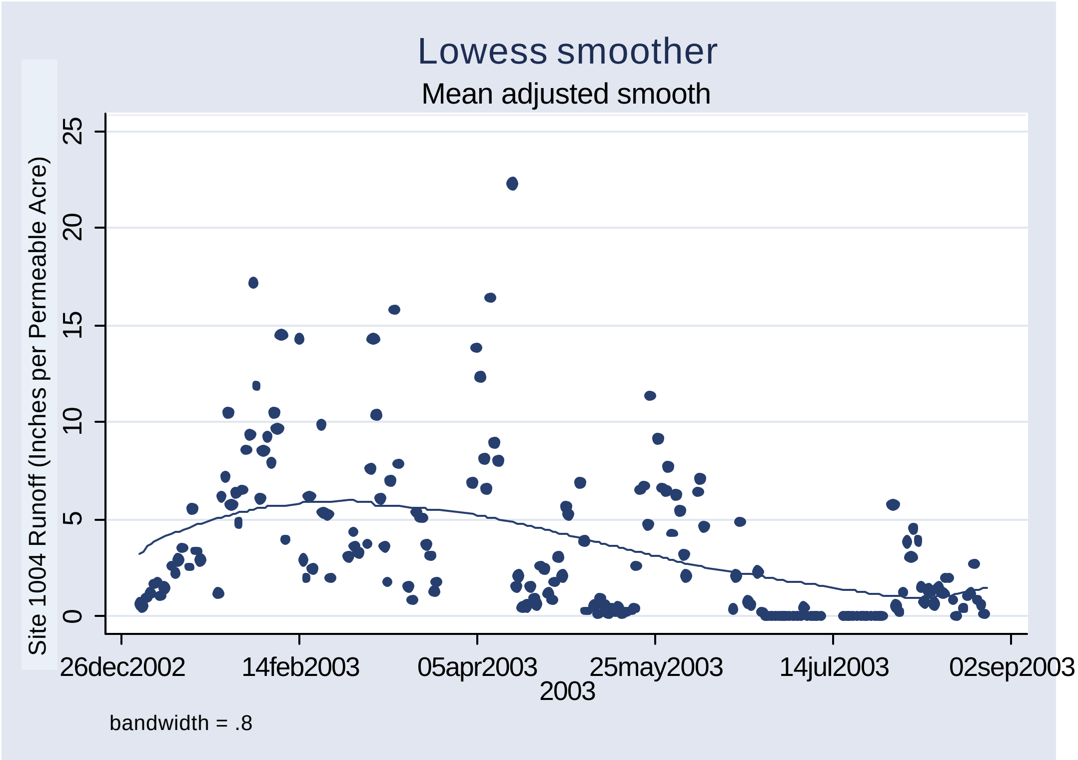

Figure 3: Site 1004 "Control" site

Appendix E1:
The Effect of Technology and Public Education on the Water Quality of Dry Weather Runoff from Residential Neighborhoods

The Residential Runoff Reduction Study

Appendix E1

The Effect of Technology and Public Education on the Water Quality of Dry Weather Runoff from Residential Neighborhoods

Prepared by Kenneth C. Schiff,
Southern California Coastal Water Research Project

May 2003

ABSTRACT

Urban runoff is one of the largest contributors of pollutants to impaired surface waters in the United States, however little is known about effectiveness of potential best management actions (BMPs) to improve water quality. The goal of this study was to quantify the effectiveness of a technological BMP compared to public education as a BMP. The technological BMP consisted of a new evapotranspiration (ET) sprinkler controller that automatically changes sprinkler timing based on weather conditions using remotely controlled radio signals at a nearby weather station. Water quality (nutrients, trace metals, bacteria, pesticides, toxicity) was measured every two weeks for six months at five similar residential neighborhoods, then the technology plus education or education only treatments were applied to one neighborhood each, and measurements continued for another year. At the end of one year post intervention, there was virtually no difference in concentrations or pollutant flux over time. The technological and education treatments provided essentially no detectable increase or decrease in water quality following the intervention. The lack of detectable differences in water quality was a result of a combination of factors including large variability among measurements within a neighborhood and insufficient sample sizes to detect small changes in concentration or pollutant flux.

INTRODUCTION

Urban runoff has been identified as a major contributor to water quality problems throughout the United States (EPA 2000). Runoff from urban areas contains numerous potential pollutants including nutrients, trace metals, pesticides, and/or bacteria (US EPA 1987, Wong et al 1997, Smullen et al 1999, Ackerman and Schiff in press). These discharges have resulted in water quality impairments such as excessive blooms of algae (Bricker et al 1999), toxicity to aquatic organisms (deVlaming et al 2000, Bay et al 1996, closures of recreational shoreline for protection of human health (Noble et al 2000).

As managers become aware of the environmental concerns resulting from discharges of urban runoff, they are seeking methods and technologies for reducing or eliminating these discharges. Best management practices (BMPs) come in a variety of forms, including structural and non-structural control measures. Structural BMPs typically include technologically driven management actions that either reduce or eliminate runoff volume and/or attempt treatment of runoff prior to discharge. Non-structural BMPs typically are aimed at changing peoples attitudes or behavior that reduce the use of potential pollutants or limit their entry into the storm drainage systems. The most commonly cited form of non-structural BMPs is public education, which often consists of advertising campaigns, mailers, and other widely distributed educational materials.

The problem with both structural and nonstructural BMPs is that the efficiency and effectiveness of these BMPs are largely unknown. There is no uniform manner or standard method for independently testing these BMPs. Manufacturer information is occasionally available for some structural BMPs, but these data are looked upon suspiciously by most urban runoff managers as a result of their potential conflict of interest. Nonstructural BMPs, such as public education, are almost entirely without rigorous evaluation of their effectiveness. Hence, managers struggle with which BMPs to select, and in which environmental application, to achieve the greatest reduction in pollutant concentrations or mass emissions. At the same time, regulatory mechanisms like National Pollutant Discharge Elimination System (NPDES) Permits for municipal separate storm sewer systems or total maximum daily loads (TMDLs) continue to push the regulatory obligation of urban runoff managers to reduce concentrations and mass emissions of many potential pollutants.

The goal of this study is to compare the effectiveness of technological BMPs versus public education for reducing concentrations or mass emissions of potential pollutants in dry weather discharges. The technological BMP consisted of evapotranspiration (ET) controllers that communicate with landscape irrigation systems of individual households. This technology is designed to optimize watering times for landscaped areas, hence reducing overwatering and resultant runoff. The public education campaign focused on not just appropriate watering times, but also minimization of pesticide, herbicide, and fertilizer usage. These two types of BMPs were tested in residential neighborhoods, typically the most common land use in urban watersheds (Wong et al. 1997). Our goal was to determine if technology or education provides more pollutant reduction so that urban runoff managers can select optimal runoff pollutant minimization strategies.

METHODS

We used a before-after, control-impact (BACI) design for evaluating the effectiveness of both the sprinkler technology and public education. Each neighborhood was sampled every other week between December 2000 and June 2001. In June 2001, homes in one of the neighborhoods were outfitted with the ET sprinkler controllers. Since homeowners with the retrofitted sprinkler controllers were simultaneously being educated, a well-defined public education campaign was also begun with these homeowners. To ascertain the difference between education and ET sprinkler technology, homeowners in a second neighborhood were targeted with an identical public education campaign, but without effect of the ET sprinkler retrofit technology. There was no education or technology intervention in the remaining three neighborhoods, which served as control neighborhoods to document the effect of no treatment. Sampling at the five neighborhoods continued every other week from June 2001 to June 2002.

ET Sprinkler Controller and Public Education

The ET controller is described in detail elsewhere (*see Chapter 2 – Study Methods*). It is similar to any automatic sprinkler timer available at most home improvement stores and nurseries, but with the capacity to receive radio signals that will alter sprinkler timing based on current weather conditions. If weather is hot and dry, the radio signals call for longer or more frequent irrigation. If the weather is cool and moist, such as recent precipitation, the radio signals call for shorter or less frequent irrigation. For this study, the existing sprinkler timers that are set manually by the homeowner were replaced with the radio controlled ET controller systems. Trained technicians were used to ensure successful installation; ET controller requires programming for each valve including area (size of yard or planter per valve), soil type (clay, sand, etc.), and landscape type (turfgrass, shrubbery, etc.). The remaining irrigation system was unchanged, including piping and sprinkler head configuration.

Public education consisted of an initial informational packet containing three items. The first item was an introductory letter that described the purpose of the packet. The second item was a booklet with irrigation, fertilization and weed and pest control information. The centerfold of the booklet was a month-by-month guide to irrigating, fertilizing and pesticide application suitable for posting near their sprinkler timer. Third, each homeowner was supplied a soil probe for measuring the water content of their landscaped soils. In addition to the initial packet, monthly reminders were mailed to each homeowner including landscape maintenance tips such as irrigation system, water schedule, fertilizing, and weed and insect control. Suggested sprinkler run times (for the non-ET sprinkler neighborhood) and fertilizer or pesticide application usage, including non-toxic alternatives, were also provided in the monthly newsletter.

Treatment Neighborhoods

The five neighborhoods were located within a three mile radius in Irvine, CA. The selection criteria for the neighborhoods included similarity in: 1) age of neighborhood (approximately 20 years old); 2) primary land use (single family residential); 3) irrigation management factors (precipitation rate, soil type, plant type, slope and sun exposure); 4) proximity to radio signal for ET controller (all neighborhoods used the same signal). The five neighborhoods were designated 1001 (sprinkler retrofit + education), 1002 (control), 1003 (control), 1004 (control), and 1005 (education only). Although each of the five neighborhoods met the selection criteria, there were some differences worth noting (Table WQ1). First, the two treatment neighborhoods were larger, up to twice as large as the control neighborhoods. Second, the two treatment neighborhoods were more impervious, up to two twice as much impervious area, as the control neighborhoods. Third, the two treatment neighborhoods had greater proportions of landscaped common areas than any of the control neighborhoods.

The treatments were not uniformly applied to all homeowners in either the 1001 or 1005 neighborhoods. In the case of sprinkler + retrofit neighborhood (1001), roughly one third of the pervious area actually retrofit their sprinkler systems. These homeowners, condominium complexes, school and city landscaped areas were recruited by trained personnel. In order to keep the relative percentages approximately the same between treatment neighborhoods, homeowners representing roughly 30% of the pervious area were selected to receive the education materials in the education only neighborhood (1005). These homeowners were selected at random.

Sampling and Laboratory Analysis

Each of the five neighborhoods were hydrologically self-contained and drained to a single underground pipe unique to each neighborhood. At each of these five locations, samples were collected for flow and water quality. Stage (water depth) and velocity were recorded at 5 min intervals using an ultrasonic height sensor mounted at the pipe invert and a velocity sensor mounted on the floor of the pipe. Flow was calculated as the product of velocity and wetted cross-sectional area as defined by the stage and pipe circumference. Despite the relatively continuous measurement of flow, many of the flow measurements were excluded due to faulty readings. Synoptic flow and water quality measurements were only available for two sites over the course of the entire study (i.e. before and after intervention), including the sprinkler + education and education only sites. Flow measurements at the time of water quality sampling for the three control sites were considered faulty and discarded.

Grab samples for water quality, collected just downstream of the flow sensors in the early morning, were collected using peristaltic pumps and pre-cleaned Teflon tubing. Samples were placed in individual pre-cleaned jars, placed on ice, and transported to the laboratory within one hour. Each sample was analyzed for 19 target analytes, five microbiological parameters, and four toxicity endpoints (Table WQ2). Target analytes included trace metals, nutrients, and organophosphorus (OP) pesticides. Microbiological parameters included fecal indicator bacteria and bacteriophage. Toxicity was evaluated using two marine species, the purple sea urchin *Strongylocentrotus purpuratus* and the mysid *Americamysis bahia*. Toxicity endpoints included the median effects concentration that estimates the concentration at which 50% of the sample population is affected (EC50) and the no effect concentration that estimates the highest concentration at which no effect is observed (NOEC). All of the laboratory methodologies followed standard protocols developed by the US EPA (1995, 1993, 1983) or Standard Methods (APHA 2001).

Data Analysis

Data analysis consisted of five steps. These steps included: 1) comparison of water quality among the five neighborhoods prior to intervention; 2) comparison of water quality concentrations over time by neighborhood; 3) comparison of water quality concentrations before and after intervention by treatment type; 4) comparison of pollutant flux before and after intervention by treatment type; and 5) correlation of toxicity measures with potential toxicants in dry weather runoff.

Comparison of water quality concentrations among the five neighborhoods prior to intervention was conducted to assess if there were inherent differences among treatment sites for each constituent. This analysis was conducted using an analysis of variance (ANOVA) using Tukey's post hoc test for identifying the significantly different neighborhoods. All data were tested for normality and homogeneous variance prior to testing. Only the microbiological data were determined to be non-normally distributed, so these results were log transformed prior to data analysis

Comparison of water quality concentrations over time was accomplished by creating temporal plots of monthly mean concentration. Comparisons of water quality concentration before and after intervention by treatment type were accomplished using a standard t-test of the mean concentration before versus mean concentration after intervention. The mean concentrations for sprinkler+education, education only, and sprinkler+education – education only for each sampling event were normalized by the grand mean of the control sites for the same sampling event.

Pollutant flux estimates were calculated by the product of the concentration and volume at the time of sampling and then normalized to the area of the sampled neighborhood. Pollutant flux before and after treatment was compared somewhat differently since the lack of flow data at the control sites did not permit an estimate of flux for these neighborhoods. Mean pollutant flux before and after intervention was compared using standard t-tests at the sprinkler+education and education only neighborhoods without normalization to control values.

Correlation of toxicity with toxicant concentrations was accomplished using a Pearson product moment correlation. These correlations are inferential only and do not presume resulting correlations automatically identify the responsible toxicants. In order to help identify potential causative toxic agents, concentrations of the correlated constituents were compared to concentrations known to induce toxicity in the respective test organisms.

RESULTS

There were significant differences in water quality among sites prior to intervention (Table WQ3). Site 1004, the control site, had the greatest mean concentrations for 15 of the 24 constituents evaluated prior to the sprinkler intervention. Mean concentrations for seven of the 15 constituents were significantly greater at site 1004 than mean concentrations at least one other site (ANOVA, $p<0.05$). In particular, all of the mean nutrient concentrations were greater at site 1004 than the other sites. Mean ammonia, nitrate/nitrite, and TKN were a factor of 13, 11, and 2.5-fold greater at site 1004 than the mean concentrations at the next greatest site, respectively. On the other hand, sites 1001 and 1002 generally had the lowest average concentrations prior to the sprinkler intervention. Cumulatively, these sites had the lowest mean concentrations for 17 of the 24 constituents evaluated. Site 1002 also had the least toxicity, on average, of all five sites. Finally, site 1003 had an intermediate status. Mean concentrations of enterococcus and fecal coliforms at this site were greater than any other site (fecal coliforms significantly greater than sites 1001 and 1002), but the mean concentrations of five trace metals (chromium, copper, cobalt, nickel, selenium) were lowest at this site.

Water quality concentrations and toxicity were highly variable over time during the study period (Figure WQ1). Temporal plots of concentrations and toxicity for each site demonstrated that there was no seasonal trend and no overall trend with time. There were, however, occasional spikes in concentrations for many constituents that appeared to fall into one of two categories. The first category was recurring spikes in concentration that were unpredictable in timing and location. For example, both fecal coliform and enterococcus consistently varied by more than an order of magnitude from month to month during the study period and there was no similarity in pattern between the sites. The second category of concentration spike was single or infrequent peaks. Occasionally these spikes would occur across multiple sites, such as the peak in both lead and zinc at all three control sites (1002, 1003, and 1004) in October 2001, without commensurate changes in concentration at the treatment sites (1001 or 1005). More often, infrequent spikes were isolated to a single site. For example, concentrations of chlorpyrifos climbed to over 10,000 ng/L in July 2001, but averaged near 50 ng/L the remainder of the year at site 1005. Similarly, concentrations of ammonia and total phosphorus spiked 10 and 25-fold prior to June 2001 at the control site (1004) with less variability and overall lower concentrations the remainder of the study.

There were few significant differences that resulted from the intervention of education, sprinkler retrofit and education, or sprinkler retrofit minus education, relative to control sites (Table WQ4). Only six of the 24 constituents evaluated showed a significant difference between pre and post-intervention concentrations after normalizing to mean control values. These significant differences were a net increase in concentrations of ammonia, nitrate/nitrite, total phosphorus, chlorpyrifos, diazinon, and fecal coliforms. These statistical analyses were the result of one of two circumstances. In the first circumstance, there were individual large spikes in concentration at treatment sites, but not at control sites following intervention (i.e. chlorpyrifos and diazinon at sites 1001 and 1005). Therefore, the net difference in concentrations between controls and treatments increased following the intervention. In these cases, removal of the outlier samples resulted in no significant difference among treatment effects relative to controls before intervention compared to after intervention. In the second circumstance, there were large spikes in concentrations at control site(s) prior to the intervention (i.e. ammonia, nitrate/nitrite, and total phosphorus at site 1004) that later subsided while treatment site concentrations and variability remained steady. Therefore, the difference between treatments and controls changed following interventions, although it was not a result of the education or technology.

Although there were no significant differences in pollutant flux as a result of the intervention, there were significant differences in pollutant flux among sites prior to intervention (Table W5). Mean flux did not change at either site from before to after the installation of technology or initiation of education. Site 1001 however, the sprinkler+education site, had the greatest mean flux for 22 of the 24 constituents evaluated prior to the sprinkler intervention. The mean flux for 20 of these 22 constituents was significantly greater at site 1001 than the mean flux at site 1005 (t-test, $p<0.05$). Site 1005 had greater mean fluxes only for MS2 phage and ammonia. The differences among the fluxes prior to (and after) intervention was the result of two factors; greater flow and, at times, greater concentrations at site 1001 compared to site 1005. Mean dry weather flow at the time of water quality sampling was nearly three times greater at site 1001 than 1005.

Toxicity was inconsistently found at all five of the sampling sites (Table WQ3, Figure WQ4) and there was no change in toxicity as a result of the intervention (Table WQ4). The two species tested did not respond similarly either among sites, among treatments, or over time. Correlation of toxicity with constituent concentrations yielded few significant relationships for either species (Table WQ6). Mysid toxicity was correlated with diazinon and several trace metals, but the strongest relationship was with diazinon concentration. Moreover, the concentrations of diazinon were well above the levels known to cause adverse effects in this species while trace metals were not (Table WQ7). Sea urchin fertilization toxicity was only correlated with concentrations of zinc. The concentrations of zinc were well above the level known to induce adverse effects in this species (Table WQ7).

DISCUSSION

This study was unable to find large, significant reductions in concentration or pollutant flux as a result of education and/or sprinkler retrofit technology. This may indicate that the technology and/or education are inefficient for improvements in water quality. Equally as important, however, was the absence of meaningful increases in concentrations. Of the small number of concentrations that showed significant increases, most could be explained by highly variable spikes in concentrations reminiscent of isolated entries to the storm drain system as opposed to ongoing chronic inputs or the effects of best management practices evaluated in this study.

If significant changes did occur, our study design may not have detected these changes due to two factors. First, the variability in concentrations within and between sites are naturally high and our study simply collected too few samples. After taking into account the variability and relative differences in mean concentrations, we used zinc as an example constituent to determine what sample sizes would be required to detect meaningful differences. Assuming that our sampling yielded the true mean and variance structure that actually existed at the five sites, power analysis indicated that a minimum sample size of no less than five-fold would have been required to detect the differences we observed in zinc concentrations during this study.

The second factor that could have hindered our ability to detect meaningful differences in water quality is that the technology and education treatments were applied at the spatial scale of individual homes, while our study design sampled at the neighborhood scale. This problem was exacerbated in this study because only a fraction (approximately one-third) of the homes within the neighborhoods we sampled had the technological or educational treatments. Therefore, the treatments were effectively diluted, decreasing our ability to detect differences in water quality.

It appears that residential dry weather flows measured in our study may contribute significant proportions of some constituents to overall watershed discharges. Our study sites were located within the San Diego Creek watershed, the largest tributary to Newport Bay. San Diego Creek is routinely monitored to provide environmental managers the information they need to properly manage the Bay (OCPFRD 2002). We compiled the dry weather monitoring data at the mouth of San Diego Creek from OCPFRD during 2001-2002 and compared the concentrations to our results from residential neighborhoods (Table wq5). Mean concentrations of chlorpyrifos, diazinon, copper and zinc were much higher in upstream residential neighborhoods, than concentrations measured at the mouth of San Diego Creek. These residential dry weather contributions are amplified by the fact that the San Diego Creek watershed is primarily composed of residential land uses. In contrast, concentrations of selenium, arsenic, and total phosphorus in the residential dry weather discharges were much lower than the cumulative dry weather discharges from San Diego Creek, indicating that residential areas may not be the primary source of these constituents.

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Table WQ1. Characteristics of the five treatment[a] study neighborhoods.

	Neighborhood				
	1001	1002	1003	1004	1005
Total Area (ft^2)	5,174,861	2,145,864	2,426,731	3,868,375	6,176,782
Impervious Area (%)	64.3	30.3	33.6	54.8	82.2
Land Use (%)					
Single Family Res	34.4	52.8	65.4	53.8	47.9
Condo	7.7	2.2	0.0	0.0	1.1
Homeowners Assoc	1.6	8.1	0.0	1.0	4.3
School	3.8	0.0	0.0	9.0	4.2
Landscape	16.3	0.1	6.6	0.0	12.5
Street	29.2	30.4	28.1	28.2	28.1
Unknown	7.0	6.5	0.0	8.0	1.9

[a] 1002, 1003, 1004=control, 1005=education, 1001=education + sprinkler retrofit

Table WQ2. Reporting level and method for target analytes.

	Reporting Level	Method
Metals (ug/L)		
Antimony	0.2	EPA 200.8
Arsenic	1.5	EPA 200.8
Barium	0.2	EPA 200.8
Cadmium	0.2	EPA 200.8
Chromium	0.3	EPA 200.8
Cobalt	0.1	EPA 200.8
Copper	1.5	EPA 200.8
Lead	0.3	EPA 200.8
Nickel	0.2	EPA 200.8
Selenium	5.0	EPA 200.8
Silver	0.4	EPA 200.8
Zinc	5.0	EPA 200.8
Microbiology		
Enterococcus (MPN/100 mL)	2	SM9230B
Fecal Coliform (MPN/100 mL)	2	SM9221B
Total Coliform (MPN/100 mL)	2	SM9221B
MS2 Phage (PFU/100 mL)	2	EPA 1602
Somatic Phage (PFU/100 mL)	2	EPA 1602
Nutrients (mg/L)		
Ammonia as N	5.0	EPA 350.1
Nitrate/Nitrite as N	5.0	EPA 353.2
Total Kjeldahl Nitrogen	10.0	EPA 351.2
Ortho-Phosphate as P	0.5	EPA 365.1
Total Phosphorus	1.0	EPA 365.4
OP Pesticides (ng/L)		
Chlorpyrifos	20.0	IonTrap GCMS
Diazinon	20.0	IonTrap GCMS
Toxicity (% effluent)		
Sea Urchin Fertilization EC50	NA	EPA 1995
Sea Urchin Fertilization NOEC	NA	EPA 1995
Mysid EC50	NA	EPA 1993
Mysid NOEC	NA	EPA 1993

Table WQ3. Mean concentration (and 95% confidence interval) of constituents in dry weather discharges collected before and after intervention[a] at five residential neighborhoods in Orange County, CA.

Parameter	Site 1001				Site 1002				Site 1003				Site 1004				Site 1005			
	Pre-Intervention		Post-Intervention		Pre-Intervention		Post-Intervention		Pre-Intervention		Post-Intervention		Pre-Intervention		Post-Inter vention		Pre-Intervention		Post-Intervention	
	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
Metals (ug/L)																				
Antimony	3.28	0.52	3.09	0.51	2.90	0.29	3.49	0.73	3.33	0.60	3.71	0.72	2.98	0.33	3.46	0.51	2.66	0.30	3.11	0.58
Arsenic	2.19	0.64	2.61	0.95	1.99	0.41	2.87	1.25	1.58	0.35	2.38	0.94	4.06	0.85	3.07	0.95	2.44	0.60	3.02	0.97
Barium	80.91	11.61	93.04	10.97	87.39	9.00	105.12	23.99	88.34	6.09	80.12	11.72	79.22	21.23	82.01	13.16	94.36	13.93	104.55	17.74
Cadmium	0.26	0.09	0.15	0.07	0.26	0.11	0.42	0.38	0.25	0.12	0.23	0.18	0.37	0.14	0.21	0.12	0.28	0.12	0.28	0.18
Chromium	2.49	0.98	1.97	0.59	3.74	1.53	4.72	3.35	1.96	0.41	2.70	1.25	3.31	1.41	2.44	0.82	4.01	2.79	3.89	2.01
Cobalt	0.43	0.11	0.50	0.21	0.65	0.28	1.19	0.81	0.40	0.11	0.53	0.26	0.97	0.49	0.73	0.25	0.64	0.19	1.08	0.54
Copper	13.91	4.31	16.14	7.27	31.50	30.24	27.12	17.30	11.82	2.57	24.30	15.41	24.02	12.64	16.81	6.71	33.98	39.62	29.67	14.38
Lead	0.57	0.18	1.63	1.15	6.95	9.32	4.23	2.90	0.88	0.40	1.45	0.88	4.09	4.84	1.34	0.69	0.79	0.23	3.09	1.98
Nickel	9.28	0.91	9.32	1.87	9.40	1.58	10.94	4.14	7.76	0.72	7.87	2.06	11.18	1.94	9.11	1.60	9.97	1.46	10.23	2.33
Selenium	2.43	0.13	2.50	0.00	2.43	0.13	2.50	0.00	2.30	0.26	2.50	0.00	2.43	0.13	2.50	0.00	2.30	0.26	2.50	0.00
Silver	0.13	0.05	0.14	0.07	0.11	0.02	0.18	0.10	0.17	0.09	0.17	0.15	0.12	0.03	0.16	0.17	0.16	0.09	0.17	0.15
Zinc	58.75	7.13	40.57	10.49	130.25	115.77	65.28	29.77	59.33	14.92	53.58	16.10	93.40	50.30	40.80	12.22	73.08	31.52	75.74	35.18
Microbiology (Log)																				
Enterococcus (MPN/100 mL)	3.95	0.43	3.24	0.18	3.80	0.38	4.16	0.35	4.36	0.68	4.22	0.24	4.49	0.61	4.35	0.25	4.34	0.31	4.37	0.29
Fecal Coliform (MPN/100 mL)	3.45	0.31	2.94	0.27	3.15	0.37	3.50	0.45	4.13	0.33	3.67	0.32	4.08	0.35	3.84	0.32	3.88	0.33	3.67	0.23
Total Coliform (MPN/100 mL)	4.16	0.27	3.82	0.24	4.30	0.30	4.51	0.46	4.70	0.33	4.36	0.26	5.04	0.39	4.50	0.27	4.53	0.34	4.51	0.24
MS2 Phage (PFU/100 mL)	-0.30	0.00	0.02	0.55	-0.30	0.00	-0.09	0.52	-0.19	0.14	0.02	0.53	0.30	0.44	0.05	0.52	0.05	0.43	0.33	0.54
Somatic Phage (PFU/100 mL)	2.00	0.35	2.02	0.49	1.84	0.42	1.81	0.69	2.59	0.40	2.24	0.62	2.88	0.32	2.52	0.54	2.16	0.46	2.37	0.47
Nutrients (mg/L)																				
Ammonia as N	0.17	0.15	0.08	0.03	0.17	0.07	0.39	0.51	0.23	0.11	0.28	0.23	7.32	4.93	0.31	0.26	0.65	0.32	0.42	0.24
Nitrate/Nitrite as N	2.72	0.50	1.48	0.28	3.00	1.14	1.00	0.33	2.35	0.96	1.63	0.78	38.71	18.21	9.29	6.58	2.94	0.61	3.70	4.48
Total Kjeldahl Nitrogen	1.62	0.51	1.87	1.20	1.75	0.62	2.38	0.92	1.96	1.33	2.61	1.75	11.18	5.71	3.60	2.03	4.49	2.64	3.51	1.65
Ortho-Phosphate as P	0.65	0.15	0.64	0.12	0.80	0.25	0.73	0.14	0.79	0.39	1.21	0.75	2.93	0.90	1.55	0.57	0.87	0.25	1.00	0.22
Total Phosphorus	0.79	0.21	0.63	0.16	0.78	0.25	0.82	0.23	1.22	0.83	1.19	1.07	3.30	1.37	1.46	0.73	0.96	0.39	1.16	0.40
OP Pesticides (ng/L)																				
Chlorpyrifos	22.66	9.27	442.78	827.29									45.54	33.48	11.34	6.31	75.27	64.41	803.44	1433.34
Diazinon	1680.45	1379.39	829.56	338.72									3265.38	3277.20	1650.50	1540.87	1159.12	553.01	1738.58	721.44
Toxicity (% effluent)																				
Fertilization EC50	47.26	8.89	53.73	6.17	57.37	3.48	51.94	9.85	41.60	8.94	49.58	10.17	49.79	8.96	55.91	6.48	43.81	9.26	58.35	2.98
Fertilization NOEC	25.36	8.61	44.62	10.32	35.00	8.54	46.23	11.11	32.07	13.27	37.69	11.15	32.50	9.66	51.92	7.67	22.00	9.31	42.88	9.76
Mysid EC50	46.76	25.04	60.00	0.00	56.32	10.22	39.04	35.71	39.10	24.16	51.94	22.38	54.28	15.88	49.36	25.33	39.32	25.25	60.00	0.00
Mysid NOEC	90.71	17.23	104.00	9.49	82.14	18.13	95.00	16.20	95.71	12.20	77.50	17.53	64.29	16.73	68.50	22.30	53.86	14.81	83.00	17.96

[a] 1002, 1003, 1004=control, 1005=education, 1001=education + sprinkler retrofit

Table WQ4. Significance of ANOVA results for the effect of sprinkler + education, education alone, and the difference between sprinkler + education and education alone relative to control concentrations. No data indicates $p > 0.05$

	Effect of Sprinkler + Education	Effect of Education Alone	Difference Between Sprinkler + Education and Education Alone
Metals			
Antimony			
Arsenic			
Barium			
Cadmium			
Chromium			
Cobalt			
Copper			
Lead			
Nickel			
Selenium			
Silver			
Zinc			
Microbiology			
Enterococcus			
Fecal Coliform	0.04		
Total Coliform			
MS2 Phage			
Somatic Phage			
Nutrients			
Ammonia as N	0.03	0.02	
Nitrate/Nitrite as N	0.02		
Total Kjeldahl Nitrogen			
Ortho-Phosphate as P			
Total Phosphorus		0.03	
OP Pesticides			
Chlorpyrifos	<0.01	<0.01	<0.01
Diazinon		<0.01	
Toxicity			
Fertilization EC50			
Fertilization NOEC			
Mysid EC50			
Mysid NOEC			

Table WQ5. Mean flux (and 95% confidence interval) of constituents in dry weather discharges collected before and after intervention[a] at two residential neighborhoods in Orange County, CA.

Parameter	Site 1001				Site 1005			
	Pre-Intervention		Post-Intervention		Pre-Intervention		Post-Intervention	
	Mean Flux	95% CI	Mean Flux	95% CI	Mean Flux	95% CI	Mean Flux	95% CI
Metals (ug/hr/km^2)								
Antimony	1564	740	920	410	167	99	1756	1666
Arsenic	1476	1006	741	427	164	107	2610	2425
Barium	41644	18423	29241	11384	6537	4624	83266	71121
Beryllium	43	17	36	15	7	5	94	79
Cadmium	157	97	40	17	13	5	207	189
Chromium	880	474	562	264	155	86	3199	2810
Cobalt	273	166	131	57	41	21	958	854
Copper	4738	2383	3600	1587	2233	1178	13717	11137
Lead	1149	861	253	133	81	52	1475	1270
Nickel	4287	2096	2743	1249	636	465	7319	6221
Selenium	1075	420	910	367	177	132	2045	1894
Silver	58	19	49	35	13	8	64	73
Zinc	28968	13481	11264	9171	5589	3276	39966	39179
Microbiology (Log)								
Enterococcus (MPN/hr/km^2)	1771	768	1437	624	281	208	1822	1464
Fecal Coliform (MPN/hr/km^2))	1254	567	955	418	234	170	3393	3251
Total Coliform (MPN/hr/km^2)	1628	607	1264	489	284	193	3902	3687
Somatic Phage (PFU/hr/km^2)	976	480	650	282	57	32	748	550
Nutrients (mg/hr/km^2)								
Ammonia as N	584	324	339	260	1145	1236	2466	2475
Nitrate/Nitrite as N	12981	6366	4316	2174	1849	1706	12102	9812
Total Kjeldahl Nitrogen	8144	4881	3621	1893	3083	2614	18149	13628
Ortho-Phosphate as P	4822	2535	1516	679	504	279	6735	6634
Total Phosphorus	4875	2573	1645	657	477	308	7782	8007
Pesticides (ng/hr/km^2)								
Chlorpyrifos	8	8	7	4	3	5	26	20
Diazinon	467	606	234	185	56	36	822	579

[a] 1005=education, 1001=education + sprinkler retrofit

Table WQ6. Correlation coefficients (and p value) of constituent concentrations with toxicity endpoints (No Observed Effect Concentration, NOEC and Median Effect Concentration, EC50) in dry weather discharges from residential neighborhoods in Orange County, CA. No data indicates $p > 0.05$

	Sea Urchin Fertilization NOEC	Mysid Survival NOEC	Sea Urchin Fertilization EC50	Mysid Survival EC50
Antimony		-0.273 (0.009)		
Arsenic		-0.3396 (0.001)		
Barium				
Cadmium				
Chromium		-0.244 (0.021)		-0.219 (0.044)
Cobalt		-0.330 (0.002)		-0.279 (0.010)
Copper				
Lead		-0.215 (0.042)		
Nickel				
Silver		-0.260 (0.013)		-0.229 (0.035)
Zinc	-0.277 (0.005)		-0.274 (0.006)	
Chlorpyrifos				
Diazinon		-0.426 (0.001)		-0.468 (0.001)
Ammonia				

Table WQ7. Comparison of median effect concentrations for the mysid survival (*Americamysis bahia*) and sea urchin (*Strongylocentrotus purpuratus*) fertilization tests.

Constituent (µg/L)	Mysid Survival (EC50)	Sea Urchin Fertilization (EC50)
Antimony	>4150	-
Arsenic	1390-2725	-
Barium	>500,000	>1500
Cadmium	16.5-90.2	1,272
Chromium	1560-2450	-
Cobalt	-	-
Copper	267	30
Lead	3130	>4,000
Nickel	387-635	-
Silver	220-283	-
Zinc	400	29
Chlorpyrifos	0.04	-
Diazinon	4.5	>1,000
Ammonia	-	69

- indicates no data available

Table WQ8. Comparison of mean concentrations (95% confidence intervals) in residential dry weather discharges from this study compared to concentrations in dry weather discharges from San Diego Creek at Campus during 2001-2002 (Data from OCPFRD).

	San Diego Creek	Residential
Parameter	Mean(95% CI)	Mean(95% CI)
Nitrate	5.16(0.72)	4.76(1.96)
Phosphate	1.98(0.07)	1.16(0.20)
Diazinon	0.13(0.07)	1.52(0.52)
Chlorpyrifos	0.05(0.01)	0.35(0.44)
Copper	11.59(2.83)	23.59(5.65)
Arsenic	6.58(0.40)	2.68(0.26)
Selenium	21.22(2.65)	2.46(0.03)
Zinc	22.08(2.75)	60.09(8.26)

Figure WQ1. Monthly average concentrations in dry weather discharges from five residential neighborhoods in Orange ounty, CA.

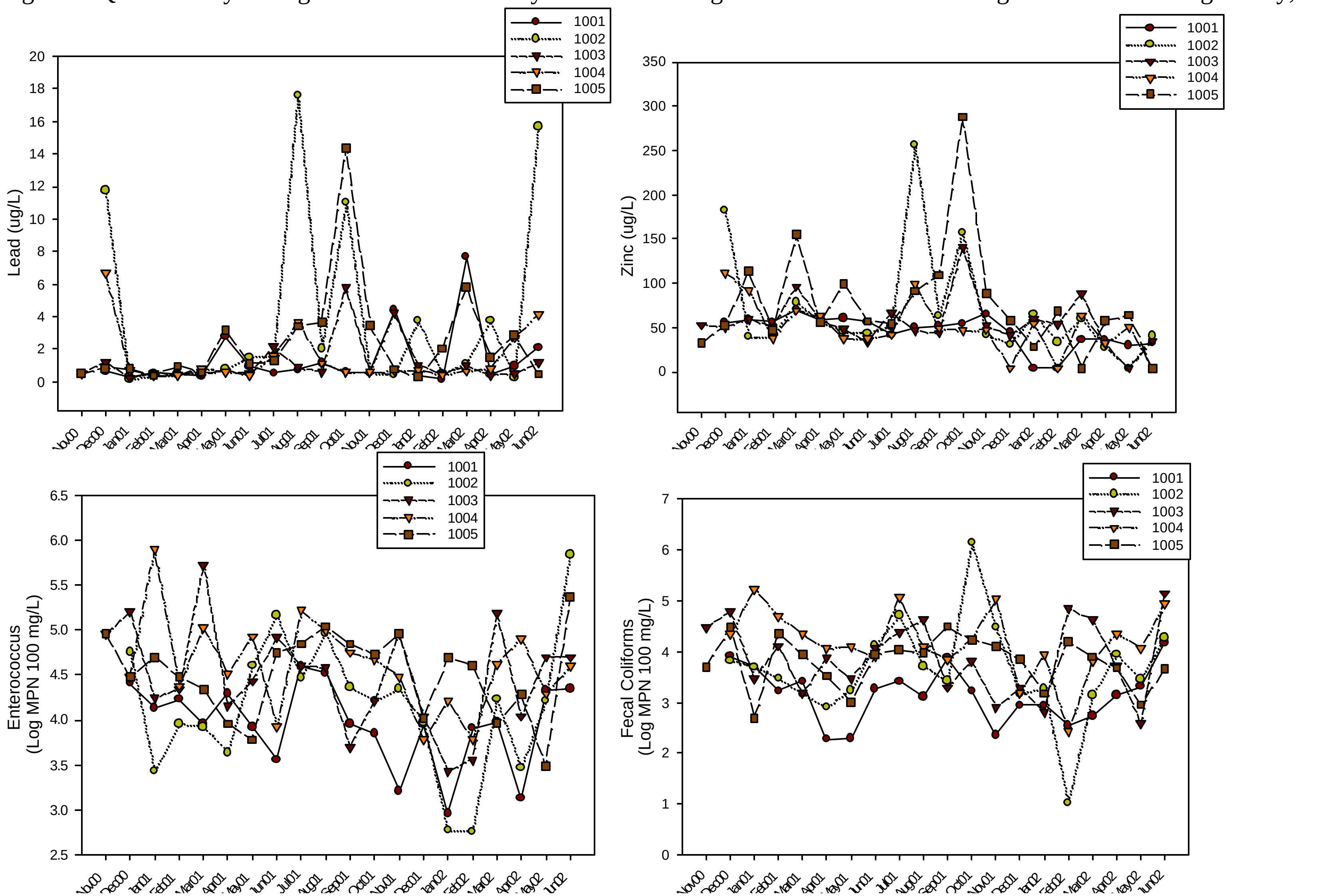


Figure WQ1 continued.

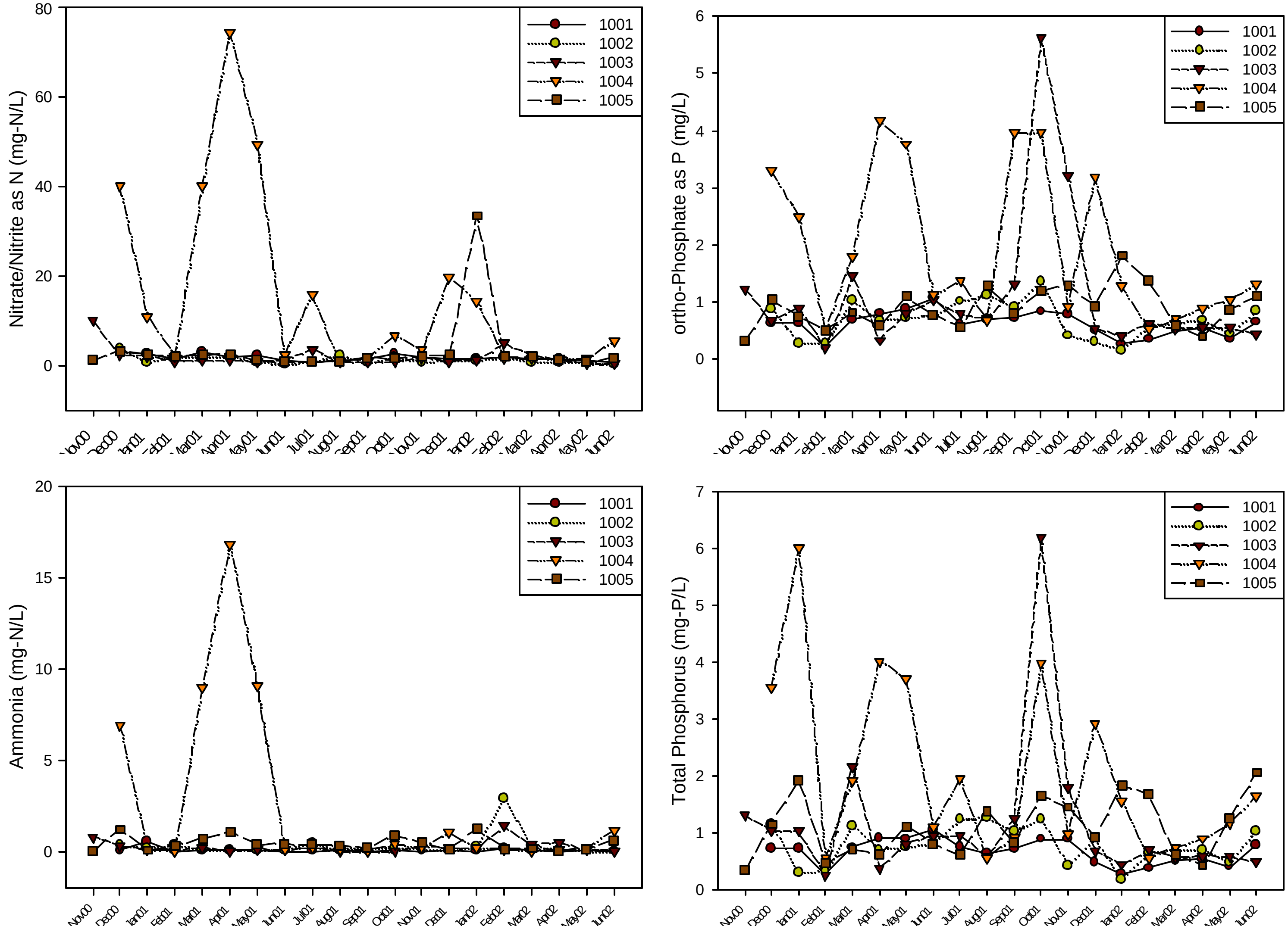
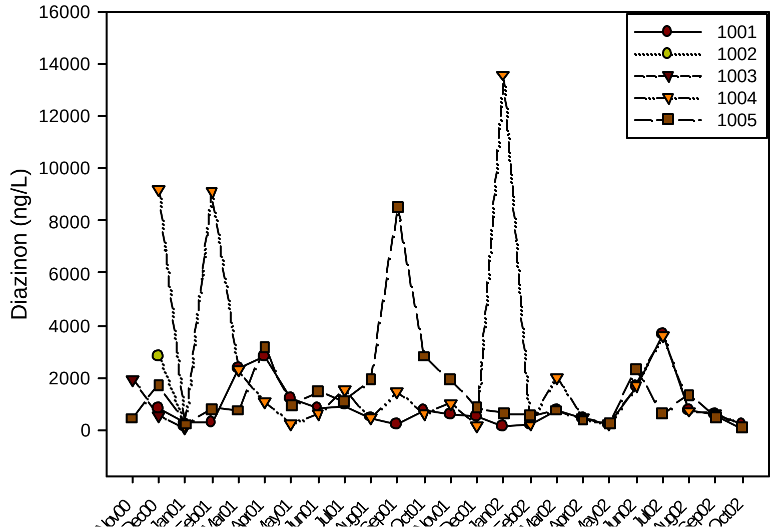


Figure WQ1 continued



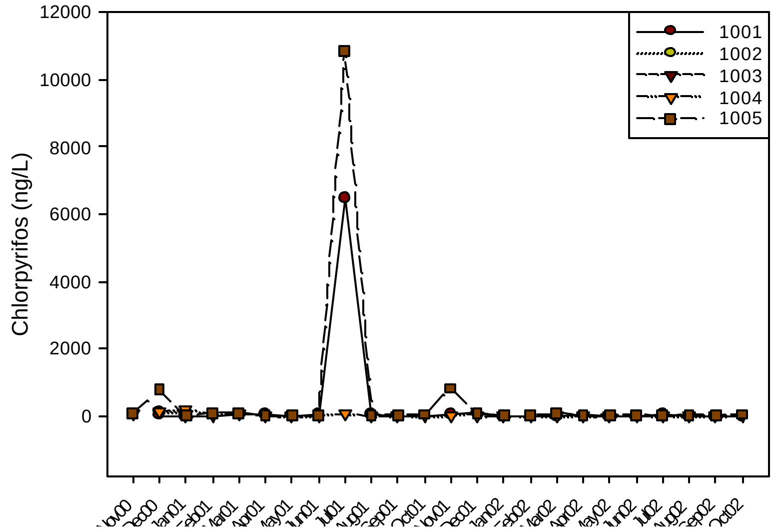
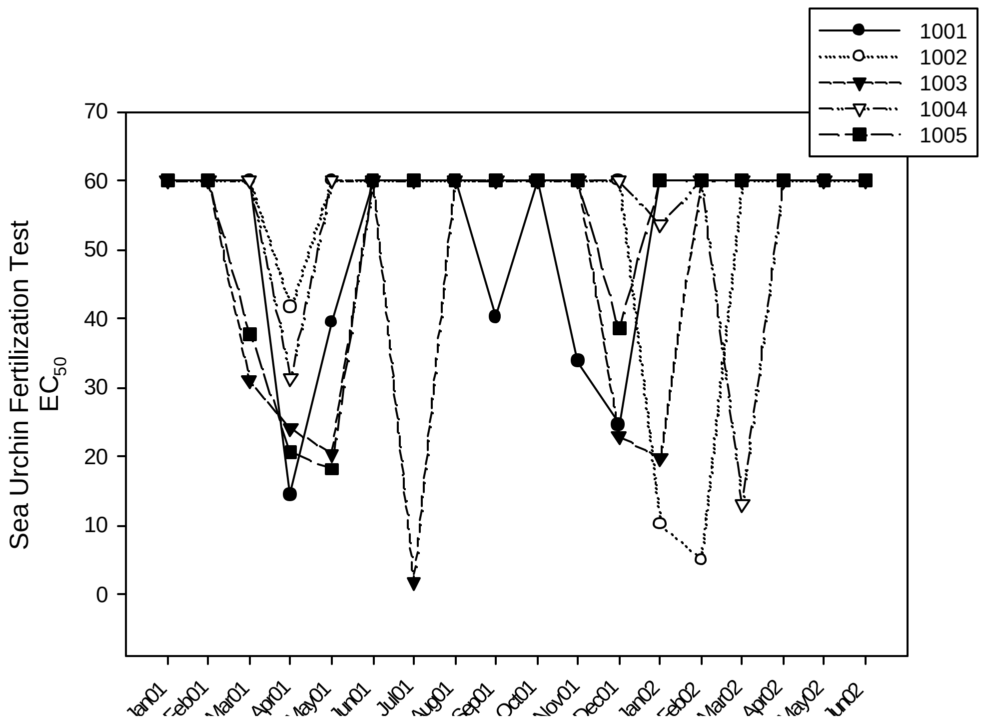
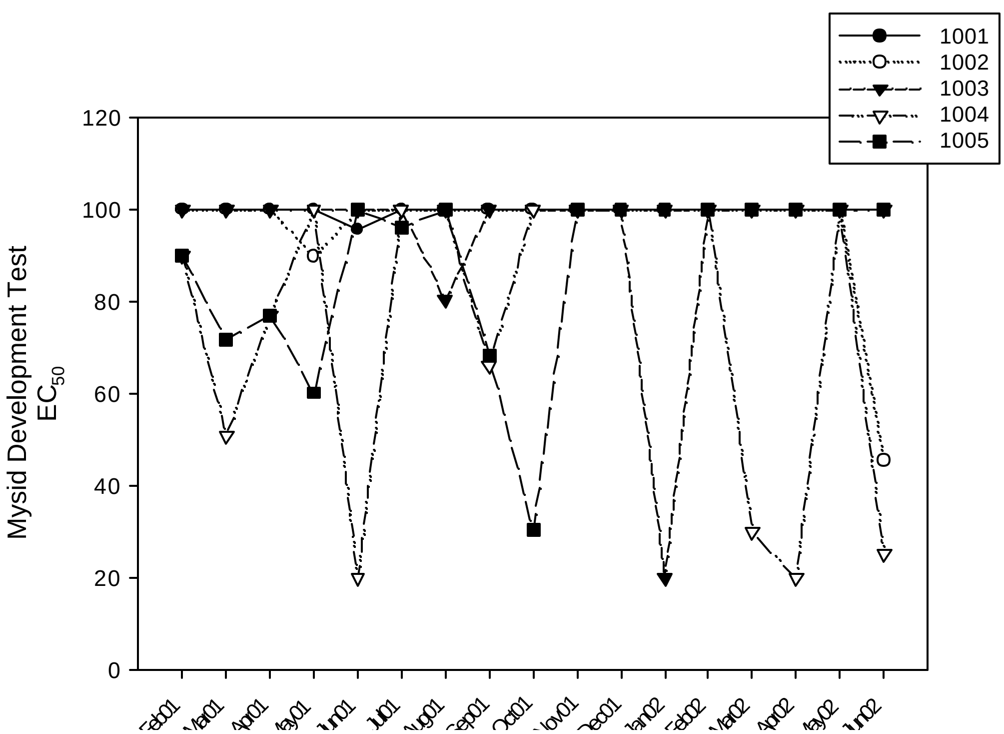


Figure WQ2. Toxicity of dry weather discharges from five residential neighborhoods in Orange County, CA





Appendix E2:
Technical Assistance

The Residential Runoff Reduction Study

Appendix E2: Technical Assistance for the Residential Runoff Reduction (R3) Report

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1. Introduction

This report describes analyses and results of work conducted by GeoSyntec Consultants for the Irvine Ranch Water District (IRWD) to assist in the completion of the Residential Reduction Runoff (R3) Study. The R3 Study is an ambitious investigation to quantify the effectiveness of BMPs in reducing dry weather discharges and associated pollutants.

GeoSyntec Consultants completed the following tasks:

1. Review and Analysis of Water Quality Data. We reviewed the analyses described in Chapter 5 of the R3 report and conducted additional analyses of the water quality data and flux calculations to explore and potentially enhance the interpretation of the monitoring results.
2. Evaluation of Possible Implications on TMDL Compliance. We reviewed and summarized applicable TMDLs in the San Diego Creek Watershed. Results from Task 1 were compared with the TMDLs to evaluate whether the BMPs are beneficial to achieving the TMDL objectives.

2. GeoSyntec Review of Section 5 of the R3 Study Report

Section 5 in the R3 report describes the water quality monitoring data and analyses. The following are GeoSyntec review comments of Section 5.

- **Abstract and Introduction**. The abstract and introduction section provides a recap of the entire study, including a description of the study motivation and objectives. This suggests that this section of the report was originally written as a stand-alone report. In the final report we recommend that most of this information should be integrated into an earlier overall report introductory chapter. The introduction of Section 5 should be limited to a recap of the water quality and flow data, and to present the purpose/goals of the data analysis described in this section.
- **Methods**. The methods section similarly presents much of the study details (watershed descriptions, intervention description-BMPs applied-, etc). We recommend this information be presented in an earlier chapter in the report that describes the study design and procedures in a high degree of detail. This study description chapter could then be referenced as needed throughout the report.
- **Data Analysis and Results**. The 5 data analysis steps are logical and reasonable, however, the procedures, assumptions made, and results are, in some cases, unclear as discussed below. Additional details of the procedures and assumptions made, as well as the use of alternative, possibly more appropriate statistical procedures could enhance the interpretation and usefulness of the monitoring data. Some specific suggestions and comments are discussed below:

1. **Comparison of water quality data prior to intervention**. ANOVA tests were used to test for differences among the treatment sites for each constituent prior to intervention. ANOVA is a parametric test, which is identical to the t-test when comparing only two groups of data. This test assumes that all data sets are normally distributed and have equal variance. The t-test has limitedpower todetect small differences among data sets if they are not normally distributed. Currently the report states that the "data were tested for normality and homogeneous variance prior to testing...[and] only the microbiological data were determined to be non-normally distributed..." However, the results of the normality tests were not included, nor were any descriptive statistics that may indicate normality. Our analyses suggest that many of the data groups are not normally distributed. In addition the mean is not considered a good measure of central tendency for many of R3 data, because mean values can be strongly influenced by outlier values, which were frequently observed. Much of our analyses, therefore, are based on the evaluation of median concentrations. Median values are resistant to the influence of outlier values, and may therefore be a more appropriate measure of central tendency in the R3 data.

   Table WQ3 includes means and 95% confidence intervals for the water quality data before and after intervention (BMPs applied). These descriptive statistics only show part of the story. At the very least, other parametric descriptive statistics, such as the standard deviation and the coefficient of skewness should be included, as well as non-parametric (i.e., resistant to outliers) descriptive statistics, such as the median, interquartile range, and the quartile skew. These will aid in interpreting the central tendency, variation, and skewness of the data. A test on the coefficient of skewness will indicate whether the data are symmetric or not. If the null hypothesis that the data are symmetric cannot be rejected, normality tests are warranted. Otherwise, it can be safely assumed that the data do not come from a normal distribution and alternative non-parametric statistical procedures that do not require normality should to be used.

   The standard methods for calculating the 95% confidence interval about the mean (based on t-distribution) are symmetric confidence intervals that require normality, especially with small data sets. While the report does not state the method used for calculating the 95% confidence intervals, it is likely that the standard method was employed since normality was assumed for the ANOVA analysis. When data are non-normal, alternative methods for calculating the 95% confidence intervals could be used, such as the non-parametric interval estimate for the median (no specific data distribution assumed) or an asymmetric confidence interval about the mean (a specific distribution is assumed, such as the lognormal distribution). However, it should be noted that 95% confidence intervals, are appropriate, but not necessary for testing whether there are significant differences between data sets. Hypothesis tests can be used to detect differences. It is recommended that confidence intervals be reserved for showing the uncertainty in an estimate of central tendency (e.g. mean or median) to determine the likelihood for a threshold to be exceeded, such as a water quality criterion.

If one or more of the pre-intervention data sets are determined to be non-normal or unequal in variance, alternatives to the single-factor ANOVA test can be used, such as the Kruskal-Wallis (K-W) test. The K-W test will determine if all of the data sets have the same distribution and if the medians are equivalent within a specified level of confidence.

2. **Comparison of water quality concentrations over time.** Monthly mean concentrations over time were included in the report. While this is a valid approach to analyzing data, it has a tendency to mask the data's true variability, and since there were generally only two samples per month, there is no apparent advantage to averaging for this exploratory data analysis. Also, Site 1004 had large spikes in the nutrient values that when plotted on the same graph as the other sites tends to dampen and make less apparent the variability in monitoring results from the other sites. It is recommended that all data are initially plotted on separate time-series graphs to identify seasonal periodicity, step-trends, or monotonic trends for each sampling site. Time series plots are an excellent approach for presenting the data and an appropriate first step for understanding the characteristics of the data. Note that unless there are obvious trends (step or monotonic), the time-series plots should probably be placed in an appendix rather than the main body of the report, as there will be a number of them and the information provided is primarily to aid the investigator in determining the next step in the analysis.

   In addition to time series plots, other plotting procedures are available that can be useful in the visual inspection of the data. Plots that should be considered for inclusion in the report include box plots that show side-by-side comparisons of central tendency and variability, and side-by-side quantile (cumulative probability distribution) plots that give an indication of the underlying distribution and any apparent differences in those distributions. These should be included in the main body of the report.

3. **Comparison of water quality data before and after intervention.** Standard t-tests were used to compare mean concentrations before and after intervention. The report states that only 6 out of 24 constituents showed significant differences, and the differences showed a net increase from pre- to post treatment. Removing the outlier points did not affect this result. As stated above, the t-test assumes that both groups of data are normally distributed about their respective means and that they have constant variance. There is no indication that the data meet these strict requirements (water resources data rarely do). The report also states that the data were "normalized" to the grand mean of the control sites, but there is no justifiable reason for doing so, especially since the control sites varied greatly amongst themselves.

   A limitation in the comparison of mean concentrations, such as through the use of the t-test, is that the mean of the concentration data is heavily influenced by outlier values. Given that outlier values were identified and recognized to influence the results, alternative measures of central tendency that are more resistant to the influence of the outliers (e.g. median) should be investigated and presented in the report. The rank-sum test, or Mann-Whitney test, is a non-parametric test that tests whether the median of one group is significantly different from the median of another group. The rank-sum test does not assume any particular distribution or even that the two data sets come from the same distribution. Also, it has the power to detect small differences among data sets and will even work on censored data (data only known to be below the detection limit) as long as less than 50% of the data are censored. The rank-sum test is equivalent to the Kruskal-Wallis test discussed above, but applied to only two data sets. Based on the relative strengths of the rank-sum test as compared to the t-test, and for consistency in the data analysis (as it is highly unlikely the assumptions of the t-test could be met for all, if any of the data sets), it is recommended that the rank-sum (or Krsuskal-Wallis) tests be performed on all data sets.

Once it is determined that a significant difference in the medians exists, the magnitude of the difference can be calculated using the Hodges-Lehmann estimator, which is the median of all possible pair-wise differences between the two data sets. Note that this is often significantly different than the simple difference in medians. A confidence interval about the Hodges-Lehmann estimator can then be calculated to illustrate the variability of the estimate.

4. **Comparison of constituent fluxes (Mass loadings per time) before and after intervention**. Similar to the analysis of concentration data discussed above, mean fluxes for the pre- and post-intervention cases were compared using standard t-tests (for 2 sites only). In general, no difference in the mean flux was found between the pre- and post-intervention data.

   Similar to the analysis of the concentration data, the mean of the flux data is heavily influenced by outliers. Therefore, alternative measures of the central tendency should be calculated and compared. The rank-sum test could be used here as well.

5. **Correlation of toxicity measures with potential toxicants in dry weather runoff**. Correlations between toxicity data and concentration data were investigated using a Pearson product moment correlation. Based on this analysis, no correlations were found to be significant. The first and foremost step in investigating whether one variable is associated with another is to plot the two variables on opposite axes (scatterplot). This step was presented in the report and should be included. A scatterplot matrix helps to identify the nature of the correlation between several variables in one concise graph. A scatterplot will also indicate whether the use of Pearson's correlation coefficient is even appropriate, as it only tests whether there is a <u>linear</u> association between two variables. Due to the nature and complexity of biotic systems, the relationship between toxicity and constituent concentration are likely to be nonlinear. Therefore, an alternative measure of association should be used such as Kendall's Tau or Spearmans Rho. Both of these statistics measure the strength of the <u>monotonic</u> relationship between two variables.

- **<u>Discussion and General Review Comments</u>**. The primary conclusions drawn from the investigation were that there is no statistically significant reductions in pollutant concentration or flux (loadings) as a result of the education and/or sprinkler retrofit technology. While this may be the case, the data analysis described and presented may have had limited ability to detect differences for the particular data sets. The discussion section included two possible explanations for not being able to detect changes between pre- and post-intervention: 1) the data had too much variability and not enough samples were taken, and 2) the treatments were applied at only about one-third of the individual homes within the test watersheds, which effectively diluted the effects of the intervention. Both of these are logical explanations and should be considered in the design of future studies. A helpful assessment would be to evaluate how much data would be needed to detect levels of differences desired to be detected. This information would be valuable for planning of future studies.

Another possible explanation for having difficulty in detecting differences that was not mentioned in the report is the difference in time periods for the pre-intervention and the post-intervention. The pre-intervention period was from December 2000 to June 2001 and the post-intervention period was from July 2001 to June 2002. In other words, the post-intervention period includes summer and fall data, while the pre-intervention period does not. Moreover, there was considerably more rainfall during the pre-intervention wet season than the post intervention wet season (see Table 1).

Based on this it may be desirable to analyze differences using a truncated post-intervention data set with only winter and spring data. The downside of this approach is that it reduces the number of data points to include in the analysis. However, it is justifiable in that in the summer and fall the observed dry-weather flows are likely more associated with irrigation practices and in the winter and spring the observed dry-weather flows are likely more associated with the leaching of saturated soils. We recommend that the use of a truncated data set should be considered if additional analyses of the data using the approaches recommended above do not reveal statistically significant differences.

Table 1: Daily Rainfall Data at the Tustin-Irvine Rain Gauge (100th of inches)

		2001												2002											
	Dec 00	Jan 01	Feb 01	Mar 01	Apr 01	May 01	Jun 01	Jul 01	Aug 01	Sep 01	Oct 01	Nov 01	Dec 01	Jan 02	Feb 03	Mar 02	Apr 02	May 02	Jun 02	Jul 02	Aug 02	Sep 02	Oct 02	Nov 02	Dec 02
1																									
2							5						15												
3																									
4				47	7							6		5											
5																									
6				3	61												12								
7																22									
8		47																							
9				33	5																				
10													10											163	
11		184										4													
12		105	36									36													
13		8	295																						
14			14																						
15																	7								
16																									99
17															40	29									8
18			3																						
19																		7							
20			9															10							85
21					52								28												
22													8												
23			29													4									9
24		32	12									46					9								
25			85																						
26		57	90	3		8											7						5		
27		13	42											46			3								
28			32											5										3	
29												18	10												13
30													35											54	
31																									
total	0	446	647	86	125	8	5	0	0	0	0	110	106	56	40	55	38	17	0	0	0	0	5	220	214

Pre-intervention period (13.2 inches from12/00-6/01) Post-intervention period (3.1 inches from12/01-6/02)

3. Examples of Recommended Approaches to Data Analysis for Chapter 5

These example analyses focus on TMDL constituents: nutrients (total nitrogen and total phosphorus), metals (copper, lead, zinc, cadmium), pesticides, and pathogens (fecal coliform). The analyses also focus on dry weather flows, as reduction of these flows was the objective of the R3 study.

Recommended Data Analysis Methods

Exploratory Data Analysis

Visual inspection of data and exploration of factors that could potentially influence data (e.g. seasonal trends, rain events)

1. Divide data into pre and post- intervention groups.
2. Construct time series plots to visually inspect data and visually examine for seasonal trends. Overlay storm event markers to identify any relation to rainfall volume or antecedent dry period (ADP).
3. Investigate normality or log normality of data sets. Select appropriate statistical tests.
4. Construct probability plots for pre-intervention and post-intervention periods.
5. Prepare quantile plots.
6. Prepare side-by-side box plots.
7. Calculate descriptive statistics

Hypothesis Testing

Test data for skewness, normality, and statistically significant differences. Note that the skewness and normality tests are only needed if parametric approaches are conducted. It is our recommendation to use non-parametric approaches for consistency because normality will not be met in all cases. Nonetheless examples have been provided to show that several of the data sets do not come from a normal distribution.

1. Skewness hypothesis test for symmetry.
2. Shipiro-Wilkes normality test.
3. Mann-Whitney rank-sum test.
4. For the data sets that have greater than 50% censored data (i.e. data only known to be less than the detection limit), hypothesis tests for differences in proportions.

Example Results

The first step in the data analysis is to construct time-series plots. Time-series plots are constructed to identify seasonal periodicity, step-trends, and monotonic trends. The original report included monthly average time-series plots with all sites included per plot. The authors noted that periodicity and trends were not apparent. However, plotting all sites on one graph tends to hide much of the information. For instance, Site 1004 had much higher nutrient concentrations than the other sites, so by including this site, the minor fluctuations in data from the other stations are less apparent. Individually plotting the time-series plots reveals more information. Also, by overlaying storm events the role of rainfall volumes and the antecedent dry period (ADP) may be more apparent and may indicate whether additional analyses are warranted (e.g., correlating ADP with concentration). Figure 1 is an example time-series plot with storm event markers overlain for total phosphorus for Site 1001. Notice the pre-intervention period had much more rainfall, which likely added to the variability in runoff concentrations and fluxes. However, it is apparent that the winter and spring concentrations appear to be lower and less variable during the post-intervention period. The irrigation controllers may have had an affect on the runoff concentrations by reducing the amount of irrigation during moister weather conditions (i.e. high soil moisture). Notice a similar effect for total nitrogen in Figure 2. Additional time-series plots are provided in Appendix A.

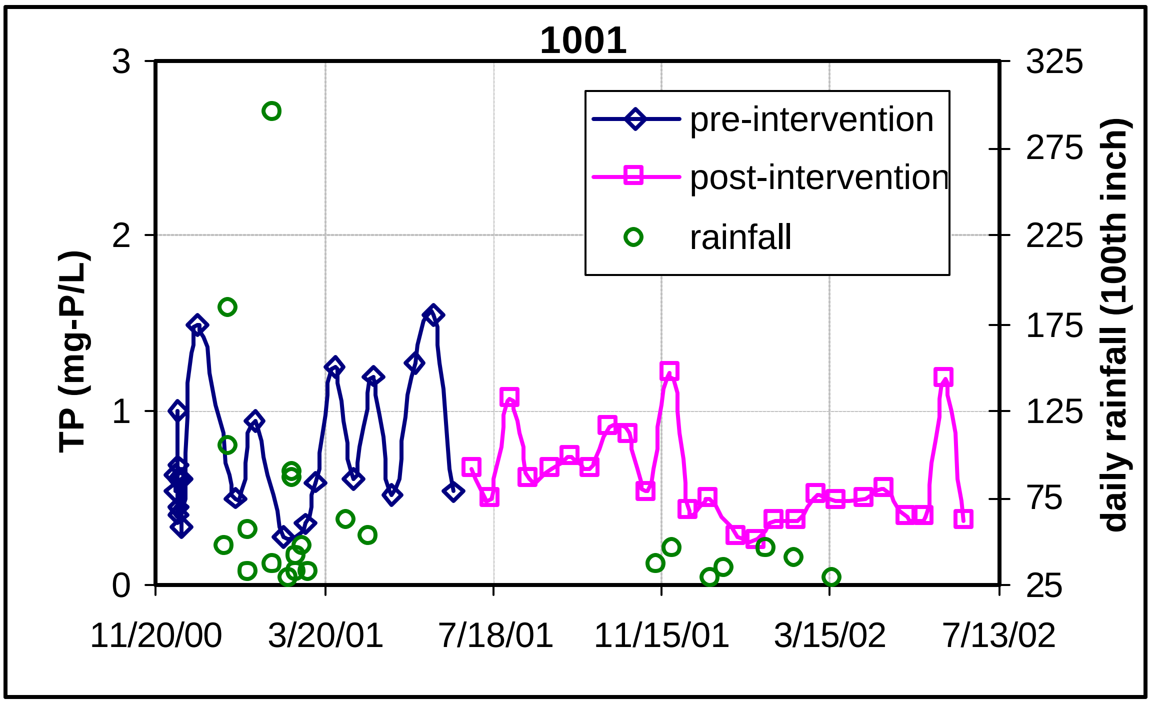


Figure 1. Example time-series plot of total phosphorus with storm event markers.

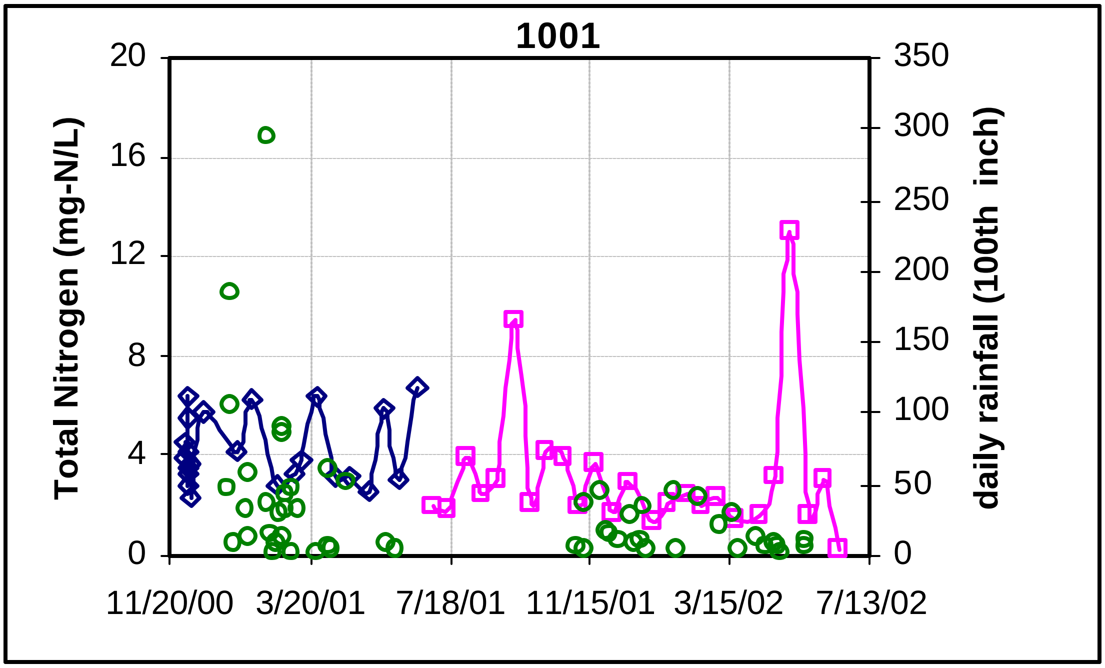


Figure 2. Example time-series plot of total nitrogen with storm event markers.

Comparison of Water Quality Data Prior to Intervention

To visually investigate whether the test sites have similar runoff characteristics, probability plots should be constructed. Figure 3 is an example of a probability plot for total phosphorus for all of the test sites. Notice that all of the sites have a similar distribution except for Site 1004. This suggests that Site 1004 should not be used for "normalizing" of the intervention sites (other information in the report indicating an unknown connection to a nursery further suggests the exclusion of site 1004). However, as mentioned above there is no advantage to normalizing the data using the control sites even if all of the sites had similar distributions.

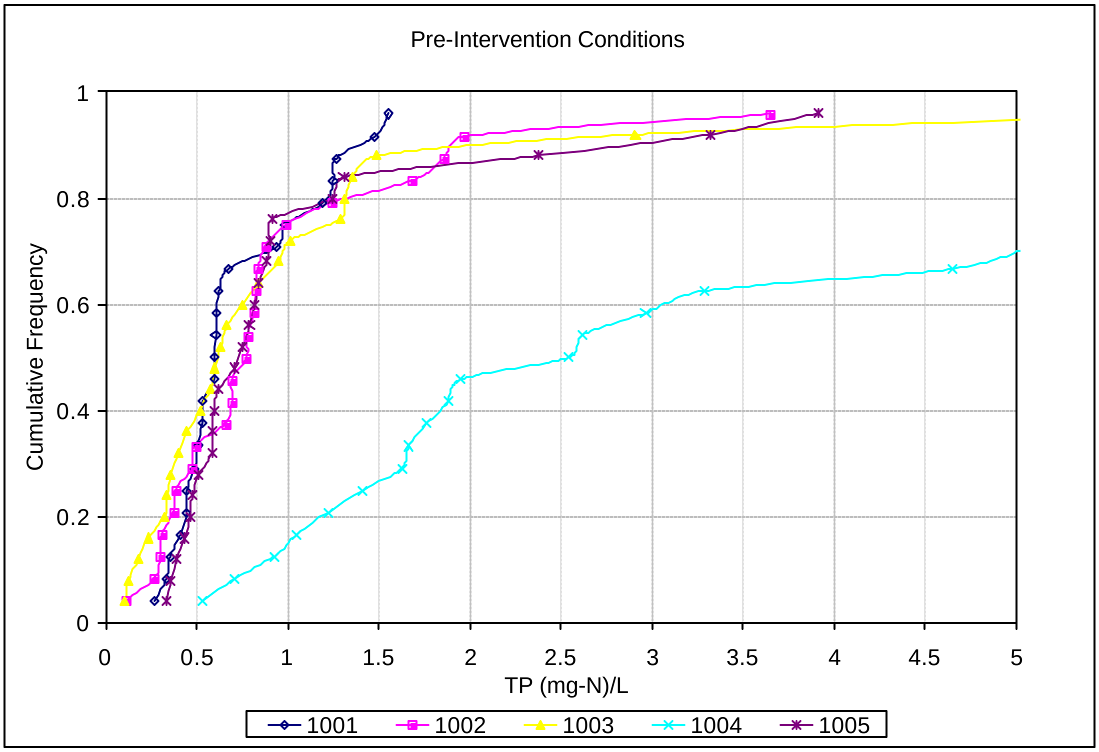


Figure 3. Example probability plot of total phosphorus for all sites prior to intervention.

The next step in the data analysis is to calculate parametric and non-parametric descriptive statistics. Table 2 is an example table of descriptive statistics for total nitrogen for all sites for both the pre- and post-intervention periods. (Additional descriptive statistics are included in Appendix B.) Table 2 includes the number of data points (n), the detection percent (%>MDL/RL), the mean, median, 25% trimmed mean, min, max, 25th percentile, 75th percentile, standard deviation, interquartile range (IQR), and the coefficient of skewness (g_s). Also included in the table are critical skewness coefficients (g_{cr}), which are readily available in statistics texts. If the coefficients of skewness are less than these critical values, then the data are symmetric. Notice that the measures of central tendency (mean and median) and variability (standard deviation) of the sites during the pre-intervention period are quite different, indicating the data arise from different distributions. The median values are consistently smaller than the mean (in some cases substantially smaller) demonstrating the influence of the outliers on the measure of central tendency. Also note that only three pre-intervention data sets are symmetric and none of the post-intervention data sets are. Failure to pass the symmetry test indicates the data are not normal. However, passing the symmetry test does not indicate the data are normal; this requires a normality test. The symmetry test, which is easier to conduct than normality tests, serves as an initial screen for normality to reduce the number of data sets needing further investigation.

Table 2. Example table of descriptive statistics for total nitrogen for each site for pre- and post-intervention.

Parameter	Statistic	1001 Pre	1001 Post	1002 Pre	1002 Post	1003 Pre	1003 Post	1004 Pre	1004 Post	1005 Pre	1005 Post
TN (calculated) (mg-N/L)	n	23	25	23	25	23	25	23	25	23	25
	% > MDL/RL	100%	80%	98%	90%	98%	96%	98%	96%	100%	98%
	Mean	4.24	3.09	5.31	3.44	3.66	4.42	48.00	10.18	6.89	7.74
	Median	3.84	2.27	3.95	2.55	2.66	2.50	19.01	5.57	5.06	4.36
	Trimmed mean	3.94	2.40	4.53	2.76	2.93	3.01	33.11	6.47	5.08	4.42
	min	2.30	0.30	1.50	0.78	1.46	0.45	3.28	0.74	2.48	1.07
	max	6.76	12.99	13.83	11.40	12.12	19.91	141.06	40.80	20.41	67.12
	25th percentile	3.20	1.79	2.27	2.10	2.11	2.04	9.05	2.71	3.52	3.47
	75th percentile	5.68	3.13	8.02	4.36	4.81	5.17	94.79	19.18	7.07	5.62
	St Dev	1.41	2.67	3.56	2.51	2.48	4.39	49.17	10.73	5.29	12.85
	IQR	2.48	1.34	5.75	2.26	2.70	3.13	85.74	16.47	3.55	2.15
	Skewness, g_s	0.55	2.82	0.84	1.87	2.13	2.27	0.74	1.37	1.88	4.46
	g_{cr}	0.96	0.92	0.96	0.92	0.94	0.92	0.96	0.92	0.94	0.92
	Symmetric ($g_s < g_{cr}$)?	Y	N	Y	N	N	N	Y	N	N	N

Non-parametric tests are recommended for all data analyses for consistency since all data sets do not meet the required assumptions for parametric tests (i.e. normality and constant variance). Non-parametric tests are not based on the assumption of normally distribution; therefore, normality tests were not warranted. It is important to note that if the data sets that passed the initial symmetry screening (Sites 1001, 1002, and 1004 in the table above) also passed a normality test, it does not indicate the data follow a normal distribution, especially for small data sets. The test simply indicates that normality cannot be rejected for the data.

As mentioned above, the non-parametric equivalent to the ANOVA test is the Kruskal-Wallis test, which tests for a difference between the medians of independent data groups. The K-W test will also test whether the datasets are derived from the same distribution. Several statistical packages will perform this test. Results of the K-W test shown in Table 3 was generated from a statistical add-on to Microsoft Excel® called Analyse-It™.

Comparison of the mean ranks in Table 3 provides an indication of whether the data groups are derived from the same distribution. A p values < 0.05 indicates that two or more the data groups have different distributions. Examination of the mean ranks in Table 3 shows that Sites 1001, 1002, and 1005 have somewhat similar mean ranks and Sites 1003 and 1004 have somewhat different mean ranks. This suggests that Sites 1003, 1004 have a different distribution than the other sites. Therefore, it is determined that the K-W test should be performed on just Sites 1001, 1002, and 1005. These results are shown in Table 4. Notice that the p-value is now greater than 0.05, so the distributions of the total nitrogen data are not significantly different. Based on this analysis, Site 1002 should be used as the only control site for comparison of total nitrogen data. These analyses will need to be repeated for the other water quality constituents.

Table 3. Example of Kruskal-Wallis test results for total nitrogen at the test sites prior to intervention.

Test	Kruskal-Wallis ANOVA		
Comparison	Total Nitrogen: 1001, 1002, 1003, 1004, 1005		
Performed by	GeoSyntec Consultants		
n	115		
Total Nitrogen	**n**	**Rank sum**	**Mean rank**
1001	23	1128.0	49.04
1002	23	1162.0	50.52
1003	23	774.0	33.65
1004	23	2150.0	93.48
1005	23	1456.0	63.30
Kruskal-Wallis statistic	41.71		
p	<0.0001	(chisqr approximation)	

Table 4: Example of Kruskal-Wallis test results for total nitrogen at the Site 1001, 1002, and 1005 prior to intervention.

Test	Kruskal-Wallis ANOVA		
Comparison	Total Nitrogen: 1001, 1002, 1005		
Performed by	GeoSyntec Consultants		
n	69		
Total Nitrogen	**n**	**Rank sum**	**Mean rank**
1001	23	710.0	30.87
1002	23	761.0	33.09
1005	23	944.0	41.04
Kruskal-Wallis statistic	3.27		
p	0.1948	(chisqr approximation)	

Based on these example analyses of the pre-intervention TN data, it is clear that Site 1004 should not be considered as a control site for total nitrogen, and Site 1003 should be used with caution.

Comparison of Water Quality Data Before and After Intervention

Side-by-side box plots and probability plot comparisons of pre-intervention and post-intervention were constructed to identify any apparent differences in the central tendency and concentration distributions between the two data sets. Figure 4 shows side-by-side box plots of total nitrogen at all of the test sites. Site 1004 was omitted due to its high variability. Notice that Site 1001 shows a distinct decrease in total nitrogen, while the other sites do not. However, other sites do show a decreasing trend in median concentration and inter-quartile ranges.

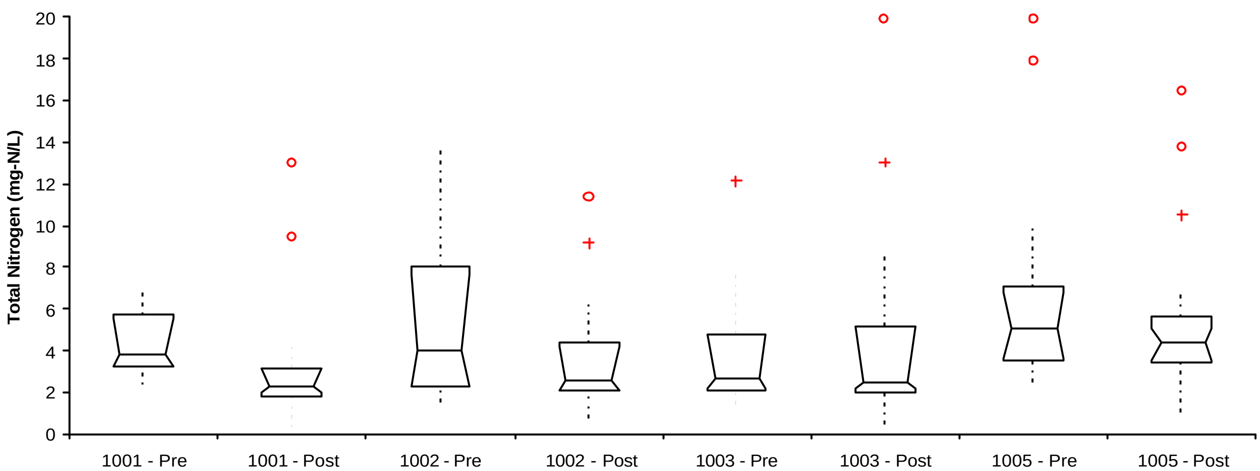


Figure 4. Side-by-side box plots of pre- versus post-intervention for total nitrogen at all sites.

Figure 5 is a probability plot of total nitrogen for Site 1001 before and after intervention. (Additional probability plot comparisons are included in Appendix C.) Notice that there is a distinct reduction in total nitrogen at the site. However, since these data are from different time-periods, this difference could be related to temporal variability.

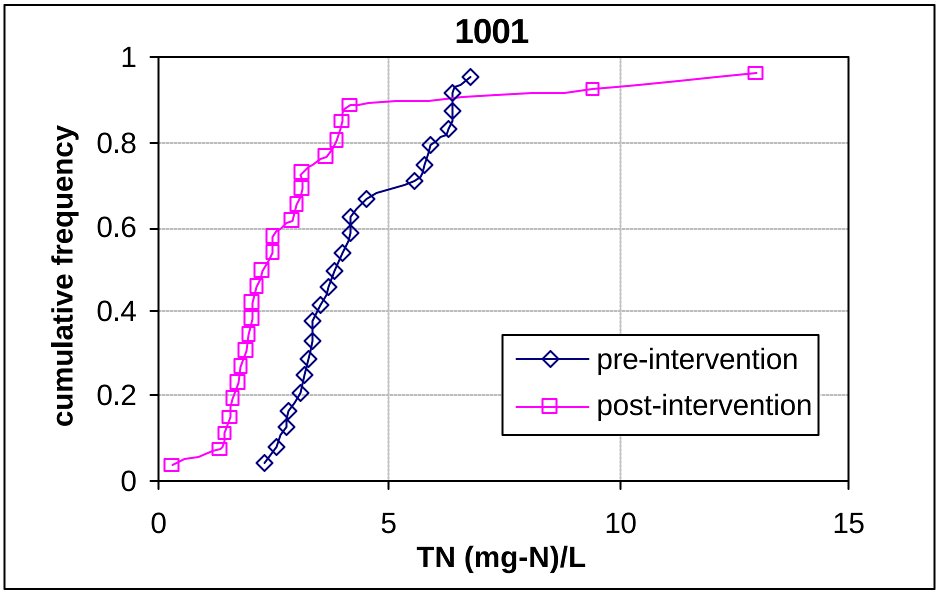


Figure 5. Example probability plot of pre- versus post-intervention at Site 1001 for total nitrogen.

To evaluate if temporal variability caused by the different monitoring periods has anything to do with the difference in total nitrogen concentrations, the probability plot of the pre- and post-intervention period for Site 1001 is plotted with those for Site 1002 and Site 1005 (as these were determined to be the only valid control sites). These comparison plots are shown in Figure 6 and Figure 7. Notice that for pre-intervention, the distribution of Site 1001 more closely follows the distribution of Site 1005 than that of Site 1002, and for post-intervention the opposite is true. This indicates that the year-to-year variability alone cannot explain the reduction in total nitrogen at Site 1001. However, this would need to be statistically verified.

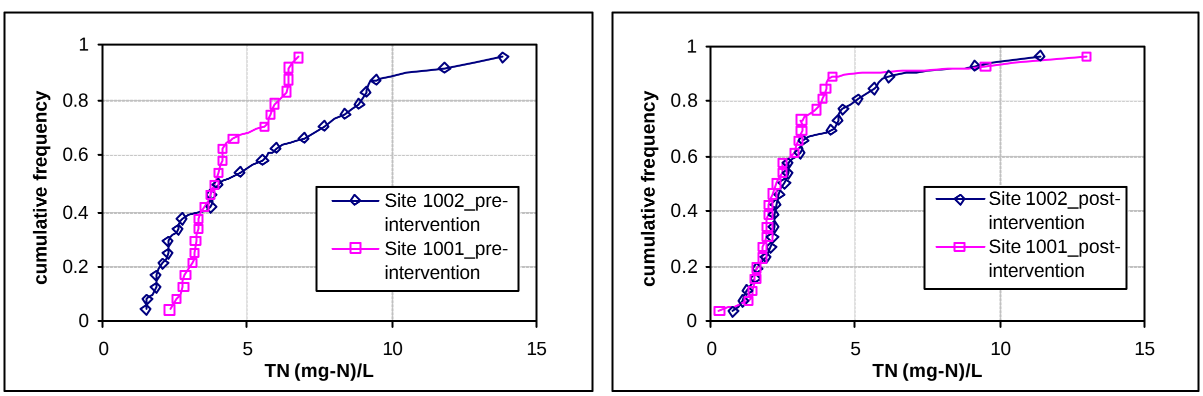


Figure 6. Example probability plot for total nitrogen of Site 1001 versus Site 1002 for the pre- and post-intervention periods.

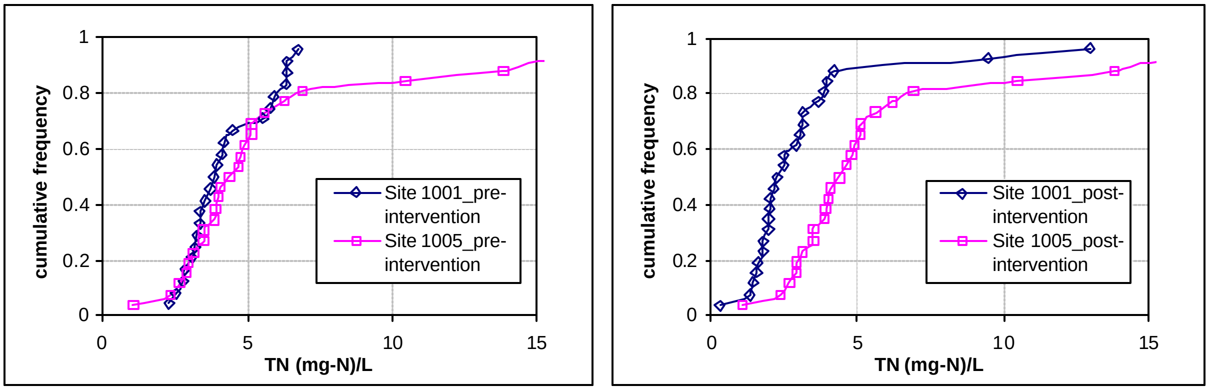


Figure 7. Example probability plot for total nitrogen of Site 1001 versus Site 1005 for the pre- and post-intervention periods.

As mentioned earlier, the Mann-Whitney test (rank-sum) can be used to determine if there is a statistical difference in the median values of two independent data sets (by rejecting the hypothesis that they are the same). Table 5, Table 6, and Table 7 show the output of the Mann-Whitney tests from the Analyse-It™ statistical package on Sites 1001, 1002, and 1005, respectively. Notice that there is a statistically significant difference ($p<0.05$) in the medians between the pre- versus post-intervention total nitrogen data at both Sites 1001 and 1002, but not at Site 1005. Furthermore, the difference in the medians at Site 1001 is at a higher level of confidence (more statistically significant) than the difference at Site 1002 (i.e., greater than 99% significant compared to about 96% significant). The magnitudes of these differences (Hodges-Lehmann estimator) are about 1.5 and 1.3 mg-N/L for Sites 1001 and 1002, respectively. These tests indicate that the difference in the total nitrogen medians at Site 1001 from pre-intervention to post-intervention cannot be explained by the year-to-year variation alone (e.g., the intervention appears to have had an effect). It also indicates that the public education applied to Site 1005 did not appear to make a significant difference.

Table 5: Example Mann-Whitney test for difference in medians for total nitrogen at Site 1001 from pre- versus post-intervention.

Test	**Mann-Whitney test**			
Alternative hypothesis	1001: Pre ≥ Post			
Performed by	GeoSyntec Consultants			
n	48			
1001	**n**	**Rank sum**	**Mean rank**	**U**
Pre	23	736.0	32.00	115.0
Post	25	440.0	17.60	460.0
Difference between medians	1.497			
95.2% CI	0.883	to +∞	(normal approximation)	
Mann-Whitney U statistic	115			
1-tailed p	0.0002	(normal approximation)		

Table 6. Example Mann-Whitney test for difference in medians for total nitrogen at Site 1002 from pre- versus post-intervention.

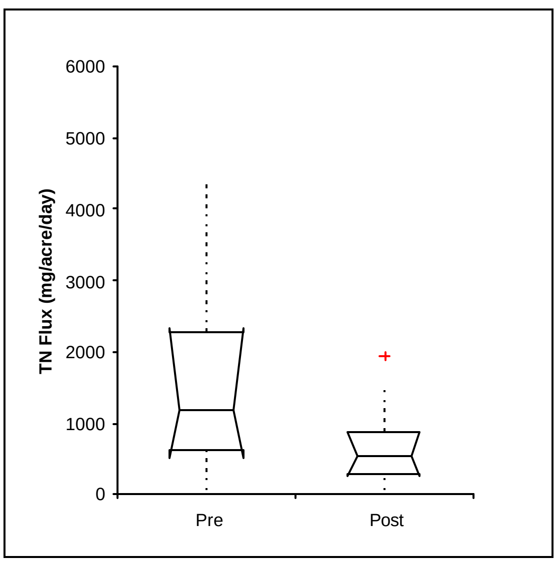
Test	**Mann-Whitney test**			
Alternative hypothesis	1002: Pre ≥ Post			
Performed by	GeoSyntec Consultants			
n	48			
1002	**n**	**Rank sum**	**Mean rank**	**U**
Pre	23	651.0	28.30	200.0
Post	25	525.0	21.00	375.0
Difference between medians	1.289			
95.2% CI	0.065	to +∞	(normal approximation)	
Mann-Whitney U statistic	200			
1-tailed p	0.0355	(normal approximation)		

Table 7. Example Mann-Whitney test for difference in medians for total nitrogen at Site 10052 from pre- versus post-intervention.

Test	**Mann-Whitney test**			
Alternative hypothesis	1005: Pre ≥ Post			
Performed by	GeoSyntec Consultants			
n	48			
1005	**n**	**Rank sum**	**Mean rank**	**U**
Pre	23	610.0	26.52	241.0
Post	25	566.0	22.64	334.0
Difference between medians	0.530			
95.2% CI	-0.446	to +∞	(normal approximation)	
Mann-Whitney U statistic	241			
1-tailed p	0.1686	(normal approximation, corrected for ties)		

Comparison of Constituent Fluxes Before and After Intervention

The statistical procedures applied to the concentrations examples above should also be applied to the constituent fluxes (mass loadings). For completeness, an abridged example analysis will be provided here. Figure 8 includes side-by-side box plots and probability plots of total nitrogen flux data (mg/acre/day) for Site 1001 at pre- and post-intervention. Note there appears to be a significant decrease in the median, as well as an overall reduction in the distribution of values.



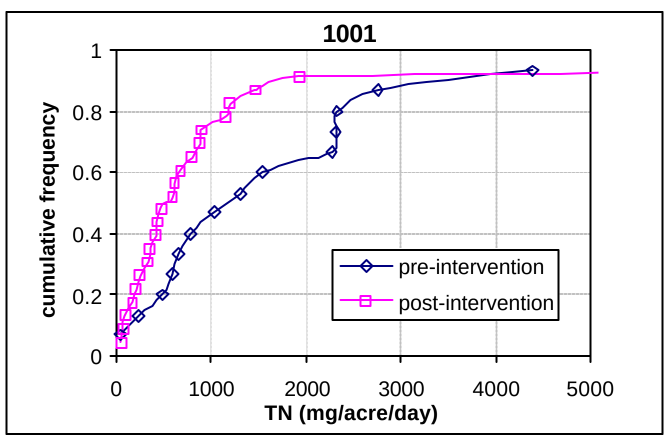


Figure 8. Side-by-side box plot and probability plots of pre- versus post-intervention for total nitrogen flues at Site 1001.

Table 8 shows the results of the Mann-Whitney test (rank-sum) for the total nitrogen flux at Site 1001. Notice the difference in the medians from pre- to post-intervention are statistically significantly different at the 95% confidence level ($p<0.05$). The magnitude of the difference (the Hodges-Lehmann estimator) is approximately 530 mg/acre/day, indicating a relatively large reduction in total nitrogen loads from the neighborhood. However, as discussed below, the extent to which the ET controllers contributed to this reduction is unclear.

The nitrogen fluxes used in this analysis were computed as the product of the measured concentration and the average daily flow. Therefore, the reduction in TN flux could be due to a reduction in flow, a reduction in concentration, or a combination of both. Analyses presented earlier showed a statistically significant reduction in median TN concentration at site 1001 between the pre- and post-intervention periods. Similarly, analyses discussed in the R3 report indicate that there was a statistically significant reduction in flow at site 1001 between the pre- to post-intervention periods; however, it was cautioned that the pre- and post-intervention periods are not comparable due to seasonal differences in the data collection period. Thus, observed reductions in flow in 1001 could be influenced by seasonal factors, and therefore the extent to which the ET controllers contributed to a reduction in flow is unknown. Consequently, reductions in TN flux could be attributed to a combination of TN reduction, flow reduction, and/or seasonal factors.

Table 8. Example Mann-Whitney test for difference in medians for total nitrogen flux at Site 1001 from pre- versus post-intervention.

Test	**Mann-Whitney test**			
Alternative hypothesis	1001_flux (mg/acre/day): Pre ≥ Post			
Performed by	GeoSyntec Consultants			
n	36			
1001_flux (mg/acre/day)	**n**	**Rank sum**	**Mean rank**	**U**
Pre	14	320.0	22.86	93.0
Post	22	346.0	15.73	215.0
Difference between medians	529.389			
95.1% CI	115.985	to +∞	(normal approximation)	
Mann-Whitney U statistic	93			
1-tailed p	0.0239	(normal approximation)		

Based upon the above results, we believe that it would be valuable to complete a more robust statistical evaluation of the data, as we believe that some significant management implications could be determined.

4. Possible Implications for TMDL Compliance.

The R3 Study results were examined in the context of existing TMDLs in the San Diego Watershed. Most of the existing TMDLs are reviewed below and possible inferences and implications of the R3 Study data for TMDL compliance are discussed. The sediment and organophosphorus pesticide TMDLs were not reviewed because sediment data were not collected (the vast majority of sediments are transported by storm flows) and because Schiff and Tiefenthaler (2003) have previously conducted an extensive analysis of the organophosphorus pesticide data.

4.1. Nitrogen

Nitrogen Water Quality Objectives and TMDLs **–** The Basin Plan water quality objectives for nitrogen in San Diego Creek are 13 mg/L Total Inorganic Nitrogen (TIN) in Reach 1, and 5 mg/L TIN in Reach 2 (RWQCB, 1995). Reach 1 extends from Newport Bay to Jefferey Road, and Reach 2 extends from Jefferey Road to the headwaters. There is no numeric standard for nitrogen in Upper Newport Bay in the Basin Plan.

The nitrogen TMDL for Upper Newport Bay is based on the general goal of reducing nutrient loads to Newport Bay by 50 percent, to levels observed in the early 1970's (USEPA, 1998b). The nitrogen TMDL sets phase-in limits on total nitrogen (TN) loads to Newport Bay (see Table 9). Separate loads are established for the dry and wet seasons (dry season is from April 1 to September 30). In addition, the winter load is exclusive of storm flows with an average daily flow greater than 50 cfs in San Diego Creek at Campus Drive.

There is no TMDL for nitrogen loads in San Diego Creek, Reach 1 because it was reasoned that attainment of the 50 percent reduction in nitrogen loads to Newport Bay would result in compliance with the Basin Plan in-stream water quality standard for Reach 1 (13 mg/l TIN). However, for Reach 2 it was determined that the average in-stream nitrogen concentrations would likely remain close to or above the Basin Plan in-stream water quality standard (5 mg/L TIN), even with attainment of the Newport Bay TMDLs. Therefore a TMDL of 14 lbs/day TN was established for Reach 2 (see Table 9) and is applicable for all flows exclusive of storm flows greater than an average daily flow of 25 cfs in San Diego Creek at Culver Drive.

Table 9: Summary of Nutrient TMDLs for Upper Newport Bay and San Diego Creek

TMDL	Dec 31, 2002	Dec 31, 2007	Dec 31, 2012
Newport Bay Watershed, TN – Summer load (4/1 to 9/30)	200,097 lbs	153,861 lbs	
Newport Bay Watershed, TN – Winter load (10/1 to 3/31; non-storm)			144,364 lbs
Newport Bay Watershed, Total Phosphorus – Annual Load	86,912 lbs	62,080 lbs	
San Diego Creek, Reach 2, daily load			14 lbs/day
Urban Runoff Allocation for the Newport Bay Watershed			
Summer load	22,963	11,481	
Winter load			38,283

Study Data Comparison with Nitrogen Water Quality Objective **–** The Basin Plan water quality objectives are expressed in terms of total inorganic nitrogen (TIN), which is comprised of nitrate/nitrite nitrogen and ammonia. By far the majority of the TIN in San Diego Creek is comprised of nitrate/nitrite nitrogen, as measured ammonia concentrations were typically quite low with a majority below the detection limit. For this reason, only the nitrate/nitrate concentration data are compared to the Basin Plan objectives in this report.

Table 10 shows the mean and median nitrate/nitrite concentrations measured in the five study watersheds. The mean and median nitrate/nitrite concentration in all watersheds except 1004 are below the Reach 2 Basin Plan objective of 5 mg/l TIN. As discussed previously, Site 1004 may not be a representative control site because the underlying distribution of pre-intervention nitrogen data appears to be different from the other sites. Similar arguments may also be true Site 1003. With exception of Site 1004, mean nitrate/nitrite concentrations suggests that, <u>on average</u>, residential runoff from these watersheds do not contribute to the exceedance of Basin Plan standards for TIN in receiving waters in San Diego Creek, Reach 1 and 2. The Reach 2 water quality objective was occasionally exceeded in the all watersheds, except for the post intervention conditions in 1001 and 1002.

The mean and median nitrate/nitrate concentrations in watershed 1004, and 1005 exhibit exceedances of the 5 mg/l standard during pre- and/or post intervention conditions. Watershed 1004, in particular, had high levels of measured nitrate/nitrite concentrations, especially during the pre-intervention period. A number of these high readings exceed the Reach 1 water quality objective of 13 mg/l TIC. The results from watershed 1004 are not consistent with those from the other four study watersheds, and the source of the high readings is unknown. Localized conditions involving excessive fertilizer usage by a few users could possibly be a factor in these elevated readings. In particular, the R3 mentions an unknown connection to a neighboring watershed, which could explain the source of elevated nutrient levels.

Table 10: Mean and Median Nitrate/Nitrite Concentration (mg/l) by Watershed (all data)

	1001		1002		1003		1004		1005	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
n	23	25	23	25	24	25	23	25	24	25
Mean	2.56	1.47	2.57	1.07	2.13	1.71	36.50	6.61	2.61	4.13
Median	2.32	1.38	1.56	0.93	1.68	0.94	16.88	2.29	2.45	1.48
n>5 mg/l	1	0	4	0	1	2	18	8	2	1
n>13 mg/l	0	0	0	0	0	0	12	4	0	1

The Mann-Whitney (rank-sum) test was performed to compare the statistical difference between median concentrations during pre- and post-intervention periods (see example in Section 3 above). The median nitrate/nitrite in the post-intervention period was lower in all watersheds, and the difference was statistically significant at the 0.05 confidence level. As the control stations exhibited this trend, these data (i.e. entire data sets with unequal seasonal coverage) cannot be used to ascertain if the structural and educational BMPs were effective in reducing the runoff concentrations of nitrate/nitrite.

Clearly there is another factor contributing to reduced concentrations in the post intervention period. One possibility that was investigated is differences in seasons, year-to-year variability, and sampling times of the pre- and post-intervention data. Table 11 shows mean and median concentrations for comparable seasons and sampling times. Note there are still noticeable reductions in all of the median concentrations, except Site 1005. Applying the Mann-Whitney (rank-sum) test to these data it was found that statistically significant differences between median nitrate/nitrite concentrations in the pre- and post-intervention periods occurred only in watersheds 1001 and 1004, as compared to all watershed when all data are considered. These results indicate that seasonal effects are present in these data and should be considered in the study evaluation. It may be inferred from these result that there were significant reductions in the nitrate/nitrite concentration in the intervention watershed during the wet season that may, in part, be attributable to the structural BMPs. It is unknown whether similar reductions would occur in dry weather runoff during the dry season because such data were not collected during the pre-intervention period.

Table 11: Mean and Median Nitrate/Nitrite Concentration (mg/l) by Watershed for Comparable Seasons and Sampling Times[1]

	1001		1002		1003		1004		1005	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
n	18	14	18	14	19	14	18	14	19	14
Mean	2.38	1.43	1.95	0.95	2.17	1.66	26.24	6.57	2.24	6.27
Median	2.22	1.48	1.16	0.96	1.50	1.02	8.94	2.06	2.03	1.96
n>5 mg/l	0	0	2	0	1	1	13	4	1	1
n>13 mg/l	0	0	0	0	0	0	7	3	0	1

1 – evening samples were deleted from the pre-intervention data. The post-intervention data include only those data collected in months identical to the pre-intervention period.

Study Data Comparison with Nitrogen TMDLs **-** The nitrogen TMDL is expressed in terms of total nitrogen (TN) loads. TN concentrations were calculated from the monitoring data as the sum of the nitrate/nitrite nitrogen and TKN nitrogen. Table 12 shows the mean and median TN concentrations measured in the five study watersheds. The mean and median TN concentration in dry weather runoff are generally in the range of 2 to 5 mg/l, with the exception of watershed 1004 where substantially higher concentrations were measured. The rank sum tests indicated that median TN concentrations are significantly lower (in a statistically sense) in the post-intervention period in watershed 1001 (structural BMPs, see Table 5), and in watershed 1002 (control, see Table 6), and based on the probability plots in Appendix C, Site 1004 is expected to as well. However, sites 1003 and 1005 did not show statistically significant reductions. These results did not change when only subsets of the data were used to consider possible affects stemming from the sampling time and sampling months.

Table 12: Mean and Median TN Concentration (mg/l) by Watershed

	1001		1002		1003		1004		1005	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
All Data										
n	23	25	23	25	23	25	23	25	23	25
Mean	4.24	3.09	5.31	3.44	3.66	4.42	48.00	10.18	6.89	7.74
Median	3.84	2.27	3.95	2.55	2.66	2.50	19.01	5.57	5.06	4.36
Subsets[1]										
n	18	14	18	14	18	14	18	14	18	14
Mean	4.18	2.78	4.51	2.63	3.71	3.71	33.99	8.91	6.98	9.91
Median	3.62	2.02	3.22	2.21	2.51	2.47	12.14	3.74	4.17	3.96

1 – Data subsets with comparable sampling time and seasons. Evening samples were deleted from the pre-intervention data. The post-intervention data include only those data collected in months identical to the pre-intervention period.

TN flux estimates were calculated for watersheds 1001 and 1005 (Table 13). The draft R3 report indicates that the flow measurements in watershed 1002-1004 are not reliable and therefore flux estimates were not calculated for these watersheds. Flux estimates were calculated as the product of the constituent concentration and the average daily flow occurring on the day of the sample collection. The flux estimates were found to be quite variable as they depend on both flow and concentration measurements. Table 13 shows that median TN flux estimates decrease from the pre- to post-intervention periods for both watersheds. Mann-Whitney (rank sum) tests show the reductions to be statistically significant (Table 8). Because comparable data are not available for the control sites, it is not possible to infer whether these reductions are influenced by the ET controllers in the intervention watershed (1001). Also, as previously discussed, the reduction in TN flux may be attributable to a reduction in flow, a reduction in concentration, seasonal factors, or a combination of these.

Table 13: Mean and Median TN Flux (mg-N/acre/day) by Watershed

	1001		1005	
	Pre	**Post**	**Pre**	**Post**
All data				
n	14	22	10	21
Mean	1476	1667	2104	6537
Median	1164	530	1568	1177
Subset[1]				
n	12	14	10*	8
Mean	1384	587	2104	1716
Median	902	497	1568	960

1 – Data subsets with comparable sampling time and seasons. Evening samples were deleted from the pre-intervention data. The post-intervention data include only those data collected in months identical to the pre-intervention period.
* – Same as the all data case

Although the flux estimates in Table 13 are limited in number, duration, and location, they can be used to speculate about the magnitude of the urban area contribution of TN loads to Newport Bay and the potential reduction in loads from structural and nonstructural BMPs. Based on the limited flux data, the annual TN load to Newport Bay in dry weather runoff from urban areas in the San Diego Creek Watershed is estimated to range between 37,000 to 50,000 lbs per year under existing land-use conditions (see Table 14). This is for the most part below the 2012 urban runoff allocation of 49,764 lbs. The annual TN load is estimated to increase to 50,000-67,000 lbs per year under built-out conditions.

According to the 2001 report on the nutrient TMDL (OCPFED, 2001), the average daily TN load in San Diego Creek at Campus Drive was 540 lbs/day between July 2000 and June 2001. This converts to an annual load of about 197000 lbs, which is below the 2007 TMDL (note: San Diego Creek is the majority but not sole contributor of TN loads to Newport Bay). Estimates in Table 14 suggest that dry weather runoff from urban areas account for about 20 to 25% of the annual TN in the San Diego Creek Watershed. If it is assumed that flux reductions observed in the post intervention period are attributable to the structural and nonstructural BMPs, and if similar interventions could hypothetically be implemented on a watershed-wide basis, then the potential reduction in annual dry weather TN loads is estimated to range between 12,500-20,000. This would represent a reduction of about 6-10% of the current TN loads and about 30-40% of the estimated current dry weather urban loads. Note these estimates are based on few data collected in a limited area, and should therefore be considered preliminary in nature.

Table 14: Estimated Annual TN Loads in Dry Weather Runoff from Urban Areas in the San Diego Creek Watershed

	TN flux (mg-N/acre/d)	Annual TN Load to Newport Bay (lbs) Existing land-use[1]	Annual TN Load to Newport Bay (lbs) Built-out land-use[2]
Pre-intervention conditions	1160 – 1560	37,300 – 50,500	50,000 – 67,000
Post-intervention conditions	530 – 1180	17,000 – 38,000	23,000 – 51,000
Potential reduction		~12,500 – 20,000	~16,000 – 27,000

1 –Used 40000 acres or about 53% of the San Diego Creek Watershed area (IRWD, 2003). For comparison, urban land use in 1999 use was estimated at 35,500 acres of the watershed area at Campus Drive (Tetra-Tech, 2000).
2 – Used 53500 acres or about 71% of the San Diego Creek Watershed area (IRWD, 2003).

The following conclusion can be made based on the analyses above:

- Average and median nitrate/nitrite concentrations in dry weather runoff are below the Reach 2 water quality objective (5 mg/l), for most but not all study watersheds.
- Occasional exceedance of the Reach 2 water quality objective occurred in all study watersheds
- The majority of measured nitrate/nitrite concentrations in watershed 1004 during the pre-intervention period were greater than the Reach 2 water quality objective of 5 mg/l. These data are not consistent with those from the other watersheds. The cause is unknown, but could possibly be related to the unknown connection to neighboring nursery discussed in the R3 report.
- Sampling periods (months) and sampling time (morning versus evening) was found to affect the statistical significance of differences between pre- and post- intervention median nitrate/nitrate concentration in some of the watersheds. The sampling period and sampling time did not affect the statistical significance of differences between pre- and post-intervention median TN concentrations.
- Median TN fluxes in watershed 1001 and 1005 were statistically smaller in the post-intervention period. The extent to which the structural and nonstructural BMPs contributed to these reductions cannot be determined due to the lack of reliable flow data in the control sites.
- Preliminary estimates of annual TN loads to Newport Bay in dry weather runoff from urban sources range between 37,000 to 50,000 lbs per year, or about 20 to 25% of the current TN loads.
- The potential reductions in annual dry weather TN loads due implementation of BMPs on a watershed basis is estimated to range between 12,500-20,000 pounds per year. This would represent a reduction of about 6-10% of the current TN loads and 30-40% of the urban loads.

4.2. Phosphorus

The majority of the annual TP load in the San Diego Creek Watershed occurs in the wet season, and has been correlated with sediment loads generated by storm events (USEPA, 1998b). This correlation suggests that a majority of phosphorus occurs in particulate form attached to sediments. The main sources of the total phosphorus (TP) are in Peters Canyon Wash and San Diego Creek above Culver Drive (USEPA, 1998b).

Phosphorus TMDL – There is no numeric objective for phosphorus for San Diego Creek in the Basin Plan. Because measured TP and sediment loads are correlated, it was determined in the TMDL that a 50 percent reduction in TP loads would be achieved through compliance with the sediment TMDL (USEPA, 1998a). Accordingly, the TMDL for TP was based on a 50 percent reduction of average annual load estimated at 124,160 lbs (USEPA, 1998b). The TMDLs are applicable for all flow conditions. The target compliance date was set for December 31, 2007.

The annual TP load allocation for urban areas is 4102 lbs by 2002, reducing to 2960 lbs by 2007. According to the USEPA (1998b) the TP is allocated in the same proportion as sediments. The annual urban area (stabilized vs. construction) sediment allocation for the Newport Bay Watershed is 50 tons distributed over 95.3 square miles (see Table 5 in USEPA, 1998a). This is a very small allocation over a large area. By contrast, note that the annual construction allocation is 6500 tons distributed over the assumed 3.0 square miles under construction in any one year. Using the same proportions of sediment load allocations, the TP load rate based on the 2007 urban allocation is 2960 lbs/95.3 square miles = 0.0485 lbs/acre/yr. If the construction and urban allocations are combined, the TP load rate based on the combined 2007 urban and construction allocations is (2960+12810) lbs/(95.3+3.0) square miles = 0.251 lbs/acre/yr.

Study Data Comparison with TMDLs **–** Similar to the nitrogen TMDL, the phosphorus TMDL is expressed in terms of total annual (TP) loads. Table 15 shows the mean and median TP concentrations measured in the five study watersheds. The mean and median TP concentrations in dry weather runoff are below 1.2 mg/l in all watersheds, with the exception of watershed 1004 where substantially higher concentrations were measured. Comparison of the pre- and post-intervention median TP concentrations in all data (Table 15) reveals an increase in the median TP concentration during the post-intervention period for all watersheds except the intervention watershed 1001 and 1004. In contrast, when subsets of the data with similar seasons and sampling times are considered (Table 15), there is a decrease in the median TP concentration in all watersheds except 1005. This indicates that there are seasonal influences in the data, which presumably are related to rainfall. Unfortunately there are no data available to permit comparison of pre- and post-intervention concentrations for dry weather flows during the dry season.

Table 15: Mean and Median TP Concentration (mg/l) by Watershed

	1001		1002		1003		1004		1005	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
All Data										
n	23	25	23	25	24	25	23	24	24	25
Mean	0.73	0.60	0.92	0.84	0.98	1.21	3.33	1.50	1.01	1.19
Median	0.60	0.51	0.77	0.82	0.62	0.67	2.54	1.05	0.73	0.85
Subsets[1]										
n	18	14	18	14	19	14	18	13	19	14
Mean	0.78	0.47	0.91	0.67	1.13	0.57	2.62	1.33	0.93	1.24
Median	0.61	0.41	0.73	0.56	0.75	0.58	1.82	1.07	0.75	0.83

1 – Data subsets with comparable sampling time and seasons. Evening samples were deleted from the pre-intervention data. The post-intervention data include only those data collected in months identical to the pre-intervention period.

TP flux estimates were calculated for watersheds 1001 and 1005 using the approach discussed in the nitrogen section above. Table 16 shows that median TP flux estimates decrease from the pre- to post-intervention periods in the intervention watershed (1001) but not in the education only watershed. Mean fluxes increase in both watersheds, but as discussed earlier, the mean values are strongly influenced by outliers and do not provide a good measure of central tendency for these data. Application of the Mann-Whitney (rank sum) test shows the reduction in median TP flux in 1001 is statistically significant. This suggests that the structural BMPs had a positive influence in reducing the TP fluxes, but because comparable data are not available for the control sites, it is not possible to ascertain the extent to which the ET controllers contributed to these reductions. Also, as discussed previously, reductions in flux could be influenced by several factors: reduction in concentration, reduction in flow, and/or seasonal variability.

Table 16: Mean and Median TP Flux (mg-P/acre/day) by Watershed (all data)

	1001		1005	
	Pre	Post	Pre	Post
All data				
n	14	22	10	21
Mean	265	370	473	1327
Median	164	109	219	219

Similar to the previous analyses of TN loads, the TP flux estimates in Table 16 can be used to speculate about the magnitude of the urban area contribution of TP loads to Newport Bay and the potential reduction in loads from structural BMPs. Based on the limited flux data, the annual TP load to Newport Bay in dry weather runoff from urban areas in the Newport Bay Watershed is estimated to range between about 5,000 to 11,000 lbs per year (see Table 17) based on a total urban area of 95.3 square miles obtained from Table 5 of the sediment TMDL (USEPA, 1998a). These estimated annual TP loads are greater than the urban allocation (for both dry and wet weather) and are less than the combined urban and construction allocations (Table 17). Note, however, that these estimates are based on dry weather data only, and it is expected that a major portion of the TP loads will occur in runoff from winter storms. Therefore, actual annual TP loads would be expected to be greater. If it hypothesized that flux reductions observed in the intervention watershed 1001 could be realized over the entire watershed, then the potential reduction in annual dry weather TP loads from urban areas is estimated at 2700 lbs. As stated previously, these estimates are based on few data collected in a limited area, and should therefore be considered preliminary in nature.

Table 17: Estimated Annual TP Loads in Dry Weather Runoff from Urban Areas in the San Diego Creek Watershed

	TP flux (mg-P/acre/d)	**Annual TP Load Rate to Newport Bay (lbs/acre/year)[1]**	**Annual TP Load to Newport Bay (lbs/year)**
2007 Urban Area Allocatoion for Newport Bay		0.0485	2960
2007 Combined Urban and Construction Area Allocatoion for Newport Bay		0.251	15770
Pre-intervention conditions (median fluxes)	164 – 219	0.132 – 0.176	8049 – 10748
Post-intervention conditions (median fluxes)	109 – 219	0.088 – 0.176	5350 – 10748
Potential reduction			2700

1 - urban area is 95.3 square miles and the construction area is 3.0 square miles based on Table 5 in USEPA, 1998a

4.3. Metals

Metals TMDLs **–** The USEPA (June 2002) determined that TMDLs are required for dissolved copper, lead, and zinc in San Diego Creek, Upper Newport Bay, and Lower Newport Bay, and that TMDLs are required for cadmium in San Diego Creek and the Upper Newport Bay. The TMDLs for San Diego Creek are expressed as concentration limits, based on the CTR criteria at various hardness values that are associated with different flow regimes (Table 18). The flow regimes are based on 19 years of flow measurements in San Diego Creek at Campus Drive. The concentration-based TMDLs apply to all freshwater discharges to San Diego Creek, including discharges from agricultural, urban, and residential lands, and storm flow discharges. The applicable flow regime at any location in the entire watershed is determined on the basis of discharge at Campus Drive.

Table 18: Summary of Dissolved Metal TMDLs for San Diego Creek

Dissolved Metal (mg/l)	Base flow (0–20 cfs) hardness @ 400 mg/L		Small flows (21-181 cfs) hardness @ 322 mg/L		Medium flows (182-814 cfs) hardness @ 236 mg/L		Large flows (>814 cfs) hardness @ 197 mg/L
	Acute	**Chronic**	**Acute**	**Chronic**	**Acute**	**Chronic**	**Acute**
Cadmium	19.1	6.2	15.1	5.3	10.8	4.2	8.9
Copper	50	29.3	40	24.3	30.2	18.7	25.5
Lead	281	10.9	224	8.8	162	6.3	134
Zinc	379	382	316	318	243	244	208

Metals Sources **–** The USEPA (June 2002) conducted a source analysis as part of the TMDL preparation. Surface runoff is the largest contributor of metals loads in the San Diego Creek Watershed, which includes natural and man made source (USEPA , June 2002). Much of the metals loads are from natural sources. The estimated anthropogenic contributions are metal specific and range from about 33% for zinc to 63% for cadmium (USEPA, June 2002). A primary anthropogenic source of heavy metals is runoff from urban roads, which contributes to sources of cadmium (tire wear), copper (brakes, tires), lead (brakes, tires, fuels and oils), and zinc (tires, brakes, galvanized metals). Use of copper sulfate by nurseries may also be a minor source of copper loads. Other copper and zinc uses in building materials (roofing and roof drains) may be another source.

The USEPA found that metal inputs were heavily influenced by rainfall and stream flow rates. Monitoring results were reported to be highly variable due to different rainfall amounts and flows during each water year. The EPA estimated that base flows account for 25% of the total metal loadings, with the remainder from low, medium and large flows caused by storms.

The EPA's preliminary analyses suggest that: 1) a primary source of metals in dry weather runoff in the study watershed is from roads (i.e. wash off of metals in driveways, parking lots, streets, gutters, etc.); 2) the runoff concentrations will be influenced by rainfall which result in wash off of accumulated metals; and 3) the concentrations can be variable depending on the amount of rainfall.

Study Data Comparison with Base Flow TMDLs **–** The metals TMDLs for base flow conditions are based on meeting the CTR criteria at a total hardness of 400 mg/l. The CTR criteria express maximum allowable concentrations in receiving waters for acute (short term) and chronic (4-day) exposure periods. The acute and chronic criteria are expressed as values that cannot be exceeded more that once in three years. Although the criteria are applicable in the receiving waters and not in the urban runoff per se (i.e. the measured dry weather discharge), exceedance of the CTR in the urban discharge would suggest a potential for the discharge to contribute to an exceedance in the receiving waters.

Table 19 shows the mean and median heavy metal concentrations in the five study watersheds. (*Note to IRWD reviewer: we assumed that the analytical results are for dissolved metals based on guidance from IRWD, but this is not clearly indicated in the data base or draft report; it is likely the case as base flows are typically low in suspended sediments.*) With the exception of mean copper concentrations in some of the watersheds, all mean and median concentrations were below the chronic and acute CTR criteria. Copper, lead, and zinc concentrations occasionally exceeded the chronic CTR criteria, and copper and zinc concentrations occasionally exceeded the acute criteria. These exceedances suggest that the dry weather runoff can potentially contribute to an exceedance in the receiving waters. However, if intervention is determined to be effective in reducing runoff flows, then the BMPs would help to reduce impacts of these potential exceedances by allowing for greater dilution with the in-stream flows.

Table 19: Mean and Median Metal Concentrations (μg/l) by Watershed (all data)

	1001		1002		1003		1004		1005	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
Cadmium										
n	23	25	23	25	24	25	23	25	24	25
Mean	0.26	0.14	0.47	0.44	0.27	0.17	0.64	0.22	0.21	0.29
Median	0.27	0.10	0.24	0.10	0.10	0.10	0.36	0.10	0.10	0.10
n>6.2 μg/l	0	0	0	0	0	0	0	0	0	0
n>19.1 μg/l	0	0	0	0	0	0	0	0	0	0
Copper										
n	23	25	23	25	24	25	23	25	24	25
Mean	13.5	16.9	27.3	30.3	11.5	26.6	21.8	17.7	32.1	30.8
Median	11.5	11.4	10.9	14.0	11.1	14.3	12.7	11.4	12.3	20.4
n>29.3 μg/l	2	2	3	7	0	2	5	4	3	5
n>50 μg/l	0	1	3	3	0	2	2	3	3	2
Lead										
n	23	25	23	25	24	25	23	25	24	25
Mean	0.8	1.6	5.9	4.7	0.8	1.6	3.5	1.5	1.0	3.2
Median	0.6	0.6	0.9	1.2	0.6	0.8	0.7	0.7	0.7	1.3
n>10.9 μg/l	2	1	2	3	0	0	2	0	0	1
n>281 μg/l	0	0	0	0	0	0	0	0	0	0
Zinc										
n	23	25	23	25	24	25	23	25	24	25
Mean	58.7	37.2	115.2	86.3	56.3	56.8	83.6	40.9	74.0	75.0
Median	56.0	50.2	53.4	57.2	50.7	53.9	50.8	43.8	52.4	54.5
n>382 μg/l	0	0	1	2	0	0	1	0	0	0
n>379 μg/l	0	0	1	2	0	0	1	0	0	0

We were unable to locate dry weather metals monitoring information in the Central Irvine Channel, which is the immediate receiving water of the study watersheds (*IRWD please confirm*). OCPFRD dry weather monitoring data are available in San Diego Creek at Campus Drive, which is quite a ways downstream from the study watersheds. Data collected between 12/01 and 6/02 (Table 20) show that average dry weather concentrations at Campus Drive are well below mean and median concentrations measured in dry weather runoff from the study watersheds. Similar comparisons cannot be made for lead and cadmium because the method detection limits in the OCPFRD data are greater than those in the R3 data. None of the OCPFRD dry weather data exceed the chronic or acute criteria.

These comparisons suggest that metal loads in dry weather runoff from the study (urban) watersheds could be a contributing factor to dry weather copper and zinc loads measured at Campus Drive. These dry weather discharges do not result in non-compliance of the base flow metal TMDL at Campus (based on the reviewed data only). It is unknown if the elevated concentrations measured in the dry weather urban runoff result in exceedance of the CTR criteria in the immediate receiving waters. Note that if flow reductions observed in the intervention watershed are attributable to the ET controllers, then these controllers would help to reduce impacts from any potential exceedances of the TMDL because the discharges would be subject to greater dilution by the in-stream flows.

Table 20: Summary of OCPFRD Dry Weather Monitoring Data in San Diego Creek at Campus Drive (12/01 to 6/02)

	Cadmium	Copper	Lead	Zinc
Sample number	24	24	24	24
Range	All < 1 µg/l	<2 – 16 µg/l	<2-2.4 µg/l	<10-16
Mean		7.4 µg/l	most <2 µg/l	most <10
Median-		6.8 µg/l		

4.4. Pathogens

Pathogens are agents or organisms that can cause diseases or illnesses, such as bacteria and viruses. Fecal coliform bacteria are typically used as an indicator organism because direct monitoring of human pathogens is generally not practical. Fecal coliform are a group of bacteria that are present in large numbers in the feces and intestinal tracts of humans and animals, and can enter water bodies from human and animal waste. The presence of fecal coliform bacteria implies the water body is potentially contaminated with human and/or animal waste, suggesting the potential presence of associated pathogenic organisms.

***Fecal Coliform TMDL* –** The RWQCB has adopted phased TMDL criteria for pathogens, with the initial focus on additional monitoring and assessment to address areas of uncertainty. The goal of the Newport Bay TMDL is compliance with water contact recreational standards by 2014:

> Fecal coliform concentration of not less than five samples per 30 days shall have a geometric mean less than 200 most probable number (MPN)/100ml, and not more than 10 percent of the samples shall exceed 400 MPN/100ml for any 30-day period.

A second goal is to achieve the shellfish harvesting standards by 2020:

> The monthly median fecal coliform concentration shall be less than 14 MPN/100 mL, and not more than 10 percent of the samples shall exceed 43 MPN/100 mL.

The TMDLs are applicable for all flow regimes.

Study Data Comparison with Fecal Coliform TMDLs **–** Table 21 shows the mean and median fecal coliform concentrations measured in the five study watersheds. 70% to 100% percent of all fecal coliform measurements were greater than 400 MPN/ml in all study watersheds. This level of exceedance is substantially greater than the allowable 10%. The mean and median fecal coliform concentrations also exceed the 400 MPN/100ml criterion in all study watersheds. There was insufficient data to calculate the 30-day geometric mean (a minimum of 5 samples per 30 days needed), however, the TMDL criterion (30-day geometric < 200 MPN/100 ml) would likely be exceeded, assuming that any additional data would be of the same magnitude as those collected. Exceedance of the TMDL criteria in all study watersheds suggests that urban dry weather runoff is likely a contributing factor to any dry weather exceedance of the TMDL in the receiving waters.

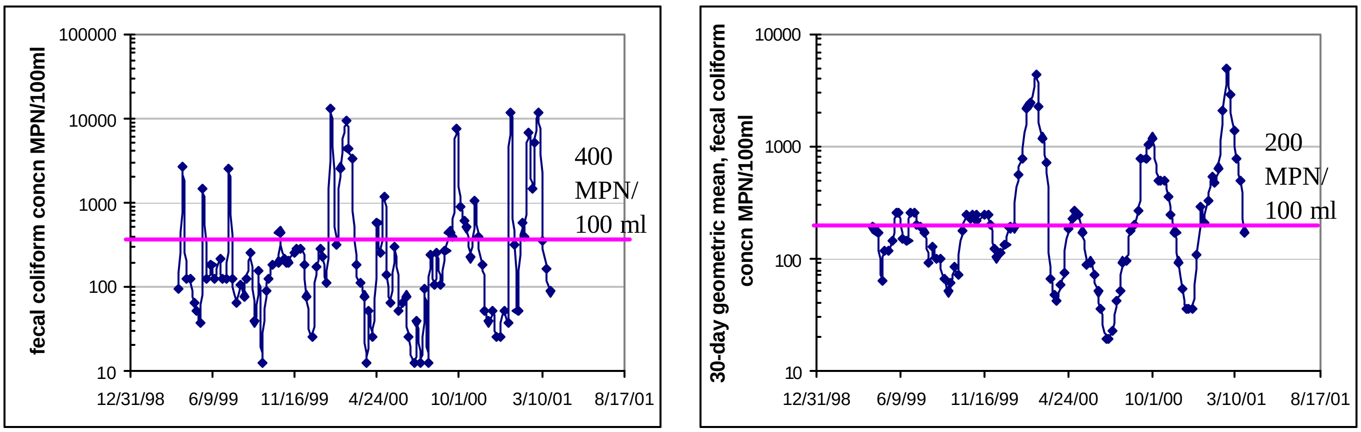
Table 21: Mean and Median Fecal Coliform Concentration (MPN/100ml) by Watershed

	1001		**1002**		**1003**		**1004**		**1005**	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
All Data										
n	22	24	21	24	23	24	21	24	23	24
Mean	4921	3003	5582	128193	34526	28980	28205	34185	17976	10326
Median	2300	1400	1700	3000	13000	4000	13000	13000	8000	8000
% > 400 MPN/100ml	82%	67%	86%	79%	100%	88%	95%	83%	92%	93%
Subsets[1]										
n	17	14	17	14	18	14	17	14	18	14
Mean	2545	3054	3090	5074	13783	37479	23312	20166	8524	6109
Median	2200	950	1400	1400	8000	2650	8000	6500	4000	2900
% > 400 MPN/100ml	100%	71%	82%	79%	100%	86%	94%	79%	100%	93%

1 – Data subsets with comparable sampling time and seasons. Evening samples were deleted from the pre-intervention data. The post-intervention data include only those data collected in months identical to the pre-intervention period.

We were unable to locate dry weather coliform monitoring information in the Central Irvine Channel, which is the immediate receiving water of the study watersheds (*IRWD please confirm*). Therefore it is unknown if elevated fecal coliform concentrations measured in the study watershed contribute to an exceedance of the TMDL in the immediate receiving waters. The OCPFRD has collected dry and wet weather *E. coli* monitoring information in San Diego Creek at Campus Drive (OCPFRD, September 2001), which is considerably downstream from the study watersheds. A plot of the equivalent fecal coliform concentration (assuming an 80% *E. coli* content) shows exceedance of the TMDL occurs primarily during the wet season, although dry season exceedances are also evident (see Figure 9). This suggests that dry weather urban runoff is potentially a contributing factor to exceedance of the TMDL in dry weather flows at Campus Drive. The ET controllers would reduce the impacts from these potential exceedances if they were determined to be effective reducing the dry weather runoff volumes.

Figure 9: Time Series of Fecal Coliform Levels San Diego Creek at Campus Drive (converted from measured E. coli concentrations)



Median fecal coliform concentrations presented in Table 21 may be used to evaluate the influence of the structural and non-structural BMPs. When all monitoring dataset is considered, the median fecal coliform concentrations are equivalent or increase from pre- to post-intervention conditions in all watersheds except the 1001 (intervention watershed) and 1003 (a control watershed). Based on the Mann-Whitney (rank-sum) test, the reduction in median concentrations in 1001 and 1003 is significantly significant at the 95% confidence level. Thus the watershed with the irrigation controllers corresponded to a significant reduction in median fecal coliform concentrations, in comparison to 2 of the 3 control sites, while the education only watershed exhibited no discernable reduction in median concentrations.

When subsets of the data with similar seasons and sampling times are considered (Table 21), there is a decrease in the median fecal coliform concentration in all watersheds except 1002. However, because of the smaller sample sizes, the decrease is median concentration is statistically significant only in watershed 1003. This suggests that there could be seasonal influences in the monitoring data, but the data are not sufficient to determine if there are statistically significant differences in the median concentrations.

5. References

IRWD, March 2003. Irvine Ranch Water District San Diego Creek Watershed Natural Treatment System Draft Master Plan.

OCPFRD, 2001. County of Orange Public Facilities and Resources Department, NPDE Annual Progress Report.

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RWQCB, 1995. Water Quality Control Plan, Santa Ana River Basin (8).

Schiff, K.C. and L.L.Tiefenthaler, June 2003. Contributions of organophosphorus pesticides from residential land uses during dry and wet weather. Technical Report 406, Southern California Coastal Water Research Project.

USEPA (Region 9), 1998a. *Total Maximum Daily Loads for Sediment and Monitoring and Implementation Recommendations; San Diego Creek and Newport Bay, California*

USEPA (Region 9), 1998b. *Total Maximum Daily Loads for Nutrients; San Diego Creek and Newport Bay, California*

USEPA, June 2002. Total Maximum Daily Loads for Toxic Pollutants – San Diego Creek and Newport Bay, California, June 14, 2002.

Tetra Tech, Inc., July 2000c. Newport Bay Watershed Urban Nutrient TMDL Compliance Evaluation.

Appendix A - Time-Series Plots

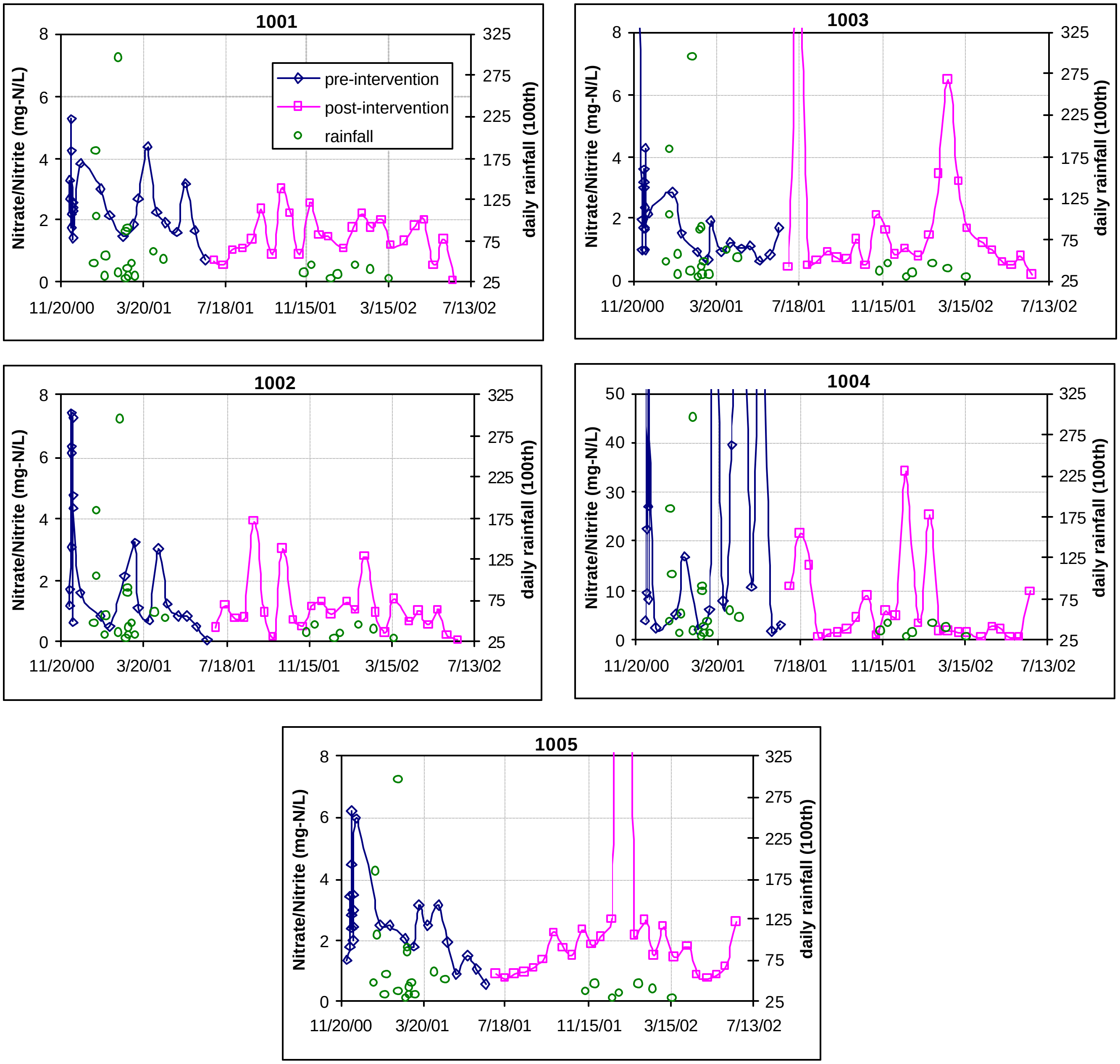


Figure A-1: Time Series of Nitrate/Nitrite in Dry Weather Samples (all data)

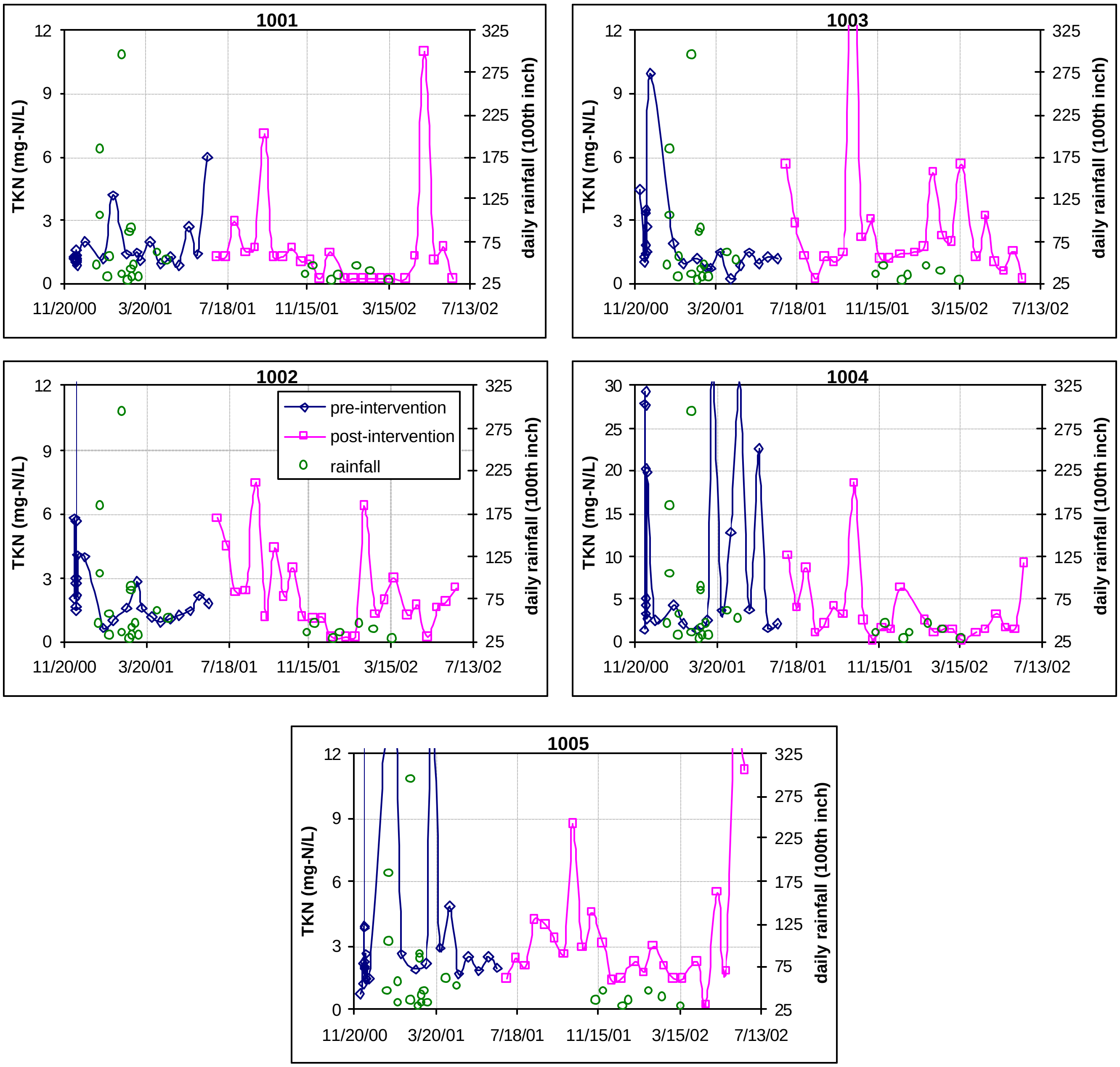


Figure A-2: Time Series of TKN in Dry Weather Samples (all data)

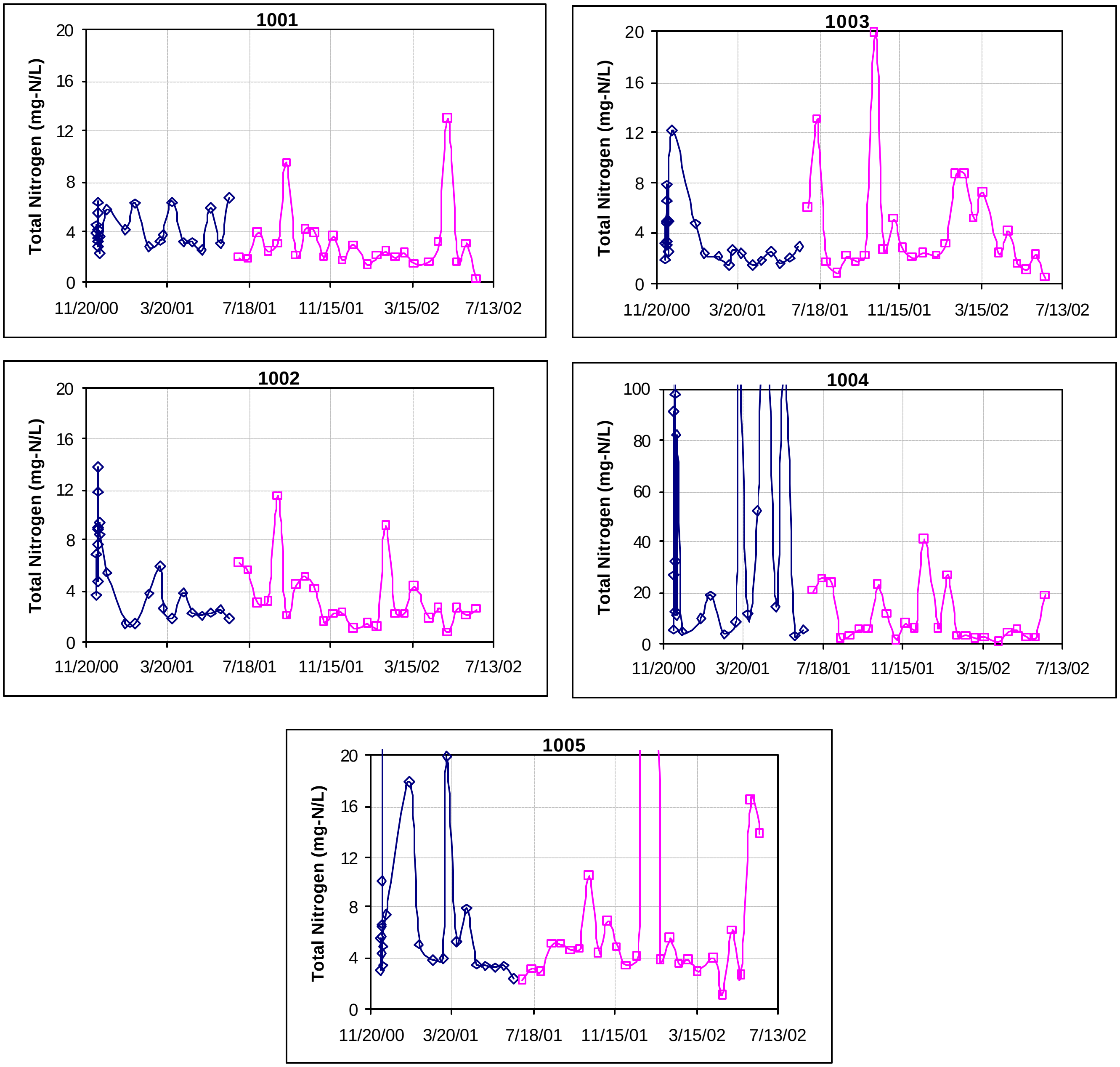


Figure A-3: Time Series of TN (Calculated) in Dry Weather Samples (all data)

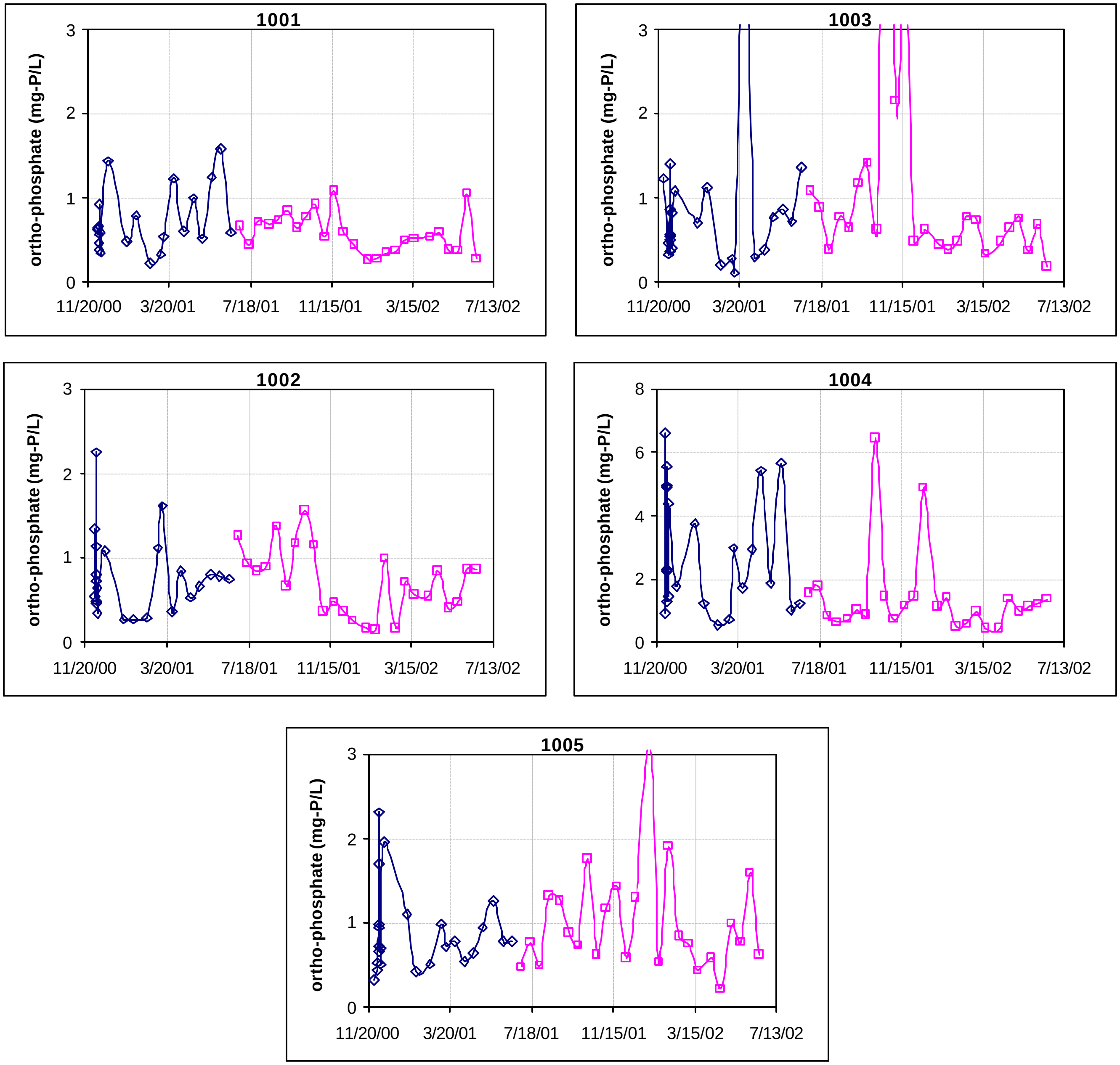


Figure A-4: Time Series of Ortho-Phosphate in Dry Weather Samples (all data)

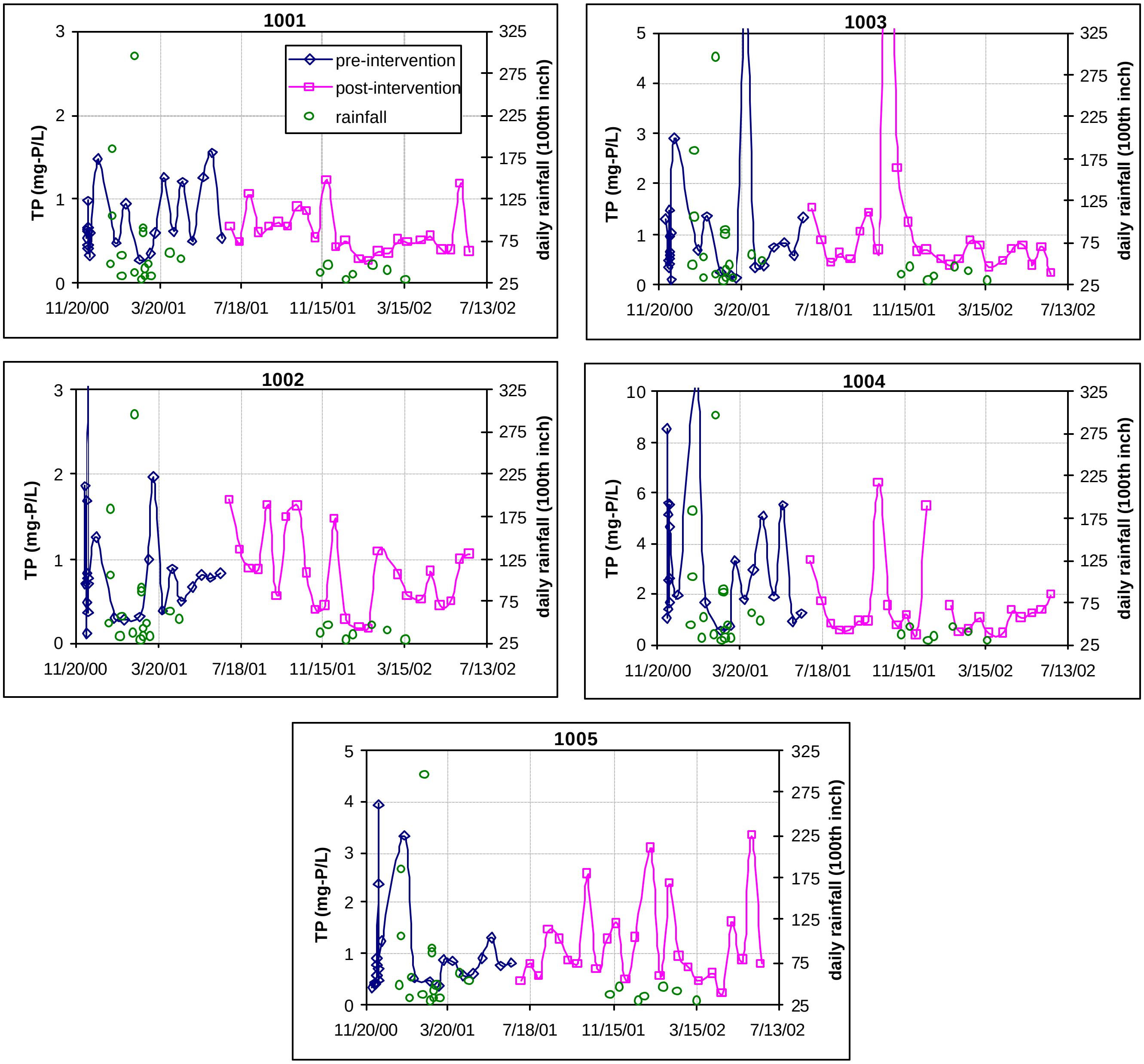


Figure A-5: Time Series of Total-Phosphorus in Dry Weather Samples (all data)

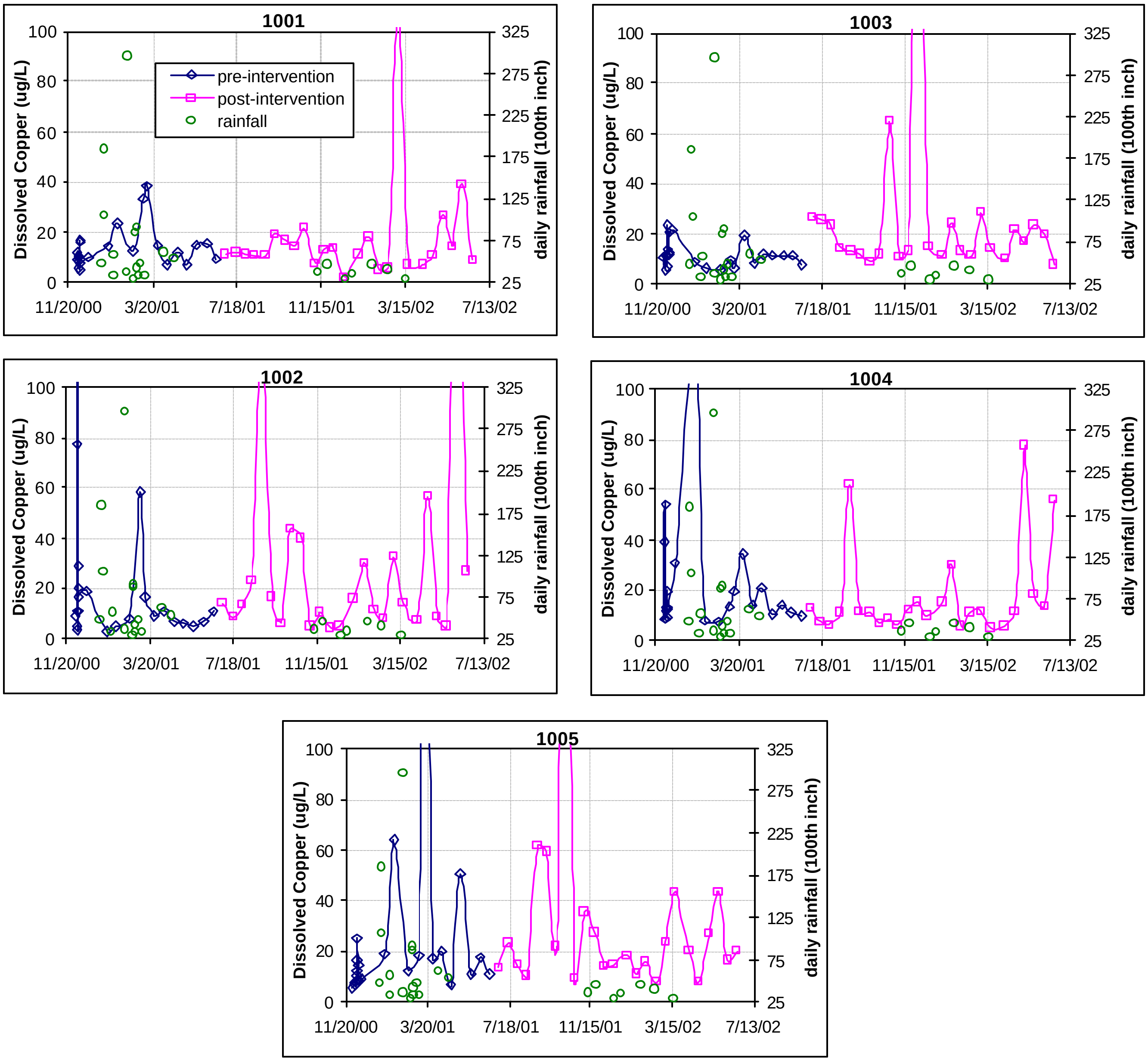


Figure A-6: Time Series of Dissolved Copper in Dry Weather Samples (all data)

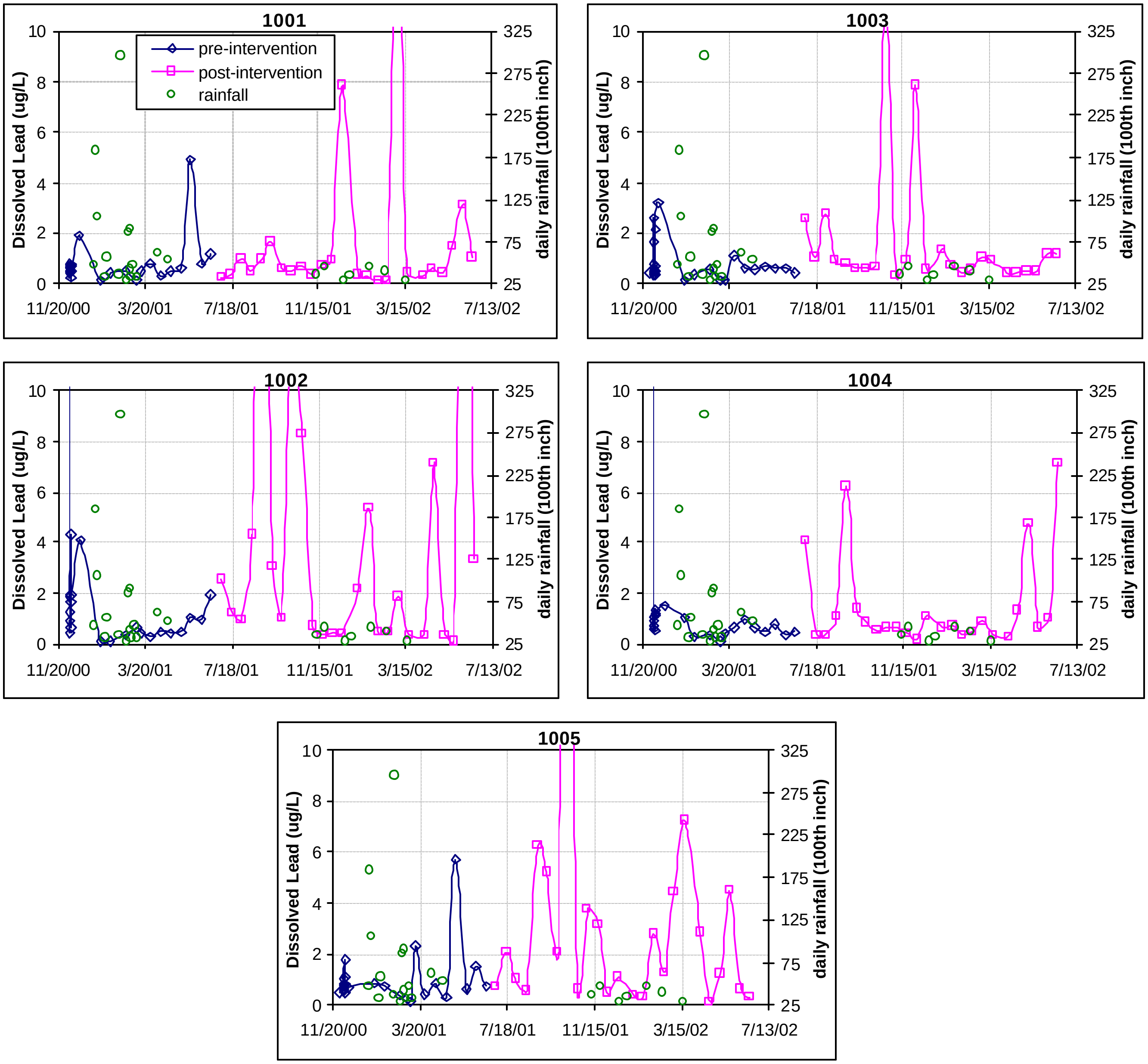


Figure A-7: Time Series of Dissolved Lead in Dry Weather Samples (all data)

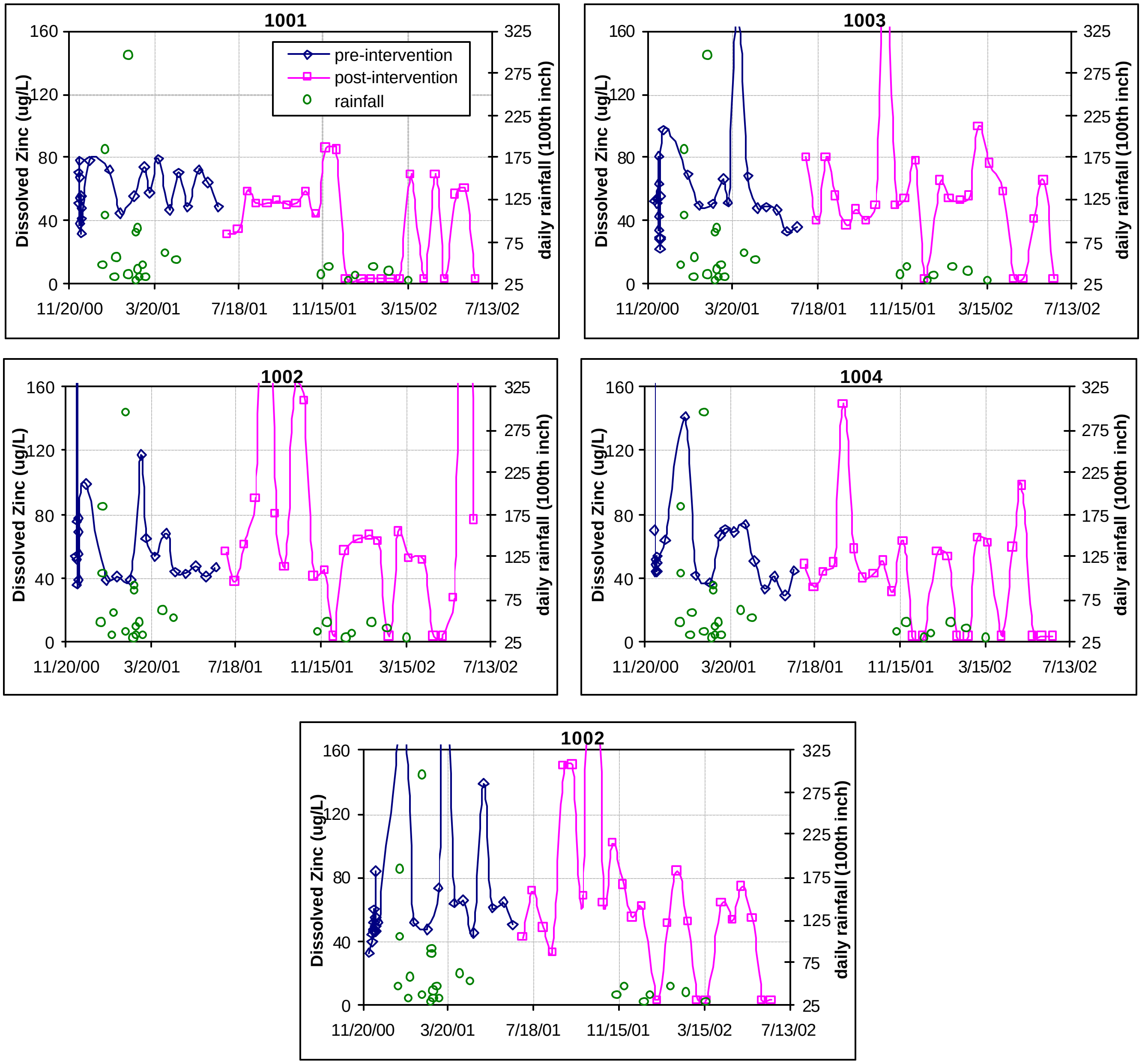
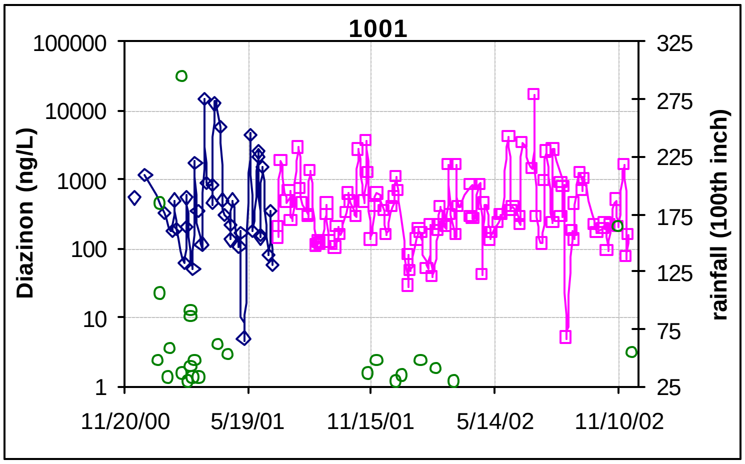
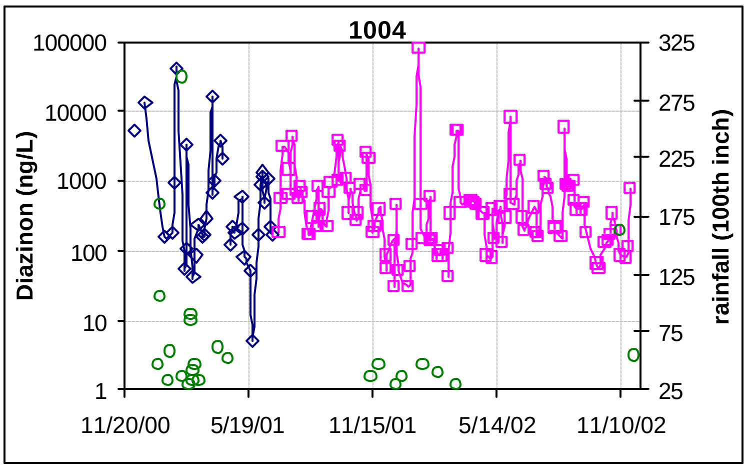


Figure A-8: Time Series of Dissolved Zinc in Dry Weather Samples (all data)





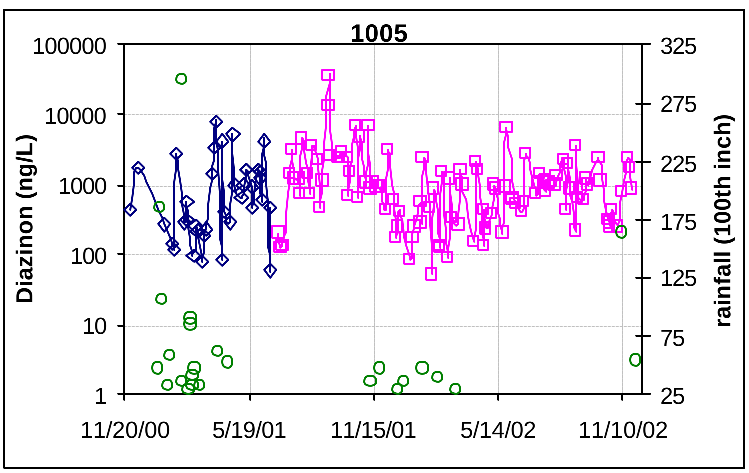


Figure A-9: Time Series of Diazinon in Dry Weather Samples (all data)

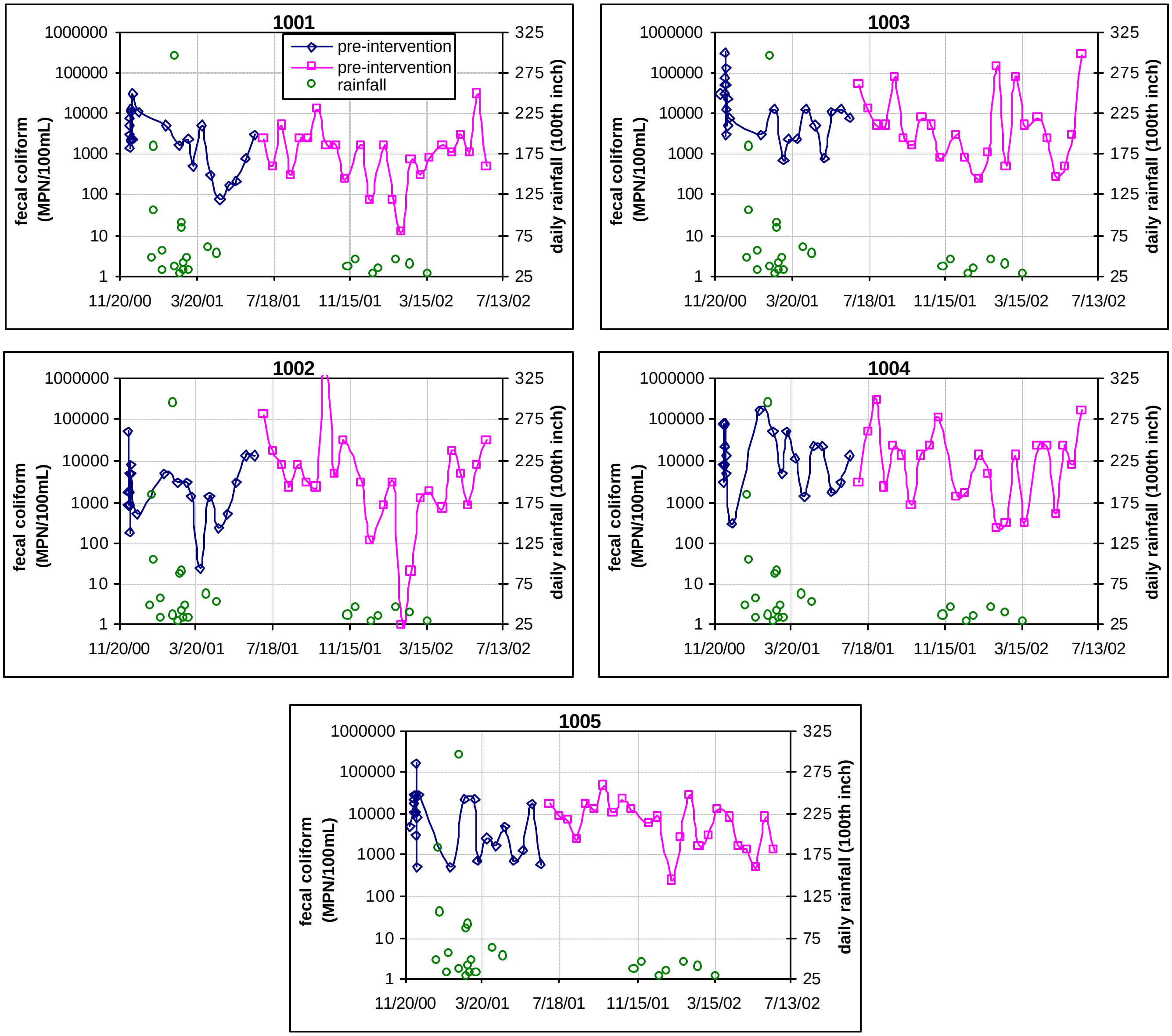


Figure A-10: Time Series of Fecal Coliform in Dry Weather Samples (all data)

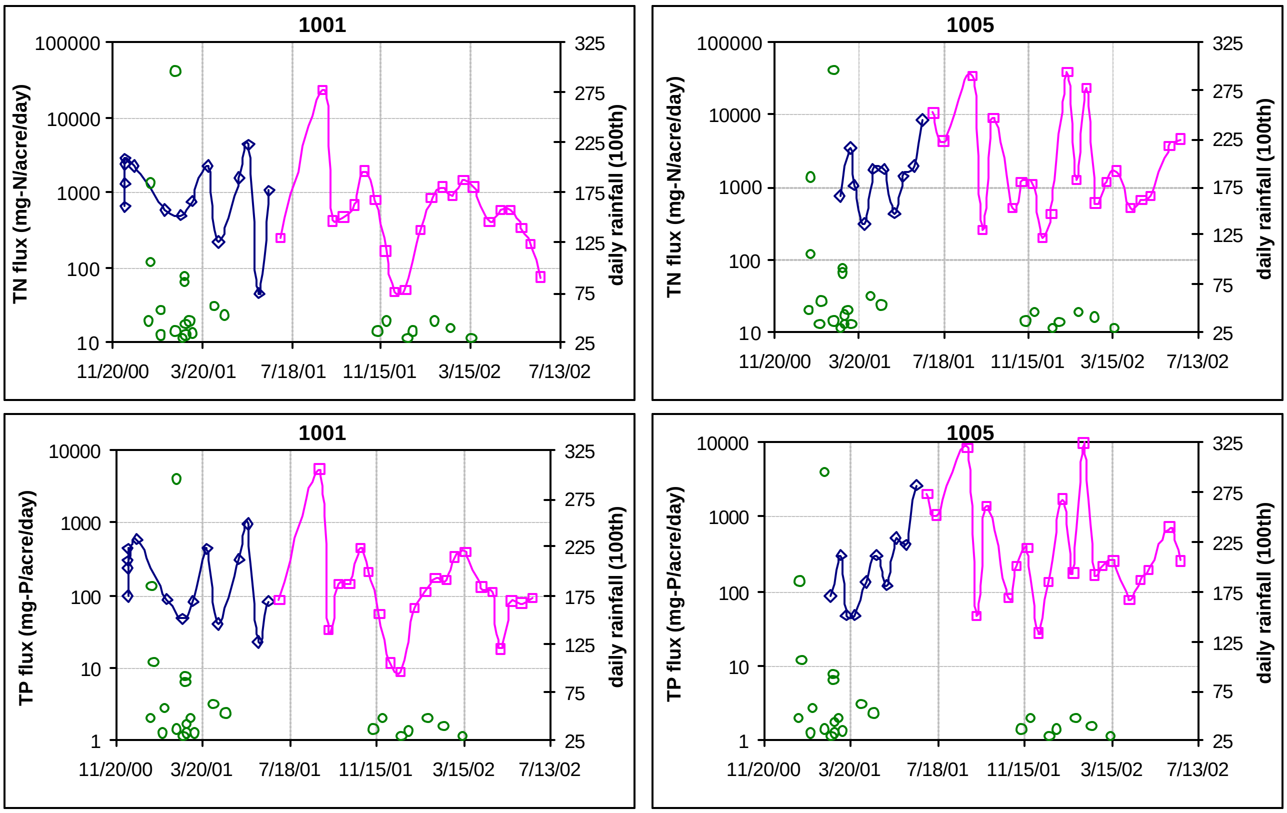


Figure A-11: Time Series of Nutrient Fluxes in Dry Weather Samples (all data)

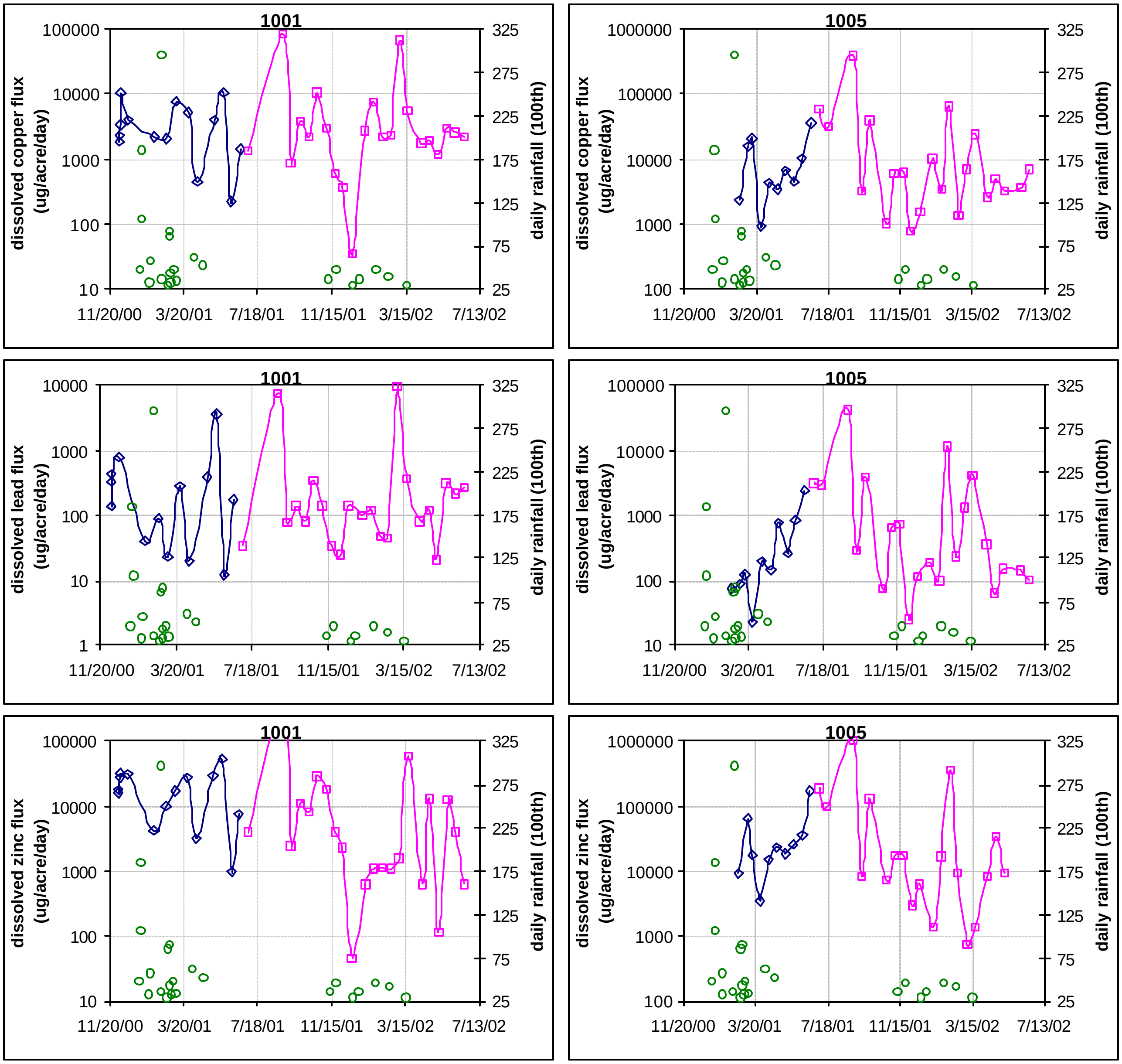


Figure A-12: Time Series of Dissolved Metal Fluxes in Dry Weather Samples (all data)

Appendix B – Summary Statistics

Table B-1: Descriptive Statistics

		1001		1002		1003		1004		1005	
Parameter	**Statistic**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
Nitrate/Nitrite as N	**n**	23	25	23	25	24	25	23	25	24	25
(mg-N/L)	**% > MDL/RL**	100%	96%	96%	96%	100%	100%	100%	100%	100%	100%
	Mean	2.56	1.47	2.57	1.07	2.13	1.71	36.50	6.61	2.61	4.13
	Median	2.32	1.38	1.56	0.93	1.68	0.94	16.88	2.29	2.45	1.48
	Trimmed mean	2.37	1.44	1.80	0.89	1.61	1.01	25.04	3.33	2.41	1.60
	min	0.74	0.05	0.05	0.05	0.65	0.20	1.70	0.60	0.54	0.73
	max	5.26	2.97	7.42	3.92	9.96	10.16	109.90	34.40	6.21	64.90
	25th percentile	1.81	1.05	0.82	0.53	0.98	0.64	5.62	1.43	1.79	0.96
	75th percentile	3.10	1.99	3.77	1.18	2.49	1.60	70.76	8.95	3.11	2.22
	St Dev	1.08	0.70	2.34	0.91	1.94	2.21	37.82	8.78	1.40	12.68
	IQR	1.29	0.94	2.95	0.65	1.51	0.96	65.14	7.52	1.32	1.26
	Skewness, gs	0.84	0.14	1.00	1.89	3.11	2.96	0.76	2.01	1.19	4.98
	gcr	0.96	0.92	0.96	0.92	0.94	0.92	0.96	0.92	0.94	0.92
	symmetric?	Y	Y	N	N	N	N	Y	N	N	N
TKN	**n**	23	25	23	25	24	25	23	24	24	25
(mg-N/L)	**% > MDL/RL**	100%	64%	100%	84%	96%	92%	96%	92%	100%	96%
	Mean	1.68	1.63	2.74	2.37	1.97	2.71	11.50	3.72	4.08	3.61
	Median	1.27	1.21	1.78	1.90	1.38	1.46	4.26	1.91	2.23	2.39
	Trimmed mean	1.29	0.77	1.95	1.87	1.40	1.69	7.51	2.23	2.29	2.57
	min	0.88	0.25	0.68	0.25	0.25	0.25	1.44	0.25	0.76	0.25
	max	6.02	11.00	13.20	7.48	9.97	18.60	31.81	18.60	17.43	15.30
	25th percentile	1.13	0.25	1.33	1.13	1.01	1.20	2.55	1.41	1.88	1.71
	75th percentile	1.57	1.46	2.86	2.98	1.85	2.87	21.46	4.03	3.15	4.01
	St Dev	1.19	2.40	2.68	1.96	1.97	3.64	11.61	4.21	4.90	3.41
	IQR	0.44	1.21	1.53	1.85	0.84	1.67	18.90	2.62	1.26	2.30
	Skewness	2.84	3.16	3.00	1.23	3.24	3.77	0.75	2.31	2.29	2.34
	Gcr	0.96	0.92	0.96	0.92	0.94	0.92	0.96	0.92	0.94	0.92
	symmetric?	N	N	N	N	N	N	Y	N	N	N
Ammonia as N	**n**	23	25	23	25	24	25	23	24	24	25

Parameter	Statistic	1001 Pre	1001 Post	1002 Pre	1002 Post	1003 Pre	1003 Post	1004 Pre	1004 Post	1005 Pre	1005 Post
(mg-N/L)	% > MDL/RL	30%	20%	74%	64%	75%	52%	87%	71%	92%	96%
	Mean	0.13	0.08	0.25	0.42	0.26	0.29	7.05	0.25	0.85	0.42
	Median	0.05	0.05	0.18	0.20	0.17	0.10	0.71	0.14	0.43	0.22
	Trimmed mean	0.05	0.05	0.19	0.13	0.19	0.11	3.43	0.12	0.50	0.24
	min	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	max	1.12	0.36	0.90	5.45	1.06	2.29	26.34	2.03	6.92	2.41
	25th percentile	0.05	0.05	0.08	0.05	0.09	0.05	0.24	0.05	0.24	0.15
	75th percentile	0.12	0.05	0.30	0.28	0.29	0.36	13.69	0.28	0.94	0.42
	St Dev	0.23	0.07	0.22	1.06	0.26	0.48	9.14	0.40	1.39	0.50
	IQR	0.07	0.00	0.22	0.23	0.20	0.31	13.45	0.23	0.70	0.27
	Skewness	4.04	3.08	1.66	4.78	1.98	3.40	0.93	4.09	3.95	3.01
	gcr	0.96	0.92	0.96	0.92	0.94	0.92	0.96	0.92	0.94	0.92
	symmetric?	N	N	N	N	N	N	Y	N	N	N
TN (calculated)	n	23	25	23	25	23	25	23	25	23	25
(mg-N/L)	% > MDL/RL	100%	80%	98%	90%	98%	96%	98%	96%	100%	98%
	Mean	4.24	3.09	5.31	3.44	3.66	4.42	48.00	10.18	6.89	7.74
	Median	3.84	2.27	3.95	2.55	2.66	2.50	19.01	5.57	5.06	4.36
	Trimmed mean	3.94	2.40	4.53	2.76	2.93	3.01	33.11	6.47	5.08	4.42
	min	2.30	0.30	1.50	0.78	1.46	0.45	3.28	0.74	2.48	1.07
	max	6.76	12.99	13.83	11.40	12.12	19.91	141.06	40.80	20.41	67.12
	25th percentile	3.20	1.79	2.27	2.10	2.11	2.04	9.05	2.71	3.52	3.47
	75th percentile	5.68	3.13	8.02	4.36	4.81	5.17	94.79	19.18	7.07	5.62
	St Dev	1.41	2.67	3.56	2.51	2.48	4.39	49.17	10.73	5.29	12.85
	IQR	2.48	1.34	5.75	2.26	2.70	3.13	85.74	16.47	3.55	2.15
	Skewness	0.55	2.82	0.84	1.87	2.13	2.27	0.74	1.37	1.88	4.46
	gcr	0.96	0.92	0.96	0.92	0.94	0.92	0.96	0.92	0.94	0.92
	symmetric?	Y	N	Y	N	N	N	Y	N	N	N
ortho-phosphate	n	23	25	23	25	24	25	23	25	24	25
(mg-P/L)	% > MDL/RL	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Mean	0.71	0.58	0.79	0.72	0.81	1.26	2.84	1.40	0.89	1.00
	Median	0.58	0.53	0.73	0.72	0.64	0.64	2.23	1.10	0.76	0.77
	Trimmed mean	0.60	0.56	0.69	0.70	0.63	0.66	2.42	1.10	0.77	0.87
	min	0.23	0.26	0.28	0.15	0.11	0.19	0.52	0.43	0.33	0.22
	max	1.58	1.08	2.25	1.56	4.01	10.60	6.57	6.45	2.31	3.11
	25th percentile	0.47	0.38	0.48	0.41	0.38	0.47	1.25	0.75	0.55	0.59
	75th	0.86	0.72	0.96	0.93	0.92	0.89	4.63	1.42	0.98	1.29

Parameter	Statistic	1001 Pre	1001 Post	1002 Pre	1002 Post	1003 Pre	1003 Post	1004 Pre	1004 Post	1005 Pre	1005 Post
	percentile										
	St Dev	0.37	0.23	0.47	0.39	0.77	2.11	1.89	1.35	0.49	0.62
	IQR	0.39	0.34	0.48	0.52	0.54	0.42	3.38	0.67	0.44	0.70
	Skewness	1.13	0.60	1.55	0.32	3.27	4.03	0.60	3.03	1.66	1.79
	gcr	0.96	0.92	0.96	0.92	0.94	0.92	0.96	0.92	0.94	0.92
	symmetric?	N	Y	N	Y	N	N	Y	N	N	N
TP (mg-P/L)	n	23	25	23	25	24	25	23	24	24	25
	% > MDL/RL	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Mean	0.73	0.60	0.92	0.84	0.98	1.21	3.33	1.50	1.01	1.19
	Median	0.60	0.51	0.77	0.82	0.62	0.67	2.54	1.05	0.73	0.85
	Trimmed mean	0.61	0.53	0.72	0.77	0.65	0.68	2.73	1.06	0.72	0.95
	min	0.27	0.26	0.11	0.16	0.11	0.23	0.53	0.34	0.33	0.22
	max	1.55	1.22	3.65	1.69	6.18	11.70	10.37	6.38	3.92	3.32
	25th percentile	0.47	0.39	0.43	0.49	0.35	0.49	1.52	0.60	0.50	0.60
	75th percentile	0.97	0.67	0.94	1.08	1.08	0.87	5.11	1.55	0.91	1.46
	St Dev	0.38	0.27	0.77	0.47	1.26	2.23	2.58	1.51	0.92	0.83
	IQR	0.50	0.28	0.51	0.59	0.73	0.38	3.59	0.96	0.40	0.86
	Skewness	1.00	1.07	2.27	0.49	3.39	4.68	1.26	2.41	2.35	1.38
	gcr	0.96	0.92	0.96	0.92	0.94	0.92	0.96	0.92	0.94	0.92
	symmetric?	N	N	N	Y	N	N	N	N	N	N
Cadmium (ug/L)	n	23	25	23	25	24	25	23	25	24	25
	% > MDL/RL	61%	12%	61%	36%	38%	16%	74%	36%	38%	44%
	Mean	0.26	0.14	0.47	0.44	0.27	0.17	0.64	0.22	0.21	0.29
	Median	0.27	0.10	0.24	0.10	0.10	0.10	0.36	0.10	0.10	0.10
	Trimmed mean	0.20	0.10	0.20	0.12	0.12	0.10	0.33	0.12	0.12	0.15
	min	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
	max	0.56	0.79	3.40	3.50	1.77	0.92	4.54	1.22	0.92	1.89
	25th percentile	0.10	0.10	0.10	0.10	0.10	0.10	0.16	0.10	0.10	0.10
	75th percentile	0.39	0.10	0.40	0.26	0.26	0.10	0.42	0.23	0.25	0.45
	St Dev	0.15	0.15	0.78	0.79	0.37	0.20	1.15	0.25	0.20	0.37
	IQR	0.29	0.00	0.30	0.16	0.16	0.00	0.27	0.13	0.15	0.35
	Skewness	0.29	4.04	3.21	3.06	3.37	3.08	3.09	3.05	2.56	3.47
	gcr	0.96	0.92	0.96	0.92	0.94	0.92	0.96	0.92	0.94	0.92
	symmetric?	Y	N	N	N	N	N	N	N	N	N
Copper (ug/L)	n	23	25	23	25	24	25	23	25	24	25
	% > MDL/RL	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Mean	13.5	16.9	27.3	30.3	11.5	26.6	21.8	17.7	32.1	30.8
	Median	11.5	11.4	10.9	14.0	11.1	14.3	12.7	11.4	12.3	20.4

Parameter	Statistic	1001 Pre	1001 Post	1002 Pre	1002 Post	1003 Pre	1003 Post	1004 Pre	1004 Post	1005 Pre	1005 Post
	Trimmed mean	11.6	12.1	10.7	15.4	10.7	16.2	13.9	11.3	13.2	19.8
	min	5.2	1.9	3.2	4.6	5.6	7.2	7.3	5.1	5.4	7.9
	max	38.4	108.0	278.4	226.6	23.4	227.0	119.3	77.4	389.6	210.0
	25th percentile	8.4	8.8	6.2	8.0	8.0	11.6	10.0	7.5	8.7	14.2
	75th percentile	15.0	16.9	17.9	29.8	12.3	23.4	20.5	15.2	18.6	27.5
	St Dev	8.3	20.5	57.5	48.2	5.1	43.3	24.2	18.9	77.4	40.2
	IQR	6.7	8.1	11.8	21.8	4.2	11.8	10.5	7.7	9.9	13.3
	Skewness	1.9	4.0	4.1	3.3	1.1	4.5	3.3	2.3	4.7	4.0
	gcr	0.96	0.92	0.96	0.92	0.94	0.92	0.96	0.92	0.94	0.92
	symmetric?	N	N	N	N	N	N	N	N	N	N
Lead	n	23	25	23	25	24	25	23	25	24	25
(ug/L)	% > MDL/RL	91%	92%	91%	96%	88%	100%	96%	100%	96%	96%
	Mean	0.79	1.59	5.93	4.72	0.82	1.59	3.47	1.47	1.01	3.24
	Median	0.60	0.60	0.89	1.20	0.59	0.81	0.72	0.69	0.74	1.30
	Trimmed mean	0.57	0.62	0.94	1.65	0.56	0.81	0.77	0.76	0.72	1.79
	min	0.10	0.10	0.10	0.10	0.10	0.28	0.10	0.21	0.10	0.10
	max	4.91	14.90	81.70	30.87	3.19	10.90	37.74	7.16	5.70	28.10
	25th percentile	0.46	0.38	0.41	0.40	0.42	0.53	0.48	0.44	0.52	0.62
	75th percentile	0.74	0.97	1.91	4.30	0.71	1.14	1.13	1.09	0.92	3.77
	St Dev	0.97	3.18	17.63	8.10	0.79	2.46	9.19	1.91	1.11	5.56
	IQR	0.28	0.59	1.50	3.90	0.29	0.61	0.65	0.65	0.40	3.15
	Skewness	3.81	3.63	4.06	2.58	1.95	3.16	3.32	2.14	3.62	4.02
	gcr	0.96	0.92	0.96	0.92	0.94	0.92	0.96	0.92	0.94	0.92
	symmetric?	N	N	N	N	N	N	N	N	N	N
Zinc	n	23	25	23	25	24	25	23	25	24	25
(ug/L)	% > MDL/RL	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Mean	58.7	37.2	115.2	86.3	56.3	56.8	83.6	40.9	74.0	75.0
	Median	56.0	50.2	53.4	57.2	50.7	53.9	50.8	43.8	52.4	54.5
	Trimmed mean	58.6	26.4	54.2	57.6	51.2	53.1	53.2	27.7	54.5	58.3
	min	32.5	2.5	35.4	2.5	22.1	2.5	29.5	2.5	32.3	2.5
	max	79.2	86.2	1069.7	429.6	171.0	231.0	429.0	149.0	330.0	512.0
	25th percentile	48.1	2.5	41.7	40.4	40.9	40.2	43.3	2.5	46.9	42.8
	75th percentile	71.4	58.2	72.1	76.9	63.9	65.5	69.0	58.6	64.6	74.5
	St Dev	14.1	29.1	219.7	109.1	29.9	44.4	97.0	35.1	63.0	99.1
	IQR	23.2	55.7	30.4	36.5	23.0	25.3	25.7	56.1	17.7	31.7
	Skewness	-0.1	-0.1	4.1	2.6	2.6	2.4	3.0	1.1	3.4	3.8
	gcr	0.96	0.92	0.96	0.92	0.94	0.92	0.96	0.92	0.94	0.92

Parameter	Statistic	1001 Pre	1001 Post	1002 Pre	1002 Post	1003 Pre	1003 Post	1004 Pre	1004 Post	1005 Pre	1005 Post
	symmetric?	Y	Y	N	N	N	N	N	N	N	N
Diazinon	**n**	37	104					36	104	39	104
(ng/L)	**% > MDL/RL**	97%	99%					97%	100%	100%	100%
	Mean	1457	748					2694	1556	1295	1711
	Median	345	291					231	346	614	884
	Trimmed mean	420	352					442	369	783	902
	min	5	5					5	29	60	53
	max	14465	16590					41402	80969	7910	34838
	25th percentile	156.8	166.6					157.6	150.2	262.8	415.8
	75th percentile	890.4	641.6					1119.2	791.3	1601.5	1609.8
	St Dev	3140.5	1753.2					7505.6	7977.2	1655.4	3741.7
	IQR	733.6	475.0					961.6	641.1	1338.7	1194.0
	Skewness	3.4	7.5					4.4	9.8	2.3	7.2
	gcr	0.77	0.47					0.78	0.47	0.75	0.47
	symmetric?	N	N					N	N	N	N
Chlorpyrifos	**n**	37	104								
(ng/L)	**% > MDL/RL**	57%	40%								
	Mean	38.3	456.4								
	Median	25.0	10.0								
	Trimmed mean	18.9	10.0								
	min	5.0	5.0								
	max	213.7	45094.0								
	25th percentile	10.0	5.0								
	75th percentile	42.2	28.7								
	St Dev	51.1	4419.7								
	IQR	32.2	23.7								
	Skewness	2.5	10.2								
	gcr	0.77	0.47								
	symmetric?	N	N								

Appendix C – Probability Plot Comparisons

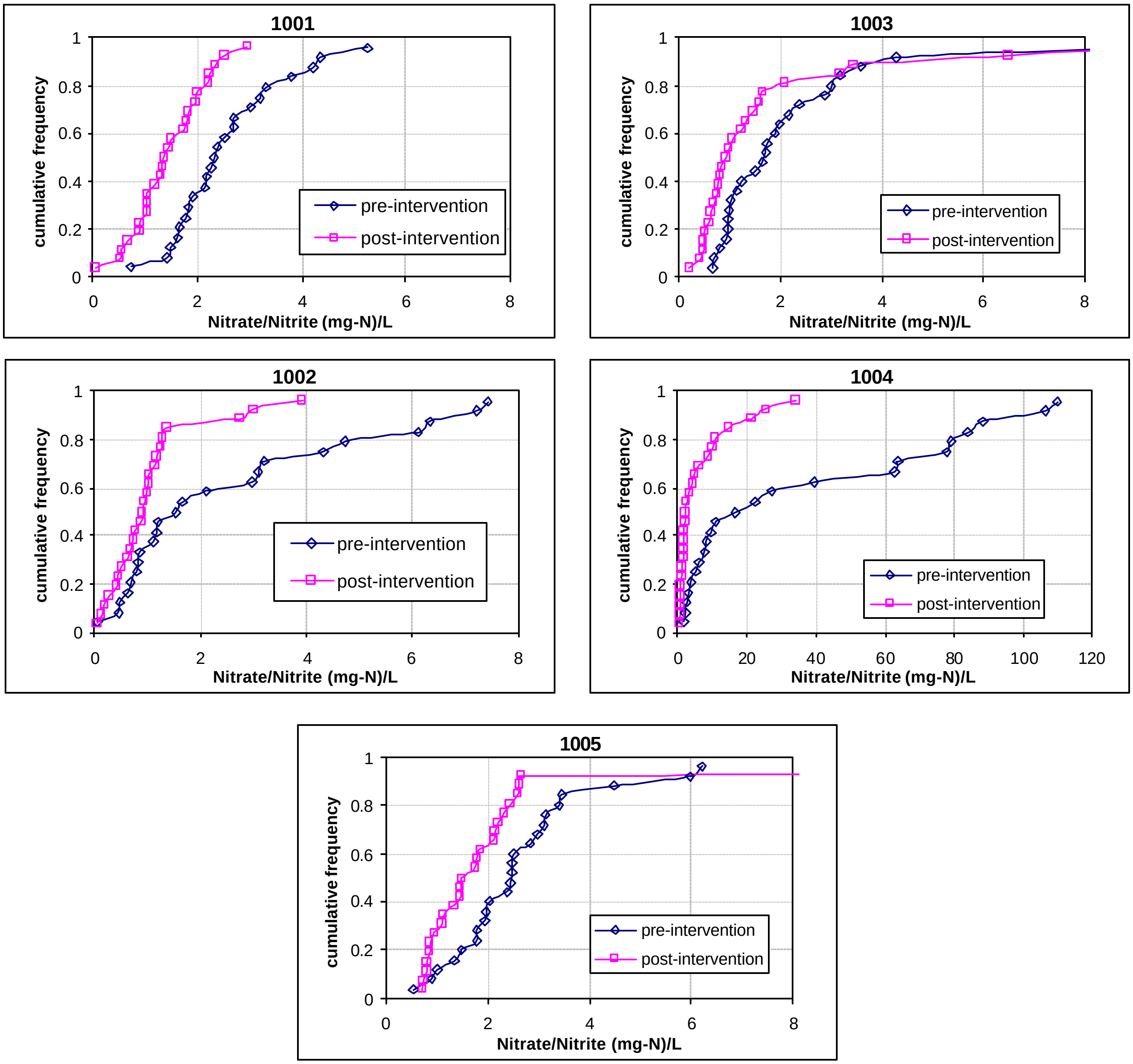


Figure C-1: Cumulative Frequency of Nitrate/Nitrite in Dry Weather Samples (all data)

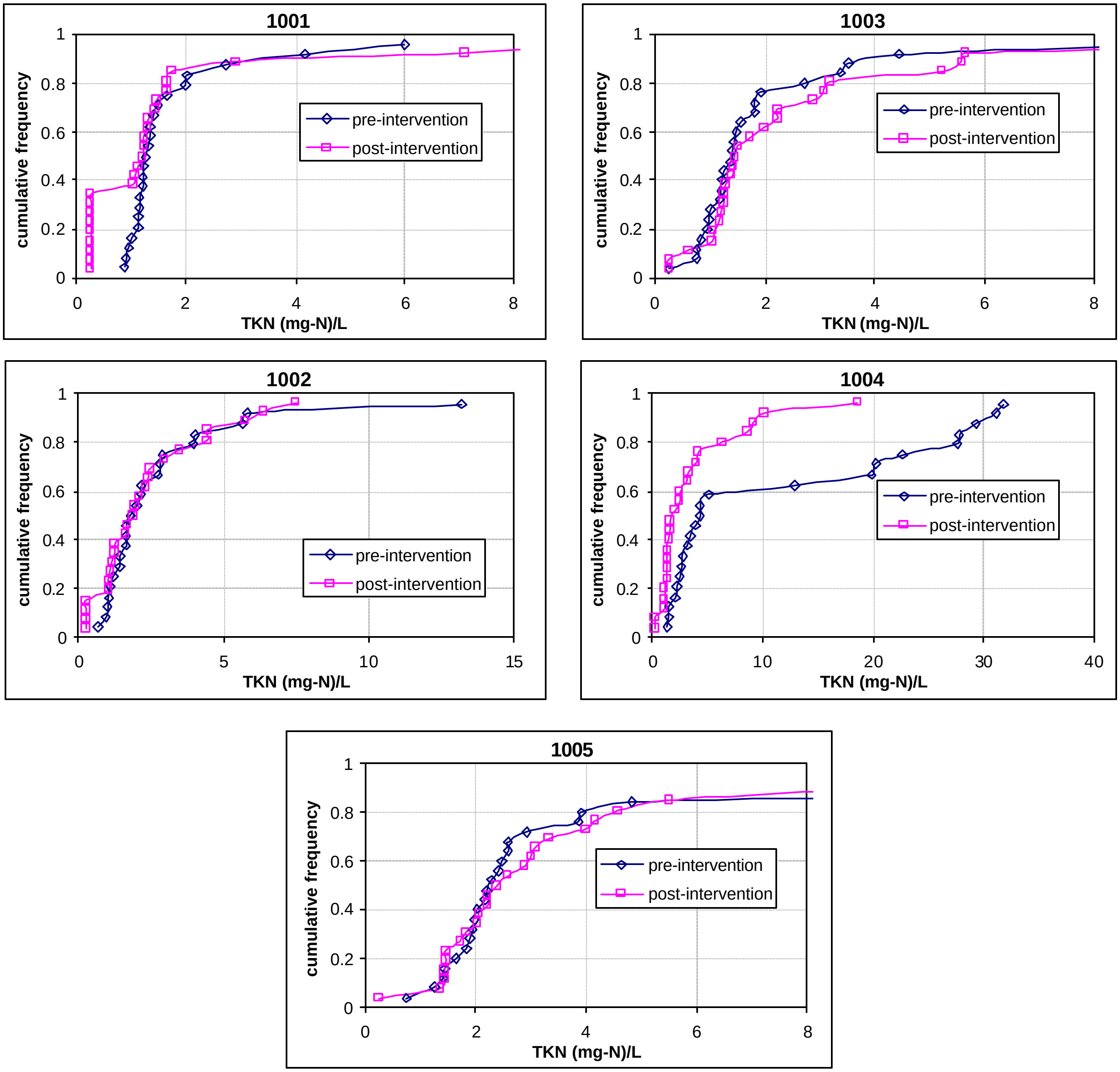
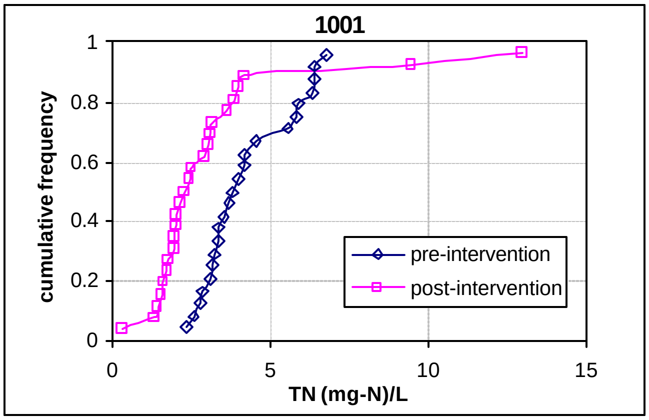
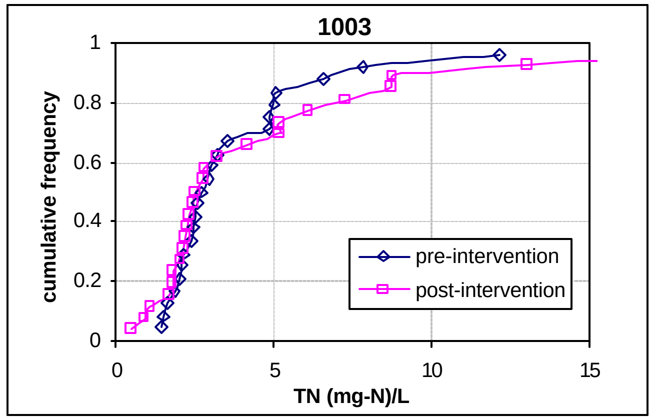
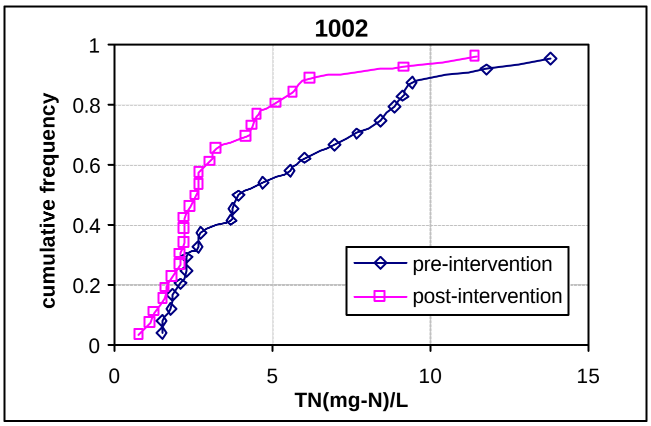
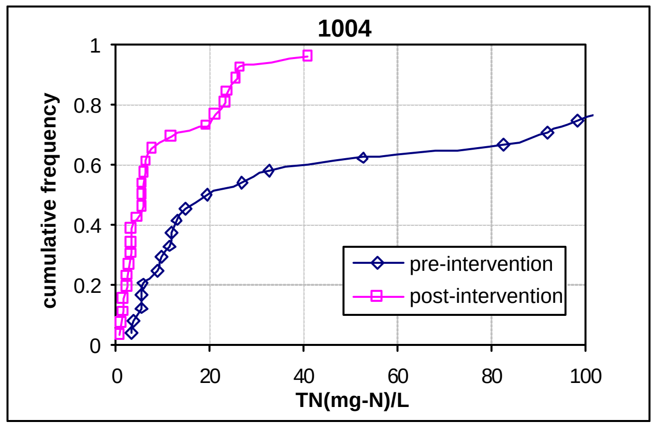


Figure C-2: Cumulative Distribution of TKN in Dry Weather Samples (all data)









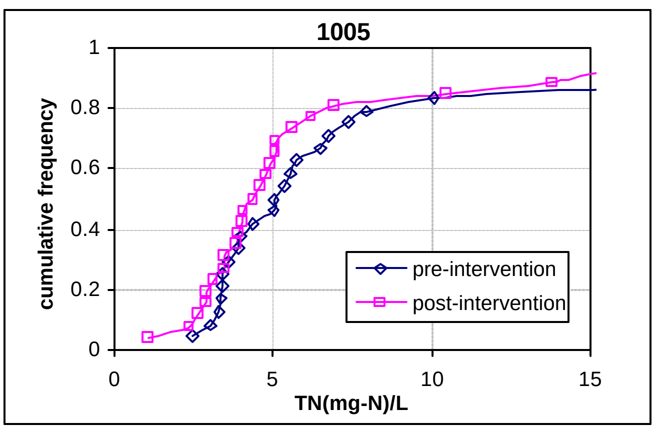


Figure C-3: Cumulative Distribution of TN (Calculated) in Dry Weather Samples (all data)

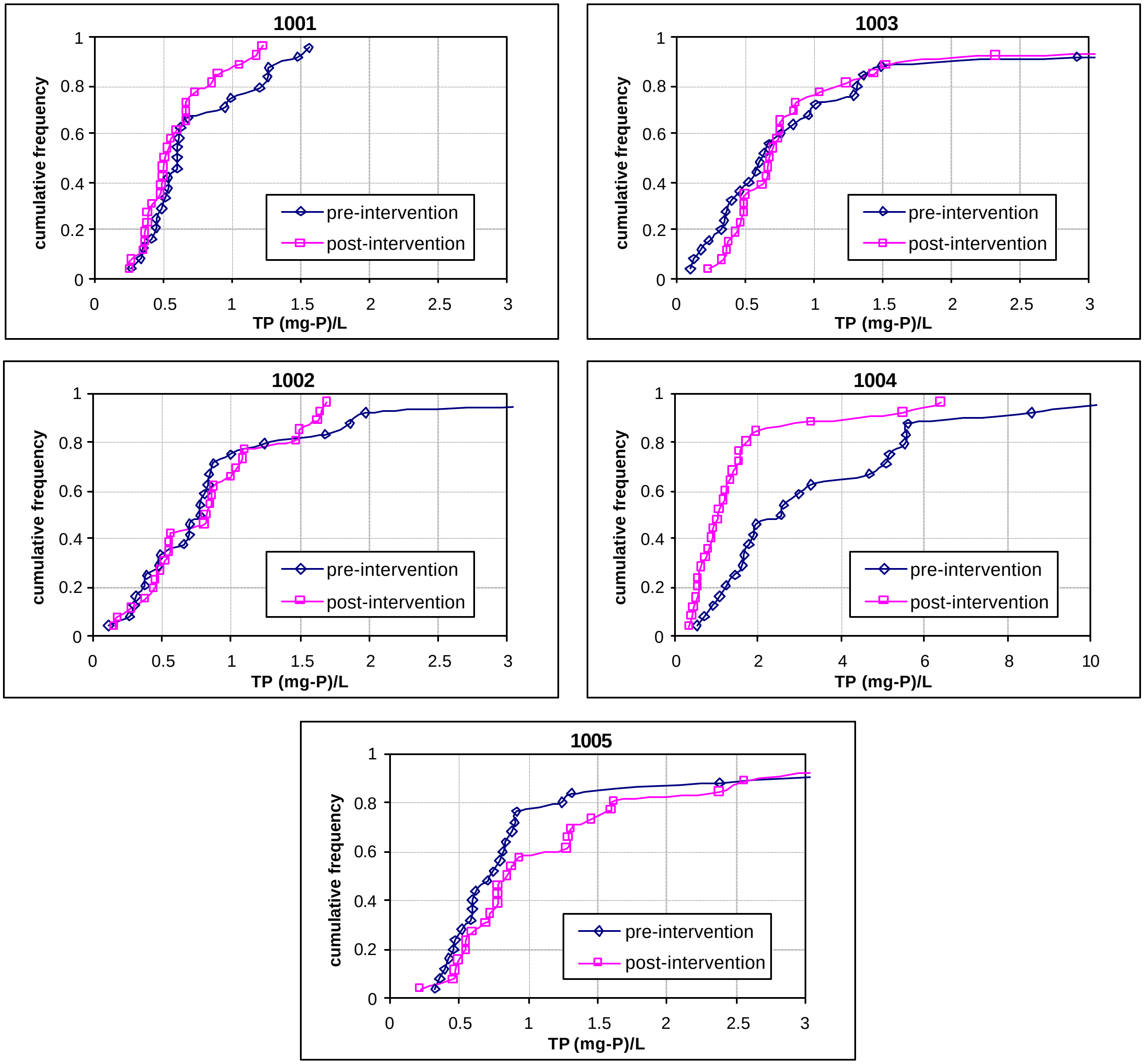


Figure C-4: Cumulative Distribution of TP in Dry Weather Samples (all data)

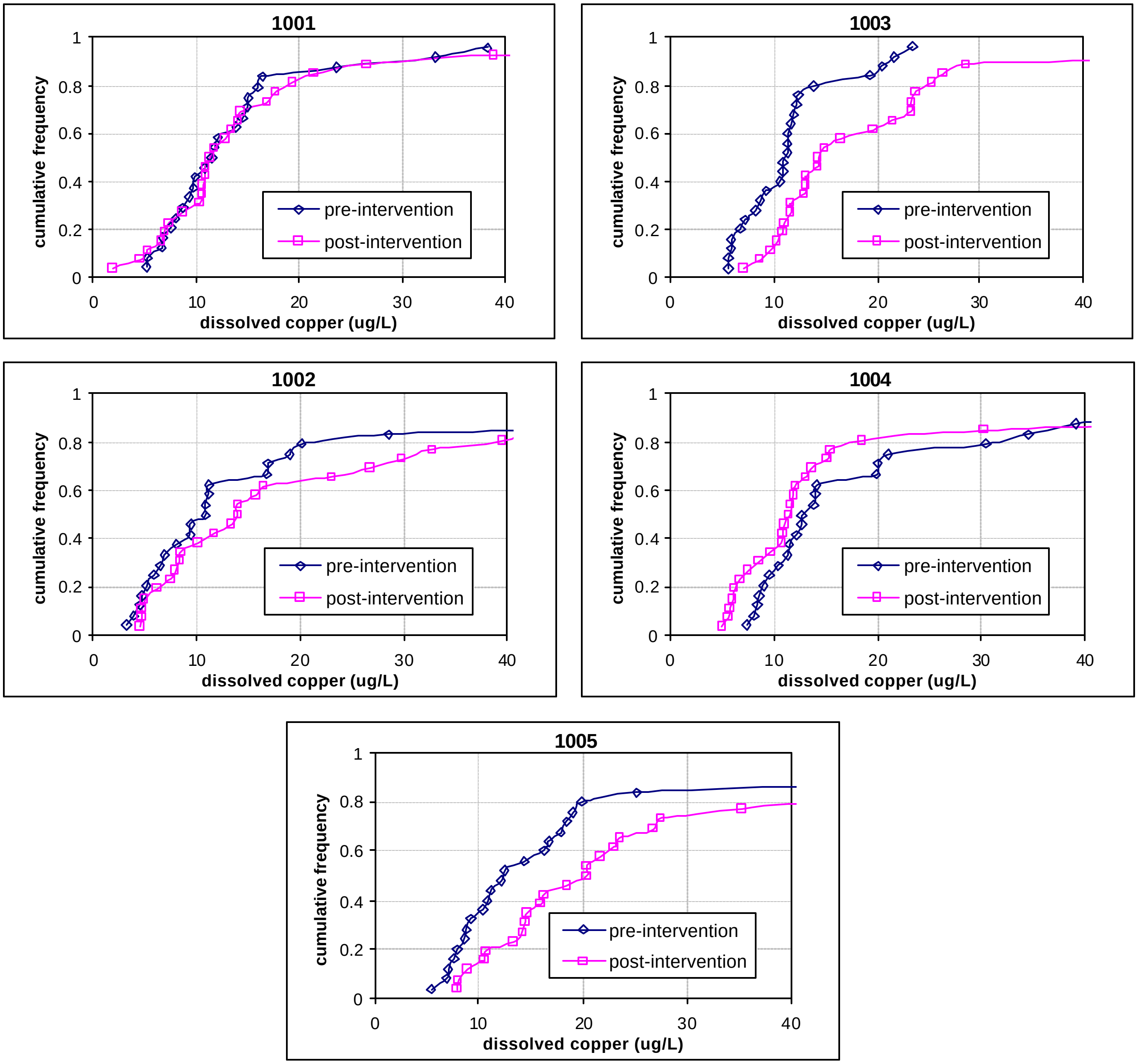


Figure C-5: Cumulative Distribution of Dissolved Copper in Dry Weather Samples (all data)

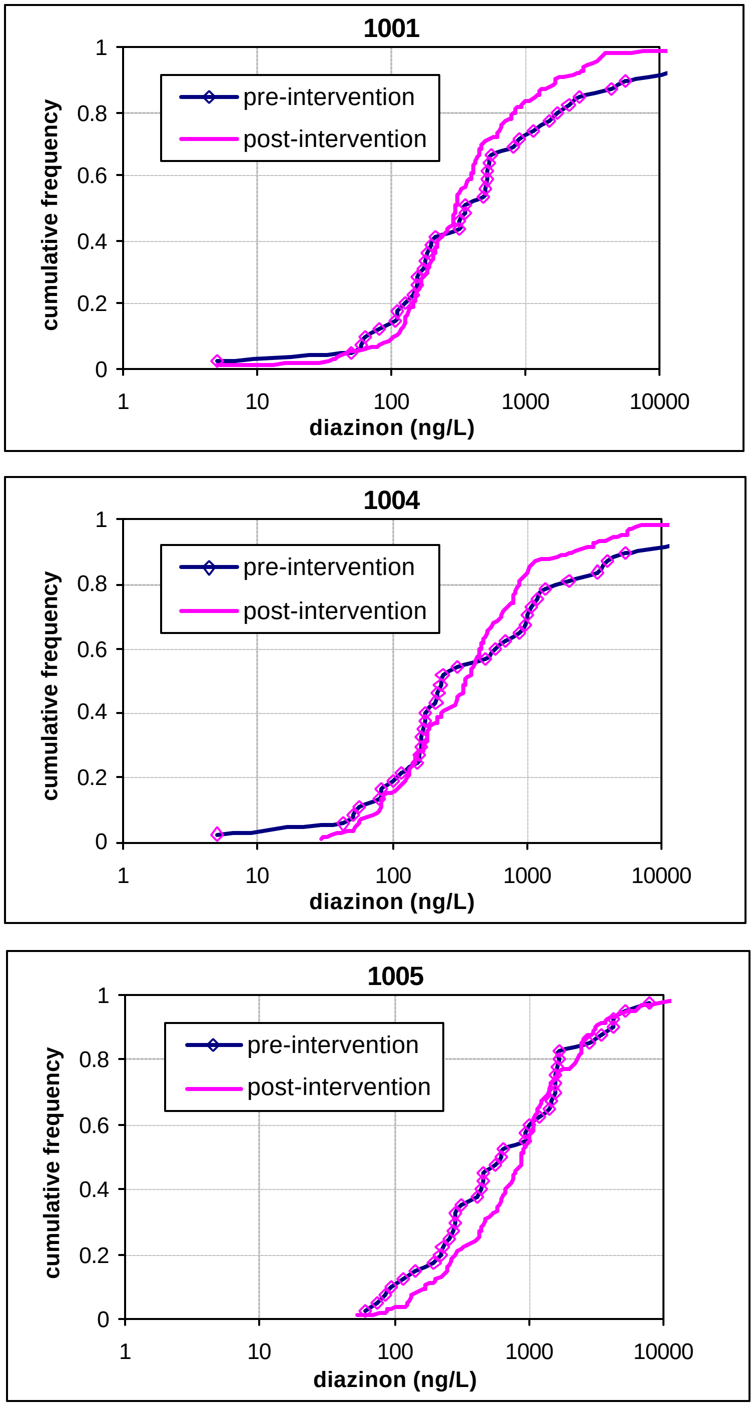


Figure C-6: Cumulative Distribution of Diazinon in Dry Weather Samples (all data)

Appendix F: Public Acceptance

The Residential Runoff Reduction Study

Appendix F: Public Acceptance

This appendix is divided into two parts. The first section describes the customer service program during the R3 Study time period and includes results of pre- and post-intervention surveys. The second part provides a representative sampling of public education materials distributed during the study. There were three groups of R3 study participants. The first group was the education group and the second group was the participants who had their home irrigation controllers replaced with an ET controller and lastly the control groups that received no treatment. The education group was self and randomly selected. Some of the education group participants voluntarily choose to participate in the study by replying to a letter. However, the majority of the education group was randomly selected through a door-to door campaign. The retrofit participants were selected through random "cold knocking" and through letter solicitations that explained the study.

Customer Interactions

ET Controller Installation Overview

ET Controllers were installed in two phases. The first phase was the installation of controllers at residences. The controllers were installed on the weekends between April and June 2001. The second phase of the installation process was the retrofit of City of Irvine and HOA sites. The retrofitted HOA sites watered the common areas of condominium and the City of Irvine sites watered the medians and streetscapes. Both of these two groups were all in the same watershed as the residential homes that were retrofitted. Initially, the time per installation was approximately one to one and one-half hours, depending on the number of valves. However, as the IRWD staff became familiar with the process, which most had never done before, the time dropped to approximately one-half hour.

Residential post-installation concerns and problems

Home residents were advised that if they had any problems with the controller or if the controller required any adjustments, they should call the water district for assistance. IRWD's customer service department telephone number was left on the ET controller on a sticker. All calls related to the ET controller were logged in separately and routed to the appropriate staff member for assistance. Table 1 presents a summary of calls received from residential residents during the R3 study period. Generally, there were four common types of calls: 1) customer misunderstanding ("no problem" category), 2) installation-related issues, 3) system flaws, and 4) ET controller malfunctions.

Table 1: Telephone Log Summary

April 2001	1	August 2001	13	December 2001	1	April 2002	2
May 2001	12	September 2001	4	January 2002	4	May 2002	3
June 2001	7	October 2001	5	February 2002	9	June 2002	6
July 2001	13	November 2001	3	March 2002	4	July 2002	2

The first type were calls where the customer had a misunderstanding on the way the ET controllers were supposed to operate. In this type of call there was a "problem, where no problem actually existed". A common example was when a resident called to say that the sprinklers were not turning on every night. The staff member would then explain to the resident that with proper irrigation management it is normal if the irrigation sprinklers do not turn on every night.

The second types of calls received were either related to programming or installation-related mistakes. These usually occurred when the installation staff entered an incorrect value in the programming process. In other cases, a landscape contractor for the City of Irvine or HOA sites had incorrectly programmed the controller. Both groups were instructed at the beginning of the study to call IRWD to meet with a staff member who would adjust the ET controller for them.

The third category of calls included problems that were a result of a lack of irrigation system maintenance or a flaw in the design of the system. These problems were the responsibility of the homeowner to fix and were not related to the actual malfunctioning of the ET controller. For example, a customer called customer service and said that his lawn was turning brown because it was not being watered correctly. A site visit by staff would discover that the controller was set correctly, but the problem was that overgrown plant material was interfering with the normal spray pattern of the nozzle. It was this obstruction by plant material that caused the brown spot and not the settings on the ET controller.

The fourth category of calls was related to the ET controller malfunctioning. The calls from study participants were that the controller had stopped responding and the display was frozen, incorrect date or time display, or a signal dropout caused by a faulty program version. If resetting the unit or resending the ET signal could not correct the problem, the ET controllers were often changed out with a new controller with the latest version of the program. City of Irvine and HOA controllers with older versions of the controller were upgraded by uploading a new version of the program from a device provided by the manufacturer.

Tracking of Water Consumption of the City of Irvine and HOA Sites

In addition to responding to CSR calls, weekly meter reads were incorporated into the study as part of irrigation water management in order to monitor each site for excessive water usage. One ET controller installed for selected City of Irvine street landscapes was able to cover a larger area than the same controller installed in a residence. In addition, each of the City of Irvine retrofit sites had dedicated landscape irrigation water. Because of this, it was easier to track weekly water consumption of 18 meters instead of monitoring 112 residential meters. Weekly meter reads was a convenient way for staff to monitor water usage and to evaluate the performance of the ET controllers. Study staff periodically met with City of Irvine landscape staff to discuss the condition of the landscape and to discuss any other concerns. The landscape supervisor said that the appearance of the landscapes with the ET controllers were equal to similar city sites that did not have the ET controller.

One of the advantages of the ET controller is that it was able to receive a new ET signal if there was an unexpected change in weather conditions after a weekly signal had already been sent out. The controllers were grouped by water district zone, ET zone, and Zip code. Changes in weather conditions warranted staff to either increase the ETo or decrease the ET_o. During the rainy weeks, a signal would be sent to the all of the controllers that would pause the watering schedule for the appropriate number of days, this was referred to as a “rain pause signal”. Additionally, the controllers had a feature that allowed each valve to be micro-managed without having to adjust the entire watering schedule.

City of Irvine and Home Owner Associations

There are numerous benefits that can result from the installation of the ET controllers in a City environment as a water management tool. Costs that are associated with maintaining a city streetscape are labor hours and equipment. During the rainy season, city staff shuts off irrigation controllers for a given number of days that is determined by the amount of rainfall. This process is completed by manually having a city employee drive to each controller and turn the controllers off. This can be a very time intensive activity. In comparison the ET controllers are able to receive a rain pause signal and all the controllers in an area can be turned off within minutes. Hence, the ET controller can provide potential savings in labor and equipment required for programming each individual controller. It eliminates the guesswork as to whether or not to turn off the controllers. This savings in time and labor can be very substantial when the system needs to be shut down and then turned back on due to rain. With this system the city can allocate their resources more efficiently by focusing on landscape system maintenance instead of spending time on those tasks that can be performed with the ET controller technology. In addition, city staff will be able to cover a larger area. The water management features of the technology can maintain healthy landscapes and can help the city avoid penalty charges.

City and HOA controllers could be installed during regular business hours and no overtime was required for staff. These two groups were flexible about the installation times. In future programs or implementation of this technology it may be possible to train the local landscaper or contractor to install and monitor the controller. Monitoring the controller includes inspections of the irrigated area and meter reads. The local landscapers are probably the most familiar with irrigation controllers and could be cost effective to have them install the ET controller.

Customer Surveys

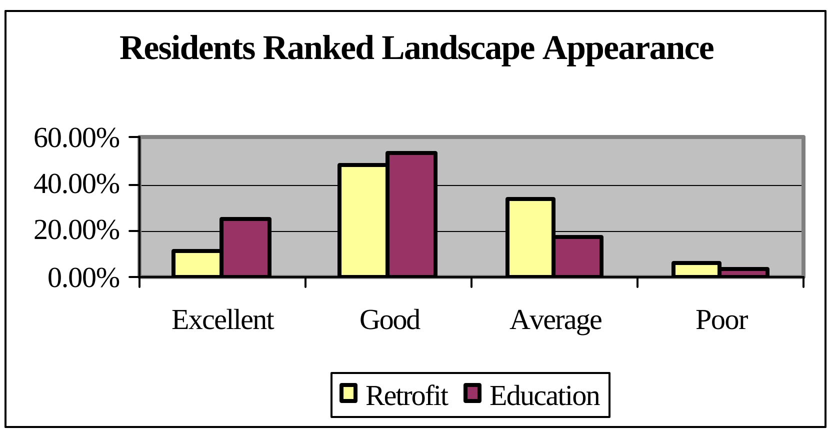
Pre-Survey Goal

The purpose of the pre-survey was to determine if the retrofit group and the education had similar irrigation practices and attitudes.

Survey Distribution

The pre-survey was distributed to the retrofit group while installation of the controller was taking place. Retrofit study participants were asked to fill-out the survey while staff was installing the controller. The education group received their survey as part of the initial educational packet that was randomly distributed to residents. Education group participants were provided a stamped addressed envelope to return their survey to the Irvine Ranch Water District. Ninety-seven (109/112) percent of those that received a survey from the retrofit group mailed the survey back. Twenty-four percent (53/225) of residents in the education group mailed back a survey.

Figure 1: Landscape Appearance

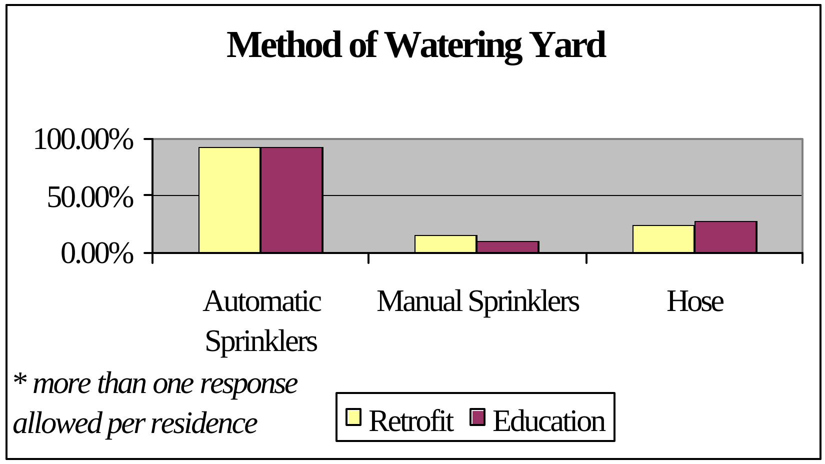


Selected Responses

A look at Figure 1 to the right shows the responses of both of the groups. Both groups gave similar responses. A majority of the residents in both groups believe that the appearance of the yard is average to good. Notice that the "excellent" response was selected by more of the education group that the retrofit group. One possible explanation for this response is that the staff was on-site while people were filling out their survey in the retrofit group.

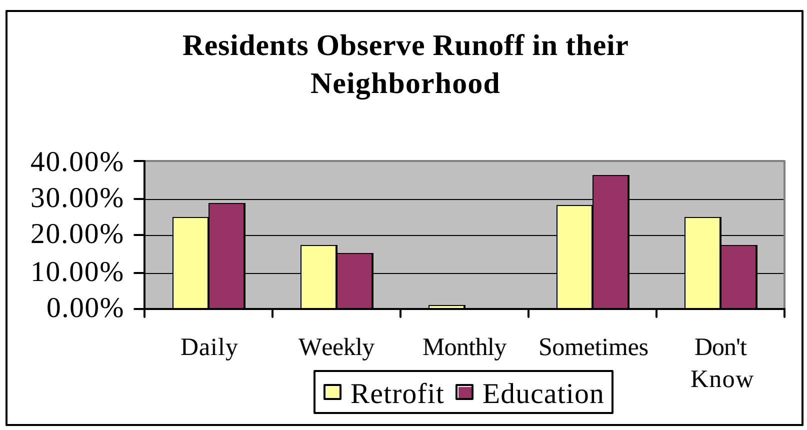
Residents were asked how they watered their lawn. Figure 2 shows responses across groups were very similar. The percentage of people in the retrofit and education group that use automatic sprinklers, manual sprinklers, or a hose are similar. The survey shows that the retrofit and education groups have similar watering behaviors. A majority of the participants used automatic sprinklers. This is important because the R3 study focuses on retrofitting the automatic irrigation controllers as a water management tool.

Figure 2: Watering Methods



Residents were asked how often they observed runoff in their neighborhood. The data presented in Figure 3 shows that residents in both groups have similar attitudes and views of urban runoff.

Figure 3: Runoff Observed



Residents were asked if they used fertilizers in their landscape. As shown Figure 4 at right, fertilizer use in both groups is almost the same. Their behavior when it comes to applying fertilizers is also the same.

Figure 4: Use of Fertilizers

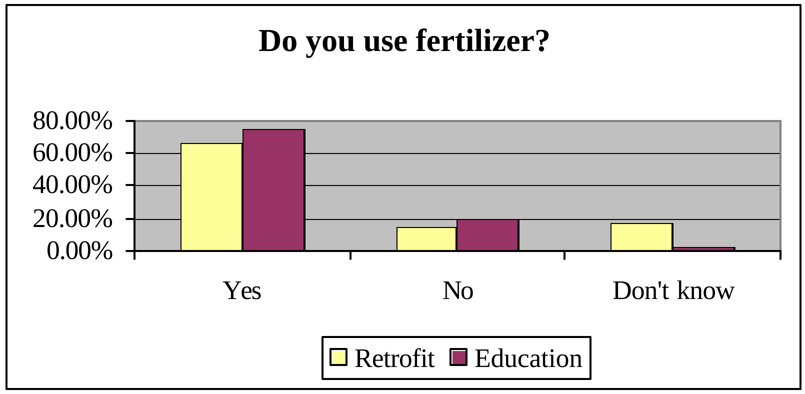


Figure 5: Use of Chemicals

Residents were also asked if they used chemicals to control pests or weeds in their yard. Figure 5 shows their responses.

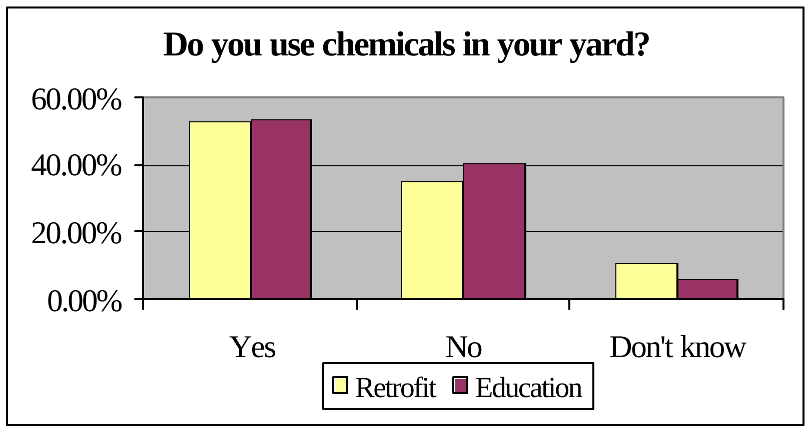


Table 2: Pre-Survey Responses

R3 Study Pre-Survey Results		
	Retro	Education
Who is responsible for yard maintenance at your home?		
Adult	68.81%	76.92%
Children	3.67%	3.85%
Yard Service	49.54%	40.38%
How is your yard watered?		
Automatic Sprinklers	92.66%	92.31%
Manual Sprinklers	14.68%	9.62%
Hose	23.85%	26.92%
How often is your yard watered?		
Summer- Days Per Week	RV	RV
Summer-Minutes Per Day	RV	RV
Summer-Don't Know	10.09%	5.77%
Winter - Days Per Week	RV	RV
Winter - Minutes Per Day	RV	RV
Winter-Don't Know	10.09%	9.62%
Controller Times Changed	RV	RV
How often do you see water runoff in your neighborhood?		
Runoff in Neighborhood-Daily	24.77%	28.85%
Runoff in Neighborhood-Weekly	17.43%	15.38%
Runoff in Neighborhood-Monthly	0.92%	0.00%
Runoff in Neighborhood-Sometimes	28.44%	36.54%
Runoff in Neighborhood-Don't Know	24.77%	17.31%
How often are patios, sidewalks, and driveways cleaned at your home?		
Driveways are cleaned-Daily	0.00%	1.92%
Driveways are cleaned-Weekly	39.45%	40.38%
Driveways are cleaned-Monthly	24.77%	21.15%
Driveways are cleaned-Sometimes	33.03%	34.62%
Driveways are cleaned-Other	RV	RV
How do you clean driveways	RV	RV
Who is responsible for pest and weed control in your yard?		
I am - Responsible for Weed/Pest Control	59.63%	67.31%
Yard Service- Responsible for Weed/Pest Control	30.28%	17.31%
Pest Control Service - Responsible for Weed/Pest Control	15.60%	25.00%
Dont Use Weed or Pest Control Service	6.42%	11.54%
Other - Responsible for Weed/Pest Control	0.00%	0.00%
Do you use chemicals to control pests or weeds in your yard?		
Chemicals are used to control pests/weeds	53.21%	53.85%
Chemicals are not used to control pests/weeds	34.86%	40.38%
Don't know if chemicals are used	11.01%	5.77%
Chemicals used are	RV	RV
Chemicals used, How often?	RV	RV

Do you use fertilizer in your yard?		
Fertilizer is used	66.06%	75.00%
Fertilizer is NOT used	14.68%	19.23%
Don't know if fertilizer is used	16.51%	1.92%
If Fertilizer used, which ones?	RV	RV
If Fertilizer used,how often?	RV	RV
Who is responsible for dispocal of unused landscape chemicals?		
I am - Responsible for disposal of unused chems	48.62%	63.46%
Pest Control - Responsible for disposal of unused chems	8.26%	5.77%
Yard Service - Responsible for disposal of unused chems	0.00%	0.00%
Don't know who - Responsible for disposal of unused chems	11.93%	7.69%
How are chems disposed of?	RV	RV
Rank the overall appearance of your yard?		
Appearance of yard-Excellent	11.93%	25.00%
Appearance of yard-Good	48.62%	53.85%
Appearance of yard-Average	33.94%	17.31%
Appearance of yard-Poor	6.42%	3.85%
Appearance of yard-Very Poor	0.00%	0.00%
How serious do you consider urban ruoff?		
Neighborhood Urban Runoff = Very Serious	6.42%	15.38%
Neighborhood Urban Runoff = Serious	16.51%	17.31%
Neighborhood Urban Runoff = Needs Improvement	46.79%	38.46%
Neighborhood Urban Runoff = No Problem	22.02%	23.08%
Irvine Urban Runoff = Very Serious	5.50%	15.38%
Irvine Urban Runoff = Serious	15.60%	11.54%
Irvine Urban Runoff = Needs Improvement	39.45%	42.31%
Irvine Urban Runoff = No Problem	18.35%	11.54%
Orange Co Urban Runoff = Very Serious	7.34%	15.38%
Orange Co Urban Runoff = Serious	21.10%	25.00%
Orange Co Urban Runoff = Needs Improvement	44.95%	34.62%
Orange Co Urban Runoff = No Problem	4.59%	1.92%
California Urban Runoff = Very Serious	13.76%	19.23%
California Urban Runoff = Serious	19.27%	21.15%
California Urban Runoff = Needs Improvement	40.37%	36.54%
California Urban Runoff = No Problem	3.67%	1.92%
Is there animal waste that gets left in you yard?		
Animal Waste is left in yard	35.78%	26.92%
Animal Wate is NOT left in yard	63.30%	69.23%
If Animal Waste is left in yard, then what type of animal	RV	RV
How many people live in your home?		
Household Adults	RV	RV
Household Children	RV	RV
*(RV) Responses Varied		

Post-Survey Goal

The purpose of the post-survey was to determine the attitudes of the study participants towards the ET controller and to determine if the education material had an impact on modifying behavior of the recipients. Specifically, determining whether or not there was an acceptance of the ET controller as a way of managing their landscape and was there a change in irrigation practices and behaviors because of the education material.

Survey Distribution

The post-survey was distributed to both of the groups through the mail. Twenty-three (52/225) percent of the education group participants responded to the survey and forty-five percent (50/112) of the retrofit group participants responded.

ET Controller

The majority of the retrofit households acknowledged their satisfaction with the ET controller's performance and agreed that they would recommend the ET controller to their friends. It appears that the residents liked the controller and did not mind having someone else manage their irrigation-watering schedule. Data shows that households accepted the controller as a method of saving water, reducing runoff, and watering their landscape. The survey shows that twice the number of retrofit households observed a decrease in their water bill than the education households did. A majority of the education households did not observe a change in their water bills. Data appears to show that the appearances of the retrofit landscapes were ranked equally with those landscapes that were part of the education group. It can therefore be concluded that the survey showed that the lower use of water did not create landscaped that were inferior to the education group. The customer's perception of a lower bill is important for the success of any long-term conservation program.

The retrofit and education group were asked if they were willing to pay for an ET controller signal. A majority of the households in both of the groups would not be willing to pay for an ET signal. The ET controller costs approximately $150.00 and the signal fee is $48 per year. The ET controller would be able to save less than 2 ccfs per month, which is a savings of about $14 per year. It appears that the savings in water use per year is not large enough for the water customer to pay for an ET signal.

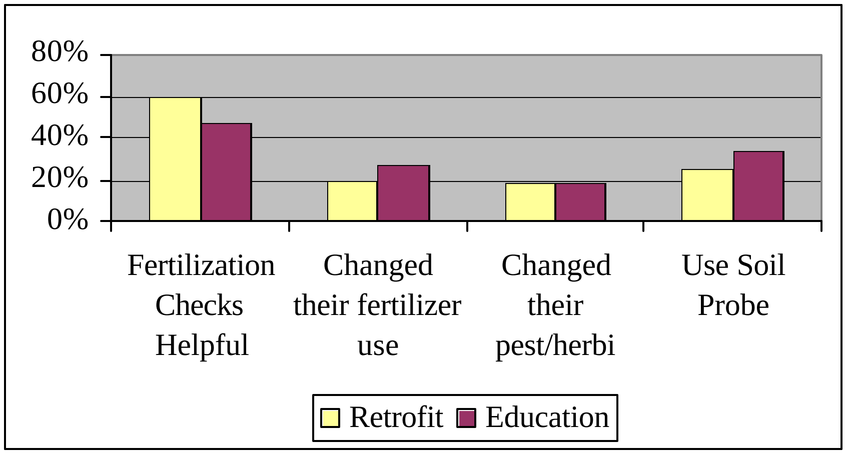
ET Controller Selected Responses

- 72% of the retrofit households were satisfied with the ET Controller.
- 70% of the retrofit households would recommend the ET Controller to others.
- 44% of the retrofit households saw a decrease in their water bill,
- 38% saw their bill as unchanged.
- 23% of the education households saw a decrease in their water bill,
- 63% saw their water bills as unchanged.
- 69% of the education households ranked the appearance of their yard as good to excellent.
- 70% of the retrofit households ranked the appearance of their yard as good to excellent.
- 69% of the education households would not be willing to pay for an ET signal.
- 58% of the retrofit households would not be willing to pay for an ET signal.

Education Program

The results of the education program are summarized on Figure 6. More than half of the education households acknowledged that they sometimes or most of the time would change the settings on their controller according to ET via the monthly letter's suggested schedule. Monthly letters provided monthly landscape maintenance tips. Here, the majority of the households in both of the groups liked the tips on the irrigation checks, and fertilization sections. Although most people read these sections, a vast majority (80%) of households in both of the groups did not change their use of pesticides, herbicides, or fertilizers. In addition to the education materials, a soil probe was given to both groups at the beginning of the study. A soil probe is a tool that takes a soil sample and allows the user to see the depth and amount of moisture available to the plants. This allows the user of the soil probe to determine if the plants require more or less irrigation. More than half of the households in both groups only used the soil probe once or not at all. The majority of the people never used the soil probe at all. From a program point of view, people enjoy the education materials but they appear to have little effect on modifying behavior.

Figure 6: Impacts on Education Program



Education Material Selected Responses

- 54% of the education households changed their irrigation controller schedule (based on the recommendations included in the monthly tips) most of the time or sometimes.
- 58% of the education households and 42% of the retrofit households believed that the irrigation checks (part of the monthly tips) were helpful.
- 44% of the education households and 58% of the retrofit households believed that the fertilization checks (part of the monthly tips) were helpful.
- 81% of the education and 82% of the retrofit households have not changed their use of pesticides and herbicides.
- 73% of the education households and 80% of the retrofit households have not changed their use of fertilizer.
- 62% of the education households and 76% of retrofit households did not use the soil probe or they only used it once.

Table 3: Post-Survey Results

R3 Study Post-Survey Results						
1. Rank the overall appearance of your yard.						
	Excellent	Good	Average	Poor	Very Poor	
Education	9.62%	59.62%	30.77%	1.92%	0.00%	
Retrofit	16.00%	54.00%	24.00%	4.00%	2.00%	
2. Have you seen any change in your water bill in the past 12 months?						
	Increase	Decrease	Unchanged			
Education	9.62%	23.08%	63.46%			
Retrofit	14.00%	44.00%	38.00%			
3. Which monthly monthly tips were helpful to you?						
	Irrigation Checks	Watching for Runoff	Pest& Weed Control	Fertilization	None were Helpful	Dd Not Read
Education	57.69%	28.85%	23.08%	44.23%	1.92%	9.62%
Retrofit	42.00%	30.00%	46.00%	58.00%	2.00%	18.00%
4. How often did you use the soil probe?						
	Once	2 to 6 times	More than 6 times	Only for the Rain	Did Not Use	
Education	11.54%	30.77%	1.92%	3.85%	50.00%	
Retrofit	12.00%	16.00%	6.00%	0.00%	64.00%	
5. How often do you see water runoff in your neighborhood? (choose one)						
	Daily	Weekly	Monthly	Sometimes	Don't Know	
Education	25.00%	32.69%	5.77%	26.92%	11.54%	
Retrofit	10.00%	36.00%	2.00%	40.00%	16.00%	
6. How often are patios, sidewalks and driveways cleaned at your home? (choose						
	Daily	Weekly	Monthly	Sometimes	Never	
Education	0.00%	46.15%	21.15%	30.77%	3.85%	
Retrofit	2.00%	48.00%	16.00%	32.00%	4.00%	
7. How do you clean patios, sidewalks and driveways at your home?						
	Hose	Broom	Blower	Other		
Education	44.23%	63.46%	30.77%	RV		
Retrofit	48.00%	58.00%	36.00%	RV		
8. Have you changed your use of pesticides and herbicides in the yard in the past 12 months?						
	Yes	No	How?			
Education	15.38%	80.77%	RV			
Retrofit	16.00%	82.00%	RV			
9. Have you changed the use of fertilizer in your yard in the past 12 months?						
	Yes	No	How?			
Education	23.08%	73.08%	RV			
Retrofit	18.00%	80.00%	RV			
10. Is there animal waste that gets left in your yard?						
	Yes	No	What type of animal			
Education	21.15%	75.00%	RV			
Retrofit	36.00%	64.00%	RV			
11. How serious a problem do you consider urban runoff? (choose one)						
	Very Serious	Serious	Needs Improvement	No Problem		
Education	3.85%	38.46%	46.15%	9.62%		
Retrofit	12.00%	28.00%	52.00%	10.00%		
12. Were you satisfied with the test irrigation controller installed to manage the landscape water?						
	YES	NO	Why			
Retrofit	72.00%	24.00%	RV			
13. Would you recommend this irrigation controller to others?						
	YES	NO	Why			
Retrofit	70.00%	24.00%	RV			
14. Would you pay a monthly fee to have signal sent to the controller for landscape water management as tested in this study						
	YES	NO	How Much?			
Education	26.92%	69.23%	RV			
Retrofit	38.00%	58.00%	RV			
15. How often did you change your irrigation controller to the times provided in the monthly tips?						
	Every Month	Most of the Time	Sometimes	Once or Twice	Never	
Education	5.77%	28.85%	25.00%	23.08%	15.38%	

Central Basin Municipal Water District

2005 Urban Water Management Plan

Prepared by:
Central Basin Municipal Water District
17140 S. Avalon Blvd., Suite 210
Carson, CA 90746

www.centralbasin.org

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MESSAGE FROM THE BOARD OF DIRECTORS

Since the District's formation in 1952, Central Basin Municipal Water District has remained steadfast in its commitment to ensure a safe and reliable water supply for the region. Through the years, the District has grown and transformed, seeking innovative and viable solutions to meet the changing needs of its communities. All of us at Central Basin continue to expand our efforts to meet the growing water demand while preserving our limited and precious water resource. Through our water recycling, conservation, education and outreach programs, Central Basin has evolved from a potable water wholesaler to a leader safeguarding the region's water supply.

We are proud to submit this 2005 Urban Water Management Plan to the State Department of Water Resources. The Plan reports all current and projected water supplies and demands within Central Basin's service area, demonstrates water reliability for the next 25 years, and provides a comprehensive overview of the District's various programs.

DIRECTORS

Division I - Edward C. Vasquez
Bell Gardens, Downey, Montebello, Norwalk and Vernon

Division II - Robert Apodaca
La Habra Heights, La Mirada, Pico Rivera, Santa Fe Springs and Whittier

Division III - George Cole
Bell, Commerce, Huntington Park, Maywood, portions of Cudahy, Monterey Park and unincorporated areas of East Los Angeles

Division IV - Olga E. Gonzalez
Lynwood, South Gate, portions of Cudahy, Carson, Florence-Graham and Willowbrook

Division V - Phillip D. Hawkins
Artesia, Bellflower, Cerritos, Lakewood, Paramount and Signal Hill

MISSION STATEMENT

"To acquire, sell and conserve imported and other water that meets all required standards and to furnish it to our customers in a planned, timely and cost effective manner that anticipates future needs. The District serves as the official representative for its public at the Metropolitan Water District of Southern California. It also provides leadership, support, advice and communication on water issues to the people and agencies within and outside its boundaries, as appropriate."

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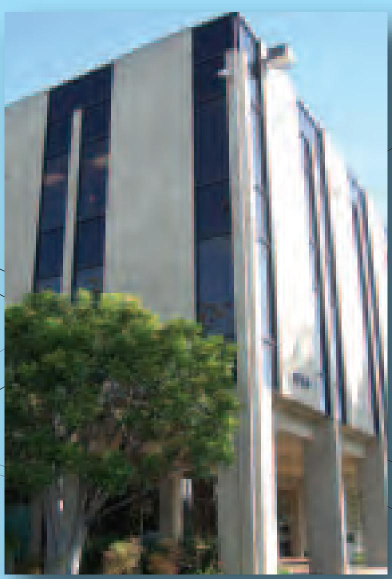


Executive Summary

Executive Summary

This section is a summary of the components of this Plan

A BRIEF HISTORY

The legislative requirement to prepare an Urban Water Management Plan (UWMP) every five years provides Central Basin Municipal Water District (Central Basin) with an opportunity to affirm and support its primary purpose - to ensure the long-term water supply reliability of its region. Although the District's overall mission has not changed in more than five decades, techniques for meeting its objective are continuously evolving.

The history of Central Basin is representative of how water resource management has evolved in southern California during the past half a century. Ensuring that residents and businesses in southern California have safe and reliable supply of water requires the cooperation of local water purveyors as well as regional wholesalers.

When native groundwater supplies in the growing southeastern part of Los Angeles County became critically over-drafted in the 1940s, groundwater producers formed a regional agency, Central Basin, in 1953 that would join the Metropolitan Water District of Southern California (MWD). MWD had been created in 1928 by 11 cities (13 in 1933 and now 26 member agencies) for the purpose of constructing a 240-mile aqueduct from the Colorado River. The era of "imported water" and mega-projects that began at the turn of the last century with construction of the Los Angeles Aqueduct from the Owens Valley by the City of Los Angeles, and continued with the extension of the California Aqueduct into southern California in the 1970s, was well underway. Central Basin joined this era to provide a new source of water for groundwater replenishment and to meet the needs of many cities and agencies with little or no access to groundwater.

Imported water was the fuel that drove the economic engine of southern California for decades. Through the 1960s, 70s and 80s, imported water provided by Central Basin offered the reliability enjoyed by groundwater producers and non-producers alike. During this time, not only did population within Central Basin's service area grow by 136% from about 593,000 in 1950 to more than 1.4 million people by 1990, but the area also became an industrial center in the region.

A DIFFERENT APPROACH TO WATER MANAGEMENT

The paradigm of ensuring reliability while continuing to provide unlimited supplies of imported water began to change with the drought of 1989-1992. Even before the near-reality of mandatory water rationing in the spring of 1992, plans had begun to enhance conservation practices and to consider the development of locally-produced sources of water that, through the long-term, would significantly reduce southern California's reliance on supply systems subject to hydrology and environmental pressures.

Central Basin was at the forefront of this change in approach to water management. By 1990, funding mechanisms were in place and designs were being drawn up for a regional recycled water distribution system that would directly offset potable imported water for non-potable uses such as irrigation and industrial applications. Central Basin would also become renowned for its highly successful conservation and education programs that, combined with recycled water, have helped conserve more than 38.3 billion gallons of potable water during the past decade.

By 1996, local programs were accounted for within MWD's Southern California Integrated Resources Plan (IRP), which established a rolling 20-year roadmap for diversified supply investments in recycled water, brackish groundwater treatment, surface and groundwater storage, water transfers and exchanges, conservation practices and accessibility to imported water. A recent update of the IRP also includes ocean water desalination as an additional resource for ensuring the long-term reliability of regional water supplies.

Central Basin's aggressive pursuit of the resource development targets within the IRP is changing the face of water supply in the region from mostly groundwater to a more diverse set of supply options.

WATER DEMAND

Total water use, or demand, within Central Basin's service area includes retail demand and groundwater replenishment. Retail demand is defined as all municipal (residential, firefighting, parks, etc.) and industrial uses, and represents the population's total direct water consumption. Replenishment includes deliveries to the Rio Hondo and San Gabriel River Spreading Grounds in the Montebello Forebay. Table ES-1 summarizes the current and projected retail and replenishment demands.

IMPACTS OF CONSERVATION AND EDUCATION: REDUCED DEMAND

Although not a traditional “wet” water supply like imported water or recycled water, water use efficiency, including conservation and education, is considered part of Central Basin's water supply portfolio because it results in less retail need, or demand, for wet supplies than would otherwise be the case. Perhaps the most telling picture of the impact of conservation and education on retail demand is conveyed by Figure ES-1.

Retail water use within Central Basin's service area is largely the same today as it was 10 years ago despite the addition of more than 145,000 people. The average retail demand for the past 15 years is approximately 260,500 AFY. Clearly, residents are now using less water on an individual, or “per capita,” basis, as shown in Figure ES-2.

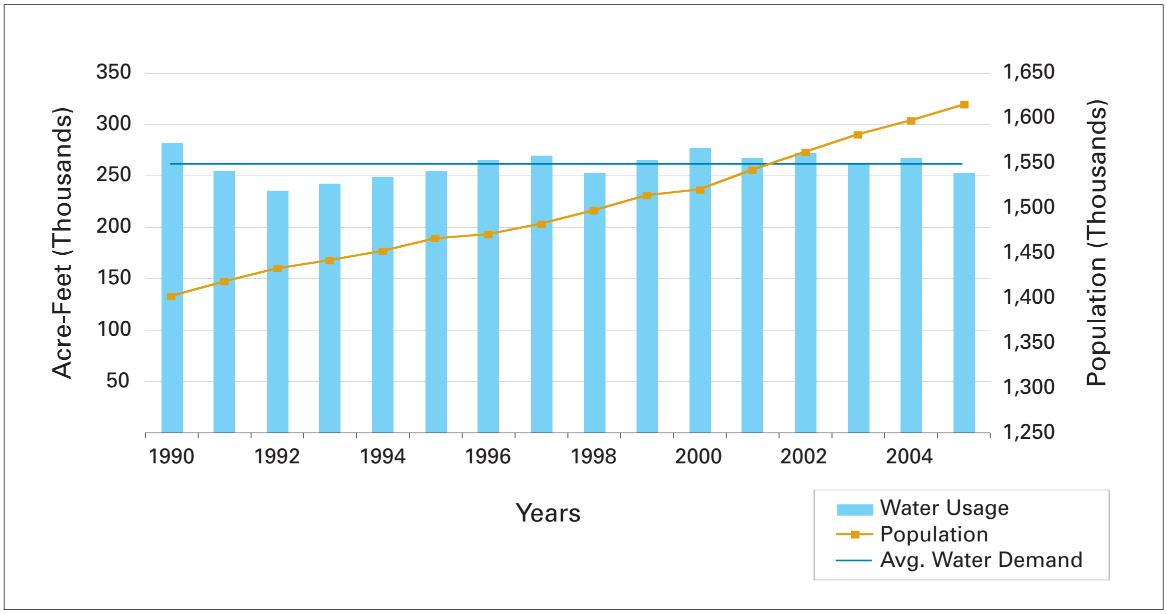
It is apparent that the trend of lower per capita water usage through time, with assistance from MWD and its member agencies, has been successful in continuing a water conservation ethic begun 15 years ago during the last major drought.

Table ES-1
Central Basin's Current and Projected Water Demand
(In Acre-Feet)

District Water Demands	2005[1]	2010	2015	2020	2025	2030
Retail Municipal & Industrial Use						
Groundwater[2]	186,549	202,000	202,000	202,000	202,000	202,000
Imported Water	61,033	59,091	64,691	70,462	74,409	82,535
Recycled Water[3]	5,217	12,900	14,150	15,400	16,650	17,900
Total Retail Demand	**252,799**	**273,991**	**280,841**	**287,862**	**295,059**	**302,435**
Replenishment Use						
Imported Water	27,758	27,600	27,600	27,600	27,600	27,600
Recycled Water	50,000	50,000	50,000	50,000	50,000	50,000
Total Replenishment Demand	**77,758**	**77,600**	**77,600**	**77,600**	**77,600**	**77,600**
TOTAL DEMAND	**330,557**	**351,591**	**358,441**	**365,462**	**372,659**	**380,035**

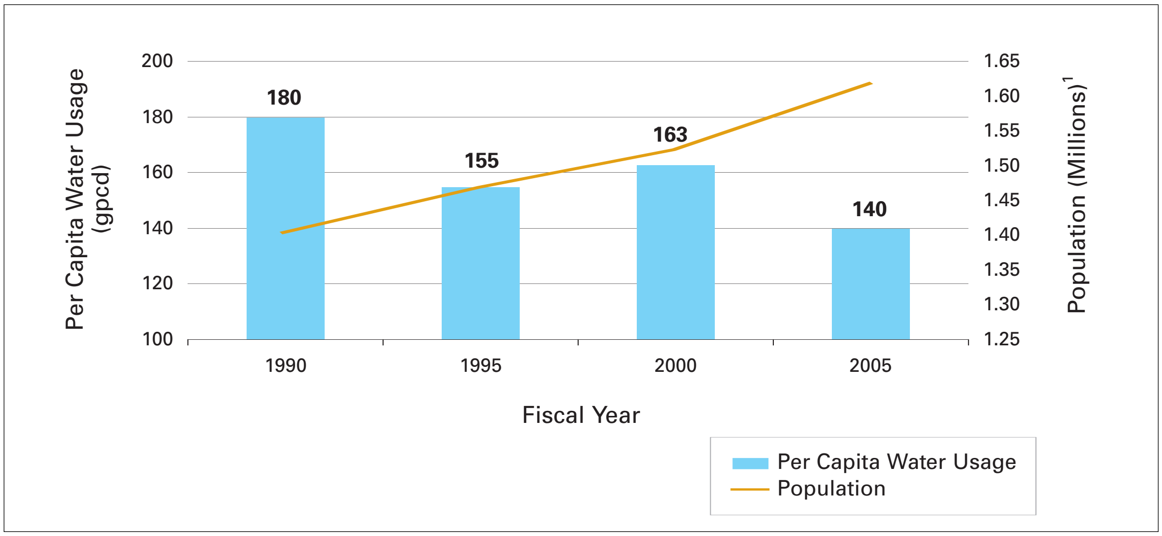
[1] The 2005 demands are based on the 2004-05 year, which is also considered one of the "wettest" years on record.
[2] Includes groundwater production from the Central and Main San Gabriel Basins (est. 42,000 AF).
[3] Includes recycled water sales from Central Basin's service area and Cerritos Water Systems.

Figure ES-1
Historical Retail Demand Compared to Population



Source: CBMWD water use database and MWD Demographic Data, 2005.

Figure ES-2
Per Capita Water Usage, 2001 - 2005



Source: CBMWD water use database
[1] Information based on MWD Demographic Data, 2005.

WATER SUPPLY

Central Basin currently relies on approximately 90,600 AFY of imported water from the State Water Project (SWP) and the Colorado River through MWD to meet the District's retail and replenishment demands. While groundwater supplies remain a significant source of water (68%) for customer agencies in the Central Basin service area, imported water supplements this resource (22%) and assists to mitigate the over-pumping of the groundwater basin. Recycled water is added to the supply mix, serving up to 2% of the area's demands, while conservation rounds out the equation at 8%.

Table ES-2 shows current (2005) and projected (2030) supplies within Central Basin's service area, with imported and recycled water being provided by Central Basin.

PLANNING FOR INCREASED DIVERSIFICATION

Given the critical importance of water to the region's growth, economic health and quality of life, the desirable quantity and mix of supply must be planned well in advance of the actual need. Implementing water projects and changing behavior and attitudes regarding water usage are lengthy and complex endeavors. While the UWMP Act requires a 20-year planning horizon for water reliability, Central Basin has used a 25-year planning horizon to ensure a minimum 20-year planning period each year until the next 5-year update of the District's UWMP.

Although implementation of supply targets is challenging, Central Basin's approach is straightforward: continue to reduce the risk of future shortage by distributing the responsibility for supply among several, well-balanced options. Central Basin's projected supply portfolio for 2030, as compared to the current mix, is shown in Figure E-3 on page ES-6.

Central Basin's diversification plan includes expansion of the District's recycled water system, increased conservation efforts and groundwater storage opportunities. The District's future dependence on traditional sources of water (groundwater and imported) will continue to decrease with the expansion of these alternative resources. During the next 25 years, conservation is expected to have a significant dampening effect on retail water demand, lowering projected water use by roughly 58,400 AF in 2030.

Central Basin's ambitious 2030 target for conservation will be directed by a Conservation Master Plan (completion in 2006) that will identify the programs, strategies and actions that will guide policy development and commitment of resources in the future.

Likewise in 2006, Central Basin will complete the update of its Recycled Water Master Plan. This effort will provide the basis for completion of the recycled water distribution system and the fulfillment of its full potential to offset the use of imported water. The future Southeast Water Reliability Project will connect the existing Rio Hondo and Century systems across the northern portion of the service area. The project will increase flow and pressure in many areas not adequately served today, reach a large new customer base in several cities

Table ES-2
Current and Projected Water Supplies
(In Acre-Feet)

District Water Supplies	2005[1]	2030
Groundwater	186,549	202,000
Imported Water	61,033	82,535
Recycled Water	5,217	17,900
Total	**252,799**	**302,435**
Conservation	21,100	58,400
Total	**273,899**	**360,835**

[1] The 2005 demands are based on the 2004-05 year, which is also considered one of the "wettest" years on record.

within the service area and enable new partnerships with neighboring agencies that wish to extend Central Basin's system into their service areas.

WATER SUPPLY RELIABILITY

During consecutive dry years, southern California has historically seen demands increase by as much as 20% while supplies have decreased. Prior to recent significant improvements in water reliability, most cities and agencies were forced to mandate conservation efforts and restrict water use in some cases in order to maintain an adequate supply. Enormous strides made by MWD, Central Basin and the entire water supply community in southern California to increase locally-developed supplies and conservation as well as imported water storage and transfers during the past decade have increased the overall supply reliability during extended dry periods.

MWD's 2005 Regional UWMP demonstrates reliability of supply in all hydrologic conditions through the year 2030. In fact, the plan shows a surplus of supply in nearly all conditions. MWD planning initiatives to ensure water supply reliability include the IRP, the Water Surplus and Drought Management Plan (WSDM Plan) and local resource investments. These initiatives provide a framework for MWD and its member agencies to manage their water resources to meet growing demands.

Through its investments into supply diversification, support of the region's IRP and the collaborative efforts with MWD, Central Basin projections show that supplies will adequately meet service area demands in normal, single-dry and multiple dry-year scenarios as well as other water shortage emergencies.

Regionally, alternative water supplies are being explored, studied and in some cases, implemented to enhance the area's water supply reliability. In addition to recycled water, alternative water supply projects include conjunctive use groundwater storage, water transfers and exchanges, and ocean and groundwater desalination. Central Basin supports the ongoing efforts of these programs.

WATER CONSERVATION

Since the drought of the 1990s, Central Basin has been a leader implementing aggressive water conservation programs to help limit water demand in its service area. District programs have included a strong emphasis on education and the distribution of rebate incentives and plumbing retrofit hardware. The results of these programs, in conjunction with passive conservation measures such as modifications to the plumbing and building codes, have resulted in significant reductions in water use. By current estimates, demand management conservation saves more than 6.9 billion gallons of imported water every year. This represents the average water use of almost 30,000 families in southern California.

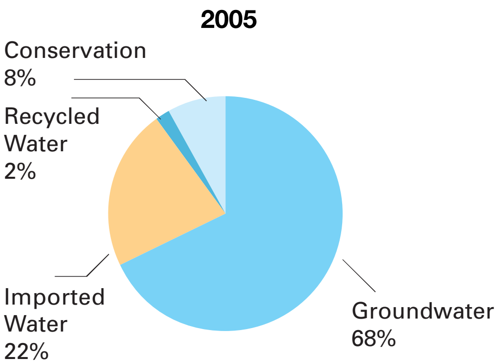
Central Basin water conservation programs follow the recommended 14 Best Management Practices (BMPs) according to the California Urban Water Conservation Council. For fiscal year 2005-06, Central Basin will complete a Conservation Master Plan that will guide the District to meet or exceed the goals of the BMPs and MWD's Conservation Strategy Plan. The plan will assess the conservation potential and incorporate local stakeholder input into a group of actions and strategies for achieving long-term targets for conservation.

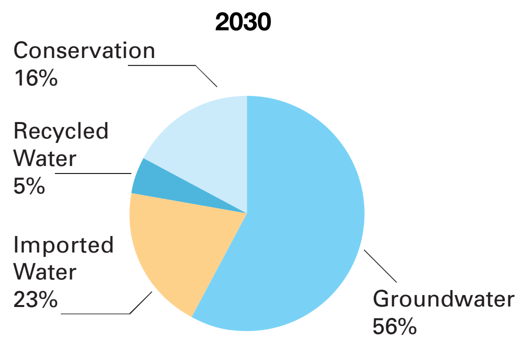
RECYCLED WATER

Recycled water is one of the cornerstones of Central Basin's efforts to augment local supplies and reduce dependence on imported water. Since the initial planning and construction of Central Basin's water recycling in the early 1990s, Central Basin has become a leader in producing and marketing recycled water. This new supply of water assists in meeting the demand for non-potable applications such as landscape irrigation, commercial and industrial processes, and seawater intrusion barriers. With more than 200 site connections, Central Basin is projected to deliver 5,000 AF both inside and outside of the District's service area in fiscal year 2005-06.

In addition to Central Basin, other agencies distribute recycled water within the District's service area. These agencies include the City of Cerritos, City of Lakewood and WRD. WRD uses recycled water to help replenish the groundwater basin and halt sea-

Figure ES-3
Comparison of Water Supply Portfolio
2005 vs. 2030





water intrusion. Central Basin purchases recycled water from both the Los Coyotes and San Jose Creek Water Reclamation Plants (WRPs) for distribution within its service area. The WRPs together produce approximately 137 MGD of tertiary-treated effluent, nearly 40% of which Central Basin and agencies within the service area reused in 2000.

Central Basin's recycling program includes the E. Thornton Ibbetson Century Recycled Water Project (Ibbetson Century Project) and the Esteban E. Torres Rio Hondo Recycled Water Project (Torres Project). Both projects deliver recycled water for landscape irrigation and industrial uses.

The Ibbetson Century Project began delivering recycled water in 1992 and now delivers tertiary-treated recycled water from the Los Coyotes WRP, serving 11 cities. In 1994, the recycled water system extension, the Torres Project, reached into the northern portion of Central Basin's service area. The Torres Project delivers tertiary-treated recycled water from San Jose Creek WRP and serves eight cities.

Central Basin anticipates recycled water use sales to increase in the future as more customers switch from potable water to recycled water due to the reliability of the supply and the economic incentives associated with the conversion. Table ES-3 summarizes the current and projected demands for recycled water within Central Basin.

Central Basin's Water Recycling Master Plan Update, slated for completion in 2006, will include future potential sites and users and help secure the alignment for the proposed Southeast Water

Table ES-3
Projected Recycled Water Used within Central Basin Service Area
(In Acre-Feet)

	2005[1]	2010	2015	2020	2025	2030
Central Basin						
Century/Rio Hondo Projects	3,150	10,500	11,750	13,000	14,250	15,500
Total	**3,150**	**10,500**	**11,750**	**13,000**	**14,250**	**15,500**
Other Programs within Central Basin						
City of Cerritos	1,714	1,950	1,950	1,950	1,950	1,950
City of Lakewood	352	450	450	450	450	450
WRD (Replenishment Spreading)	50,000	50,000	50,000	50,000	50,000	50,000
Total	**52,067**	**52,400**	**52,400**	**52,400**	**52,400**	**52,400**
Central Basin's Service Area Total	**55,217**	**62,900**	**64,150**	**65,400**	**66,650**	**67,900**

[1] The 2005 demands are based on the 2004-05 year, which is also considered one of the "wettest" years on record.

Reliability Project (SWRP). This project will "loop" the overall system and connect the Rio Hondo and Century projects and benefit an additional six cities. When operational in 2009, the SWRP will ultimately serve an additional 5,500 AFY of recycled water.

WATER QUALITY

Water quality regulations are an important factor in Central Basin's water management activities. Imported water quality is the responsibility of MWD to comply with State and Federal drinking water regulations. Purveyors that Central Basin sells imported water to are responsible for ensuring compliance in their individual distribution systems and at the customer tap. MWD maintains a rigorous water quality monitoring program and is also proactive in protecting its water quality interests in the SWP and the Colorado River through active participation. Imported water meets or exceeds all drinking water standards set by the California Department of Health Services.

Water quality of the Basin is continually monitored by both Central Basin and WRD. Challenges to water quality include potential contamination from adjacent basins, the Basin's susceptibility to seawater intrusion and the migration of shallow contamination into deeper aquifers. WRD and Central Basin have several active programs to monitor, evaluate and mitigate water quality issues.

Central Basin actively assists retail agencies in its service area in meeting drinking water standards through its Cooperative Basin-Wide Title 22 Groundwater Quality Monitoring Program. Central Basin offers this program to water agencies for wellhead and reservoir sample collection, water quality testing and reporting services.

Another potential water quality concern for the Basin is the presence of perchlorate, trichloroethylene and perchloroethylene in the San Gabriel Valley aquifer. In accordance with the plan to "clean up" the contaminated groundwater before it migrates to the Central Groundwater Basin, Central Basin has completed and is successfully operating extraction and treatment facilities that not only protect the local Basin but also recover potable water for distribution to retail agencies in the vicinity.

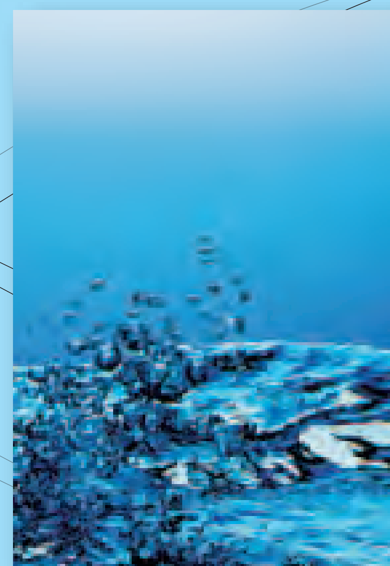
Recycled water meets Title 22 standards through tertiary treatment. Central Basin relies on the Sanitation District of Los Angeles County to meet all applicable State and Federal water quality regulations for recycled water it purchases and distributes through its two systems.

WATER RATES AND CHARGES

In 2002, MWD adopted a new rate structure to support its strategic planning vision as a regional provider of services, incentivize the development of local supplies like recycled water and conservation, and encourage long-term planning for imported water demand. To achieve these objectives, MWD called for voluntary purchase orders from its member agencies, unbundled its water rates, established a tiered supply rate system and added a capacity charge. In all, these new rate structure components have provided a better opportunity for MWD and its member agencies to manage their water supplies.

MWD's 2002 rate structure changes were passed through to Central Basin's customer agencies in a manner that preserved the water management benefits while minimizing financial impacts. With the purchase order and tiered supply rate elements, Central Basin has successfully implemented a conservation-based structure that encourages agencies to stay within their annual water budget and uses revenue from agencies that exceed their water budget to fund service-area wide conservation studies and programs. Central Basin also assesses a capacity charge at the retail level designed to recover the cost of MWD's capacity charge. In addition to the pass-through elements of MWD's rate structure, Central Basin's rates include a volumetric administrative surcharge and a fixed water service charge.

Since 1992, Central Basin has encouraged the maximum use of recycled water through the economic incentive of its rates and charges. Central Basin recycled water commodity rates cover the operation, maintenance, labor and power costs associated with the delivery of recycled water. These rates are set up in a declining tiered structure and are maintained at a significant reduction to imported water so they may further encourage the use of recycled water.



Section 1

Introduction

1

Introduction

1.1 PURPOSE AND UWMP SUMMARY

An Urban Water Management Plan (UWMP or Plan) prepared by a water purveyor is to ensure the appropriate level of reliability of water service sufficient to meet the needs of its various categories of customers during normal, single dry or multiple dry years. The California Urban Water Management Planning Act of 1983 (Act), as amended, requires urban water suppliers to develop an UWMP every five years in the years ending in zero and five.

The legislature declared that waters of the state are a limited and renewable resource subject to ever increasing demands, that the conservation and efficient use of urban water supplies are of statewide concern, that successful implementation of plans is best accomplished at the local level, that conservation and efficient use of water shall be actively pursued to protect both the people of the state and their water resources, that conservation and efficient use of urban water supplies shall be a guiding criterion in public decisions and that urban water suppliers shall be required to develop water management plans to achieve conservation and efficient use.

Central Basin Municipal Water District's (District) 2005 UWMP has been prepared in compliance with the requirements of the Act, as amended to 2005[1] (Appendix A), and includes the following:

- *Water Wholesale Service Area*
- *Water Demands*
- *Water Sources and Supplies*
- *Water Reliability Planning*
- *Water Quality Information*
- *Water Demand Management Measures*
- *Water Shortage Contingency Plan*
- *Water Recycling*

1.2 URBAN WATER MANAGEMENT PLAN UPDATE PREPARATION

The District's 2005 UWMP revises the 2000 UWMP prepared by the District and incorporates changes enacted by legislation, including SB 610 (2001), AB 901 (2001), SB 672 (2001), SB 1348 (2002), SB 1384 (2002), SB 1518 (2002), AB 105 (2004) and SB 318 (2004). The UWMP also incorporates water use efficiency efforts the District has implemented or is considering implementing pursuant to the Memorandum of Understanding Regarding Urban Water Conservation in California (MOU).[2] The District was one of the first agencies to become signatory to the MOU in September 1991.

The sections in this Plan correspond to the outline of the Act, specifically Article 2, Contents of Plans, Sections 10631, 10632 and 10633. The sequence used for the required information, however, differs slightly in order to present information in a manner reflecting the unique characteristics of the District. The Department of Water Resources Review for Completeness form has been completed, which identifies the location of Act requirements in this Plan and is included as Appendix B.

1.2.1 PLAN ADOPTION

The 2005 UWMP was adopted by a resolution of the District's Board of Directors in December 2005, following a public hearing. The Plan was submitted to the California Department of Water Resources within 30 days of Board approval. Copies of the Notice of Public Hearing and the Resolution of Plan

[1] California Water Code, Division 6, Part 2.6; §10610, et. seq. Established by Assembly Bill 797 (1983).

[2] The Memorandum of Understanding Regarding Urban Water Conservation in California (MOU) was adopted in September 1991 by a large number of water suppliers, public advocacy organizations and other interested groups. It created the California Urban Water Conservation Council and established 16 Best Management Practices (BMPs) for urban water conservation, recently refined to 14 BMPs. The District became signatory to the MOU in September 1991.

Table 1-1
Coordination with Appropriate Agencies

	Participated in UWMP Development	Commented on the Draft	Attended Public Meetings	Provided Assistance	Received Copy of Draft	Sent notice of intention to adopt
Regional Water Agency	Metropolitan Water District of Southern California	✔	✔		✔	✔
Customer Agencies	Bellflower-Somerset Mutual Water Co	✔	✔	✔	✔	✔
	California American Water Company			✔	✔	✔
	California Water Service Company	✔		✔	✔	✔
	City of Bell Gardens*				✔	✔
	City of Cerritos	✔	✔	✔	✔	✔
	City of Commerce	✔		✔	✔	✔
	City of Downey	✔		✔	✔	✔
	City of Huntington Park		✔	✔	✔	✔
	City of Lakewood	✔	✔	✔	✔	✔
	City of Lynwood			✔	✔	✔
	City of Montebello	✔		✔	✔	✔
	City of Norwalk	✔		✔	✔	✔
	City of Paramount		✔	✔	✔	✔
	City of Pico Rivera			✔	✔	✔
	City of Santa Fe Springs	✔	✔	✔	✔	✔
	City of Signal Hill*				✔	✔
	City of South Gate			✔	✔	✔
	City of Vernon			✔	✔	✔
	City of Whittier			✔	✔	✔
	County of Los Angeles-Rancho Los Amigos			✔	✔	✔
	La Habra Heights County Water District*				✔	✔
	Maywood Mutual Water Co. #1*				✔	✔
	Maywood Mutual Water Co. #2*				✔	✔
	Maywood Mutual Water Co. #3*				✔	✔
	Montebello Land & Water Co.			✔	✔	✔
	Orchard Dale Water District	✔		✔	✔	✔
	Park Water Company	✔	✔	✔	✔	✔
	Pico Water District			✔	✔	✔
	San Gabriel Valley Water Company			✔	✔	✔
	South Montebello Irrigation District			✔	✔	✔
	Southern California Water Company	✔	✔	✔	✔	✔
	Suburban Water Systems			✔	✔	✔
	Walnut Park Mutual Water Company*				✔	✔
	Water Replenishment District*	✔	✔		✔	✔

* Agencies were not required to do a 2005 Urban Water Management Plan.

Adoption are included in Appendix C. Copies of the Plan were made available to the public within 30 days following Board approval.

1.2.2 AGENCY COORDINATION

A notice of preparation for the 2005 UWMP Update was prepared and sent to the Metropolitan Water District of Southern California (MWD), the County of Los Angeles and all of the District's various cities and customer agencies, as shown in Table 1-1. The Notice of Preparation is included in Appendix D.

Development of this Plan was performed by District staff in coordination with its water purveyors and the MWD. District staff has met with many of its customer agencies to discuss the UWMP, answer questions related to the UWMP and/or projects occurring throughout the service area, and provide assistance when requested. Staff provided many of its agencies with conservation data that they were able to use in their conservation section of the UWMP.

The District is a water wholesaler and is fully dependent on MWD for its imported water supplies to its service area. This UWMP details the specifics as they relate to the District and its service area and will refer to MWD throughout the document. The District held two UWMP workshops, one in January 2005 for the public, in coordination with MWD and the California Urban Water Conservation Council, and the other in June 2005 for the District's water purveyors. Further, MWD held multiple UWMP information meetings for stakeholders and the public throughout its service area during the months of June and July 2005. On August 24, 2005, MWD held an additional Public Information Meeting at the Southern California Water Dialogue monthly forum. The Southern California Water Dialogue participants meet voluntarily to explore water-related issues of vital interest to the Southern California region.

The UWMP is intended to serve as a general, flexible and open-ended document that periodically can be updated to reflect changes in the region's water supply trends as well as conservation and water use efficiency policies. This Plan, along with the District's other planning documents, will be used by District staff to guide the service area's water use and management efforts through the year 2010, when the UWMP is required to be updated.

1.3 THE DISTRICT'S SERVICE AREA

1.3.1 BACKGROUND

The District was established by a vote of the people in 1954 to help mitigate the overpumping in the Central Groundwater Basin (Basin). Central Basin's founders realized they would have to curtail the use of pumping by providing the region with imported water. Therefore, Central Basin joined MWD to purchase, on a wholesale level, potable water imported from the Colorado River and the SWP and then sell it to the local municipalities, investor-owned and mutual water companies and districts. As a water supplier, MWD provides the Southern California region with a reliable supply of imported water. Central Basin remains one of the largest member agencies in MWD's family of wholesalers.

Today, Central Basin wholesales potable water to 24 cities, mutual water companies, investor-owned utilities, water districts and private companies in the region. In addition, the District supplies recycled water to the region for municipal, commercial and industrial use. Central Basin supplies imported and recycled water to its customer agencies to help reduce their reliance on groundwater supplies.

Central Basin is governed by a five member elected Board of Directors from within the service area of the District. Each Director serves a four-year term once elected. The Board of Directors guides the mission and policy of the District. Also, Central Basin's Board of Directors appoints two representatives to serve on the 37-member MWD Board of Directors. Central Basin's representation on the MWD Board is critical to shaping a regional voice on water issues.

1.3.2 DISTRICT'S SERVICE AREA

Central Basin's service area covers approximately 227 square miles and includes 24 cities and several unincorporated areas in Los Angeles County. Approximately 1.61 million people are served within Central Basin's service area. The cities and their associated divisions include:

Division 1:
Bell Gardens, Downey, Montebello, Norwalk and Vernon

Division 2:
La Habra Heights, La Mirada, Pico Rivera, Santa Fe Springs and Whittier

Division 3:
Bell, Commerce, Huntington Park, Maywood, portions of Monterey Park and areas of unincorporated East Los Angeles

Division 4:
Portions of Carson and Cudahy, Lynwood, South Gate, Florence-Graham and Willowbrook

Division 5:
Artesia, Bellflower, Cerritos, Hawaiian Gardens, Lakewood, Paramount and Signal Hill

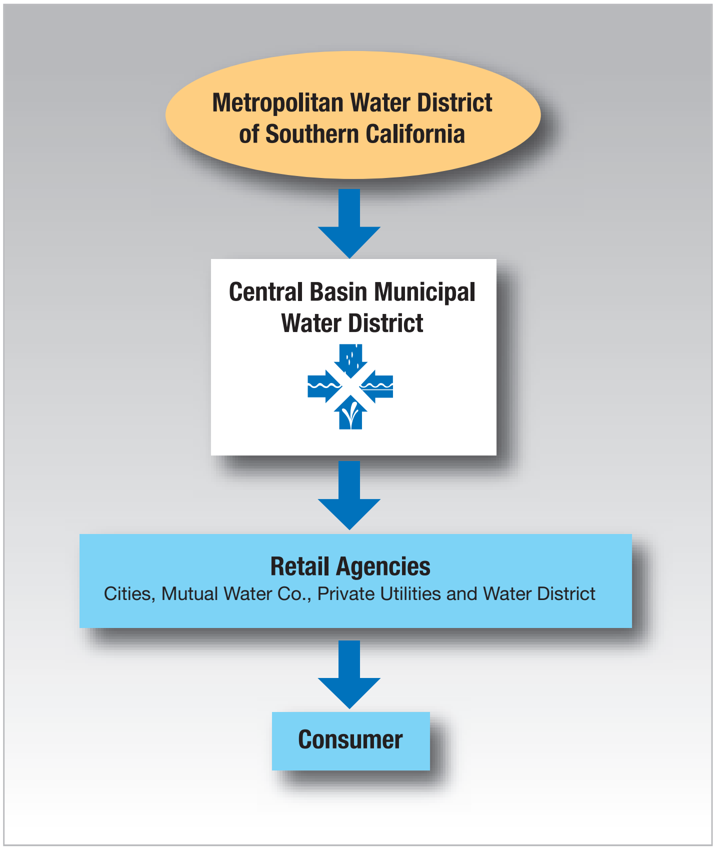
1.3.3 RELATIONSHIP TO METROPOLITAN WATER DISTRICT

Realizing that the Basin could not meet the overlying demand for water in the early 1950s, the cities' leaders and residents formed the District to petition for annexation to the MWD family in order to receive supplemental imported water.

The District plays an important role in managing the imported supplies for the region. Through various programs and projects, the District ensures that its residents have a safe and reliable supply of water.

Figure 1-1 shows the supply chain, which illustrates the relationship the District plays to its customer agencies. The District is the voice and representative of its customers to MWD. As such, the District takes great pride in knowing that its retailers are receiving a safe and reliable supply of drinking water.

Figure 1-1
Imported Water Supply Chain



Section 2

Water Demand

2
Water Demand

This section describes current and future water demand trends within Central Basin's service area

2.1 OVERVIEW

Today, the total water demand for the 1.61 million people living within Central Basin's service area is approximately 280,400 acre-feet (AF) with replenishment demand making up 27,600 AF. One acre-foot equals 326,000 gallons and serves the annual water needs of two families. In 1980, Central Basin's population was 1.22 million and the service area's water demand was 260,960 AF. In those 25 years, Central Basin's retail water demand has grown 7.4% while population has grown 30%. One of the contributing factors to this low growth in demand has been in large part because of conservation and education efforts by the water community.

In the last five years, Central Basin's water demand has increased by only 1% while population has increased by more than 5%. This gradual increase in water usage is attributed to Central Basin's efforts in education and promotion of water conservation as well as incentives for people to retrofit their homes and businesses with more efficient water use devices.

Despite the flattening demand trend, water use will continue to increase. However, projections show that Central Basin's water usage is expected to increase roughly 0.5% per year during the next 25 years, as illustrated in Table 2-5 on page 2-8.

This section will explore in greater detail Central Basin's population trends and historical and current water demands as well as offer some insight into expected future water demands for the next 25 years.

2.2 CLIMATE CHARACTERISTICS

Central Basin's service area lies in the heart of Southern California's coastal plain. The climate is Mediterranean, characterized by typically warm, dry summers and wet, cool winters with an average precipitation level of approximately 14.9 inches per year[1]. The combination of mild climate and low rainfall makes the area a popular residential destination, creating a challenge for water agencies in meeting for increasing water demands with a limited water supply.

Areas with low precipitation, such as Southern California, are typically vulnerable to droughts. Historically, Central Basin has experienced some severe dry periods (Droughts of 1977-78 and 1989-92) and until recently the Los Angeles region had the five driest years on record (1999-2004). In fact, anything less than the average yearly rainfall causes concern for water agencies. Central Basin has been actively pursuing and accomplishing these water saving techniques for the last 15 years to ensure adequate future water reliability.

Table 2-1 illustrates the climate characteristics for the Los Angeles region, taken at both the Long Beach Station and the Montebello Station, for the period between 1979 and 2004 (25 years) including standard monthly average ETo[2] (Long Beach Station), the average rainfall (Montebello Station) and the average temperature (Montebello Station). In comparison to other cities with an abundant supply of precipitation each year, the low rainfall in this region invariably challenges Central Basin to provide sufficient, reliable, quality water to meet the area's increasing water needs. The average precipitation for the last 25 years is approximately 16.02 inches, indicating the need for water conservation in an area with a water demand that will continue to grow as urban infiltration continues to rise.

1 According to the National Weather Service
2 Evapotranspiration is the water lost to the atmosphere by two processes-evaporation and transpiration. Evaporation is the loss from open bodies of water, such as lakes and reservoirs, wetlands, bare soil and snow cover; transpiration is the loss from living-plant surfaces.

Table 2-1
Climate Characteristics - Los Angeles Region
Period 1/1/1979 to 12/31/2004

	Jan	Feb	Mar	Apr	May	June
Standard Monthly Average Eto[1]	1.65	2.15	3.59	4.77	5.12	5.71
Average Rainfall (inches)[2]	3.71	4.07	3.19	0.94	0.24	0.07
Average Temperature (Fahrenheit)[2]	69.4	71.1	72.7	77.8	79.4	83.7

	July	Aug	Sept	Oct	Nov	Dec	Annual
Standard Monthly Average Eto	5.93	5.91	4.39	3.22	2.18	1.68	**46.3**
Average Rainfall (inches)	0.02	0.02	0.20	0.32	1.28	1.96	**16.02**
Average Temperature (Fahrenheit)	88.6	89.7	87.9	82.6	75.4	70.9	**79.1**

[1] Data taken from the California Irrigation Management Information System (CIMIS) at the Long Beach Station for the Los Angeles Region for Calendar Year 2004: http://www.cimis.water.ca.gov/cimis/welcome.jsp

[2] Data taken from the Western Regional Climate Center's web site at the Montebello Station: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?camont

2.3 DEMOGRAPHICS

Central Basin's service area encompasses 227 squares miles in southeast Los Angeles County, including 24 cities, water agencies, publicly-owned mutual water companies and publicly regulated utilities. This service area includes some of the most densely populated areas in the County. According to the 2000 U.S. Census Report and the Metropolitan Water District of Southern California's (MWD) demographics data, Central Basin has grown from 1.4 million people in 1990 to 1.61 million people today.

Based on MWD's demographic projections, population is expected to increase an average of 3.01% every five years for the next 25 years, or 0.64% annually. By 2030, Central Basin's population is expected to grow by more than 258,000 people. Table 2-2 displays the demographic projections for the next 25 years.

Table 2-2 also displays Central Basin's total households, which are expected to increase 19% by 2030, especially in the Multi-family category where households will increase by 48,000 people. As it relates to water demand, the availability of more households increases the demand on water supplies. As for employment, Central Basin is expected to see a 25% increase by 2030. As urban employment grows, so does the demand on water supplies.

2.4 HISTORICAL AND CURRENT WATER DEMANDS

The key factors that affect water demands are growth in population, increases in land use development, industrial growth and hydrology. However, since the end of the 1989-1992 drought, retail water demands in Central Basin's service area have remained fairly consistent. As illustrated in Figure 2-1, the Central Basin region has not seen significant increases in water demands during the past 15 years despite population growth at an average rate of 10,350 persons per year and continued in-fill development in the service area. Central Basin's FY 2004-05 retail water demand was 252,800 AF.

Total water use, or demand, within Central Basin's service area includes retail demand and groundwater replenishment. Retail demand is defined as all municipal (residential, firefighting, parks, etc.) and industrial uses, and represents the population's total direct water consumption. Replenishment uses, including deliveries to the saline barriers (Alamitos) or to the spreading grounds (Montebello), are not directly delivered to the public but enable continued groundwater production to help satisfy retail demand.

Table 2-2
Demographic Projections for Central Basin's Service Area[1]

Year	2005	2010	2015	2020	2025	2030
Population	**1,614,400**	**1,655,200**	**1,712,300**	**1,768,000**	**1,821,200**	**1,872,500**
Single-family	291,200	300,200	301,800	311,400	320,500	323,800
Multi-family	124,900	132,600	147,000	153,400	160,200	172,900
Total Household	**416,100**	**432,800**	**448,800**	**464,800**	**480,700**	**496,700**
Persons per Household	3.84	3.78	3.78	3.77	3.75	3.74
Employment	591,700	659,700	682,600	702,600	720,500	736,900

[1] Information based on MWD Demographic Data, 2005.
Note: All units are rounded to the nearest hundred; totals may not sum exactly due to rounding.

Figure 2-1 displays Central Basin's total retail water demand from FY 1990 to 2005. As previously discussed, retail demands have remained fairly consistent since 1995 following several years of increasing demands after the drought. The average retail demand for the past 15 years is 260,468 AF.

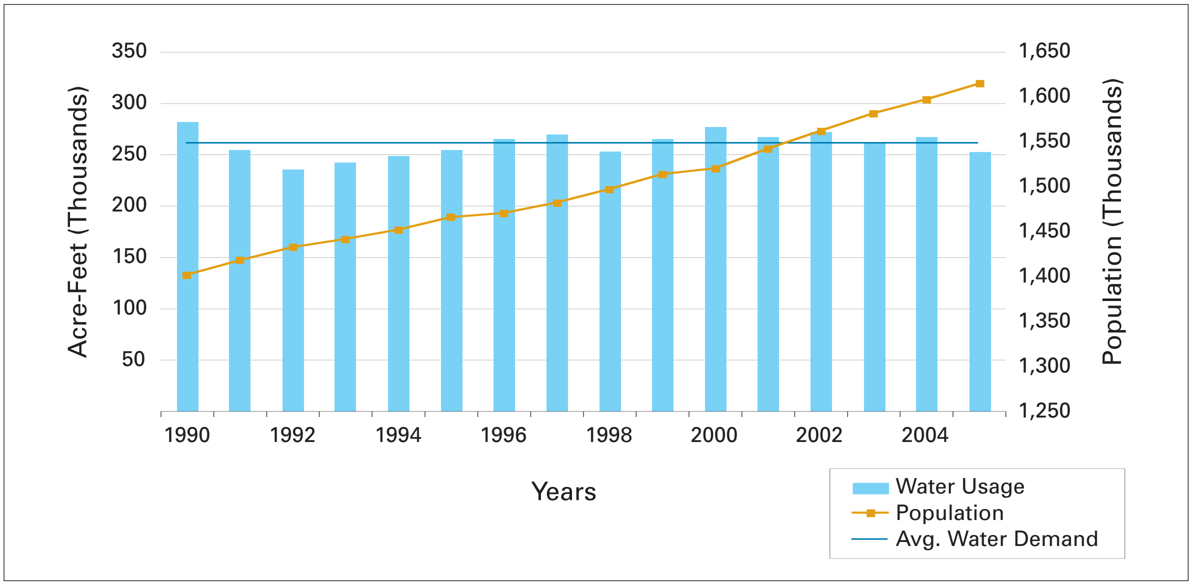
The District averaged 264,167 AF for the past five years, which is only 1.4% above the 15 year average.

Central Basin's service area is using the same amount of water as it did 10 years ago, despite the addition of 148,560 people. This indicates that water conservation and education has significantly affected the manner in which Central Basin's residents are using water today. We can further verify this by reviewing Central Basin's water usage per person in "Per Capita Water Usage."

2.4.1 HISTORICAL PER CAPITA WATER USAGE

According to the Pacific Institute[3], the State's total water usage is equivalent to 183 gallons per capita

Figure 2-1
Central Basin's Historical Total Retail Water Demand[1] vs. Population



[1] Information based on MWD Demographic Data, 2005.

3 Pacific Institute, Waste Not, Want Not: The Potential for Urban Water Conservation in California, 2003. pg. 4 per day (gpcd) for the nearly 34 million people living in California. Through conservation measures such as Ultra-Low-Flush Toilets (ULFT), High Efficiency Clothes Washers, low-flow showerheads, new technologies in water irrigation and education programs, Central Basin has gradually reduced Per Capita water usage.

For the last five years the usage has decreased to an average of 152 gallons per day gpcd. Figure 2-2 illustrates the retail water usage per capita for the last five fiscal years comparative to population in Central Basin's service area.

As displayed below, population has been steadily increasing in the last five years while Per Capita water usage decreased to 140 gpcd, verifying the notion that the District's current water resources efforts are meeting the growing water demands of today.

2.4.2 REPLENISHMENT DEMANDS

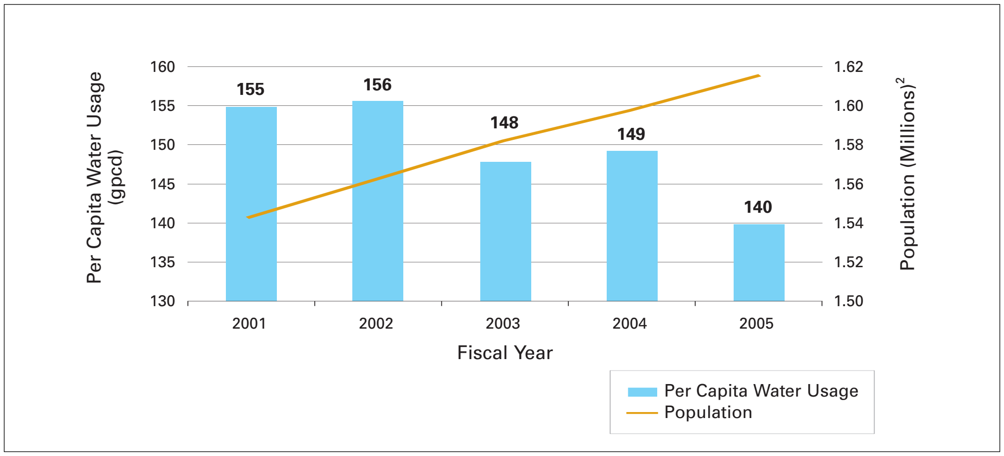
Replenishment water is defined as water that is used to refill or protect the groundwater basin. The Water Replenishment District of Southern California (WRD) is the entity responsible for maintaining and replenishing the West Coast and Central Groundwater Basins. WRD is a special district created by the State and governed by a five-member elected body to replenish and protect these groundwater basins with imported water and recycled water.

Spreading Demands

As groundwater is extracted annually beyond the natural level of replenishment known as basic yield, WRD purchases supplemental water to refill the basin and replenish the amount that is extracted above the basin yield. This replenishment water is a combination of allowable deliveries of recycled water and the purchases of untreated imported water.

As the imported wholesaler, Central Basin sells untreated imported water to WRD to be conserved at the Rio Hondo and San Gabriel River Spreading Grounds (Spreading Grounds) in the Montebello Forebay. Demands at the Spreading Grounds have varied year to year. As shown in Figure 2-3 on the opposite page, imported spreading purchases can range from 45,000 AF to 0 AF in any given year. The cause for variation can be the result of available seasonal water from MWD or operations, maintenance and construction activities at the

Figure 2-2
Historical Per Capita Retail Water Usage[1]



[1] Retail water usage includes groundwater, imported water and recycled water.
[2] Information based on MWD Demographic Data, 2005.

spreading grounds, or unpredictable replenishment needs of the Basin. For example, spreading water deliveries were limited in 1997-98 due to the "El Nino" effect, which brought on heavy rains that met the replenishment needs for the Basin. By contrast, the drought conditions in the region in 1990 increased the need for replenishment deliveries to reach more than 50,000 AF. Nevertheless, WRD's purchases average 27,000 AFY of imported water per year.

Rio Hondo Spreading Grounds. Courtesy of WRD.

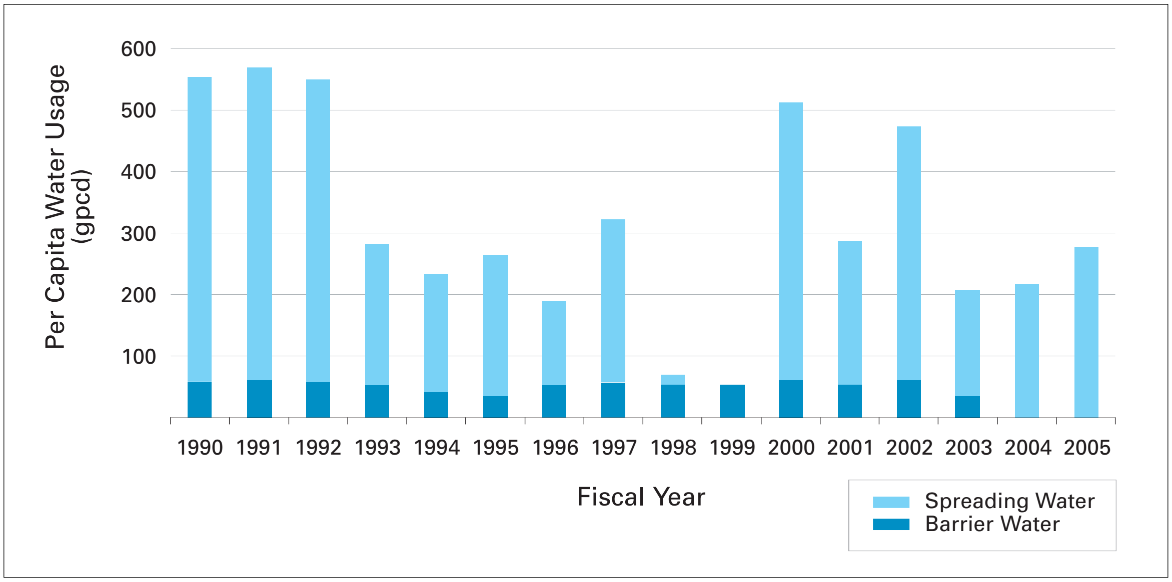
Barrier Demands

Unlike the Spreading Grounds, the demands at the Alamitos Barrier (Barrier) are mostly consistant year to year. This is mainly due to the required regular injection of imported water needed to prevent seawater intrusion from entering into the Basin. For the last 10 years, the average demand at the Barrier has been about 5,300 AF. However, in 2003 the City of Long Beach took over the connection that serves the Barrier with imported water, and Central Basin no longer supplies water to meet those demands. Looking forward, WRD plans to reduce imported demands at the Barrier by 3,000 AF, replacing it with the delivery of highly treated recycled water through WRD's new Leo J. Vander Lans Advanced Water Treatment Center located in Long Beach.

2.4.3 RETAIL WATER DEMAND BY CUSTOMER AGENCY

As mentioned above, Central Basin, as a wholesaler, has not seen significant increases in water demands for the past 10 years. However, local retail customer agencies have experienced

Figure 2-3
Replenishment Demands in Central Basin's Service Area



Source: Central Basin Wateruse Database, 2005

Table 2-3
Total Water Demand Per Central Basin Customer Agency
FY 1990-1995 vs. FY 2000-2005
(In Acre-Feet)

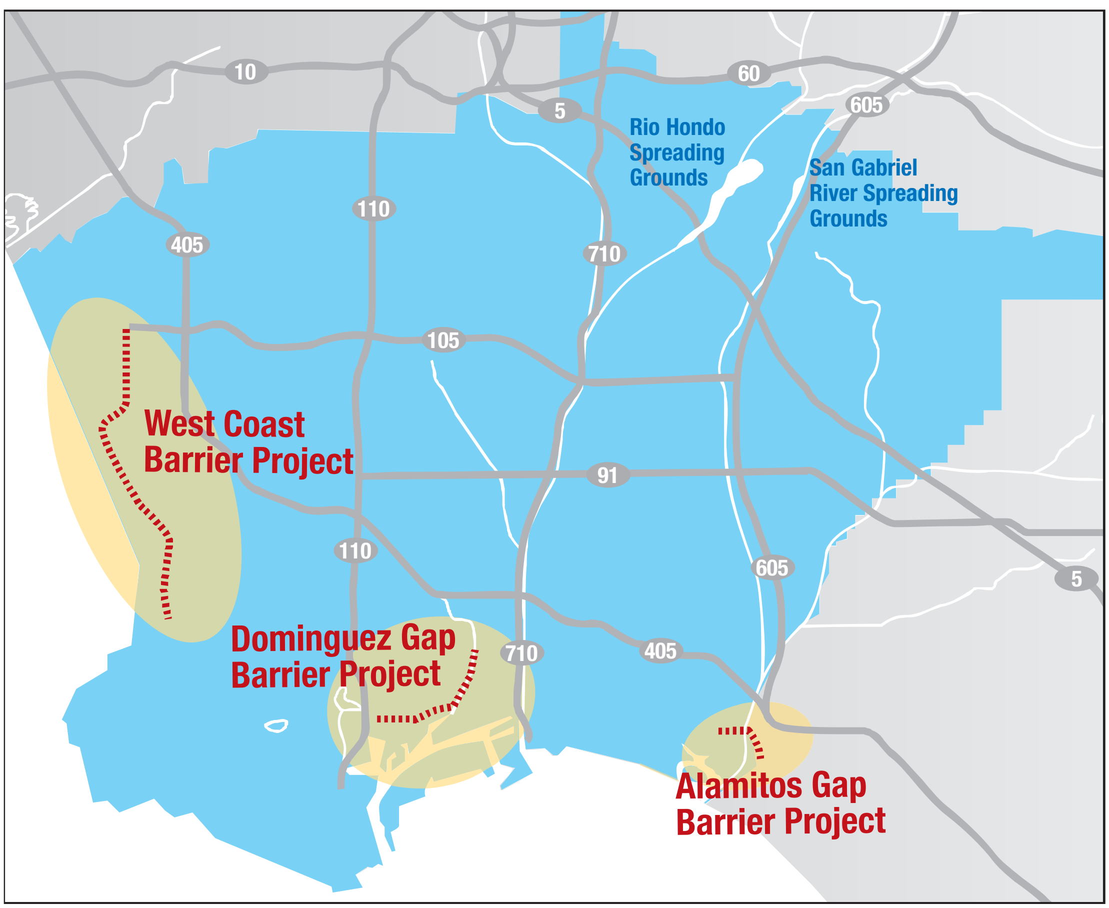
Customer Agency	1990-1995 Average Total Water Use	2000-2005 Average Total Water Use	% Increase/ (Decrease)
Bellflower- Somerset MWC	8,102	6,465	(20.2%)
Cal-Water- East LA	20,500	21,098	2.9%
Cal-Water- Commerce	2,663	2,689	1.0%
City of Bell Gardens	1,204	1,252	4.0%
City of Cerritos	12,239	14,644	19.7%
City of Downey	16,263	18,297	12.5%
City of Huntington Park	5,746	5,826	1.4%
City of Lakewood	8,733	9,545	9.3%
City of Lynwood	6,710	6,850	2.1%
City of Montebello	1,594	1,627	2.1%
City of Norwalk	1,358	1,564	15.2%
City of Paramount	7,407	7,923	7.0%
City of Santa Fe Springs	8,549	8,462	(1.0%)
City of Signal Hill	1,908	2,295	20.3%
City of South Gate	9,368	11,281	20.4%
City of Vernon	8,941	11,729	31.2%
LA Co. - Rancho Los Amigos	947	880	(7.1%)
La Habra Heights Water District	2,331	2,824	21.1%
Maywood MWC No.1	884	941	6.4%
Maywood MWC No.2	1,461	1,318	(9.8%)
Maywood MWC No.3	1,478	1,518	2.7%
Orchard Dale Water District	2,276	2,448	7.6%
Park Water Company	10,928	14,043	28.5%
San Gabriel Valley WC	5,255	3,555	(32.4%)
Southern California WC	30,256	29,998	(0.9%)
Suburban Water System	15,743	15,441	(1.9%)
Walnut Park Mutual WC	1,491	1,567	5.1%
Total	**194,335**	**206,080**	

changes in their overall water demand since 1990. Table 2-3, on the opposite page, illustrates the changes, either increases or decreases, in each retail customer agencies' average water usage during two different five-year periods since 1990.

Although some agencies have seen some dramatic shifts in water demand usage during the past 15 years, the overall average per customer agency saw a 5.5% increase in water demand. Some of the significant changes among customer agencies may be attributed to reductions and/or expansions in service area, an increase or decrease in industrial customers and/or further land use development.

2.5 PROJECTED WATER DEMANDS

One of the objectives of this Plan is to provide some insight into Central Basin's expected water demands for the next 25 years. The predictability of water usage is an important element in planning future water supplies. The methodology used to determine demand forecasting is a combination of historical water use analysis, population growth and commercial and residential development. Central Basin, with the assistance of MWD's forecasting model known as MWD-MAIN (Municipal and Industrial Needs) Water Use Forecasting System, is able to develop some well formulated water demand projections.



Courtesy of WRD.

Water Replenishment District service area and locations of spreading grounds and seawater intrusion barriers

The MWD-MAIN forecasting model determines expected urban water usage for the next 25 years. This model incorporates Census data, industrial growth, employment and regional development from regional planning agencies, such as SCAG (Southern California Association of Governments), to project water demands. It also features demands in sectors such as single family, multi-family, industrial, commercial and institutional usage for the region. MWD also takes into account current and future water management efforts, such as water conservation Best Management Practices (BMPs) and education programs.

Table 2-4 illustrates the current and projected retail water demands to the year 2030 for Central Basin under normal demand conditions.

As displayed below, the retail demand in Central Basin is expected to grow approximately 0.5% each year. Groundwater will remain consistent, due to the limited amount of extractable pumping rights within the basin, with imported and recycled water meeting the growth during the next 25 years.

2.5.1 PROJECTED PER CAPITA

As discussed previously, water demand is determined by the water usage per person. The future Per Capita usage shows how water demand is growing at a modest pace.

Table 2-5 shows a gradual decrease in Per Capita usage at a time when water has become a scarce commodity in a region where population is projected to increase. Although the total retail water usage continues to increase, the amount of water used per person will decline during the next 25 years. Essentially, more people are using less water.

Table 2-5
Projected Per Capita Retail Water Usage in Central Basin's Service Area

Year	Estimated Population[1] (Millions)	Retail Water Usage[2] (AF)	Per Capita (GPCD)
2010	1.655	273,991	148
2015	1.712	281,122	147
2020	1.768	287,400	145
2025	1.821	294,650	144
2030	1.873	301,900	144
		Average	**146**

[1] Information based on MWD Demographic Data, 2005.
[2] Retail Water Usage includes recycled water but does not include replenishment sales.

2.5.2 PROJECTED REPLENISHMENT DEMAND

Future replenishment demands are difficult to project because of the variation in operational changes and replenishment needs. WRD expects reduced deliveries of imported water at the Barrier with increased deliveries of recycled water.
Furthermore, there are projects currently being studied to increase the amount of storm and recycled water at the Spreading Grounds within the Central Basin. Any one of these projects can affect

Table 2-4
Central Basin's Current and Projected M&I Water Demand
(In Acre-Feet)

District Water Demands	2005[1]	2010	2015	2020	2025	2030
Retail Municipal & Industrial Use						
Groundwater[2]	186,549	202,000	202,000	202,000	202,000	202,000
Imported Water	61,033	59,091	64,691	70,462	76,409	82,535
Recycled Water[3]	5,217	12,900	14,150	15,400	16,650	17,900
Total	**252,799**	**273,991**	**280,841**	**287,862**	**295,059**	**302,435**

[1] The 2005 demands are based on the 2004-05 year, which was considered one of the "wettest" years on record.
[2] Includes groundwater production from the Central and Main San Gabriel Basins (est. 42,000 AF).
[3] Includes Recycled Water sales from Central Basin's service area and Cerritos Water Systems.

the projections of replenishment water demands. Below are the estimated replenishment demands during the next 25 years under normal conditions. Although replenishment demands may fluctuate year to year, the overall demand should stay relatively the same because groundwater production within the Central Basin is limited according to the allowable pumping rights each producer is allocated in the Central Basin. Furthermore, groundwater production is at or around its maximum amount; therefore, replenishment demands should not significantly increase.

Table 2-6
Projected Replenishment Demands
(In Acre-Feet)

District Water Demands	2005	2010	2015	2020	2025	2030
Replenishment						
Imported Water[1]	27,600	27,600	27,600	27,600	27,600	27,600
Recycled Water[2]	50,000	50,000	50,000	50,000	50,000	50,000
Total	**77,600**	**77,600**	**77,600**	**77,600**	**77,600**	**77,600**

[1] Imported water demands are based on the Water Replenishment District's projected estimate needs, although they may adjust depending upon groundwater production.

[2] Recycled water is limited to 50,000 AF according to the California Department of Health Service's permit which allows a maximum of 150,000 AF over three years.

Section 3

Water Supply

3

Water Supply

This section discusses the current and future water supply within Central Basin's service area

3.1 OVERVIEW

It is Central Basin's mission to ensure a safe, adequate and reliable supply of water for the region it serves. However, with a limited supply and growing demand for water, the task of meeting this mission is becoming increasingly challenging.

Sixty years ago the average customer agency in Central Basin relied completely on groundwater. Today, however, it relies on a more diverse mix of water resources: 68% groundwater, 22% imported, 2% recycled water (only M&I) and 8% conservation efforts. It is projected that by 2030, the resource mix on average will be 56% groundwater, 23% imported and 5% recycled water, with conservation meeting the remaining 16%. Diversification of water supplies has become one of the District's answers to ensuring a reliable supply of water for its service area.

This section provides an overview of the current and future water supplies needed to meet the expected demands of Central Basin, including a review of the District's current and projected water supply mix, a description of each water source on which Central Basin's customer agencies currently rely and expected future supplies that Central Basin is planning and/or developing to meet its region's future demands.

3.2 CENTRAL BASIN'S WATER SUPPLY PORTFOLIO

Since its formation in 1952, Central Basin has fulfilled its responsibility of providing its customer agencies with supplemental supplies to ensure reliability. Today, diversification is the key to an ample future supply of water throughout its service area. As illustrated in Figure 3-1, Central Basin's supply portfolio has changed through the years.

Similar to creating a balanced investment portfolio to reduce risk, the District plans to further diversify the water resource mix during the next 25 years with the expansion of the District's recycled water system, increased conservation efforts and groundwater storage opportunities. The District's dependence on traditional sources of water (groundwater and imported) will continue to decrease with the expansion of these alternative resources. Figure 3-1 and Table 3-1 show the historical, current and projected water supply portfolio that the District is anticipating meeting by the year 2030.

Figure 3-1
Historical, Current & Projected Water Supplies

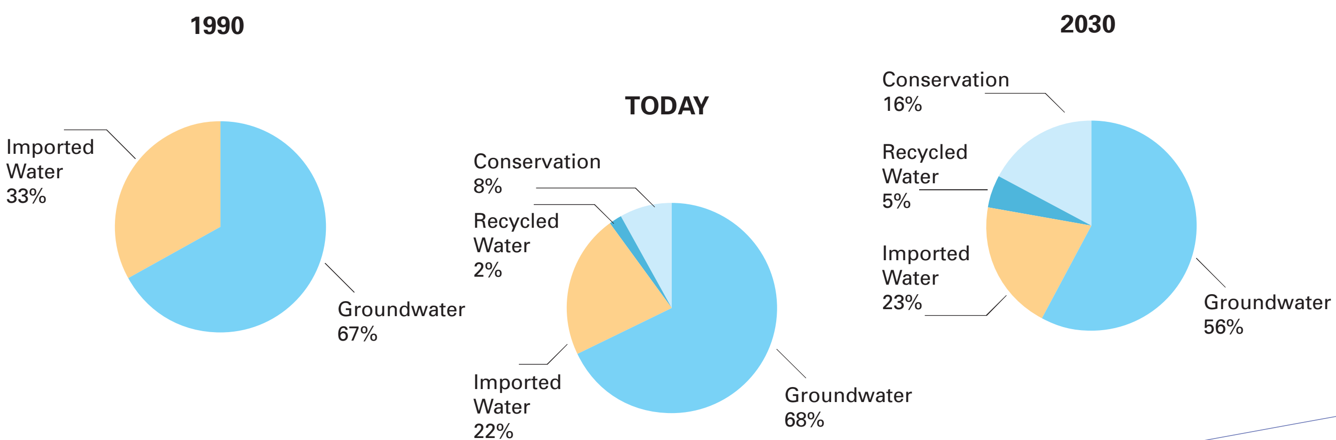


Table 3-1
Historical, Current & Projected Retail Water Supplies
(In Acre-Feet)

Type of Water		FY 1990	Today[1]	2030
Groundwater[2]		187,931	186,549	202,000
Imported Water[3]		94,059	61,033	82,535
Recycled Water[4]		-	5,217	17,900
	Total	**281,989**	**252,799**	**302,435**
Conservation[5]		-	21,100	58,400
	Total	**281,989**	**273,899**	**360,835**

[1] Sales based upon FY 2004-05.
[2] Groundwater production within Central Basin service area only, including imported groundwater production from Main San Gabriel Basin (Avg 42,000 AFY).
[3] Imported retail use only; does not include replenishment deliveries (i.e. Spreading or Barrier).
[4] Recycled retail use only; does not include replenishment deliveries (i.e. Spreading or Barrier).
[5] Conservation consists of active and passive savings according to the District's projected estimates.

3.3 CENTRAL BASIN'S WATER SOURCE

3.3.1 IMPORTED WATER SUPPLY

Central Basin relies on approximately 90,600 acre-feet per year (AFY) of imported water from the Colorado River and SWP to meet the District's retail and replenishment demands. MWD receives this supply from these two major water systems that supplies a majority of the Southern California region.[1]

Colorado River

MWD was established to develop a supply from the Colorado River. Its first mission was to construct and operate the Colorado River Aqueduct (CRA), which can deliver roughly 1.2 million acre-feet (MAF) per year. Under its contract with the federal government, MWD has a basic entitlement of 550,000 AF per year of Colorado River water. MWD also holds a priority for an additional 662,000 AF per year. MWD can obtain water under this priority when the U.S. Secretary of the Interior determines that either one or both of the following exists:

- surplus water; and/or
- water is apportioned to but unused by Arizona and/or Nevada.

MWD and the State of California have acknowledged that they could obtain less water from the Colorado River in the future than they have in the past, but the lack of clearly quantified water rights hindered efforts to promote water management projects. The U.S. Secretary of Interior asserted that California's users of Colorado River water had

1. *A third aqueduct to Southern California, the Los Angeles Aqueduct, supplies imported water from the eastern Sierra Nevada region to the City of Los Angeles.*

to limit their use to a total of 4.4 MAF per year, plus any available surplus water. The resulting plan, known as “California's Colorado River Water Use Plan” or the “California Plan,” characterizes how California would develop a combination of programs to allow the state to limit its annual use of Colorado River water to 4.4 MAF per year plus any available surplus water. The Quantification Settlement Agreement (QSA) among the California agencies is the critical component of the California Plan. It establishes the baseline water use for each of the agencies and facilitates the transfer of water from agricultural agencies to urban uses.

In the context of the QSA, MWD has identified a number of storage and transfer programs that could be used to achieve long-term development targets for a full CRA and it has entered into or is exploring agreements with a number of agencies.

State Water Project

California's State Water Project (SWP), MWD's second main source of imported water, is the nation's largest state-built water and power development and conveyance system. It includes facilities-pumping and power plants, reservoirs, lakes and storage tanks, and canals, tunnels and pipelines that capture, store and convey water from the Lake Oroville watershed in Northern California to 29 water agencies in Central and Southern California. Planned, designed, constructed and now operated and maintained by the California Department of Water Resources (DWR), this unique facility provides water supplies for 23 million Californians and for 755,000 acres of irrigated farmland.

The original State Water Contract called for an ultimate delivery capacity of 4.2 MAF, with MWD holding a contract for 2,011 MAF. More than two-thirds of California's drinking water, including all of the water supplied by the SWP, passes through the San Francisco- San Joaquin Bay-Delta (Bay-Delta). For decades, the Bay-Delta system has experienced water quality and supply reliability challenges and conflicts due to variable hydrology and environmental standards that limit pumping operations.

In 1999, MWD's Board of Directors set new goals for the SWP with the adoption of its CALFED Policy Principles. These goals committed MWD to water quality objectives, the development of 0.65 MAF minimum dry-year supply from the SWP by 2020 and average annual deliveries of 1.5 MAF (excluding transfers and storage programs along the SWP). To achieve these goals while minimizing impacts to the Bay-Delta ecosystem, MWD would maximize deliveries to storage programs during wetter years, implement a number of source water qualities and supply reliability improvements in the Delta, remove operational conflicts with the Central Valley Project (CVP) and better coordinate planning and operations between the SWP and CVP.

Types of Imported Supplies

MWD offers different types of imported water to its member agencies depending on the ultimate use. Among them, Central Basin has delivered Non-Interruptible Water (treated full-service), Seasonal Treated Replenishment Water and Seasonal Untreated Replenishment Water.

Non-Interruptible Water is the treated firm supply that is available all year round. Central Basin delivers an average of 63,000 AFY of non-interruptible water annually. It is used as the main supplemental supply of cities and water agencies and has historically been used as the main supply for the Alamitos Barrier; however, the City of Long Beach now provides water for that barrier.

Seasonal Treated Replenishment Water, also known as the “In-Lieu” water, is delivered to customer agencies that are eligible to offset groundwater production with imported water. This program incentivizes customer agencies to take imported surplus water which indirectly replenishes the groundwater basin. This surplus water is purchased at a discount rate in exchange for leaving groundwater in the basin for no less than a year so that it can be used subsequently during dry years.

Seasonal Untreated Replenishment Water, better known as “Spreading” water, is delivered to the replenishment spreading grounds in the Montebello Forebay. Spreading water does not require treatment and is generally provided during the seasonal months (October through April), which allows for it to be purchased at a discounted rate. WRD is the sole purchaser of spreading water, and the amount varies year to year depending on replenishment needs of the Basin, with the long term average being approximately 27,600 acre-feet per year.

3.3.2 GROUNDWATER SUPPLY

Groundwater has for many years been the primary supply of water within Central Basin’s service area. In fact, it was the sole source of water supply until the Central Groundwater Basin (Basin) was overdrafted in the late 1940s. Today, the average customer agency in Central Basin relies on groundwater production for 62% of its water supply, although there still remain a few agencies in the District’s service area that rely exclusively on groundwater to meet all current water needs.

Ultimately, the extensive overpumping of the Basin through the years led to critically low groundwater levels. This overpumping of the Basin resulted in a legal judgment, or adjudication, that limited the allowable extraction that could occur in any given year and assigned water rights to basin pumpers. The adjudicated water rights were greater than the Basin yield; therefore, the Basin was operating with an annual overdraft. In order to address this overdraft, imported and recycled water sources and a means to purchase these sources were required. The groundwater producers (pumpers) in the area, which are members of the Central Basin Water Association, led the creation of the Water Replenishment District of Southern California (WRD), which manages the replenishment of the groundwater basin.

In 1959, the State Legislature enacted the Water Replenishment Act, enabling the water associations for the Basin to secure voter approval for the formation of the “Central and West Basin Water Replenishment District” (now referred to as the Water Replenishment District of Southern California or “WRD”) to be the permanent agency in charge of replenishing the Basin. The State Legislature has vested in WRD the statutory responsibility to manage, regulate, replenish and protect the quality of the groundwater supplies within its boundaries for the beneficial use of the approximately 3.5 million residents and water users who rely upon those groundwater resources to satisfy all or a portion of their beneficial water needs.

Although the water rights have been bought, sold, exchanged or transferred through the years, the total amount of allowable extraction rights within the entire groundwater basin has remained virtually the same. The adjudicated pumping rights available within Central Basin's service area totaled 163,960 AF. However, not all of these water right holders are water retail agencies. Many of these holders are nurseries, businesses, cemeteries and private entities that make up approximately 23% (37,287 AF) of the total water rights. Shown in Table 3-2 are all of the water retailers' adjudicated groundwater rights in Central Basin's service area for fiscal year 2003-04.

Although most of the groundwater supply is extracted from the Central Basin, there are a number of water retailers that retain groundwater rights within the Main San Gabriel Basin that are extracted and imported within their Central Basin service area. The Main San Gabriel Basin underlies most of the San Gabriel Valley, above Central Basin. It is bounded by the San Gabriel Mountains to the north, San Jose Hills to the east, Puente Hills to the south and by the Raymond Fault and a series of other hills to the west.

Table 3-2
Groundwater Pumping Rights 2003-2004

Central Basin Retail Agencies	Adjudicated Pumping Rights in Central Basin
Bellflower- Somerset MWC	4,313
California Water Service Company- East LA	11,774
California Water Service Company- Commerce	5,081
City of Bell Gardens	1,914
City of Cerritos	4,680
City of Downey	16,553
City of Huntington Park	3,853
City of Lakewood	9,423
City of Lynwood	5,337
City of Montebello	387
City of Norwalk	1,267
City of Paramount	5,883
City of Santa Fe Springs	4,036
City of Signal Hill	2,022
City of South Gate	11,183
City of Vernon	8,039
County LA- Rancho Los Amigos	490
La Habra Heights County Water District	2,498
Maywood Mutual Water Company No.1	741
Maywood Mutual Water Company No.2	912
Maywood Mutual Water Company No.3	1,407
Orchard Dale Water District	1,107
Park Water Company	1
San Gabriel Valley Water Company	2,616
Southern California Water Company	16,439
Suburban Water System	3,721
Walnut Park Mutual Water Company	996
Non-Retail Water Agencies[1]	37,287
Total	**163,960**

Source: Central Basin Watermaster Report, 2004
[1] Water right holders that are not water retail agencies; i.e. nurseries, cemeteries, industries, etc.

The total amount of water extracted from the Main San Gabriel Basin and imported within Central Basin service area totals approximately 42,000 AFY. Table 3-3 displays the water retailers and the amount produced from this adjoining basin for the past five fiscal years.

As illustrated in Table 3-4, the total amount of groundwater produced through the past five years in the Central and Main San Gabriel Basins has remained fairly consistent. The amount of groundwater produced ranges from 94% to 98% of the total groundwater supply available.

The total amount of groundwater projected to be extracted during the next 25 years will be fairly consistent due to the adjudication in both basins. The economic costs to pump groundwater versus the purchases of imported water will pressure water retailers to maximize their groundwater rights. Therefore, the total amount of groundwater produced is projected to range in the 98% percentile of available supply, as illustrated in Table 3-5 on the next page.

Groundwater Recharge

For the past 42 years, WRD has replenished the Basin through "Spreading Grounds" and prevented further seawater intrusion by injecting recycled and imported water into the Alamitos Barrier, which were created by the Los Angeles County Flood Control District (LACFCD) and owned and operated by the Los Angeles County Department of Public Works.

WRD assesses a groundwater production fee, known as their "Replenishment Assessment," to pumpers in the Basin. This assessment provides funds that WRD uses to purchase and produce water for both spreading and injection to replace groundwater pumped as well as hydrological barriers to seawater intrusion. The available supply of replenishment water to physically recharge the basins can be classified as follows:

Table 3-3
Amount of Groundwater Pumped from Main San Gabriel Basin
(In Acre-Feet)

Water Retailer	2000	2001	2002	2003	2004
California Domestic Water Co.	19,886	18,603	21,204	21,338	21,233
San Gabriel Valley Water Co.	279	300	1,500	1,454	1,450
Suburban Water Systems	13,570	12,885	13,773	11,497	12,353
City of Whittier	8,952	8,107	8,116	7,411	8,021
Total	**42,687**	**39,895**	**44,593**	**41,700**	**43,057**

Source: Central Basin Watermaster Report

Table 3-4
Total Amount of Groundwater Pumped
(In Acre-Feet)

Basin Name	2000	2001	2002	2003	2004
Central Groundwater Basin[1]	158,516	153,242	157,036	152,802	151,785
Main San Gabriel Basin[2]	42,687	39,895	44,593	41,700	43,057
Total	**201,203**	**193,137**	**201,629**	**194,502**	**194,842**
% of Total Water Supply	98%	94%	98%	94%	95%

[1] Includes Central Basin's service area groundwater production.
[2] Water Production from Main San Gabriel Basin and imported into Central Basin's service area.

Table 3-5
Total Amount of Groundwater Projected to Be Pumped
(In Acre-Feet)

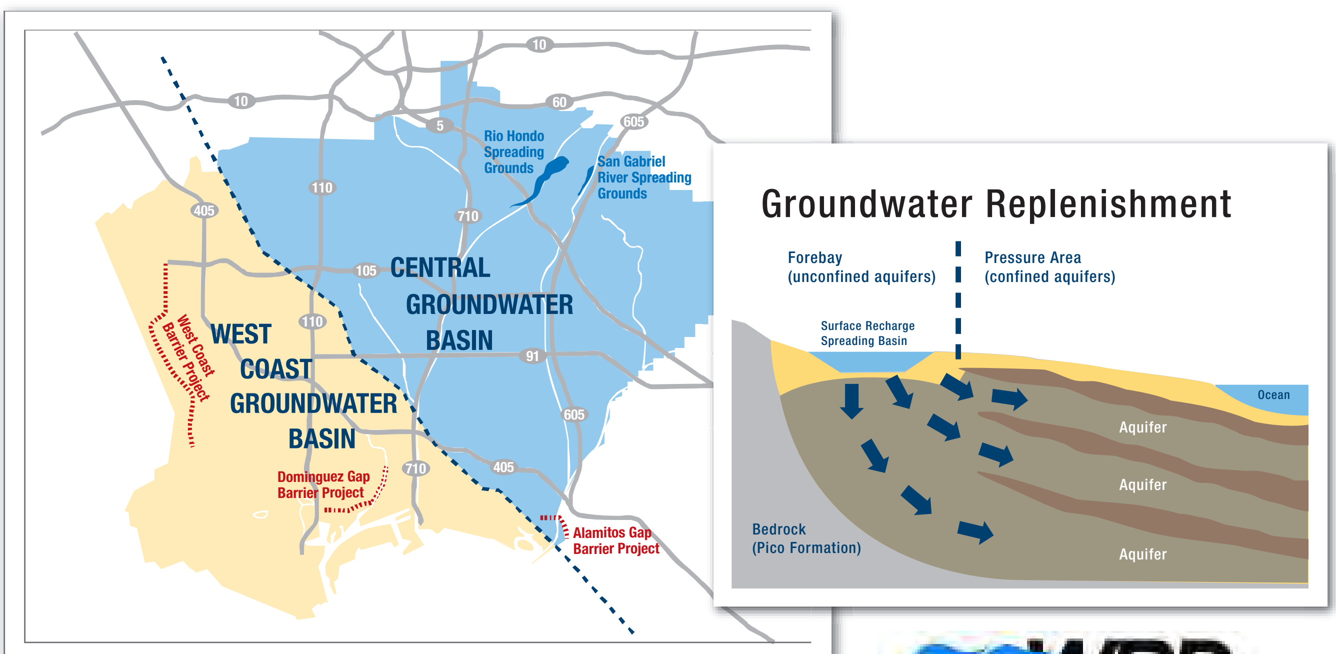
Basin Name	2010	2015	2020	2025	2030
Central Groundwater Basin[1]	160,000	160,000	160,000	160,000	160,000
Main San Gabriel Basin[2]	42,000	42,000	42,000	42,000	42,000
Total	**202,000**	**202,000**	**202,000**	**202,000**	**202,000**
% of Total Water Supply	98%	98%	98%	98%	98%

[1] Includes Central Basin's service area groundwater production.
[2] Water Production from Main San Gabriel Basin and imported into Central Basin's service area.

- **Local water**
  Storm flows from the San Gabriel River, Rio Hondo and other waterways within the San Gabriel Valley and flow obligations under the San Gabriel River Judgment with the Upper Area of the Central Basin, defined as "Make-up Water."

- **Recycled water**
  Recycled water purchased from the County Sanitation Districts of Los Angeles County for deliveries at the Montebello Forebay Spreading Grounds or highly treated water for injection into the Alamitos seawater barrier.

- **Imported water**
  Purchased untreated imported water from Central Basin for deliveries at the Montebello Spreading Grounds or treated imported water from the City of Long Beach for injection into the Alamitos seawater barrier.



Courtesy of WRD.

Colorado River Aqueduct. Courtesy of MWD.

WRD also encourages in-lieu replenishment of the Basin. Under the In-Lieu program, pumpers are encouraged through a financial incentive to purchase surplus imported water from Central Basin "in-lieu" of pumping groundwater.

Table 3-6 summarizes the historical amounts of imported water purchased to replenish the Basin at both the Spreading Grounds and at the Alamitos Barrier.

3.3.3 RECYCLED WATER SUPPLY

Recycled water is one of the cornerstones of Central Basin's efforts to augment local supplies and reduce dependence on imported water. Since the planning and construction of Central Basin's water recycling system in the early 1990s, Central Basin has become a leader in producing and marketing recycled water. This new supply of water assists in meeting the demand for non-potable applications such as landscape irrigation, commercial and industrial processes, and seawater barriers. Recycled water is a resource that is reliable and environmentally beneficial to the region. It is only limited by the infrastructure needed to deliver this source of water. With approximately 201 site connections, Central Basin has delivered an average of 3,800 AF per year both inside and outside of the District's service area. This upcoming fiscal year, the District anticipates recycled water sales to reach 5,000 AF.

Table 3-6
Historical Imported Water Replenishment Deliveries
(In Acre-Feet)

Fiscal Year	Spreading Water	Barrier Water[1]	Total
1990	49,531	5,756	**55,287**
1991	50,785	6,168	**56,953**
1992	49,229	5,757	**54,986**
1993	22,987	5,261	**28,248**
1994	19,239	4,145	**23,384**
1995	23,008	3,496	**26,504**
1996	13,693	5,269	**18,962**
1997	26,440	5,739	**32,179**
1998	1,562	5,336	**6,898**
1999	0	5,330	**5,330**
2000	45,037	6,169	**51,206**
2001	23,451	5,398	**28,849**
2002	41,268	6,062	**47,330**
2003	17,297	3,479	**20,776**
2004	21,788	0	**21,788**
2005	27,785	0	**27,785**

Source: Central Basin Wateruse Database, 2005
[1] Barrier supplies transferred to the City of Long Beach in 2003.

In addition, the City of Cerritos has its own recycled water system that currently treats and supplies within its City's boundaries and its neighbor, the City of Lakewood, a total of 2,400 AF per year. Together, both these recycled water programs plan to offset potable supplies by 7,400 AF this next fiscal year.

Recycled water deliveries within Central Basin are projected to reach 10,500 AF by year 2010. Refer to a more detailed description of Central Basin's water recycling program in Section 8 of this Plan.

Recycled water effluent from San Jose Creek Plant.

3.4 ALTERNATIVE WATER SUPPLY PROJECTS

3.4.1 CONJUNCTIVE USE GROUNDWATER STORAGE

Conjunctive Use can be defined as the coordinated management of surface and groundwater supplies to increase the yield of both supplies and enhance water supply reliability in an economic and environmentally responsible manner. Central Basin sees the development of Conjunctive Use Storage Programs as part of the District's core responsibility to ensure a reliable supply of water for its service area. If done in a publicly responsible manner, groundwater storage can be viewed as an additional source in diversifying our water resource supply portfolio.

The potential benefits of a Conjunctive Use program include:

- Operational flexibility for groundwater production;
- Increased yield of the basin;
- More efficient use of surplus surface water during wet years;
- Financial benefits to groundwater users;
- Better distribution of water resources and
- Increased measures of reliability.

At this time there are programs available for water retailers to create groundwater storage both within and outside of the Basin judgment. Included is the availability for a District-sponsored storage program with MWD in which retail agencies with imported water connections could partake. The size of such a program would depend on retailers' total demand and the amount that they could realistically shift of groundwater to imported water.

3.4.2 WATER TRANSFERS & EXCHANGES

Water transfers and exchanges are management tools to address increased water needs in areas of limited supply. Although they do not generate a new supply of water, they do better distribute water from where it is abundant to where it is limited.

MWD, in recent years, has played an active role statewide in securing water transfers and exchanges as part of their IRP goals. Although Central Basin is a member of MWD, there has not been a compelling reason or opportunity to pursue transfers directly.

3.4.3 DESALINATED WATER

Desalination is viewed as a way to develop a local, reliable source of water that assists agencies in reducing their demand on imported water, reducing groundwater overdraft and in some cases make unusable groundwater available for municipal uses. Although Central Basin currently has not identified any projects for desalination of seawater or impaired groundwater, the District is a strong supporter of the endeavor. This additional source of water supply would provide greater water reliability for the District.

In 2005, the District passed a resolution supporting the efforts of its sister agency, West Basin Municipal Water District (West Basin), in the development of a seawater desalination project. West Basin has been operating a desalination pilot project since May 2003 to identify optimal performance conditions and evaluate the water quality of the water produced. The project is located at the El Segundo Power Plant and processes 40 gallons per minute.

Section 4

Water Reliability

4

Water Reliability

This section discusses Central Basin's plan of maintaining a reliable source of water

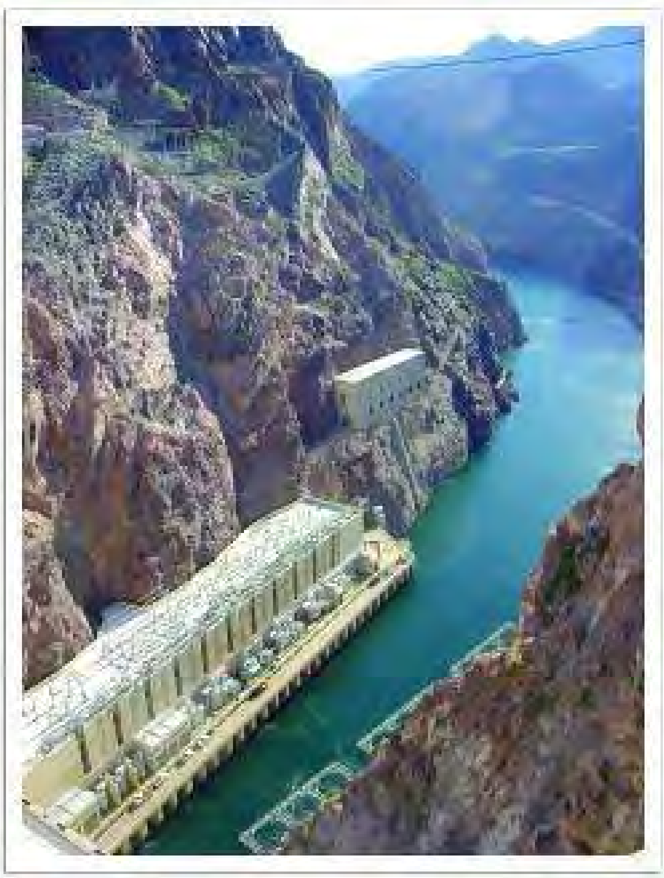
4.1 OVERVIEW

Among the future challenges of continued urbanization in Southern California is the question of water reliability. In other words, can Southern California meet the necessary water demands of the region during times of drought? During consecutive dry years, Southern California has historically seen demands increase by as much as 20% while supplies have decreased. Prior to recent significant improvements in water reliability, most cities and agencies were forced to mandate conservation efforts and restrict water use in some cases in order to maintain an adequate supply.[1]

This section will discuss how the regional supplier, MWD, in partnership with its member agencies such as Central Basin, plans on ensuring future reliability through water management measures, long-term planning and investment in local resources, Central Basin's projections for meeting its service area's future demands during single and multiple dry-year conditions and, finally, a review of the District's Water Shortage Contingency Plan in the event MWD limits deliveries.

4.2 MWD WATER SUPPLY RELIABILITY

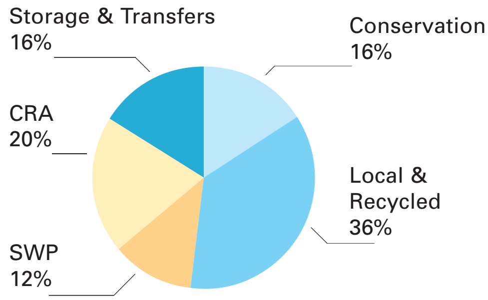
With the experience of the droughts of 1977-78 and 1989-92, MWD has undertaken a number of planning initiatives to ensure water supply reliability. Included among them are the Integrated Resources Plan (IRP), the Water Surplus and Drought Management Plan (WSDM Plan) and local resource investments. Together, these initiatives have provided the policy framework for MWD and its member agencies to manage their water resources in such a way to meet a growing population even under recurrences of the worst historical hydrologic conditions locally and in the key watersheds that supply Southern California. Below is a brief description of each water management initiative MWD has undertaken to ensure 100% reliability during the next 20 years.



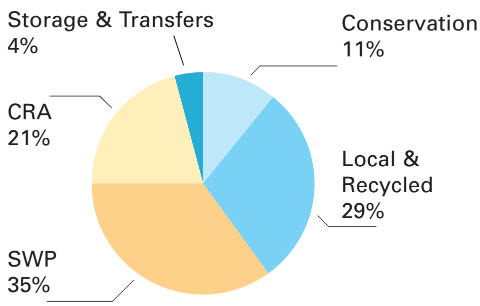
Colorado River water at Hoover Dam in Nevada.

1 By contrast, the loss of a large portion of our Colorado River supply in 2004 during an extended dry period in Southern California did not cause hardship or require any drastic return on the part of the general population. This was a tribute to planning and investments made into water reliability during the past decade.

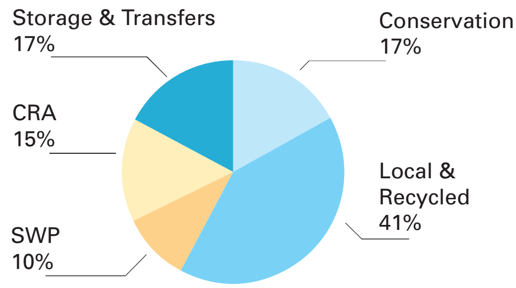
1996 IRP
2020



Prior to the IRP
2020



2003 IRP Update
2025



4.2.1 MWD INTEGRATED RESOURCE PLAN

To meet the challenges of the supply shortages on the State and Colorado River Aqueducts under increases in population and growing State and Federal regulatory requirements, MWD's Board of Directors called for the development of an IRP in 1996. The IRP's objective was to determine the appropriate combination of water resources to provide 100% reliability for full service demands during the next 20 years. With the support of its member agencies, MWD developed a preferred supply mix that includes conservation, local supplies (recycled, brackish, desalination), SWP supplies, CRA supplies, groundwater banking and water transfers that could meet projected water demands under severe shortage conditions. The IRP identifies supply targets for each supply option and has become the blueprint for guiding investment and policy decisions for decades to come.

By design, the IRP is also subject to revision when conditions and opportunities change through time. In 2003, MWD completed its first update to the IRP, which included revised projected demands and an updated resource supply mix. MWD has three clear objectives for the IRP update: (1) to review the goals and achievements of the 1996 IRP, (2) to identify changed conditions for water resource development and (3) to update the resource targets through 2025.

Among the most significant findings from the updated IRP was the increased participation of local agencies in developing local supplies such as recycled water and brackish groundwater desalination as well as promoting savings from conservation. The result revealed a greater source of local supply reliability than anticipated among MWD member agencies. However, it also identifies the limitations expected on the Colorado River and the need for local infrastructure improvements to provide the flexibility to manage and overcome supply risks.

Overall, the 2003 IRP Update revealed a decrease in the region's reliance on Colorado River and SWP supplies compared to the 1996 IRP, while continuing to provide 100% reliability through the year 2025.

4.2.2 MWD WATER SURPLUS AND DROUGHT MANAGEMENT PLAN

In order for MWD to be 100% reliable in meeting all non-discounted non-interruptible demands in the region, MWD adopted the WSDM Plan in 1999. The WSDM Plan provides the policy guidance to manage the region's water supplies to achieve the reliability goals of the IRP. This is achieved by integrating the operating activities of surplus and shortage supplies through a series of stages and principles.

Those principles include water management actions to secure more imported water during times of drought by promoting efficient water usage, increasing public awareness and seeking additional water transfers and banking programs. Should supplies become limited to the point where imported supplies are truncated, the WSDM Plan would allocate water through a calculation on the basis of need as opposed to any historical purchases through MWD. MWD and its member agencies have not yet decided on a formula for the allocation calculation.

4.2.3 MWD LOCAL RESOURCE INVESTMENTS

A key element within MWD's IRP objectives to ensure regional reliability is to further enhance local resources. In addition to the traditional supplies of imported water and groundwater, MWD has looked to invest in numerous local resources projects including recycled water, conservation, groundwater, surface water storage and even ocean water desalination to meet future demands.

Since 1982, MWD has provided financial assistance to more than 75 projects in the areas of water recycling and groundwater recovery totaling approximately $124 million and $41 million, respectfully.

MWD has already invested more than $290 million in water conservation, which has produced significant water savings for the past 15 years.

One of MWD's most significant investments is Diamond Valley Lake. Built in the saddle of two mountains, Diamond Valley Lake, Southern California's newest and largest reservoir, is a vital link in the regional system that has brought water to Southern California for the past 60 years. The lake nearly doubled the region's surface water storage capacity and provides additional water supplies for drought, peak summer and emergency needs. This newly created reservoir, located in southwestern Riverside County, holds enough water to meet the region's emergency and drought needs for six months and is an important component in MWD's plan to provide a reliable supply of water to the 18 million people in Southern California who rely on this water. Water began pouring into the reservoir in November 1999 and the lake was filled by early 2002. Diamond Valley Lake holds 800,000 AF, or 260 billion gallons, of water. By comparison, Lake Havasu on the Colorado River holds just 648,000 acre-feet, or 201 billion gallons. The lake nearly doubled the area's surface water storage capacity and provides additional water supplies for drought, peak summer and emergency needs.

Diamond Valley Lake. Courtesy of MWD.

4.3 CENTRAL BASIN'S WATER SUPPLY RELIABILITY

Along with MWD's reliability initiatives, Central Basin has also taken important steps during the past decade to reduce the District's vulnerability to extended drought or other potential threats. The District's investments in recycled water to replace imported water for non-potable uses and the implementation of conservation devices and education have resulted in more self-reliance.

Courtesy of MWD.

Colorado River Aqueduct traverses 240 miles of desert to Southern California.

Based on the District's current water supply portfolio, as illustrated in Table 4-1, Central Basin provides an adequate supply for the single dry-water year and multiple dry-water year scenarios. The "Normal Water Year" used in this plan is based on the average rainfall year - FY 2000-01. According to the National Weather Service, the recorded rainfall in FY 2000-01 was 17.94 inches - one of the closest years to the historical average of 16.42 inches. The "Single Dry Year" is based on the lowest rainfall year - FY 2001-02. The recorded rainfall in FY 2001-02 was at 4.42 inches - the lowest recorded year in more than 100 years. The three "Multiple Dry-Water Years" used below were based upon the most recent multiple dry-year period - FY 2001-02, 2002-03, and 2003-04.

Groundwater is shown constant in all scenarios due to the Basin's adjudication, which limits the total amount that each customer within Central Basin's service area is able to extract. Recycled water, which includes both Central Basin and the City of Cerritos systems, is also constant in all scenarios because the availability of recycled water is not subject to hydrologic variation. This leaves imported water as the only supply currently that can fluctuate under different hydrological scenarios.

The supply reliability scenarios described in this section focus exclusively on municipal and industrial usage within the District's service area. It does not include replenishment water.

Looking forward, Central Basin will continue to evaluate opportunities to increase its water supply portfolio within its service area. These opportunities include the expanded use of recycled water, brackish water recovery and additional conservation programs as well as the exploration of investments in groundwater storage through Conjunctive Use programs.

Table 4-1
Central Basin Municipal Water District
Retail Supply Reliability
(In Acre-Feet)

Supplies	**Normal Water Year**	**Single Dry-Water Year**	**Multiple Dry-Water Years**		
	FY 2000-01	**FY 2001-02**	**FY 2001-02**	**FY 2002-03**	**FY 2003-04**
Groundwater[1]	205,960	205,960	205,960	205,960	205,960
Imported Water	63,000	68,000	68,000	59,308	64,816
Recycled Water[2]	7,400	7,400	7,400	7,400	7,400
Total Supply	**276,360**	**281,360**	**281,360**	**272,668**	**278,176**

Note: Supply Reliability covers only retail water demand; does not include replenishment deliveries such as Spreading water
[1] Based upon the total allowable pumping allocation (APA) for each customer agency within Central Basin's service area plus the average amount produced and imported from Main San Gabriel Basin, according to the 2004 DWR Central Basin Watermaster Report.
[2] Includes the available supply of recycled water system for both Central Basin and the City of Cerritos.

4.3.1 NORMAL-YEAR RELIABILITY COMPARISON

As discussed in Section 2.0 Water Demand, Central Basin's normal demands are projected to increase modestly during the next 25 years. Increases in recycled water use during the 25-year planning period equate to a corresponding reduction in the need for imported water.

4.3.2 SINGLE DRY-YEAR RELIABILITY COMPARISON

Central Basin's projected single dry-year water supply is expected to call for additional imported supplies from MWD. According to historical demands, the total water demands in a single dry-year are projected to be 3.5% greater than normal year projections. Table 4-3 compares the dry-year supply and demand projections for the Central Basin MWD service area.

Table 4-2
Projected Normal Water Year Supply and Demand
(In Acre-Feet)

Supplies	2005	2010	2015	2020	2025	2030
Groundwater[1]	205,960	205,960	205,960	205,960	205,960	205,960
Imported Water	63,000	59,091	64,691	70,462	76,409	82,535
Recycled Water[2]	7,400	12,900	14,150	15,400	16,650	17,900
Total Supply	**276,360**	**277,951**	**284,801**	**291,822**	**299,019**	**306,395**
Total Demand[3]	**252,799**	**273,991**	**280,841**	**287,862**	**295,059**	**302,435**
Surplus/(Shortage)	**23,561**	**3,960**	**3,960**	**3,960**	**3,960**	**3,960**

Note: Supply Reliability covers only retail water demand; does not include replenishment deliveries such as Spreading
[1] Based upon the total allowable pumping allocation (APA) for each customer agency within Central Basin's service area plus the average amount produced and imported from Main San Gabriel Basin, according to the 2004 DWR Central Basin Watermaster Report.
[2] Includes the available supply of recycled water system for both Central Basin and the City of Cerritos.
[3] Total Demand includes Projected Groundwater within Central Basin's service area, Imported and Recycled M&I Demands.

Table 4-3
Projected Single Dry-Year Water Supply and Demand
(In Acre-Feet)

Supplies	2005	2010	2015	2020	2025	2030
Groundwater[1]	205,960	205,960	205,960	205,960	205,960	205,960
Imported Water	68,000	68,000	70,560	76,577	82,776	89,160
Recycled Water[2]	7,400	12,900	14,150	15,400	16,650	17,900
Total Supply	**281,360**	**286,860**	**290,670**	**297,937**	**305,386**	**313,020**
Total Demand[3]	**261,647**	**283,581**	**290,670**	**297,937**	**305,386**	**313,020**
Surplus/(Shortage)	**19,713**	**3,279**	**0**	**0**	**0**	**0**

Note: Supply Reliability covers only retail water demand; does not include replenishment deliveries such as Spreading
[1] Based upon the total allowable pumping allocation (APA) for each customer agency within Central Basin's service area plus the average amount produced and imported from Main San Gabriel Basin, according to the 2004 DWR Central Basin Watermaster Report.
[2] Includes the available supply of recycled water system for both Central Basin and the City of Cerritos.
[3] Total Demand includes Projected Groundwater within Central Basin's service area, Imported and Recycled M&I Demands.

4.3.3 MULTIPLE DRY-YEAR RELIABILITY COMPARISON

Under the multiple dry-year water scenarios, Central Basin is projected to meet demands by continuing to implement conservation and water recycling. Tables 4-4 through 4-8 illustrate the projected water supplies and demands within multiple dry-year reliability comparisons for the next 25 years.

Table 4-6
Projected Water Supply and Demand during Multiple Dry-Year 2018-2020
(In Acre-Feet)

Supplies	2018	2019	2020
Groundwater[1]	205,960	205,960	205,960
Imported Water	69,346	59,308	64,816
Recycled Water[2]	14,900	15,150	15,400
Total Supply	**290,206**	**280,418**	**286,176**
Total Demand[3]	**290,206**	**277,647**	**284,602**
Surplus/(Shortage)	**0**	**2,771**	**1,574**

Table 4-4
Projected Water Supply and Demand during Multiple Dry-Year 2008-2010
(In Acre-Feet)

Supplies	2008	2009	2010
Groundwater[1]	205,960	205,960	205,960
Imported Water	68,000	59,308	64,816
Recycled Water[2]	10,900	11,400	12,900
Total Supply	**284,860**	**276,668**	**283,676**
Total Demand[3]	**281,484**	**269,302**	**270,888**
Surplus/(Shortage)	**3,376**	**7,366**	**12,788**

Table 4-7
Projected Water Supply and Demand during Multiple Dry-Year 2023-2025
(In Acre-Feet)

Supplies	2023	2024	2025
Groundwater[1]	205,960	205,960	205,960
Imported Water	75,351	62,228	69,108
Recycled Water[2]	16,150	16,400	16,650
Total Supply	**297,461**	**284,588**	**291,718**
Total Demand[3]	**297,461**	**284,588**	**291,718**
Surplus/(Shortage)	**0**	**0**	**0**

Table 4-5
Projected Water Supply and Demand during Multiple Dry-Year 2013-2015
(In Acre-Feet)

Supplies	2013	2014	2015
Groundwater[1]	205,960	205,960	205,960
Imported Water	68,000	59,308	64,816
Recycled Water[2]	13,650	13,900	14,150
Total Supply	**287,610**	**279,168**	**284,926**
Total Demand[3]	**283,128**	**270,875**	**277,661**
Surplus/(Shortage)	**4,482**	**8,293**	**7,265**

Table 4-8
Projected Water Supply and Demand during Multiple Dry-Year 2028-2030
(In Acre-Feet)

Supplies	2028	2029	2030
Groundwater[1]	205,960	205,960	205,960
Imported Water	81,538	68,094	75,150
Recycled Water[2]	17,400	17,650	17,900
Total Supply	**304,898**	**291,704**	**299,010**
Total Demand[3]	**304,898**	**291,704**	**299,010**
Surplus/(Shortage)	**0**	**0**	**0**

Note: Supply Reliability covers only retail water demand; does not include replenishment deliveries such as Spreading
[1] Based upon the total allowable pumping allocation (APA) for each customer agency within Central Basin's service area plus the average amount produced and imported from Main San Gabriel Basin, according to the 2004 DWR Central Basin Watermaster Report.
[2] Includes the available supply of recycled water system for both Central Basin and the City of Cerritos.
[3] Total Demand includes Projected Groundwater within Central Basin's service area, Imported and Recycled M&I Demands.

4.4 WATER SHORTAGE CONTINGENCY PLAN

The State requires that each urban water supplier should provide a water shortage contingency analysis within its urban water management plan. Below is a brief description of the District's plan for water shortage according to the state's water code requirements.

4.4.1 MINIMUM SUPPLY

Currently, the District's water supplies are groundwater, imported water and recycled water. As it relates to the estimated minimum supply available during a severe drought, the District's groundwater supply, as stated in Section 3, is not affected by hydrology because the Basin is adjudicated. The available supply for each groundwater producer (Allowable Production Allocation), set by the Judgment, remains the same regardless of the Central Basin service area's rainfall. The same relates to recycled water, where the supply is not affected by hydrology but rather through the number of service connections and production capacity. The benefit of recycled water is that it is drought-proof and the supply of recycled water remains available regardless of the rainfall. Imported water, on the other hand, is the only supply affected by hydrology. As the wholesaler of imported water to the region, the District's minimum imported water supply is based upon the recent historical demand of imported water during a dry-year sequence of fiscal years 2001-02 to 2003-04; rainfall for these three years range among the lowest on record. The estimated minimum supplies during the next three years for the District is shown in Table 4-9.

4.4.2 STAGES OF ACTION TO REDUCE IMPORTED DELIVERIES

As the area's wholesaler of MWD imported water, the District's stages for reduction are subject to MWD's WSDM Plan, which guides the management of water supplies for the region during shortages conditions.

According to MWD's WSDM Plan, an array of water resource management measures would take place prior to any supply reductions. Through a series of seven shortage stages, MWD will seek the steps to encourage more efficient water usage with its member agencies. Not until the last stage, under an extreme shortage condition, will MWD discontinue imported water deliveries according to an allocation formula. Currently, however, MWD has not determined the shortage allocation methodology to complete the WSDM Plan. Conversely, MWD's 2005 Regional UWMP demonstrates 100% reliability in multiple dry years through 2030. Nevertheless, given the resources described in MWD's IRP, MWD fully expects to be reliable, under the most extreme supply shortage scenarios, during the next 10 years.

However, if imported water supplies were discontinued according to MWD's WSDM Plan, the District would consider reducing supplies through a series of action stages, which would include an allocation methodology similar to MWD. Once MWD determined such an allocation, the District would work with each of its customer agencies to set a specific allocation level to cumulatively meet the District's allocation from MWD. The following page shows a four step stage rationing plan that the District would implement to reduce imported deliveries up to 50%.

Table 4-9
Three-year Estimated Minimum Water Supply
(In Acre-Feet)

Supplies	2006	2007	2008
Groundwater[1]	205,960	205,960	205,960
Imported Water	68,000	59,308	64,816
Recycled Water[2]	7,400	9,400	10,900
Total Supply	**281,360**	**274,668**	**281,676**
Total Demand[3]	**278,690**	**266,629**	**273,375**
Surplus/(Shortage)	**2,670**	**8,039**	**8,301**

Note: Supply Reliability covers only retail water demand; does not include replenishment deliveries such as Spreading
[1] Based upon the total allowable pumping allocation (APA) for each customer agency within Central Basin's service area plus the average amount produced and imported from Main San Gabriel Basin, according to the 2004 DWR Central Basin Watermaster Report.
[2] Includes the available supply of recycled water system for both Central Basin and the City of Cerritos.
[3] Total Demand includes Projected Groundwater within Central Basin's service area, Imported and Recycled M&I Demands.

Central Basin Municipal Water District Stages of Action

Minimum Shortage - The District would request for a voluntary effort among its customers to reduce imported water deliveries. In addition, the District would pursue an aggressive Public Awareness Campaign to encourage residents and industries to reduce their usage of water.

Moderate Shortage - In addition to the stage above, the District would work with its customer agencies to promote and adopt water waste prohibitions and ordinances to discourage unnecessary water usage.

Severe Shortage - In addition to the two stages above, the District would seek to adopt a rate structure that penalizes increased water usage among its customer agencies.

Extreme Shortage - In addition to all the stages above, the District would call for the discontinuance of imported water based upon an allocation methodology similar to MWD for each of its customer agencies.

Since these action stages are contingent upon MWD's WSDM Plan's allocation methodology and such a formula has yet to be determined, the District's shortage stages will remain in draft form. Until MWD completes the WSDM formula, the District's implementation of any rationing stage will be subject to a variety of conditions, among them the severity of the drought, the District allocation level and the current water supply mix available to each customer agency before the Board would apply any action stage listed above.

Once the Board determines action is necessary, the Board would adopt, by resolution, the appropriate stage of action, which would take effect immediately and the District customer agencies would be notified. A draft resolution is included in Appendix E.

4.4.3 PROHIBITIONS, PENALTIES AND CONSUMPTION REDUCTION METHODS

Through the years the District has developed strong relationships with its customer agencies to promote community awareness of water conservation. Should water reductions become necessary, the District will work with each city and water agency within its service area to encourage the adoption of water waste prohibition measures that establish mandatory water use restrictions. Moreover, the District will provide the necessary assistance and information to apply the best suited water reducing practice(s) for each customer agency.

Additionally, the District will encourage behavioral change through the adoption of an appropriate water rate structure. As part of MWD's WSDM Plan, the District will pass through additional charges, where MWD will enforce water reductions by setting a minimum amount per AF for any deliveries exceeding a member agency's allotment up to 102%, once an allocation plan is determined. Any deliveries exceeding 102% will be assessed a surcharge equal to three times MWD's full-service rate. The District will impose MWD's penalties for excess use to its customer agencies that exceed their allocation.

4.4.4 IMPACTS TO REVENUE

The District will seek to recover the shortfall of revenue caused by water reductions from its Rate Stabilization Fund as well as from any surplus revenues collected from excess penalties. Moreover, the District will closely monitor its revenue and expenditure impacts on a monthly basis, and respond with any rate adjustments needed at each action stage.

Through the District's imported water invoices per connection, the District will measure each customer agencies' actual performance on a monthly basis.

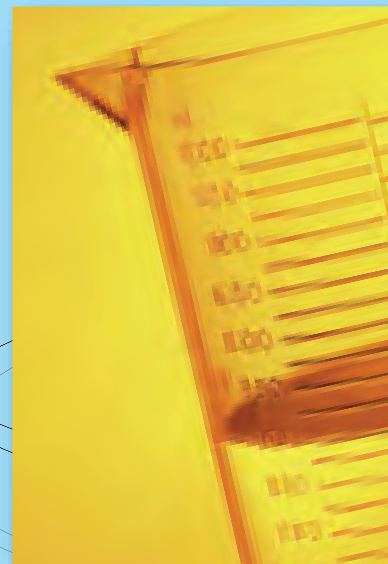
4.4.5 CATASTROPHIC SUPPLY INTERRUPTION

In the event imported water supplies are interrupted from a catastrophic event, the District, through coordination with MWD, can respond at both a regional and a local level.

In the event that an emergency such as an earthquake, system failure or regional power outage, etc. affected the entire Southern California region, MWD would take the lead and activate its Emergency Operation Center (EOC). The EOC coordinates MWD's and the District's responses to the emergency and concentrates efforts to ensure the system can begin distributing potable water in a timely manner.

If circumstances render the Southern California's aqueducts to be out of service, MWD's Diamond Valley Lake can provide emergency storage supplies for its entire service area's firm demand for up to six months. With few exceptions, MWD can deliver this emergency supply throughout its service area via gravity, thereby eliminating dependence on power sources that could also be disrupted. Furthermore, should additional supplies be needed, MWD also has surface reservoirs and groundwater conjunctive use storage accounts that can be draw upon to meet additional demands. The WSDM plan guides MWD's management of available supplies and resources during an emergency to minimize the impacts of a catastrophic event.

Locally, the District has the Member Agency Response System (MARS) to immediately contact its customer agencies and MWD during an emergency about potential interruption of services and the coordination of critical resources to respond to the emergency, also known as mutual aid. The MARS is a radio communication system developed by MWD and its member agencies to provide an alternative means of communication in extreme circumstances. The District is currently in the process of enhancing its communication system in order to provide a more rapid response.



Section 5

Water Quality


English
ml.
1200
1150
1100
1050
1000
950
900
850
800

5

Water Quality

This section discusses the Water Quality within Central Basin's service area

5.1 OVERVIEW

Water quality regulations are an important factor in Central Basin's water management activities. MWD is responsible for complying with State and Federal drinking water regulations on imported water sold to Central Basin. Purveyors to which Central Basin sells imported water are responsible for ensuring compliance in their individual distribution systems and at the customer tap.

For groundwater quality, Central Basin assists purveyors in its service area in meeting drinking water standards through its Cooperative Basin-Wide Title 22 Groundwater Quality Monitoring Program. Title 22 is in reference to the California Code of Regulations section pertaining to both domestic drinking water and recycled water standards. Central Basin offers this program to water agencies for wellhead and reservoir sample collection, water quality testing and reporting services. Sampling is conducted for compliance with the Federal Safe Drinking Water Act and Title 22 regulations. Twenty-nine agencies in Central Basin's service area participate in the monitoring program. Results are compiled in a published annual report.

In March 1999, Governor Gray Davis signed an executive order requiring the use of MTBE (methyl tertiary-butyl ether), a gasoline oxygenate, be phased out by January 1, 2003. This deadline was later postponed to January 1, 2004. Central Basin has been monitoring its groundwater wells since 1996 for MTBE; to date it has not been detected in any wells.

In another development, the California Department of Health Services (CDHS) recommended that drinking water wells be tested for the rocket fuel component perchlorate. Central Basin began monitoring for perchlorate voluntarily in 1997 as part of the Title 22 Monitoring program. CDHS required all water purveyors in the State to monitor for perchlorate under the 2001 Unregulated Contaminant

GAC vessels at Central Basin's Water Quality Protection Project.

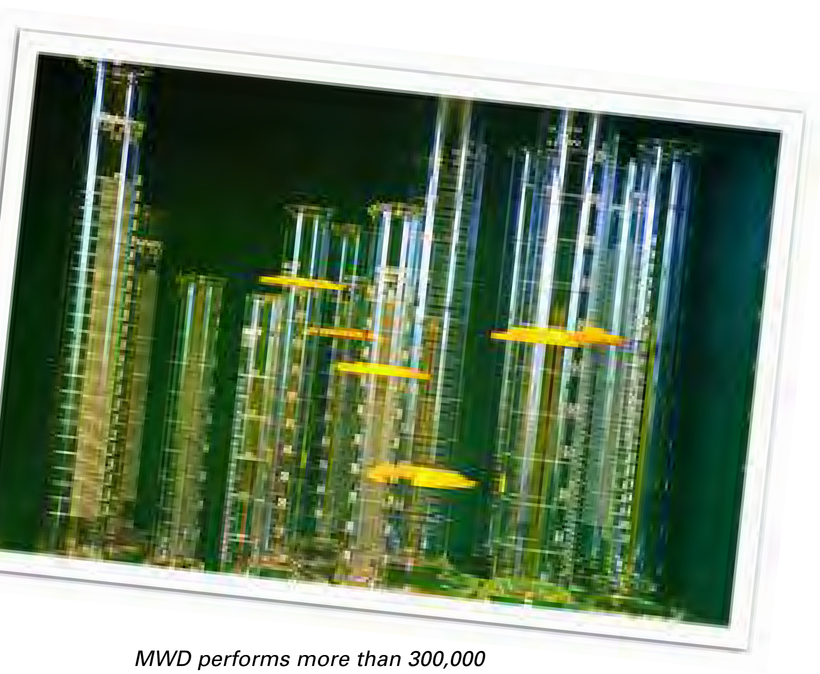
Monitoring Rule. To date, perchlorate has been detected in nine separate wells. Furthermore, the presence of perchlorate in the San Gabriel Basin could impact water quality in Central Basin's service area. In response, the Central Basin Board of Directors has supported a plan to clean up the contaminated groundwater before it migrates into the Central Basin. The "San Gabriel Basin Restoration Fund" was created, and 11 firms agreed to pay $200 million to construct treatment facilities throughout the San Gabriel Valley to remove contaminants and restore the groundwater basin.

5.2 QUALITY OF EXISTING WATER SUPPLIES

A number of issues are considered when evaluating alternative water supply options. Of primary consideration is a project's ability to provide a safe, reliable and cost-effective drinking water supply. Providing a safe drinking water supply to Central Basin's customers is a task of paramount importance. All prudent actions are taken to ensure that water delivered throughout the service area meets or exceeds drinking water standards set by the State's primary water quality regulatory agency, the CDHS. MWD is also proactive in its water quality efforts, protecting its water quality interests in the State Water Project and Colorado River through active participation in processes that would provide for the highest water quality from both sources.

5.2.1 IMPORTED WATER

Central Basin's imported water comes from the State Water Project and Colorado River via MWD pipelines and aqueducts. MWD tests its water for microbial, organic, inorganic and radioactive contaminants as well as pesticides and herbicides. Protection of MWD's water system is a top priority. In coordination with its 26 member agencies, MWD added new security measures in 2001 and continues to upgrade and refine procedures. Changes have included an increase in the number of water quality tests conducted each year (more than 300,000) as well as contingency plans that coordinate with the Homeland Security Office's multicolored tiered risk alert system. MWD also has one of the most advanced laboratories in the country where water quality staff performs tests, collects data, reviews results, prepares reports and researches other treatment technologies. Although not required, MWD monitors and samples elements that are not regulated but have captured scientific and/or public interest.



MWD performs more than 300,000 water quality tests annually.

MWD has a strong record of identifying those water quality issues that are most concerning and have identified necessary water management strategies to minimize the impact on water supplies. Part of its strategy is to support and be involved in programs that address water quality concerns related to both the SWP and Colorado River supplies. Some of the programs and activities include:

- **CALFED Program –** This program coordinates several SWP water feasibility studies and projects. These include:

  1. A feasibility study on water quality improvement in the California Aqueduct.

  2. The conclusion of feasibility studies and demonstration projects under the Southern California-San Joaquin Regional Water Quality Exchange Project. This exchange project was discussed earlier as a means to convey higher quality water to MWD.

  3. DWR's Municipal Water Quality Investigations Program and the Sacramento River Watershed Program. Both programs address water quality problems in the Bay-Delta and Sacramento River watershed.

- **Delta Improvement Package –** MWD in conjunction with DWR and U.S. Geologic Survey have completed modeling efforts of the Delta to determine if levee modifications at Franks Tract would reduce ocean salinity concentrations in water exported from the Delta. Currently, tidal flows trap high saline water in the tract. By constructing levee breach openings and flow control structures, it is believed saline intrusion can be reduced. This would significantly reduce total dissolved solids and bromide concentrations in water from the Delta.

- **Source Water Protection –** In 2001, MWD completed a Watershed Sanitary Survey as required by CDHS to examine possible sources of drinking water contamination and identify mitigation measures that can be taken to protect the water at the source. CDHS requires the survey to be completed every five years. MWD also completed a Source Water Assessment (December 2002) to evaluate the vulnerability of water sources to contamination. Water from the Colorado River is considered to be most vulnerable to contamination by recreation, urban/storm water runoff, increasing urbanization in the watershed, wastewater and past industrial practices. Water supplies from SWP are most vulnerable to urban/stormwater runoff, wildlife, agriculture, recreation and wastewater.

5.2.2 GROUNDWATER

Groundwater in the Central Basin is continually monitored for the quality of the water because of its susceptibility to seawater intrusion, potential contamination from adjacent basins and migration of shallow contamination into deeper aquifers. The Alamitos Barrier, located in the southwest portion of Central Basin's service area, provides a buffer between the groundwater basin and seawater intrusion. The available supply of replenishment water to physically recharge the Basin includes local and imported water. The local water that recharges the groundwater basin comes from storm flows from the San Gabriel Valley and flow obligations under the San Gabriel River Judgment with the Upper Area of the Central Basin. This water is defined as “Make-Up Water.” Imported Water is purchased from MWD to be used for surface spreading at the Montebello Forebay and for seawater barrier injection at the Alamitos Barrier. Recycled water is purchased from the County Sanitation Districts of Los Angeles County for spreading and injection.

As a voluntary service to its purveyors, the District’s Water Quality staff coordinates wellhead testing at approximately 150 groundwater wells within the service area to ensure high quality of local supply.

Dual Pump System. Courtesy of WRD.

By outsourcing laboratory services for complex analytical tests, Central Basin helps purveyors save time and money while providing a valuable service for public safety. Due to the mixture of imported and natural groundwater in the Central Basin, testing of the water ensures that the water is safe for drinking purposes.

Water Replenishment District Programs

As the regional groundwater management agency for the Central and West Coast Groundwater Basins, WRD has several active programs to monitor, evaluate and mitigate water quality issues.

Under its Groundwater Quality Program, WRD continually evaluates current and proposed water quality compliance in agency production wells, monitoring wells and recharge/injection waters of the groundwater basins. If non-compliance is identified, WRD staff develops a recommended course of action and associated cost estimates to address the problem and to achieve compliance. WRD also monitors and evaluates the impacts of pending drinking water regulations and proposed legislation.

WRD's Regional Groundwater Monitoring Program consists of a network of about 200 WRD and USGS-installed monitoring wells at 45 locations throughout the District. Monitoring well data is supplemented with information from production wells to capture the most accurate information available. WRD staff, comprised of certified hydrogeologists and registered engineers, provides the in-house capability to collect, analyze and report groundwater data. This information is stored in the District's GIS and provides the basis to better understand the characteristics of the Central and West Coast Groundwater Basins.

WRD's Safe Drinking Water Program (SDWP) is intended to promote the cleanup of groundwater resources at specific well locations. Through the installation of wellhead treatment facilities at existing production wells, the District hopes to remove contaminants from the underground supply and deliver the extracted water for potable purposes. Projects implemented through the program are accomplished through direct input and coordination with well owners. The current program focuses on the removal of volatile organic compounds (VOCs) and offers financial assistance for the design and equipment of the selected treatment facility.

More information regarding these and other groundwater management programs can be found in the current WRD Engineering and Survey Report and Regional Groundwater Monitoring Report.

5.2.3 RECYCLED WATER

Tertiary recycled water meeting Title 22 standards can be used for a wide variety of industrial and irrigation purposes where high-quality, non-potable water is needed.

Central Basin relies on the County Sanitation Districts of Los Angeles County (CSDLAC) to meet all applicable State and Federal water quality regulations for recycled water it purchases and distributes through its two systems. Central Basin purchases recycled water from CSDLAC's San Jose Creek Water Reclamation Plant and Los Coyotes Water Recycling Plant (WRP). These two plants together produce approximately 120 MGD of tertiary-treated effluent. Recycled water from CSDLAC's reclamation plants not reused is discharged to the ocean directly and through major flood control channels.

Settling Basin at San Jose Creek Water Reclamation Plant.

5.3 EFFECTS ON WATER MANAGEMENT STRATEGIES

Poor water quality makes a water source unreliable, affects overall supply and increases the cost of serving water to the public. A water source that fails drinking water regulations must be taken out of service. The source can be restored through treatment or other management strategies.

Groundwater can become impaired through leaching of contaminants into an aquifer, or by excessive concentrations of naturally-occurring constituents that impact quality, such as arsenic. Surface water sources become contaminated from human activities in the watershed or deliberate contamination.

5.4 EFFECTS ON SUPPLY RELIABILITY

The District assists the purveyors in meeting new State and Federal drinking water standards and guidelines. The District also manages research and development projects to find effective solutions to improve water treatment for non-potable use.

As part of a voluntary service offered by the District, the staff coordinates regular wellhead testing through a contract laboratory at approximately 160 groundwater wells in Central Basin's service area. Analytical reports are sent to Central Basin's purveyors and the CDHS. This voluntary service saves purveyors time and money while ensuring high quality of local groundwater supply.

The quality of recycled water is regularly monitored for process control, regulatory compliance and customer development. Through special sampling and testing, customers can have the confidence of knowing that they are receiving the quality of recycled water needed for their use.

5.5 WATER QUALITY PROTECTION PROJECT

In the early 1980s, the San Gabriel Valley aquifer was discovered to have contaminants including trichloroethylene (TCE) and perchloroethylene (PCE) in the water supply. Based on the contamination level, the Environmental Protection Agency (EPA) declared the area as a superfund site. As the contamination plume moved south toward the Central Groundwater Basin during the next 20 years and threatened the local groundwater supplies, Central Basin developed a containment plan known as the Water Quality Protection Project (WQPP).

By taking necessary steps to ensure removal of the contaminants, it prevented any further migration of contamination from the San Gabriel Valley into the Central Groundwater Basin, preventing the contamination from reaching the spreading grounds. The cleanup of the aquifer at no cost to Central Basin produces a safe and reliable supply of potable water to participating producers without affecting water rates and minimizes the impact of rising energy costs to participating producers. Central Basin obtained necessary Federal funds for the implementation of the WQPP with the objective of preventing the further migration of contaminants into the Central Groundwater Basin. Funding legislation was enacted in December 2000 with congressional support.

The $10 million project consists of the construction of two extraction wells with a collector pipeline and treatment facility. The extraction wells will pump out the contaminated groundwater with a combined rate of approximately 3,600 gallons per minute and convey it via the collector pipeline to the central treatment facility for purification. To ensure service while saving costs, Central Basin entered into an agreement with the City of Whittier to co-locate components of the WQPP with Whittier's existing water facilities. Whittier's facilities are utilized to distribute the treated groundwater to purveyors.


Central Basin's Water Quality Protection Project.

Section 6

Water Conservation

6

Water Conservation

This section discusses the Water Conservation efforts within Central Basin's service area

6.1 OVERVIEW

Since the drought of the 1990s, Central Basin has been a leader implementing aggressive water conservation programs to help limit water demand in its service area. District programs have included a strong emphasis on education and the distribution of rebate incentives and plumbing retrofit hardware. The results of these programs, in conjunction with passive conservation measures such as modifications to the plumbing and building codes, have resulted in significant reductions in retail water use within Central Basin's service area. By current estimates, demand management conservation saves more than 4.5 billion gallons of imported water every year. This represents the average water use of almost 30,000 families in Southern California.

Central Basin's conservation programs are made up of a wide array of cost-effective programs that contribute to conserving water, improving water quality, reducing imported water needs and increasing the region's water supply reliability.

Central Basin prides itself in the partnerships it has created with Federal, State and local entities to offer these programs. By developing integrated programs with its partners, Central Basin has been able to leverage funding and resources to provide effective programs throughout its region.

This section will present the past and current water conservation efforts Central Basin has undertaken for the past 15 years, provide a detailed analysis of Central Basin's water conservation programs, according to the California Urban Water Conservation Council's (CUWCC) recommended Best Management Practices (BMPs), and give a brief description of Central Basin's upcoming conservation efforts and its Conservation Master Plan to promote additional water savings for the service area by the year 2030.

Water Conservation is made of two main elements: Active and Passive. Below is a brief description of these two.

<u>Active Conservation</u>:
Water savings produced from incentive based programs: Rebates, Free Devices, Retrofits, etc.

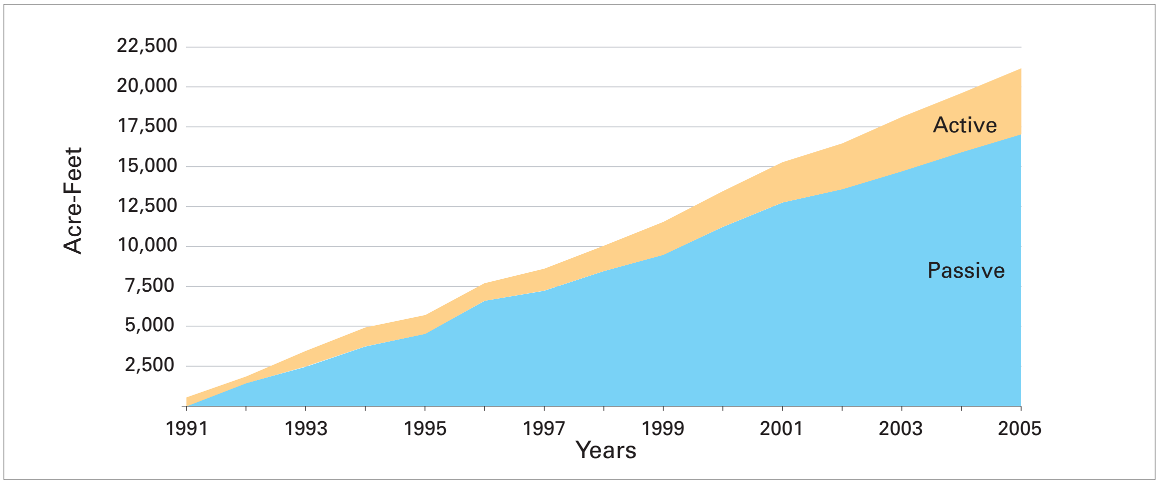
<u>Passive Conservation</u>:
Water savings produced from building and plumbing codes, consumer behavioral changes and price responses.

6.2 CENTRAL BASIN'S PAST AND CURRENT WATER CONSERVATION EFFORTS

Today, Central Basin's conservation programs are made up of a wide array of cost-effective programs as shown below.

- Zero Water Consumption Urinal Program
- Ultra-Low-Flush Toilets
- High Efficiency Clothes Washer Rebate Program
- Commercial, Industrial and Institutional Rebates
- Commercial Clothes Washers
- Water Brooms
- Cooling Towers Conductivity Controllers
- Pre-Rinse Spray Nozzles
- X-Ray Machine Recirculating Devices
- Landscape Conservation Programs
- Weather-Based Irrigation Controller
- Landscape Classes
- School Education Programs
- Public Outreach

Figure 6-1
Central Basin Conservation Water Savings
From 1990 to 2005

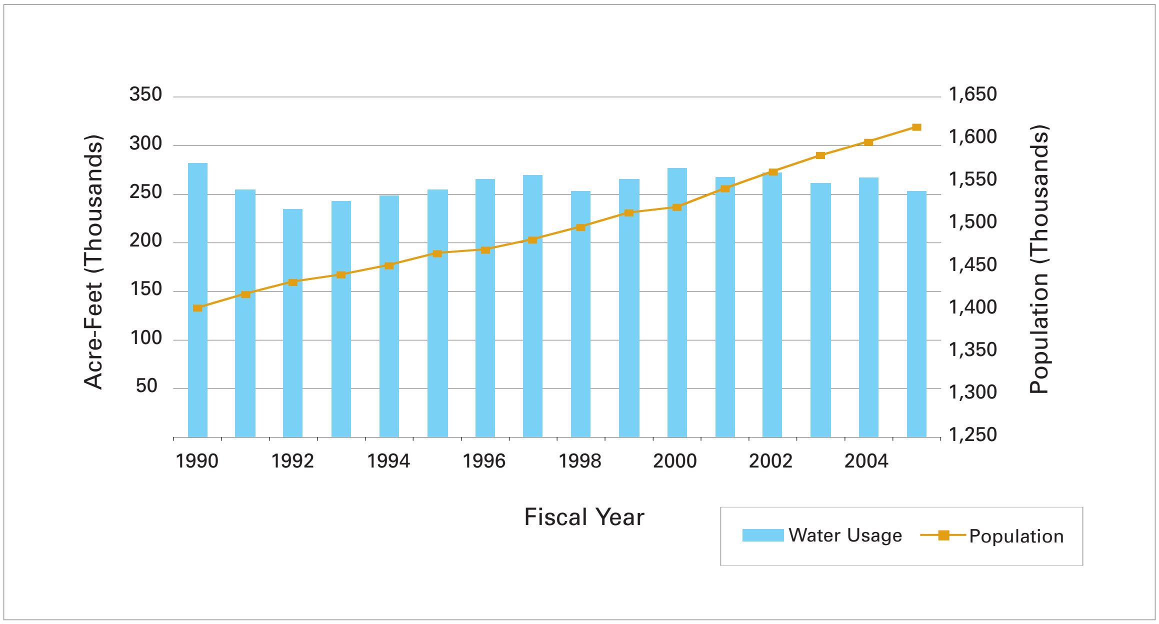


Source: Estimated total water savings from conservation from MWD-MAIN Model 2004.

It is estimated that Central Basin has distributed and installed more than 327,100 devices from 1990 to 2003. As a result, it is estimated that Central Basin currently saves, from active and passive conservation combined, more than 21,100 AF (6.8 billion gallons), or 8% percent annually, of Central Basin's total water demand. The total cumulative savings to date since 1990 is more than 158,900 AF.

Conservation savings can further be verified by comparing Central Basin's water usage versus population. As shown in Figure 6-2, water usage has remained relatively consistent while population has escalated an average of 1% annually.

Figure 6-2
Central Basin Service Area
Total Water Demand vs. Population Growth
From 1990 to 2005



Source: Central Basin's water use database and MWD Demographic Data, 2005.

6.2.1 METROPOLITAN WATER DISTRICT'S CONSERVATION GOAL

MWD, in adopting its 2004 IRP Update, is committed to an aggressive conservation goal. MWD's IRP Update set water supply targets for Southern California through 2025, which includes a conservation target of 1.1 MAF during the next 20 years. MWD's strategy and approach for meeting the conservation targets is outlined in a "Conservation Strategy Plan." The Strategy Plan emphasizes three main areas of incentive based conservation: Residential, Landscape and Commercial, Industrial and Institutional (CII), and provides Board policy guidelines and action plans for the implementation of conservation under MWD's Conservation Credit Program.

6.3 CALIFORNIA URBAN WATER CONSERVATION COUNCIL

In 1991, the CUWCC was created to increase water use efficiency by integrating urban water conservation BMPs into the planning and management of California water agencies. It is a partnership of agencies and organizations concerned with water supply and conservation of natural resources in California.

To encourage water use efficiency, the CUWCC asked water agencies and organizations to sign a Memorandum of Understanding (MOU) regarding urban water conservation in California, which committed participating urban water suppliers to use their "good faith efforts" to implement the CUWCC's 14 BMPs.

Central Basin was one of the first urban water suppliers to become signatory to the CUWCC's MOU. In addition, Central Basin has submitted a Best Management Practices Wholesaler Water Agency Report to the CUWCC every other year that details Central Basin's progress in implementing the 14 BMPs as currently specified in the MOU. In Appendix F, the District has attached its 2003-04 Agency Report.

The BMPs are becoming increasingly important as benchmarks of agency conservation efforts throughout the State. This UWMP, for example, requires agencies that are not members of the CUWCC to describe current and future implementation efforts for all 14 BMPs (referred to as Demand Management Measures, or DMMs). Eligibility for grant funding from State agencies, such as DWR, is now contingent upon satisfactory completion of the UWMPs and the conservation reporting within them.

6.3.1 BEST MANAGEMENT PRACTICES (BMPS)

The BMPs are a list of recommended conservation measures that have been proven to provide reliable savings to a given urban area. There are currently 14 BMPs that a signatory member is committed to implement. Table 6-1 below, lists the 14 existing BMPs.

Table 6-1
List of Best Management Practices for California Urban Water Conservation Council

1. Residential Water Surveys Indoor and outdoor audits of residential water use and distribution of water-saving devices
2. Residential Plumbing Retrofits Distribution or installation of water-saving devices in pre-1992 residences
3. System Water Audits Unaccounted for water calculated annually and distribution system audits as required
4. Metering with Commodity Rates Metering of consumption and billing by volume
5. Large-Landscape Conservation ET-based water budget for large landscape irrigators
6. High Efficiency Clothes Washers Rebates for efficient washing machines
7. Public Information Public information to promote water conservation

(Table continues on next page.)

(Table 6-1 continued from previous page.)

8. School Education Provision of education materials and services to schools
9. Commercial, Industrial and Institutional Conservation (CII) Programs to increase water use efficiency in CII sectors
10. Wholesale Agency Assistance Support by wholesalers for conservation programs of retail water suppliers
11. Conservation Pricing Uniform or increasing block rate structure, volume related water charges and service cost recovery
12. Conservation Coordinator Designation of staff coordination of agency conservation programs
13. Water Waste Prohibition Enforced prohibition of wasteful use of water
14. Residential Ultra-Low-Flush Toilet Replacement Programs promoting replacement of high-water-using toilets with Ultra-Low-Flush Toilets

As a signatory to the MOU, Central Basin currently implements the wholesaler BMPs, which are BMPs #3, 7, 8, 10, 11 and 12. Although only certain BMPs apply to a wholesaler, Central Basin also provides additional support to its cities and water retailers (customers) through BMP #10. As a water wholesaler representing 24 cities throughout southeast Los Angeles County, Central Basin also supports its customers with BMPs #5, 6, 9 and 14. In order to enhance the programs, Central Basin offers partnership opportunities to its customers who can add additional funding and resources in order to increase the size of the programs or rebates, which increases participation and water savings.

6.4 CENTRAL BASIN'S CONSERVATION PROGRAMS

Central Basin's mission is to ensure a safe and reliable supply of water to its service area. Since the drought of the 1990s, Central Basin has strived to expand its role in water use efficiency. Not only is water conservation and education a method for public outreach but it's an essential part of Central Basin's water resources portfolio to drought-proof the region.

Although Central Basin is required to meet only the wholesaler BMPs, Central Basin is committed to assisting its customer agencies with their conservation efforts. Described below are Central Basin's efforts in each of the 14 BMPs.

6.4.1 BMP #1 - WATER SURVEY PROGRAMS FOR SINGLE-FAMILY RESIDENTIAL AND MULTI-FAMILY CUSTOMERS

Residential surveys look to all the water using devices inside the home such as toilets, faucets, showerheads, etc. A trained surveyor checks for leaks and tests the flow indoors and outdoors. Once the survey is completed, recommendations are provided for retrofitting certain water use devices, and educational materials are also supplied to the resident.

Because Central Basin is a water wholesaler and does not have direct access to single- or multi-family customer account data, Central Basin can only provide support to the water retailers. MWD currently provides funding for residential survey devices, and if requested, Central Basin will act as the liaison to MWD and provide retailers with funding available through MWD. It is anticipated that Central Basin will review the market strategy for promoting residential water use surveys within the Conservation Master Plan.

Residential surveys provide cities and water retailers with a great opportunity to provide their customers with a program that offers customer outreach opportunities.

Table 6-2
Residential Plumbing Retrofit Devices

	1990-2000		2000-2005		Total	
Devices	**# units**	**AF**	**# units**	**AF**	**# units**	**AF**
Faucet Aerators	1,154	3.6	0	0	**1,154**	**3.6**
Low-Flow Showerheads	237,049	1,115	7,500	35	**244,549**	**1,150**

6.4.2 BMP #2 - RESIDENTIAL PLUMBING RETROFIT

This BMP recommends the distribution and retrofit of low-flow showerheads, Ultra-Low-Flush Toilets and faucet aerators as well as the adoption of enforceable ordinances.

Since 1990, it is estimated that Central Basin has distributed the following number of faucet aerators and low-flow showerheads, shown in Table 6-2.

6.4.3 BMP #3 - SYSTEM WATER AUDITS, LEAK DETECTION, AND REPAIR

In 1996, Central Basin and its sister agency, West Basin Municipal Water District, partnered with the United States Bureau of Reclamation (USBR) and hired a consultant to develop and provide a Water Audit and Leak Detection Program (Program). The Program was offered to 40 water purveyors. Of the 40, only 10 participated in the audit, and of the 10, only three agencies found their unaccounted for water to be above 10%.

According to BMP #3, water retailers shall complete an annual pre-screening system audit of its potable water system to determine the need for a full-scale system audit.

This BMP is geared more toward a water retailer, but Central Basin has provided support in the past. As part of its Conservation Master Plan, Central Basin will seek input from its water retailers regarding support for this program.

6.4.4 BMP #4 - METERING WITH COMMODITY RATES FOR ALL NEW CONNECTIONS AND RETROFIT OF EXISTING CONNECTIONS

Since Central Basin is a water wholesaler, this BMP does not directly apply. However, every water agency within Central Basin's service area bills their retail customers according to meter consumption. This BMP requires that agencies identify intra- and inter-agency disincentives and barriers to retrofitting mixed use commercial accounts with dedicated landscape meters and conduct a feasibility study to assess the merits of a program that provides incentives to switch mixed use accounts to dedicated landscape meters.

By encouraging the installation of dedicated landscape meters, agencies will be able to recommend the appropriate irrigation schedules through future landscape programs.

6.4.5 BMP #5 - LARGE LANDSCAPE CONSERVATION PROGRAMS AND INCENTIVES

Despite the urbanization of Southern California, the region is dotted with large turf areas that require year-round irrigation to keep them green. Large turf areas include city and county parks, golf courses, schools, cemeteries and street medians.

South Gate Park outfitted with irrigation controllers.

Central Basin is reducing demand for imported water for irrigation purposes by providing recycled water in its service area. Virtually anywhere potable water is used to irrigate, recycled water can, and should, replace it. However, in areas where recycled water cannot reach or be applied to large landscape areas, Central Basin provides other programs to conserve water. Below is a list of the programs Central Basin is currently implementing.

Irrigation Controller Programs

In 2004, MWD was awarded a Proposition 13 grant for a new Weather-Based Irrigation Controller (CBIC) Program. MWD and its member agencies developed a Project Advisory Committee (PAC) to work on developing the program, which includes marketing, reporting, databasing and implementing. MWD allocated a limited amount of funding to each member agency for this program. Central Basin has been working with the PAC to develop the program. Central Basin recognizes the water savings potential and is beginning to test weather-based irrigation controllers in sites that use potable imported water. The plan is to use the new controllers in areas where recycled water cannot reach. The funding incentives provided vary on the number of stations and acreage at each site. The funding is used to help pay for the hardware and to help motivate cities, parks and schools to participate in the program.

Irrigation controllers can save between 20-50 percent of outdoor water use.

Protector Del Agua Irrigation Program

Central Basin also partners with MWD on the "Protector Del Agua" or "Protector of Water" landscape classes. In partnership with cities, classes are offered to residents as a way to teach them about various topics that help conserve water and reduce urban runoff. Residents learn about gardening with native plants and using weather-based irrigation controllers to conserve water and reduce runoff.

More than 50% of the potable water used in Southern California goes to maintain landscaping; therefore, offering these classes is an ideal way to reduce outdoor water waste. By educating the public on properly maintaining the irrigation system and trouble-shooting problems, such as over-watering, that are simple yet difficult to address, can be solved without spending additional funding.

Wireless Irrigation Controllers

Central Basin, along with its partners, submitted and received Proposition 50 funding for a research project to test how wireless irrigation controllers can be used to conserve water in outdoor landscaping. Central Basin will partner with cities and water retailers to offer wireless irrigation controllers to schools, parks, businesses and other large landscape areas that are currently using older hydraulic-type irrigation systems. By providing wireless irrigation controllers, sites will have the ability to inexpensively retrofit their current irrigation systems. Wireless irrigation controllers use weather data to irrigate and can save between 20- 50% of outdoor water use and also reduce urban runoff by up to 70%. This research program will be implemented in 2006.

6.4.6 BMP #6 - HIGH-EFFICIENCY WASHING MACHINE REBATE PROGRAMS

Beginning in 1999, Central Basin participated with MWD in a pilot program with Southern California Edison (Edison) to offer rebates to residents who replaced their existing clothes washer with a high efficiency model. The rebate from Edison varied according to the model purchased (which was tied into the total energy savings), but the amount offered by Central Basin and MWD at the time was capped at $35 per washer. That pilot program ended in September 1999.

In 2003, Central Basin again partnered with MWD on a new program. MWD received funding from CALFED and provided a higher rebate incentive. Central Basin developed the program and offered residents a $100 rebate.

The CALFED portion of the funding expired, but the program was so successful that, at the request of the MWD member agencies, MWD continued to provide funding at the current level. The High-Efficiency Clothes Washer (HECW) Program has exceeded all expectations and continues to be one of Central Basin's more successful programs. When the HECWs first hit the market, they were quite expensive. But market demand has helped to drive the price down. The new HECWs cost twice as much as regular inefficient models, but by providing a $100 rebate (along with other utility/store incentives), consumers are purchasing the new HECWs. In addition to saving 50% water, the HECWs also have other benefits: they save 60% electricity and use less detergent. Consumer acceptance has been very positive.

In 2004, the MWD Board of Directors, along with the support of Central Basin, approved additional funding to continue the program through 2005. At the same time, MWD applied for Proposition 50 funding in an effort to maintain the program at the higher incentive level through 2006. MWD was successful in its Prop. 50 application and was awarded roughly $1.6 million from the California Department of Water Resources for the High-Efficiency Clothes Washer Rebate Program. This funding will allow MWD and Central Basin to continue offering its $100 rebate to residents in an effort to encourage the purchase of high-efficient clothes washers with a Water Factor (WF) of 6.0 or less.

Table 6-3
High-Efficiency Washing Machine

	2003	2004	Total
$ per Rebate	$100	$100	**n/a**
# of Rebates	541	758	**1,299**
Water Savings (AF)	8	11	**19**

The Water Factor of a clothes washer can range from 13.5 to 3.6, with the lower number being more efficient. A complete list of qualifying washers can be obtained at MWD's web site, www.bewaterwise.com, or by calling the District's program vendor at 1-877-732-2830.

In 2003, the Governor of California signed Assembly Bill 1561 that would require clothes washer manufacturers to only manufacture and provide residential washers with a WF of 8.5 in 2007 and 6.0 by 2010. The legislation was adopted by the California Energy Commission and was submitted to the Federal Government for approval. The Federal Government must approve this legislation before the new standards can be applied. This process is anticipated to take 1–2 years.

As long as funding is available, MWD and Central Basin will continue offering its $100 rebate to residential customers for clothes washers with a WF of 6.0 or less. Table 6-3 illustrates the number of rebates Central Basin has distributed during the past two years.

In an effort to continue the successful washer rebate program, MWD along with its member agencies, applied for and received Proposition 50 funding from DWR in the amount of $1,660,000. This funding will allow Central Basin to continue its rebate program through 2006.

6.4.7 BMP #7 - PUBLIC INFORMATION PROGRAMS

Public information is a very broad term with various meanings. Since Central Basin operates a strong outreach program, public information about Central Basin and its mission, programs and events are constantly disseminated to many interested parties. The method by which the public receives this information is important.

- The first significant method is the Public Information Committee (PIC), formed several years ago. The Committee is made up of Public Information and Public Affairs Officers from cities and water agencies within Central Basin's service area. The purpose is to share information on a variety of topics that would be of interest to customers.

- Central Basin, in cooperation with MWD, also provides inspection tours of the Colorado River Aqueduct and the State Water Project to legislators, local elected officials, retail agency staff and the general public on various dates throughout the year. The purpose of the three-day trips is to give local decision-makers a better understanding and appreciation of the water supply throughout the State.

- Central Basin, through its Speaker's Bureau, provides speakers to local community groups, service clubs and schools when requested. In addition, Central Basin operates a very successful and aggressive school education program that promotes the importance of conservation and recycled water.

- Central Basin is also active in the California Water Awareness Campaign (CWAC), which is an association formed several years ago to coordinate efforts throughout the state during "May is Water Awareness Month." With this effort, water agencies throughout the State, large and small, can tap into a large pool of knowledge and materials to promote a water awareness message not only in May but throughout the year.

- Central Basin maintains a strong link with the local news media through press releases on important subjects and periodic meetings with newspaper editorial boards.

Children are encouraged to participate in the education programs that Central Basin offers.

6.4.8 BMP #8 - SCHOOL EDUCATION PROGRAMS

Water and environmental education continue to be critical components of Central Basin's outreach strategy. Therefore, Central Basin offers a variety of elementary through high school programs free of charge to all schools within its service area. The following is a list of Central Basin's current and future education programs. Descriptions of every program can be found in Section 6.5.

- *Planet Protector Water Explorations*
- *Think Earth It's Magic*
- *Conservation Connection*
- *Think Earth Curriculum Kits*
- *Water Is Life Poster Contest*
- *Water Wanderings: A Journey Through Water*
- *SEWER SCIENCE*

6.4.9 BMP #9 - CONSERVATION PROGRAMS FOR COMMERCIAL, INDUSTRIAL AND INSTITUTIONAL (CII) ACCOUNTS

Central Basin, in partnership with MWD, participates in MWD's region-wide CII rebate program. Central Basin helps promote these rebates to the businesses, schools and facilities throughout its service area. Rebates are offered for commercial clothes washers, waterbrooms, cooling tower conductivity controllers, pre-rinse spray nozzles, x-ray machine recirculating devices and commercial toilets and urinals.

In 2002, the CUWCC pursued and received a $2.3 million grant from the California Public Utilities Commission (CPUC) to purchase and install restaurant pre-rinse spray nozzle valves. The new nozzles use 1.6 gpm compared to 2 - 6 gpm valves. These valves conserve water and heating costs and reduce wastewater discharge. Central Basin supported CUWCC's efforts in marketing the program. The nozzles and installations were provided free of charge to the food services sector.

In 2003, Central Basin applied for and received a $780,000 Proposition 13 grant for the purchase and installation of 2,600 Waterfree Urinals. Waterfree urinals can save an average of 40,000 gallons of water per year. Central Basin is currently working with cities, water purveyors, schools, businesses and other facilities to install the devices.

In 2005, Central Basin entered into a 10-year agreement with MWD to help support the on-going regional marketing efforts of the CII rebate program. As a way to increase the success of this program, Central Basin offers the cities and water purveyors partnering opportunities to increase the rebate amounts. Through the years, agencies have partnered to provide higher rebate incentives in an effort to increase program participation of their customers.

6.4.10 BMP #10 - WHOLESALE AGENCY PROGRAMS

The programs provided by Central Basin are done in partnership with and benefit the retail water agencies that are located within the 24 cities serviced by Central Basin.

Among the 14 BMPs Central Basin provides assistance for are:

- **BMP #3** - System Audits
- **BMP #5** - Landscape Programs
- **BMP #6** - Washing Machines
- **BMP #7** - Public Information
- **BMP #8** - School Education
- **BMP #9** - CII Rebates
- **BMP #10** - Wholesaler Incentives
- **BMP #12** - Water Conservation Coordinator
- **BMP #14** - ULFT Replacement

Since 2000, Central Basin has acquired more than $1 million from State and local grant funding sources for program development and implementation. Furthermore, Central Basin markets, designs and implements a majority of the BMPs within its service area. Central Basin has also invested more than $1 million to provide conservation programs that help increase water supply reliability for the region.

School children enjoy Think Earth It's Magic Program.

Central Basin plans on expanding its conservation programs and the support it provides to cities and water retailers in their conservation program efforts.

6.4.11 BMP #11 - CONSERVATION PRICING

In 2003, Central Basin passed through MWD's two-tiered rate structure to its customer agencies to promote water conservation and regional water supply reliability. This rate structure called for customer agencies, in coordination with Central Basin, to develop a reasonable budget for their Tier 1 annual maximum limit for imported water. Through voluntary purchase agreements, these customers will pay a higher price (Tier 2) for purchases that exceed their Tier 1 allotment.

To help assist agencies from exceeding their Tier 1 allocation limits, Central Basin works with agencies to enhance conservation, education and expand recycled water use.

6.4.12 BMP #12 - WATER CONSERVATION COORDINATOR

As the regional wholesaler, Central Basin has a water conservation coordinator that not only promotes Central Basin's conservation programs and devices but also works with cities and water agencies to enhance their conservation efforts. This close collaboration between Central Basin's conservation coordinator and the customer agencies' staff provides for a successful execution of the BMPs. In addition, Central Basin's conservation coordinator represents the service area at regional and statewide workshops and organizations.

Central Basin's conservation coordinator also seeks Federal, State and local funding to develop new programs that cities and water purveyors can partner on and provide additional benefits to the end-users.

6.4.13 BMP #13 - WATER WASTE PROHIBITION

Central Basin encourages its customer agencies to adopt water waste prohibition ordinances. Central Basin can also assist local cities and agencies to develop ordinances that will reduce water wasting in the area.

6.4.14 BMP #14 - RESIDENTIAL ULTRA-LOW-FLUSH TOILET (ULFT) REPLACEMENT PROGRAMS

One of Central Basin's more successful programs has been its free ULFT distribution program. Since 1991, Central Basin has provided more than 80,000 ULFTs to the public "free of charge" in an effort to conserve water. These devices have proven water savings and have contributed to the overall water reduction through the years.

In 2004, Central Basin partnered with MWD on a joint project to identify the existing opportunity within Central Basin's service area for this device. Data shows that there are still many inefficient toilets that need to be replaced. Within Central Basin, there is a 30-40% saturation level in many of its cities. The saturation levels and program performance will continue to be evaluated. For the time being, Central Basin plans on continuing to provide ULFTs and rebates as long as funding is available, programs continue to be cost-effective and a significant saturation level has not been met.

Due to the large areas of high density and numerous multi-family facilities, there are still many older toilets that need replacing. Central Basin will continue to partner with cities and water purveyors in order to implement these programs. In addition, Central Basin will continue to offer its $50 rebate for the purchase and installation of ULFTs.

ULFT giveaway event in La Mirada.

Table 6-4
ULFT Rebate Program

	2000	2001	2002	2003	2004	Total
$ per Rebate	$50	$50	$50	$50	$50	**n/a**
# of Rebates	662	895	619	493	649	**3,318**
Water Savings (AF)	19	26	18	14	18	**95**

Table 6-5
ULFT Replacement Program (Free ULFT Distributions to the Public)

	2000	2001	2002	2003	2004	Total
# of Devices	7,250	5,975	3,650	2,574	2,608	**22,057**
Water Savings (AF)	211	174	106	74	75	**640**

Central Basin also provides a $70 rebate for the purchase and installation of dual-flush toilets. These new toilets have the capability of flushing at either 0.8 gallons for liquids and 1.6 gallons for solids; they average 1 gallon per flush. Also, new 1 gallon per flush High-Efficiency Toilets (HET) are beginning to enter the market place. Advances in technology continue to create new conservation devices that are more water efficient than today's products.

Tables 6-4 and 6-5 illustrate the ULFT Rebate Program and the ULFT Replacement Program for the last five years.

6.4.15 ADDITIONAL CONSERVATION PROGRAMS

Central Basin is very active in working with MWD to develop new conservation programs that are included in the CUWCC BMPs. In 2005, MWD implemented several new programs that Central Basin supports, including:

Synthetic Turf Program
MWD, in partnership with the USBR, developed and provided funding to test the effectiveness of using synthetic turf. Central Basin helped promote the program by issuing press releases and forwarding information to cities, water purveyors, non-profit organizations and others.

City Makeover Program
Central Basin continues to support MWD's City Makeover Program. Through a competitive application process, MWD provides funding for development of new water efficient landscapes that promote California native plants and water efficient techniques. More information about this program can be found on MWD's web site, www.mwdh2o.com.

Community Partnering Program
MWD, in cooperation with the Member Agencies, accepts applications from nonprofit organizations and public agencies that promote discussions and educational activities for regional water quality, conservation and reliability issues. This program provides support for the following types of programs:

- after-school water education
- community water festivals
- watershed education outreach
- environmental museum exhibits
- library water resources education book drives

Local residents inspect high efficiency toilet.

- public policy water conferences
- other projects that directly support water conservation or water quality education

6.5 CURRENT AND FUTURE EDUCATION PROGRAMS

6.5.1 CURRENT PROGRAMS

Planet Protector Water Explorations
Now in its 10th year of operation, Planet Protector Water Explorations is a collaborative water education field trip program between Central Basin and the Roundhouse Marine Lab and Aquarium in Manhattan Beach. The Roundhouse is operated by Oceanographic Teaching Stations, a non-profit organization, and is affiliated with the Los Angeles County Office of Education.

The objectives of Planet Protector Water Explorations are:

1. To increase the awareness of water as a valuable and limited resource.
2. To encourage water conservation efforts.
3. To introduce the concept of water recycling.
4. To introduce the concept of ocean water desalination.

Think Earth It's Magic School Education Program.

5. To increase the awareness of urban runoff pollution.
6. To teach about local marine life.
7. To promote the concept of stewardship of the environment and its resources.

By the end of the 2004-2005 school year, more than 25,000 students will have experienced Planet Protector Water Explorations since the program began in September 1995. Table 6-6 displays the number of students that have been educated through the Plant Protector Water Exploration program from fiscal year 2000-01 to fiscal year 2004-05. Beginning in fiscal year 2004-05, additional programs have become available to students, therefore increasing the number of students that are educated through the various programs.

Think Earth It's Magic
Through Central Basin's membership as part of the Think Earth Environmental Education Foundation, Think Earth It's Magic is a collaborative program between Central Basin, the CSDLAC and MWD. Think Earth It's Magic combines Think Earth's award-winning environmental education curriculum, which is designed to promote conservation behaviors and stewardship of the environment, with an environmental magic show that cleverly ties together what students learn in the classroom. By the end of the 2004-2005 school year, more than 500 elementary school students will have participated in Think Earth It's Magic.

Conservation Connection
We turn on the tap and water flows out. We turn on a lamp and light fills the room. We depend on water and energy. We need water and energy to live in this world. But where do we get the water and energy that we use? And will we always have enough to meet our needs?

Conservation Connection answers those questions, showing the connections between California, our water and energy supply, and us. But providing information is only part of Conservation Connection. The goal of the curriculum is to get students actively involved – in their homes and at school – in conserving water and energy. Within the program, students have the opportunity to sur-

Table 6-6
School Education Program
(Number of Students)

Grade Level	FY 2000-01	FY 2001-02	FY 2002-03	FY 2003-04	FY 2004-05[1]	Total
Grades K-3rd	250	110	190	330	1,014[2]	**1,894**
Grades 4th-6th	1,121	872	830	1,190	1,632	**5,645**
Grades 7th-8th	140	95	105	60	876	**1,276**
High School	0	0	0	0	174	**174**
Total	**1,511**	**1,077**	**1,125**	**1,580**	**3,696**	**8,989**

[1] Program includes Planet Protector Water Exploration in addition to Think Earth It's Magic, Conservation Connection and Think Earth curriculum kits for Fiscal Year 2004-05 only.
[2] Only third graders participate in this program.

vey their family's water and energy use and survey water and energy use at their school.

After gathering data, analyzing their findings and reviewing recommendations, students make, implement and monitor plans to decrease water and energy use. By participating in this action-based curriculum, students will learn to look critically at important environmental issues and take responsibility for finding solutions. By the end of the 2004-2005 school year, more than 500 middle school students will have participated in Conservation Connection.

Think Earth Curriculum Kits
Through Central Basin's membership as part of the Think Earth Environmental Education Foundation, all teachers that participate in Planet Protector Water Explorations receive a grade appropriate Think Earth curriculum unit. Think Earth units are usually distributed each March so that teachers have them prior to Earth Day in April. Each Think Earth unit contains a video, two color posters, a teacher's guide and student booklets. The entire Think Earth curriculum is correlated to the California State Content Standards for the following content areas: language arts, science, social science and mathematics. During the past 10 years more than 25,000 students within Central Basin's service area have participated in Think Earth.

"Water Is Life" Poster Contest
All teachers who have or will participate in Planet Protector Water Explorations during the 2004-2005 school year will be notified in February that their students can participate in the 2005 "Water Is Life" Poster Contest, which is sponsored by Central Basin and MWD. In addition, teachers at each of Central Basin's primary through secondary schools will be notified in February. As in previous years, one grand-prize winner is selected from each District and receives a fully-loaded laptop computer during an award ceremony in June 2005. Each grand-prize winner will also have his or her artwork featured in MWD's "Water Is Life" 2006 Calendar. During the past 10 years more than 25,000 students within Central Basin's service area have had an opportunity to participate in this program.

Winner of the 2005 "Water Is Life" Poster Contest. Fifth-grade student Kimberly Cuchilla from Abraham Lincoln Elementary School in the City of Whittier.

6.5.2 FUTURE PROGRAMS

Water Wanderings: A Journey Through Water
Water Wonderings is a collaborative classroom visitation program between Central Basin and the S.E.A. Lab in Redondo Beach. This collaborative hands-on classroom program will take fourth graders on a 2 1/2 hour journey through California's water. The program will be correlated to many of the fourth grade State standards for social science and science. Included in the program will also be a "touring tide pool," a van outfitted with touch tanks that will enable students to touch live marine creatures and plants. The program schedule calls for classes to begin October 2005 and last through June 2006 for the 2005-06 fiscal year.

SEWER SCIENCE
Staff is currently partnering with the CSDLAC on this exciting high school science program. SEWER SCIENCE is a hands-on laboratory program that teaches students about wastewater treatment. During a week-long lab, students create wastewater, treat it through the use of tanks employing physical, biological and chemical methods, and apply analytical procedures to test its quality. SEWER SCIENCE is correlated to the California State Content Standards for the following high school sciences: chemistry, physics and microbiology. It is staff's intention to have the program developed by the end of Summer 2005 and then to begin marketing efforts to schedule program dates from September 2005 through June 2006.

6.6 FUNDING PARTNERSHIPS

In addition to partnering with MWD on programs, Central Basin also seeks State funding. In 2004 and 2005, the Department of Water Resources and the State Water Resources Control Board provided funding for programs through various chapters of Proposition 50. As a leader in water conservation, Central Basin, in partnership with its cities and water retailers, developed several conservation programs and applied to the State's grant funding competitive process. If funding is awarded, Central Basin will work with its cities and water purveyors to provide programs to the local communities.

In 2005, the City of South Gate in conjunction with Central Basin received a grant through MWD's City Makeover Program for $6,000 for a demonstration garden at Hollydale Elementary Garden.

6.6.1 PROPOSITION 50 PROGRAMS

In 2005, Central Basin, with support from cities, water retailers and environmental groups, applied for and received Proposition 50 - Chapter 7 - Water Use Efficiency Research Grant in the amount of $164,052. This grant funding from the Department of Water Resources will allow the District to work with its partners to purchase and test wireless irrigation controllers. These controllers will be used to retrofit older hydraulic systems and make them more water efficient. Wireless technology has been proven as an effective way for various devices to communicate and Central Basin, along with its partners, will be using the technology to conserve water in large outdoor landscapes. This program will be implemented in 2006.

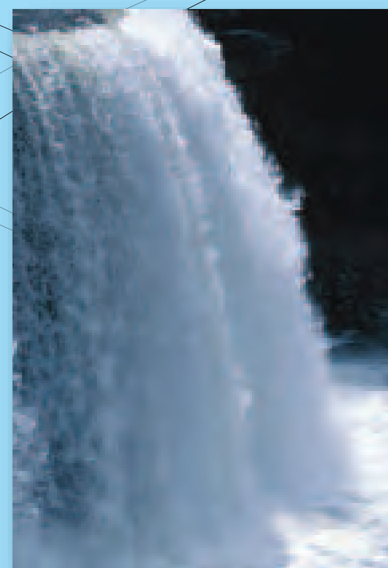
Central Basin also applied for the Proposition 50 - Chapter 8 - Integrated Regional Water Management Grant Program. Central Basin partnered with various cities, water purveyors and stakeholders to develop an integrated approach at developing regional programs. Funding is being sought for the purchase and installation of Weather-Based Irrigation Controllers and for the development of landscape workshops and demonstration gardens. If successful, Central Basin will provide education and devices that will conserve water, reduce urban runoff, reduce imported water and increase local water supply reliability.

6.7 CENTRAL BASIN'S CONSERVATION MASTER PLAN

Water Conservation, along with water recycling, will be used to meet a substantial portion of Central Basin's water demands that are gradually increasing. The goal is to minimize Central Basin's need for new imported water sources and enhance this drought-proof resource that has no environmental impacts and is not subject to weather conditions.
Measures such as tiered water pricing, financial incentives for the installation of Ultra-Low-Flush Toilets and water efficient washing machines and large landscape irrigation efficiency programs are just some of the ways Central Basin provides leadership and results in the conservation arena. Conservation is a key component of Central Basin's water resource planning activities and will be implemented to the fullest extent practicable through the long-term.

6.7.1 WATER CONSERVATION MASTER PLAN

Central Basin is in the process of developing its own specific Conservation Master Plan (Plan) to meet and exceed the goals of the BMPs and MWD's Conservation Strategy Plan. The goal of the Plan is to assess the conservation potential within Central Basin's service area and incorporate local stakeholder input into a group of actions and strategies for achieving long-term targets for conservation. The Plan will be launched and completed within the 2005-06 fiscal year.



Section 7

Water Rates & Charges

Water Rates & Charges

7

Water Rates & Charges

This section discusses Central Basin's Water Rates & Charges

7.1 OVERVIEW

The residential water bill in Southern California is most likely the least expensive of a typical household's major utility bills. In fact, tap water can be purchased for much less than a penny per gallon–remarkable considering investments by water utilities into regulatory compliance, water use efficiency, infrastructure and other reliability programs. This paradox applies to Central Basin's service area as well, although residential water bills vary from retail water agency to retail water agency depending primarily on the mix of source water purchased and/or produced.

Retail agencies that serve exclusively groundwater, for example, tend to have water rates that are lower than those that serve all imported water or a mix of groundwater and imported water. Imported water purchased from Central Basin and provided by MWD carries not only the cost of acquiring importing, purifying (treating) and distributing the commodity throughout the region but also a long-term action plan for ensuring adequate supplies to meet growing demands through conservation, education and new locally produced supplies.

7.2 MWD RATE STRUCTURE

In 2002, the MWD Board adopted a new rate structure to support its strategic planning vision as a regional provider of services, encourage the development of local supplies such as recycled water and conservation, and ensure a reliable supply of imported water. To achieve these objectives, MWD called for voluntary purchase orders from its member agencies, unbundled its water rates, established a tiered supply rate system and added a capacity charge. In all, these new rate structure components provide a better opportunity for MWD and its member agencies to manage their water supplies and proactively plan for future demands.

7.2.1 PURCHASE ORDERS

One of the important changes in the new rate structure was the call for voluntary purchase orders among MWD's member agencies. The Purchase Order is an agreement between MWD and a member agency, whereby the member agency agrees to purchase a minimum amount (60% of their highest year's delivery of non-interruptible water times 10) of non-interruptible water during a 10-year period - "Purchase Commitment." The economic incentive for a Purchase Commitment is that it entitles the member agency to purchase annually a set amount of non-interruptible water (Tier 1 Annual Maximum) at the lower Tier 1 rate, which is 90% of its highest year's delivery of non-interruptible water.

In the case of Central Basin, the highest delivery of non-interruptible water was 80,700 AF in 1990. As shown below in Table 7-1, Central Basin's Tier 1 Annual Maximum is 72,360 AF with a Purchase Commitment of 482,400 AF by the end of 2013.

Since signing a Purchase Order with MWD, Central Basin has remained below its Tier 1 Annual Maximum and has been on track to meet its Purchase Commitment by the year 2013.

Table 7-1
Central Basin Purchase Order Terms

Initial Base Allocation	Tier 1 Annual Maximum (90% of Base)	Purchase Commitment (60% of Base x 10)
80,400 AF	72,360 AF	482,400 AF

7.2.2 UNBUNDLED RATES AND TIER 1 & 2

In order to clearly justify the different components of the costs of water on a per acre foot basis, MWD unbundled its full service water rate. Among the components MWD established are:

Supply Rate Tier 1 – Reflects the average supply cost of water from the Colorado River and State Water Project.

Supply Rate Tier 2 – Reflects the MWD costs associated with developing new supplies, which is assessed when an agency exceeds its Tier 1 limit of firm deliveries.

System Access Rate – Recovers a portion of the costs associated with the conveyance and distribution system, including capital and operating and maintenance costs.

Water Stewardship Rate – Recovers MWD's cost of providing incentives to member agencies for conservation, water recycling, groundwater recovery and other water management programs approved by the MWD Board.

System Power Rate – Recovers MWD's electricity-related costs, such as the pumping of water through the conveyance and distribution system.

Treatment Surcharge – Recovers the treatment cost and is assessed only for treated water deliveries, whether firm or non-firm.

Recycled water use at Pico Rivera Golf Course.

Table 7-2
Metropolitan Water District Unbundled
Water Rate Components Adopted for 2006

Category of Water	$/AF
Supply Rate Tier 1	$73
Supply Rate Tier 2	$169
System Access Rate	$152
Water Stewardship Rate	$25
System Power Rate	$81
Treatment Surcharge	$122
Total Tier 1 Treated Rate	**$453**
Total Tier 2 Treated Rate	**$549**

The unbundled MWD water rates for calendar year (CY) 2006 are displayed in Table 7-2.

7.2.3 REPLENISHMENT SERVICE

Although a majority of the MWD water sold is full service at the Tier 1 rate, there is imported water sold at a discounted rate, better known as Replenishment Service Water. This type of water is used for groundwater storage and/or replenishment. There are two main types of replenishment water – treated and untreated. Because the replenishment water can be interrupted at anytime, MWD has provided a discount to the rates. However, these rates are not tied to the unbundled rate structure illustrated above. These rates are established by MWD to provide the best incentive to replenish the groundwater basins. Replenishment Service rates for 2006 are shown in Table 7-3.

Table 7-3
Metropolitan Water District
Replenishment Service Rate Adopted for 2006

Category of Water	$/AF
Replenishment Water Rate Untreated	$238
Treated Replenishment Water Rate	$335

7.2.4 MWD CAPACITY CHARGE

MWD's new rate structure also established a new charge labeled "Capacity Charge." This charge was developed to recover the costs of providing

Table 7-4
Metropolitan Water District Capacity Charge for 2006

	Peak Flow 2002	Peak Flow 2003	Peak Flow 2004	3-Year Max
Central Basin	128.3 cfs	133.4 cfs	149.6 cfs	149.6 cfs

Note: These peak flows are based upon Central Basin's coincident peak of all its MWD connections.

distribution capacity use during peak summer demands. The aim of this new charge is to encourage member agencies to reduce peak day demands during the summer months (May 1 through September 30) and shift usages to the winter months (October 1 through April 30), which will result in more efficient utilization of MWD's existing infrastructure and defers capacity expansion costs. Currently, MWD's Capacity Charge for 2006 is set at $6,800/cubic feet per second (cfs).

The Capacity Charge is assessed by multiplying Central Basin's maximum usage by the rate. The maximum usage is determined by a member agency's highest daily average usage (per cfs) for the past three summer periods, as shown in Table 7-4 above for Central Basin's maximum usage for 2006 – 149.6 cfs.

7.2.5 READINESS-TO-SERVE CHARGE

The Readiness-to-Serve Charge (RTS) recovers a portion of MWD's debt service costs associated with regional infrastructure improvements. The RTS charge is a fixed charge assessed to each member agency regardless of the amount of imported water delivered in the current year. Rather, it is determined by the member agencies' firm imported deliveries for the past 10 years. Central Basin elected to have MWD collect the majority of the RTS obligation through a "Standby Charge" assessed on all parcels within its service area. The remainder is collected as a surcharge on Central Basin's commodity rates.

7.2.6 MWD STANDBY CHARGE

In 1992, the State Legislature authorized MWD to levy a standby charge that recognized that there are economic benefits to lands that have access to a water supply, whether or not such lands are using it. A fraction of the value of the benefit accruing to all landowners in MWD's service territory can therefore be recovered through the imposition of a standby charge. MWD assessed this charge only within the service area of the member agencies that requested such a parcel charge to help fund a member agency's RTS obligation. Within Central Basin, the MWD Standby Charge is currently $10.44 per parcel.

7.3 CENTRAL BASIN'S IMPORTED WATER RATES

As MWD adopted a new rate structure so did Central Basin. In 2003, Central Basin passed through MWD's Purchase Order by offering customer agencies voluntary purchase agreements and assessing MWD's new Capacity Charge. Central Basin also revised the administrative surcharge to be applied uniformly to all classes of imported water sold. Described below are elements of the rate structure that Central Basin applies to the delivery of imported water.

7.3.1 PURCHASE AGREEMENTS

In order to meet the Purchase Order Commitment with MWD, Central Basin established its own purchase contract policy with its customer agencies. Central Basin's Imported Water Purchase Agreements mimic the MWD version in terms of an Annual Tier 1 Maximum and Total Purchase Commitment but offer more flexibility to the customer. Central Basin requires only a five-year commitment, as opposed to a 10-year term. Furthermore, customer agencies have the option to adjust their Tier 1 and Purchase Commitment amounts annually if certain conditions are favorable and can also reduce their commitment amounts by offsetting imported water demand with recycled water purchased from Central Basin. For purchases above the Tier 1 limit, or in the absence of a Purchase Agreement, the customer agency pays the Tier 2 rate (currently $81/AF above the Tier 1 rate).

Out of the 24 cities, water agencies and private water companies that have an imported water connection, seven do not currently have a purchase agreement with Central Basin.

7.3.2 ADMINISTRATIVE SURCHARGE

One of the main revenue sources for Central Basin is the Administrative Surcharge applied to all imported water sold. In 2003, Central Basin revised the Administrative Surcharge to be uniformly applied to all imported water regardless of the type delivered. Revenue from the surcharge recovers Central Basin's administrative costs including planning, outreach and education, and conservation efforts. As of July 1, 2005, Central Basin's Administrative Surcharge is $38/AF.

In 2004, Central Basin and WRD entered into a five-year purchase agreement for untreated replenishment water (Seasonal Spreading). This agreement replaces Central Basin's Administrative Surcharge rate of $37 per acre-foot to an annual fixed payment ($800,000). As a result, this agreement provided Central Basin with a predictable revenue stream and gave WRD a price discount for replenishment purchases above the baseline quantity (21,622 AF).

Central Basin partnered with Upper San Gabriel Valley Municipal Water District to serve recycled water to Rose Hills Cemetery in the City of Montebello.

7.3.3 READINESS-TO-SERVICE SURCHARGE

As described above, MWD levies to Central Basin a RTS charge to recover a portion of its debt service costs, which is covered mostly by the MWD Standby Charge. However, the remaining balance is collected on the commodity rate. This RTS surcharge is added to Central Basin's commodity rates for only non-interruptible water. As of January 1, 2006, Central Basin's RTS surcharge is $8/AF.

7.3.4 WATER SERVICE CHARGE

Water utility revenue structures benefit from a mix of fixed and variable sources. Central Basin's Water Service Charge recovers a portion of the agency's fixed administrative costs but is a relatively small portion of its overall revenue from water rates. As of July 1, 2005, the Water Service Charge is $30/cfs of a customer agency's meter capacity for imported water meters.

7.3.5 CENTRAL BASIN'S CAPACITY CHARGE

This charge, as described in Section 7.2.4, is intended to encourage customers to reduce peak day demands during the summer months, which will result in more efficient utilization of MWD's existing infrastructure. Central Basin has passed through this MWD charge to its customer agencies by mimicking MWD's methodology. Each customer's Capacity Charge is determined from their highest daily average usage (per cfs) for the past three summer periods. However, because MWD assesses Central Basin on the coincident daily peak of all the connections and aggregate of all its customers' daily peak is the non-coincident peak, Central Basin is able to lower the Capacity Charge to its customers from $6,800/cfs to $5,300/cfs.

7.4 RECYCLED WATER RATES

Central Basin's recycled water program is comprised of two distribution systems: the E. Thornton Ibbetson Century Water Recycling Project and the Esteban Torres Rio Hondo Water Recycling Project with more than 70 miles of pipeline and three pump stations. Since 1992, Central Basin has encouraged the maximum use of recycled water to industries, cities and landscape irrigation sites through the economic incentive of its rates and charges. Below is a description of Central Basin's recycled water rates and charges.

7.4.1 RECYCLED WATER RATES

Central Basin commodity rates cover the operation and maintenance and labor and power costs associated with the delivery of recycled water. These rates are set up in a declining tiered structure so they may further encourage the use of recycled water. Furthermore, these rates are wholesaled at a significant reduction to imported rates to promote the usage of recycled water. Central Basin's recycled water rates for FY 2005-06 are shown in Table 7-5.

As shown in Table 7-5, the "outside of the Central Basin service area" rate is assessed to customers outside of Central Basin's service boundaries which pay an additional $20/AF for each tier. This additional charge is applied to make up for the recycled water Standby Charge they are not levied on their parcels.

7.4.2 RECYCLED WATER STANDBY CHARGE

In addition to the MWD Standby Charge, there is a recycled water standby charge that is levied by Central Basin to each parcel within the service area. A $10 per parcel charge is administered by Central Basin to provide a source of non-potable water completely independent of drought-sensitive supplies. The revenue collected from this charge is used to pay the debt service obligations on Central Basin's water recycling facilities. Each year the Board holds a public hearing where they adopt Central Basin's Engineer's Report and Resolution to assess this charge.

Recycled water customer
Metro State Hospital in Norwalk.

7.5 FUTURE WATER RATE PROJECTIONS

As the demand for water increases in Southern California so does the cost to administer, treat and distribute imported and recycled water. However, Central Basin has worked diligently to ensure that stable and predictable rates are managed for the future. Below are discussions of imported and recycled water rate trends during the next 10 years.

7.5.1 IMPORTED WATER RATE PROJECTIONS

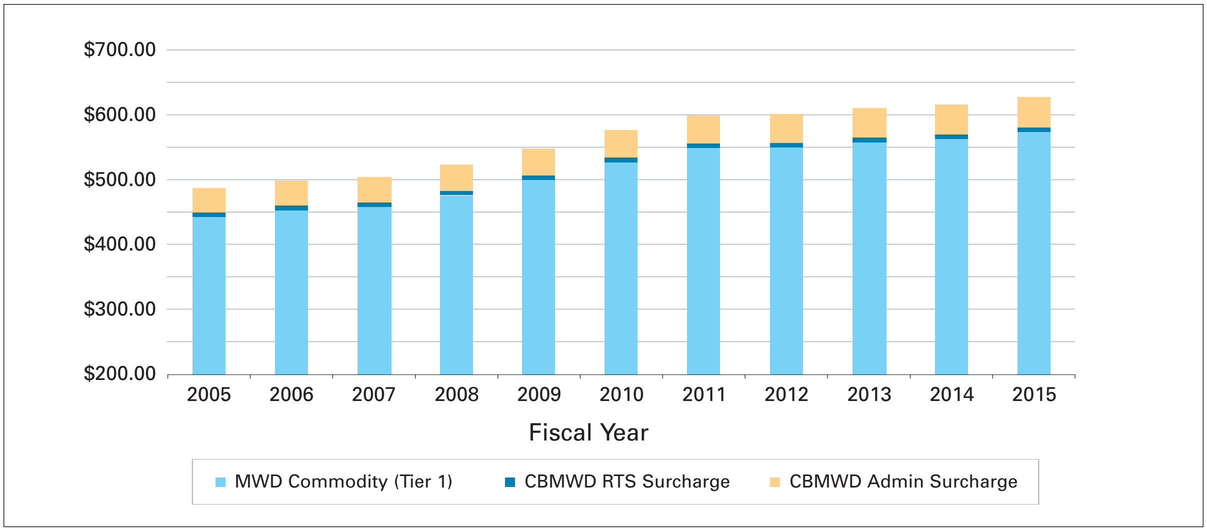
In 2004, the MWD Board adopted its Long Range Financial Plan. This plan was developed to forecast future costs and revenues necessary to support its operations and capital investments. Furthermore, it lays out the financial policy MWD will pursue during the next 10 years. According to projected MWD sales, with investments into local resources, MWD estimates imported water rates will increase 4-6% annually.

Central Basin's Administrative Surcharge is projected to increase at an annual average rate of 3-4%. This increase is determined by Central Basin's Long Range Financial analysis and the budget's revenue requirements.

Table 7-5
Recycled Water Rates
Fiscal Year 2005-06

Volume (AF/month)	Central Basin Service Area	Outside of Central Basin Service Area
0-25	$308/AF	$328/AF
25-50	$286/AF	$306/AF
50-100	$266/AF	$286/AF
100+	$244/AF	$264/AF

Figure 7-1
Central Basin Imported Water Rates
10 Year Projections



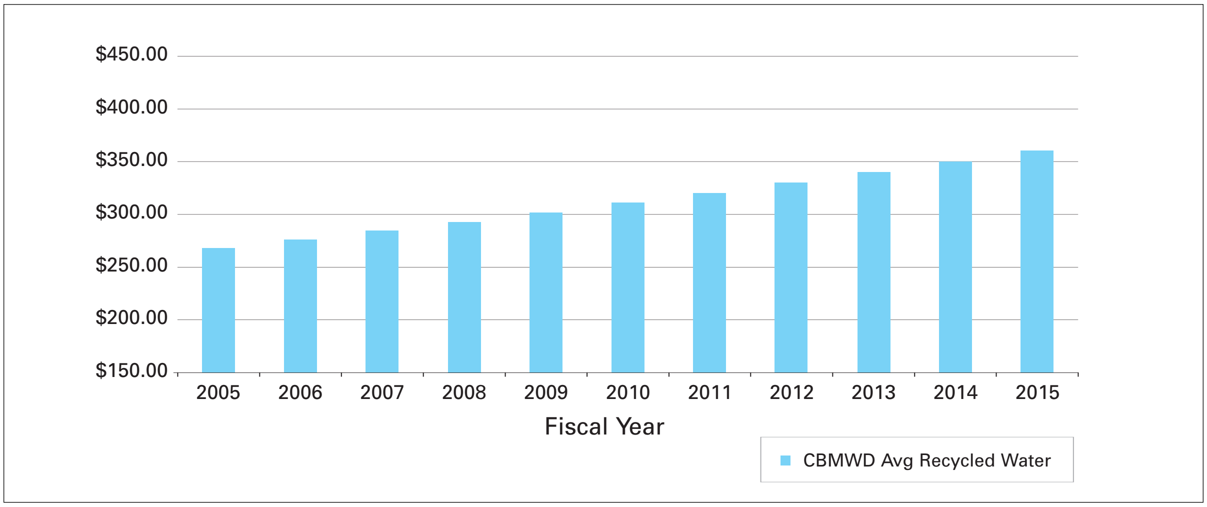
Source: MWD 2004 Long Range Financial Plan & Central Basin's Financial Plan.

Figure 7-1 displays Central Basin's imported water rate projections for the next 10 years.

7.5.2 RECYCLED WATER RATE PROJECTIONS

Similar to imported water rates, recycled water rates are expected to increase because of higher treatment, maintenance and power costs. However, Central Basin believes in setting the rate of recycled water at a competitive level to help offset imported water. In order to achieve this economic incentive, recycled water rates have been projected by Central Basin to increase at a slightly lower level than imported water. The recommended rate increases are projected to be 3% annually. As shown in Figure 7-2, Central Basin's average recycled water rate will be at a competitive level versus imported water rates during the next 10 years.

Figure 7-2
Central Basin Recycled Water Rates
10 Year Projections



Source: Central Basin Financial Plan for the average recycled water rates for within "service area."

Section 8

Water Recycling

8

Water Recycling

This section discusses Water Recycling Efforts within Central Basin's service area

8.1 OVERVIEW

Recycled water is a cornerstone of Central Basin's efforts to augment local supplies and reduce dependence on imported water. Since planning and constructing its recycled water systems in the early 1990s, Central Basin has become an industry leader in water re-use. Recycled water is used for non-potable applications such as landscape irrigation, commercial and industrial processes, and indirect potable use through groundwater replenishment.

In 2005, recycled water M&I deliveries within Central Basin's service area totaled 5,217 AF, representing 2% of the service area's total water supplies. Recycled water sales are projected to reach 17,900 AF by the year 2030, representing 5% of expected total water supplies.

This section provides an overview of the District's water recycling system and water treatment and distribution. In addition, this section includes a discussion of the District's past, current and projected sales as well as the District's system expansion projects and Master Plan. The section concludes with a brief description of the Cerritos, Lakewood and WRD recycled water programs within Central Basin's service area.

8.2 RECYCLED WATER SOURCES AND TREATMENT

8.2.1 SOURCE WATER

The source of Central Basin's recycled water is the County Sanitation Districts of Los Angeles County (CSDLAC). CSDLAC operates one wastewater treatment plant and six water recycling plants in the Los Angeles Basin. These combined systems produce approximately 489 MGD of effluent, of which approximately one-third is available for re-use. Central Basin purchases a portion of this recycled water from two reclamation plants, Los Coyotes and San Jose Creek, located just outside of the District's service area. Both of these plants provide approximately 55 MGD of tertiary-treated (Title-22) water for distribution. Below is a detailed description of the two recycling plants.

San Jose Creek Water Recycling Plant

The San Jose Creek WRP provides tertiary treatment for 100 MGD of wastewater. The plant serves a largely residential population of approximately one million people. Approximately 35 MGD of recycled water is reused at 17 different reuse sites. These include groundwater recharge at the Montebello Spreading Grounds and irrigation of parks, schools and greenbelts. The San Jose Creek WRP was built in the early 1970s as part of Central Basin and West Basin MWD's Joint Outfall System. This system uses six water reclamation plants and the Joint Water Pollution Control Plant to serve a major portion of metropolitan Los Angeles County.

The goal of the CSDLAC is to recycle as much of the reclaimed water from its water reclamation plants as possible. Approximately 35 MGD of the purified water from San Jose Creek WRP is sent to percolation basins for groundwater recharge. In 1994, the San Jose Creek WRP was connected to the E. Thornton Ibbetson Century and Esteban Torres Rio Hondo Water Recycling projects which supply the water recycling needs of more than a dozen cities combined from the Central Basin water recycling distribution system.

The high quality San Jose Creek WRP final effluent meets the National Pollution Discharge Elimination System (NPDES) requirements for water quality. The following discussion includes

San Jose Creek Water Reclamation Plant.

readings of the sampled constituents in 2003.

The Regional Water Quality Control Board (RWQCB) established a new limit for chloride levels through Resolution No. 97-02 in 2002. The Resolution requires monitoring data and assessment reports on chloride by Publicly Owned Treatment Waterworks on an annual basis. During 2003, chloride levels in the final effluent of San Jose Creek WRP were consistently below the limit (180 mg/l).

The daily maximum final effluent turbidity was 3.4 NTU, and the 24-hour composite final effluent turbidity was 1.0 NTU. All the water reused in 2003 was adequately chlorinated to comply with the coliform limit. Also, all water discharged to the San Gabriel River was properly disinfected and dechlorinated.

Los Coyotes Water Recycling Plant

The Los Coyotes WRP provides tertiary treatment for 37 MGD of wastewater. The WRP serves a population of approximately 370,000 people. More than 5 MGD of the purified water is reused at more than 200 reuse sites. These include irrigation of schools, golf courses, parks, nurseries and greenbelts and industrial use at local companies for carpet dying and concrete mixing.

Regional water recycling projects such as Century and Rio Hondo are the next step in the evolution of water reuse as the Los Angeles area heads toward a planned basin-wide system linking numerous sanitary agencies and regional and local water purveyors in a highly flexible and reliable reclaimed water distribution system to complement and supplement the precious, limited drinking water supply.

More than 200 reuse sites have been receiving recycled water, which is used for irrigation of parks, golf courses, schools, nurseries, freeway and street medians, and slopes and other greenbelt areas. In addition, various industries, such as the Tuftex Carpet Mill (right), will use recycled water for carpet and textile dyeing, metal finishing, concrete mixing and cooling tower supply.

CSDLAC operates 10 laboratories including the San Jose Creek Water Quality Lab and Treatment Plant Laboratories. These laborato-

Los Coyotes Water Reclamation Plant.

ries have greatly increased the capability to control plant water quality and quality assurances and offer laboratory services in order to monitor the quality of effluent before it reaches the recycled water users.

8.2.2 TREATMENT PROCESS

The wastewater that is recycled at the Los Coyotes and the San Jose Creek plants undergoes tertiary treatment. Tertiary recycled water begins with secondary treated water that undergoes coagulation, flocculation, filtration and disinfection. Tertiary treated water can be used for a wide variety of industrial and irrigation purposes where high-quality, non-potable water is needed. Section 5, Water Quality, of this Plan explains in more detail the wastewater treatment facilities that provide Central Basin with recycled water.

Recycled water undergoes a rigorous, multi-stage treatment process to clarify it to high quality standards. The level of treatment necessary is approved by the California Department of Health Services (CDHS). CDHS requires recycled water to meet California Code of Regulations Title 22 standards (Title 22). Title 22 standards address specific treatment requirements for recycled water and lists approved uses. Approximately 2,000 tests are performed monthly to ensure water quality meets or exceed all State and Federal requirements.

Table 8-1 illustrates the past, current and projected amount of wastewater collected and treated as well as the amount of recycled water delivered by these two plants to the District's distribution system.

The amount of wastewater collected and treated by these two reclamation plants are expected to

Carpet dyeing with recycled water at Tuftex in Santa Fe Springs.

remain consistent during the next 25 years, despite population increases. According to CSDLAC analysis, these increases are projected not to be significant enough to make it economically feasible to expand these CSDLAC facilities to accommodate an already "Build out" area.

8.3 CENTRAL BASIN'S RECYCLED WATER SYSTEM

8.3.1 EXISTING SYSTEM

Central Basin's recycling system is comprised of two separate projects: E. Thornton Ibbetson Century Water Recycling Project (Ibbetson Century Project) and the Esteban E. Torres Rio Hondo Water Recycling Project (Torres Project). Both projects deliver recycled water for landscape irrigation and industrial uses throughout the District's service area.

The Ibbetson Century Project began delivering recycled water in 1992. The project currently deliv-

Table 8-1
Wastewater Collected and Treated[1]
(In Acre-Feet)

	2000	2005	2010	2015	2020	2025	2030
Wastewater collected & treated[2]	136,000	103,000	140,000	142,000	145,000	148,000	150,000
Recycled water delivered	32,500	38,000	45,000	47,000	50,000	52,000	55,000

[1] Data supplied by the County Sanitation District of Los Angeles County.
[2] From both the Los Coyotes WRP and the San Jose Creek WRP

ers tertiary-treated recycled water from the CSDLAC's Los Coyotes WRP and serves the cities of Bellflower, Bell Gardens, Compton, Cudahy, Downey, Lakewood, Lynwood, Norwalk, Paramount, Santa Fe Springs and South Gate.

In 1994, the water recycling system was extended into the northern portion of Central Basin's service area. This extension, known as the Torres Project, delivers tertiary-treated recycled water from CSDLAC's San Jose Creek WRP and serves the cities of Bell, Bell Gardens, Commerce, Huntington Park, Montebello, Pico Rivera, Santa Fe Springs and Whittier.

In fiscal year 2004-2005, Central Basin's recycled water system delivered approximately 3,150 AFY to more than 200 sites. It is anticipated, during the next five years that Central Basin will triple its sales with new connections across the northern portion of the service area.

Every year Central Basin connects new customers to recycled water and further reduces demands on potable water.

8.3.2 RECYCLED WATER USE BY TYPE

The types of sites that Central Basin currently serves, as shown in Table 8-2, vary from parks and landscape medians to textile industries and cooling towers.

Table 8-2
Types of Recycled Water Customers

• Landscape	• Textile
• Golf Course	• Median
• Co-Generation (Cooling Tower)	• Nursery
• Cemetery	• Park
• Concrete Mixing	• School (Irrigation)
• Cal-Trans (Irrigation)	• Others

As illustrated in Figure 8-1, the predominated use of recycled water deliveries is landscape irrigation, accounting for almost 66% of the total use. However, in the upcoming years Central Basin plans on increasing its deliveries to the industrial sector. Once the City of Vernon begins receiving

Installation of recycled water pipeline.

recycled water via the Malburg Generating Station and subsequently when the Southeast Water Reliability Project begins operation, the percentage of industrial usage is projected to change significantly during the next 10-15 years.

8.3.3 HISTORICAL AND CURRENT SALES

For the past 10 years, Central Basin has seen its recycled water sales gradually increase each year. With landscape irrigation constituting two-thirds of Central Basin's current recycled water use, there have been years where sales have varied primarily due to weather changes. As shown in Figure 8-2, on the opposite page, there have been years, most notably fiscal years 2000-01 and 2004-05, where total recycled water sales have increased or decreased from projected levels because of rainfall.

Figure 8-1
Central Basin Recycled Water Use
By Type of Site FY 2004-05

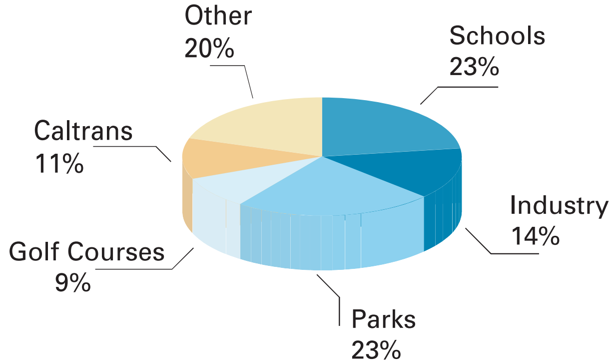
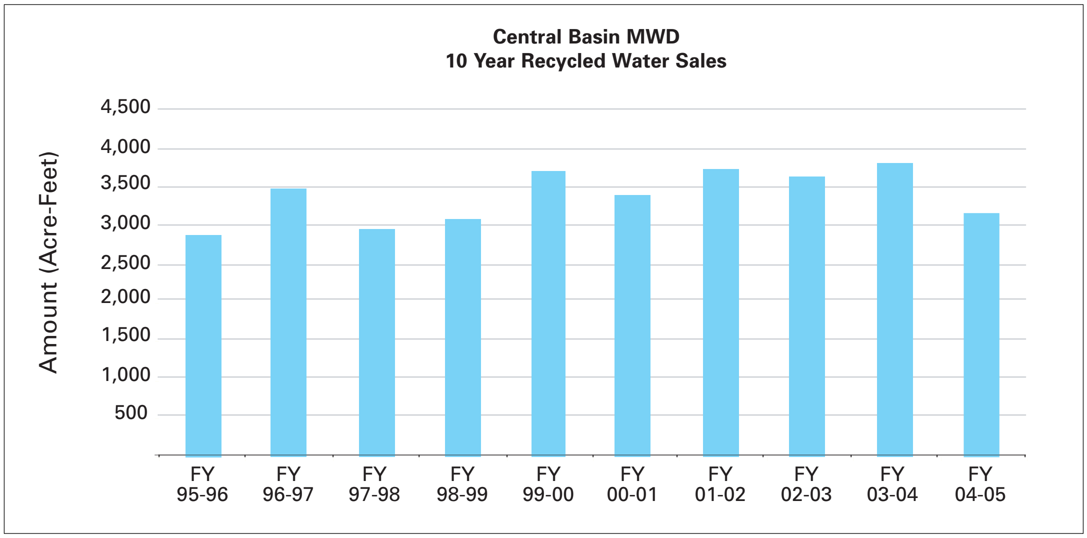


Figure 8-2
Historical Recycled Water Sales
FY 1996-2005



Source: Central Basin Watermaster Report, 2005

The amount of recycled water supplied by Central Basin during the last 10 years has totaled more than 33,800 AF, replacing enough potable water to supply the needs of approximately 67,700 families for more than a year. Central Basin anticipates recycled water sales to increase in the future as more customers switch from potable water to recycled water due to the reliability of the supply and the economic incentives associated with converting from potable water to recycled water.

Table 8-3, on page 8-6, displays a more detailed breakdown of historical sales by showing each retail customer agency's annual purchases from Central Basin for fiscal years 1996 to 2005.

Hollydale Pump Station at Hollydale Park in the city of South Gate.

In Central Basin's 2000 UWMP, the District projected deliveries of recycled water to reach 5,800 AF by 2005. As shown in Table 8-4 on page 8-6, actual sales for 2005 fell below this target. Combined with a record rainfall year and delays in connecting large based customers, Central Basin lacked the number of connections to reach the projections set in 2000. Nevertheless, Central Basin anticipates increases in sales during the next 5 - 10 years due to some large projects and partnering efforts among its customer agencies.

8.3.4 SYSTEM EXPANSIONS AND PROJECTED SALES

In 2000, Central Basin conducted a Recycled Water Program Master Plan (Master Plan) to help the District identify all of the potential customers that could benefit from recycled water. In addition, the Master Plan would provide the best system expansion routes to benefit the entire system from which the following system expansion projects were devised:

Southeast Water Reliability Project

The planned Southeast Water Reliability Project (SWRP) represents the fulfillment of the current Central Basin program as originally envisioned. The proposed project would

Table 8-3
Historical Recycled Water Sales by Retail Customer Agency of Central Basin
FY 1996 to 2005
(In Acre-Feet)

Central Basin	FY 95-96	FY 96-97	FY 97-98	FY 98-99	FY 99-00	FY 00-01	FY 01-02	FY 02-03	FY 03-04	FY 04-05	Total
Bellflower-Somerset Mutual	114	125	95	117	133	131	159	118	125	108	**1,225**
City of Cudahy	-	-	3	9	9	9	8	7	5	6	**56**
City of Downey	532	612	517	636	710	642	733	664	686	617	**6,349**
City of Huntington Park	21	61	44	56	57	49	60	48	64	49	**509**
City of Lynwood	44	74	75	59	55	69	66	70	67	46	**625**
City of Norwalk	87	118	75	89	128	100	120	109	111	53	**990**
City of Paramount	354	376	364	382	485	429	453	431	443	360	**4,077**
City of Pico Rivera	-	-	-	-	-	-	-	35	39	28	**102**
City of Santa Fe Springs	864	1,018	919	817	835	858	893	815	774	630	**8,423**
City of South Gate	144	165	151	151	189	164	191	162	177	213	**1,707**
City of Whittier	94	114	82	102	136	78	77	82	98	66	**929**
Park Water Company	363	448	315	353	479	428	469	471	489	341	**4,156**
Peerless Water Company	17	32	25	20	26	21	22	17	20	16	**216**
San Gabriel Valley Water Co	44	94	56	68	81	72	77	65	76	48	**681**
Southern California Water Co	227	244	224	234	359	358	418	506	610	523	**3,703**
Upper San Gabriel Valley MWD	-	-	-	-	-	-	-	7	35	45	**87**
Total	**2,905**	**3,481**	**2,945**	**3,093**	**3,682**	**3,408**	**3,746**	**3,607**	**3,819**	**3,150**	**33,836**

Source: Central Basin Wateruse Database, 2005

"loop" the overall system hydraulically by connecting the Rio Hondo and Century projects across the northern part of the service area (also known as the "Southeast" area because it roughly covers the southeast portion of Los Angeles County). Cities that will benefit directly from the SWRP include Pico Rivera, Montebello, East Los Angeles, Commerce, Maywood and Vernon.

Table 8-4
Recycled Water Uses
2000 Projections Compared with 2005 Actual

Type of Use	2000 Projection for 2005	2005 Actual Use[1]
Irrigation	4,600	2,654
Commercial	0	0
Industrial	1,200	496
Total	**5,800**	**3,150**

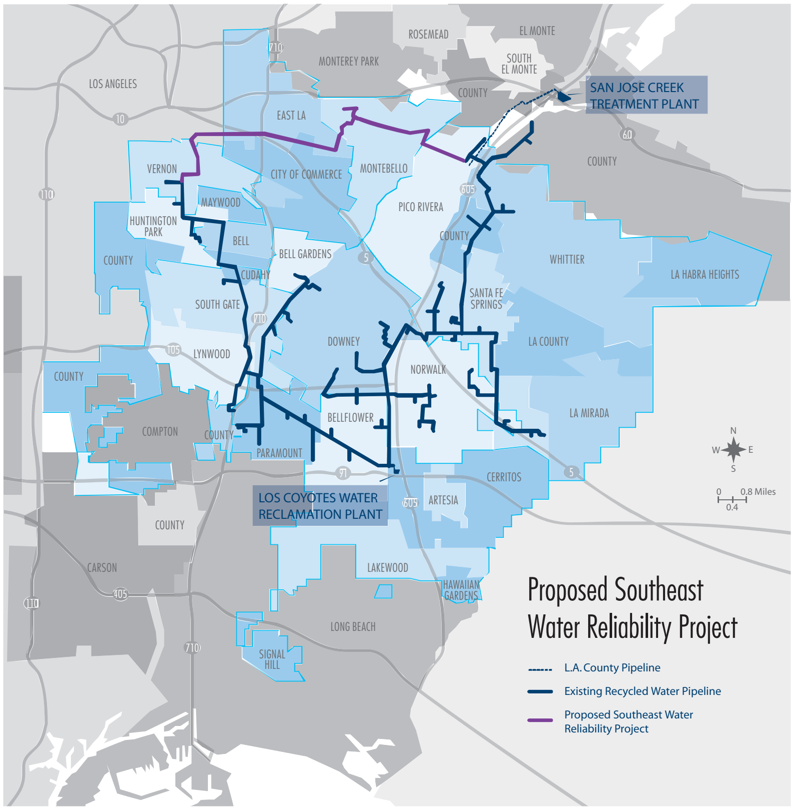
Source: Central Basin Water Use Database, 2005.
[1] Based upon 2004-05 actual sales for Central Basin.

Because the 2000 Master Plan may not accurately reflect recent changes in the industrial base of the areas to be served by the SWRP project, a Master Plan update will be completed in 2006. The Master Plan update will allow Central Basin to refine the alignment of the SWRP project and forecast more accurately future recycled water sales.

Connecting Central Basin's existing projects with the SWRP will increase flow and pressure in many areas of the distribution system that are not adequately served today, and it will provide recycled water to new customers in several cities. Figure 8-3 illustrates the connection of the SWRP to the existing system as it is currently envisioned.

Central Basin is aggressively pursuing State and Federal grant funding to reduce the cost of construction for the SWRP to be borne by Central Basin.

Figure 8-3
Southeast Water Reliability Project
Recycled Water Distribution System



Other Potential System Expansions

The Cities of South Gate, Lynwood and La Mirada have expressed interest in receiving recycled water, in some cases to augment existing demand. These potential new connections will be planned either concurrently or subsequently to the SWRP since they are dependent on the hydraulic benefits of the larger project. Other capital projects planned for the next five years include improvements that will increase the efficiency and reliability of existing facilities, including the pipeline connection in the City of Norwalk.

Projected Recycled Water Sales

According to the Master Plan, the Central Basin's recycled water system is projected to increase from its current sale of 3,150 AF to 15,500 AF by 2030.

As Table 8-5 displays, on the following page, the area of greatest potential growth in sales for the District is within landscape/irrigation. However, with system expansions planning to reach heavy industrial areas, i.e. the City of Vernon, the area of industrial recycled water usage does expect to increase.

The SWRP is anticipated to begin operation in 2009 and ultimately serve an additional 5,600 AFY of recycled water to various customers in the northern service area. However, depending upon the outcome of the updated Master Plan, the ultimate capacity of the SWRP may provide additional sales. Full project capacity will be phased in more than roughly five years to account for the construction of the many lateral distribution lines required to serve individual users.

Based on the current 5,600 AFY estimate of SWRP deliveries, Central Basin's total sales of recycled water is projected to reach approximately 10,500 AFY by FY 2010.

Table 8-5
Projected Future Use of Recycled Water in Service Area
(in Acre-Feet)

Type of Use	2010	2015	2020	2025	2030
Irrigation	7,000	7,750	8,500	9,250	10,000
Commercial	0	0	0	0	0
Industrial	3,500	4,000	4,500	5,000	5,500
Total Projected Use of Recycled Water	**10,500**	**11,750**	**13,000**	**14,250**	**15,500**

8.3.5 POTENTIAL RECYCLED WATER USE

The potential of recycled water use will increase among cities, water agencies and businesses/ industries through the years. The increased cost of imported and groundwater will enhance the beneficial usages of recycled water.

Central Basin will continue to pursue new cost-effective projects both within its service area and in partnership with willing neighboring agencies. Efforts are currently focused on maximizing the potential of the original regional system, for which Central Basin receives an incentive payment from MWD for every acre-foot delivered up to 10,500 AFY through 2019. Although current projections discussed above show Central Basin exceeding that 10,500 AFY incentive limit, the agency is preparing for the long-term financial viability of the water recycling system.

Although there is great potential to increase recycled water use in Central Basin, there are challenges and limitations in connecting customers. Among them are proximity to recycled water pipelines, capacity and pressure to serve, and retrofit cost-feasibility. These factors play a significant role in meeting the potential growth of recycled water. The ability to connect new customers dictates when and how much recycled water will be sold in the future.

In 2000, the Master Plan identified and prioritized areas within Central Basin's service area where recycled water has the potential to expand. In this study, a database was established to locate and identify future customers. The approach considered pipeline routing, hydraulic analysis and economic interests to project the growth of recycled water in Central Basin's service area. Figure 8-4 presents conceptual recycled water projects based on pipeline routing.

Although the Master Plan is in the process of being updated and could influence Central Basin's near-term and long-term projections depending primarily on the potential changes to industrial water, the principle goal of maximizing the potential usage of recycled water throughout the service area will not change.

Partnerships with neighboring agencies have already resulted in projects that expand the Central Basin system and sales beyond the service area limits. Phase I and II of an agreement with Upper San Gabriel Valley Municipal Water District to serve Rose Hills will add approximately 1,500 AFY of sales beginning in 2006, and discussions have already begun to expand this partnership further.

Within Central Basin, discussions have begun with the City of Vernon for a new agreement to potentially delivery between 6,000 to 10,000 AFY of recycled water to a new planned power generation facility.

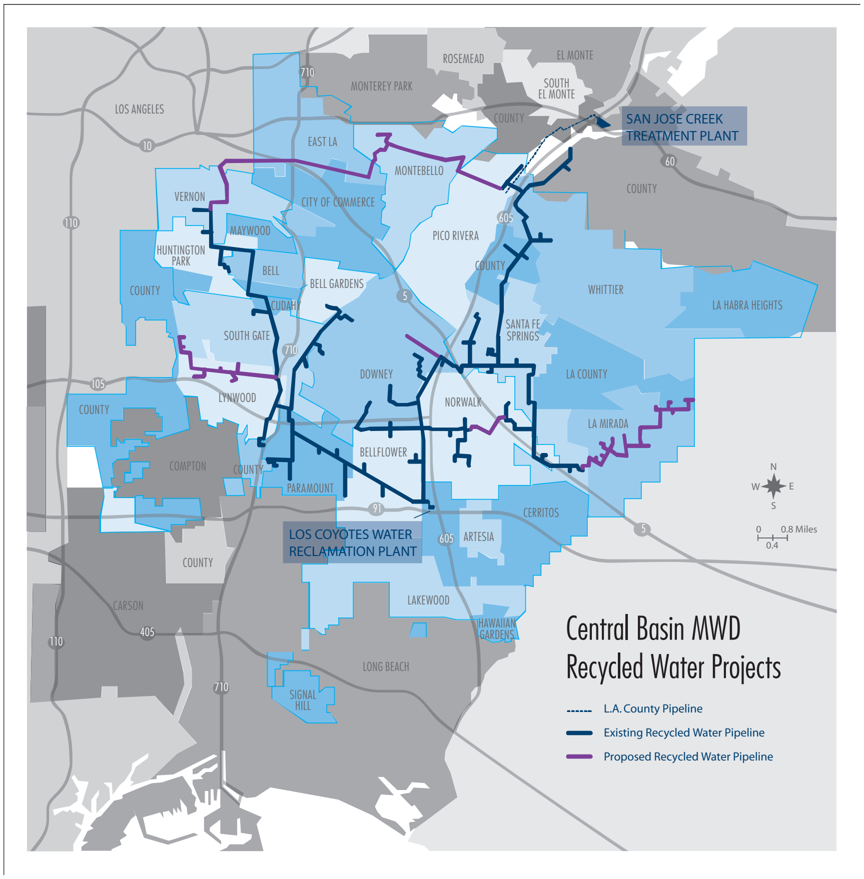
8.3.6 ENCOURAGING RECYCLED WATER USE

Central Basin's marketing efforts have been successful in changing the perception of recycled water from merely a conservation tool with minimal application to a business enhancement tool that lowers operating costs while increasing the reliability of the water supply. Central Basin markets recycled water as a resource that:

- Is less expensive than potable water;
- Is more reliable than imported water in a drought and
- Is consistent with statewide goals for water supply and ecosystem improvement on both the SWP and Colorado River systems.

The target customer is expanding from traditional irrigation users such as golf courses and parks to unconventional commercial and industrial users.

Figure 8-4
Conceptual Recycled Water Projects



Through innovative marketing, recycled water is now being used by oil refineries and dye houses. In addition, Central Basin is investigating recycled water use in paper production, co-generating plants and printing plants.

In addition to Central Basin wholesaling recycled water at a rate lower than potable water, Central Basin provides other financial incentives as well to encourage recycled water use. Some potential recycled water customers do not have the financial capability to pay for onsite plumbing retrofits necessary to accept recycled water. Therefore, Central Basin advances funds for retrofit expenses and are reimbursed through the water bills. The on-site plumbing retrofit costs are amortized through a period of time, up to 10 years at Central Basin's cost of funds. Repayment is made using the differential between potable and recycled water rates so that the customer never pays more than the potable rate. Once the loan is repaid, the rate reverts to the current recycled rate.

Optimizing Recycling Water Use

Central Basin's plan for optimizing the use of recycled water will be carried out through two efforts, both of which will be updated during the 2005-06 fiscal year, the Recycled Water Master Plan and the Recycled Water Marketing Plan (Marketing Plan). The Master Plan is Central Basin's guiding document for identifying and prioritizing potential customers. The 2000 Master Plan is currently being updated to capture changes in the industrial and commercial base within the service area, particularly in the northern portion to be served by the Southeast Water Reliability Project.

Recycled water for commercial irrigation in Santa Fe Springs.

The Marketing Plan is the companion effort to the Master Plan and will revisit the strategies and tools employed by Central Basin's staff and consultants in generating interest in recycled water with potential customers and the cities in which they do business. The thrust of the Marketing Plan will be to emphasize the benefit of recycled water as a "tool for profitability" for businesses and not just the right thing to do in terms of water conservation and the environment.

Coordination Efforts

Table 8-6 illustrates the District's coordinated effort among key stakeholders in the development of the 2000 Central Basin Water Recycling Master Plan. Central Basin plans on continuing the same coordinated effort in the updated Master Plan as well as include some participating agencies in the development process of the Marketing Plan.

8.3.7 FUNDING

Capital costs for projects planned for the future have been budgeted to average per fiscal year approximately $5,600,000.[1] These costs will be covered by the sources identified here and other sources as they become available:

- MWD Local Resources Program Incentive. To qualify, proposed recycled water projects by member agencies must cost more than projected MWD treated non-interruptible water rates and reduce potable water needs. Since founding MWD with other municipal water utilities in 1928, Central Basin has remained affiliated as a member agency and is therefore considered for the rebates for up to $250/AF offered under the program.

- Grant Funding. Central Basin continuously applies for Federal and State grant funding for recycled water projects as they become available. In 2005, Central Basin applied for a Water Recycling Construction grant for the Southeast Water Reliability Project, Phase I Water Recycling Construction Project through

[1] Approximation is an average based on fiscal year capital project projections during a five year period (FY: 2005-2006 to 2009-2010).

Table 8-6
Recycled Water Master Plan Coordination

Participating Agencies	Role in Plan Development
1. Water Agencies (Purveyors)	Customer Development, Facilities, Impacts, Rates
2. Wastewater Agencies	Recycled Water Supply, Water Quality, Reliability
3. Groundwater Agencies	Rates, Customer Involvement
4. Planning Agencies	Economic Analysis, Rates, Data Assessment, Customer Assessment, Rates, Community Impacts, Customer Involvement, Conceptual Pipeline Routes, Cost Estimates

1. Water Purveyor Agencies: See Table 8-3.
2. Wastewater Agencies: County Sanitation Districts of Los Angeles County
3. Groundwater Agencies: Water Replenishment District of Southern California
4. Planning Agencies: Purveyors and Cities within Central Basin's service area

Proposition 50. Central Basin submitted an application to the SWRCB to fund 25% of the $15.2 million cost of the pipeline. An additional source of funding is through the U.S. Army Corps of Engineers Program, which affords qualified programs 75% project funding.

8.4 RECYCLED WATER PROJECTS WITHIN CBMWD SERVICE AREA

8.4.1 CITY OF CERRITOS WATER RECYCLING PROGRAM

The City of Cerritos has its own water recycling system, which is not associated with Central Basin's recycled water program. It serves approximately 80 sites within the cities of Cerritos and Lakewood, which are located in Central Basin's service area. The City of Cerritos receives tertiary-treated recycled water from the CSDLAC's Los Coyotes WRP and serves a little more than 2,400 AFY, of which 450 AFY is sold to the City of Lakewood.

8.4.2 CITY OF LAKEWOOD WATER RECYCLING PROGRAM

The City of Lakewood purchases 450 AFY of recycled water from the City of Cerritos to help offset an equal demand of potable water.

8.4.3 WATER REPLENISHMENT DISTRICT-MONTEBELLO FOREBAY GROUNDWATER RECHARGE

The Montebello Forebay Groundwater Recharge Project allows the spreading of treated recycled water to be melded with imported and storm water within the recharge grounds with CSDLAC and Los Angeles County Department of Public Works (LACDPW). WRD has an agreement to recharge the basin with recycled water. LACDPW owns and operates the recharge facilities, while WRD purchases the recycled water from the CSDLAC. Under the conditions of a regulation permit from the Los Angeles RWQCB, approximately 50,000 AF of recycled water is the annual limit that can be recharged into the spreading grounds.

Montebello Forebay. Courtesy of WRD.

8.5 TOTAL RECYCLED WATER USE IN CENTRAL BASIN

Within Central Basin's service area there are three key water recycling programs that help offset potable water usage and provide groundwater replenishment. Among the three are the Central Basin, Cerritos and WRD water recycling programs. As illustrated in Table 8-7, together these programs delivered 52,400 AF of water recycling in 2005 and during the next 25 years they plan to increase deliveries by 10,500 AF.

Hollywood Sports Park in Bellflower.

Table 8-7
Total Projected Recycled Water Use in Central Basin's Service Area
(in Acre-Feet)

	2005[1]	2010	2015	2020	2025	2030
Central Basin						
Century/Rio Hondo Projects	3,150	10,500	11,750	13,000	14,250	15,500
Total	**3,150**	**10,500**	**11,750**	**13,000**	**14,250**	**15,500**
Other Programs within Central Basin						
City of Cerritos	1,714	1,950	1,950	1,950	1,950	1,950
City of Lakewood[2]	352	450	450	450	450	450
WRD (Replenishment Spreading)	50,000	50,000	50,000	50,000	50,000	50,000
Total	**52,067**	**52,400**	**52,400**	**52,400**	**52,400**	**52,400**
Central Basin's Service Area Total	**55,217**	**62,900**	**64,150**	**65,400**	**66,650**	**67,900**

[1] 2005 demands are based on the 2004-05 year, which is also considered one of the "wettest" years on record.
[2] City of Lakewood receive its recycled water from the Cerritos water recycling system.

Appendices

Appendix A

Urban Water Management Planning Act of 1983, as amended 2005

Established: AB 797, Klehs, 1983
Amended: AB 2661, Klehs, 1990
AB 11X, Filante, 1991
AB 1869, Speier, 1991
AB 892, Frazee, 1993
SB 1017, McCorquodale, 1994
AB 2853, Cortese, 1994
AB 1845, Cortese, 1995
SB 1011, Polanco, 1995
AB 2552, Bates, 2000
SB 553, Kelley, 2000
SB 610, Costa, 2001
AB 901, Daucher, 2001
SB 672, Machado, 2001
SB 1348, Brulte, 2002
SB 1384, Costa, 2002
SB 1518, Torlakson, 2002
AB 105, Wiggins, 2004
SB 318, Alpert, 2004

CALIFORNIA WATER CODE DIVISION 6
PART 2.6. URBAN WATER MANAGEMENT PLANNING

CHAPTER 1. GENERAL DECLARATION AND POLICY

10610. This part shall be known and may be cited as the "Urban Water Management Planning Act."

10610.2. (a) The Legislature finds and declares all of the following:

(1) The waters of the state are a limited and renewable resource subject to ever-increasing demands.

(2) The conservation and efficient use of urban water supplies are of statewide concern; however, the planning for that use and the implementation of those plans can best be accomplished at the local level.

(3) A long-term, reliable supply of water is essential to protect the productivity of California's businesses and economic climate.

(4) As part of its long-range planning activities, every urban water supplier should make every effort to ensure the appropriate level of reliability in

its water service sufficient to meet the needs of its various categories of customers during normal, dry, and multiple dry water years.

(5) Public health issues have been raised over a number of contaminants that have been identified in certain local and imported water supplies.

(6) Implementing effective water management strategies, including groundwater storage projects and recycled water projects, may require specific water quality and salinity targets for meeting groundwater basins water quality objectives and promoting beneficial use of recycled water.

(7) Water quality regulations are becoming an increasingly important factor in water agencies' selection of raw water sources, treatment alternatives, and modifications to existing treatment facilities.

(8) Changes in drinking water quality standards may also impact the usefulness of water supplies and may ultimately impact supply reliability.

(9) The quality of source supplies can have a significant impact on water management strategies and supply reliability.

(b) This part is intended to provide assistance to water agencies in carrying out their long-term resource planning responsibilities to ensure adequate water supplies to meet existing and future demands for water.

10610.4. The Legislature finds and declares that it is the policy of the state as follows:

(a) The management of urban water demands and efficient use of water shall be actively pursued to protect both the people of the state and their water resources.

(b) The management of urban water demands and efficient use of urban water supplies shall be a guiding criterion in public decisions.

(c) Urban water suppliers shall be required to develop water management plans to actively pursue the efficient use of available supplies.

CHAPTER 2. DEFINITIONS

10611. Unless the context otherwise requires, the definitions of this chapter govern the construction of this part.

10611.5. "Demand management" means those water conservation measures, programs, and incentives that prevent the waste of water and promote the reasonable and efficient use and reuse of available supplies.

10612. "Customer" means a purchaser of water from a water supplier who uses the water for municipal purposes, including residential, commercial, governmental, and industrial uses.

10613. "Efficient use" means those management measures that result in the most effective use of water so as to prevent its waste or unreasonable use or unreasonable method of use.

10614. "Person" means any individual, firm, association, organization, partnership, business, trust, corporation, company, public agency, or any agency of such an entity.

10615. "Plan" means an urban water management plan prepared pursuant to this part. A plan shall describe and evaluate sources of supply, reasonable and practical efficient uses, reclamation and demand management activities. The components of the plan may vary according to an individual community or area's characteristics and its capabilities to efficiently use and conserve water. The plan shall address measures for residential, commercial, governmental, and industrial water demand management as set forth in Article 2 (commencing with Section 10630) of Chapter 3. In addition, a strategy and time schedule for implementation shall be included in the plan.

10616. "Public agency" means any board, commission, county, city and county, city, regional agency, district, or other public entity.

10616.5. "Recycled water" means the reclamation and reuse of wastewater for beneficial use.

10617. "Urban water supplier" means a supplier, either publicly or privately owned, providing water for municipal purposes either directly or indirectly to more than 3,000 customers or supplying more than 3,000 acre-feet of water annually. An urban water supplier includes a supplier or contractor for water, regardless of the basis of right, which distributes or sells for ultimate resale to customers. This part applies only to water supplied from public water systems subject to Chapter 4 (commencing with Section 116275) of Part 12 of Division 104 of the Health and Safety Code.

CHAPTER 3. URBAN WATER MANAGEMEMENT PLANS

Article 1. General Provisions

10620.

(a) Every urban water supplier shall prepare and adopt an urban water management plan in the manner set forth in Article 3 (commencing with Section 10640).

(b) Every person that becomes an urban water supplier shall adopt an urban water management plan within one year after it has become an urban water supplier.

(c) An urban water supplier indirectly providing water shall not include planning elements in its water management plan as provided in Article 2 (commencing with Section 10630) that would be applicable to urban water suppliers or public agencies directly providing water, or to their customers, without the consent of those suppliers or public agencies.

(d)

(1) An urban water supplier may satisfy the requirements of this part by participation in areawide, regional, watershed, or basinwide urban water management planning where those plans will reduce preparation costs and contribute to the achievement of conservation and efficient water use.

(2) Each urban water supplier shall coordinate the preparation of its plan with other appropriate agencies in the area, including other water suppliers that share a common source, water management agencies, and relevant public agencies, to the extent practicable.

(e) The urban water supplier may prepare the plan with its own staff, by contract, or in cooperation with other governmental agencies.

(f) An urban water supplier shall describe in the plan water management tools and options used by that entity that will maximize resources and minimize the need to import water from other regions.

10621.

(a) Each urban water supplier shall update its plan at least once every five years on or before December 31, in years ending in five and zero.

(b) Every urban water supplier required to prepare a plan pursuant to this part shall notify any city or county within which the supplier provides water supplies that the urban water supplier will be reviewing the plan and considering amendments or changes to the plan. The urban water supplier may consult with, and obtain comments from, any city or county that receives notice pursuant to this subdivision.

(c) The amendments to, or changes in, the plan shall be adopted and filed in the manner set forth in Article 3 (commencing with Section 10640).

Article 2. Contents of Plans

10630. It is the intention of the Legislature, in enacting this part, to permit levels of water management planning commensurate with the numbers of customers served and the volume of water supplied.

10631. A plan shall be adopted in accordance with this chapter and shall do all of the following:

(a) Describe the service area of the supplier, including current and projected population, climate, and other demographic factors affecting the supplier's water management planning. The projected population estimates shall be based upon data from the state, regional, or local service agency population projections within the service area of the urban water supplier and shall be in five-year increments to 20 years or as far as data is available.

(b) Identify and quantify, to the extent practicable, the existing and planned sources of water available to the supplier over the same five-year increments described in subdivision (a). If groundwater is identified as an existing or planned source of water available to the supplier, all of the following information shall be included in the plan:

(1) A copy of any groundwater management plan adopted by the urban water supplier, including plans adopted pursuant to Part 2.75 (commencing with Section 10750), or any other specific authorization for groundwater management.

(2) A description of any groundwater basin or basins from which the urban water supplier pumps groundwater. For those basins for which a court or the board has adjudicated the rights to pump groundwater, a copy of the order or decree adopted by the court or the board and a description of the amount of groundwater the urban water supplier has the legal right to pump under the order or decree.

For basins that have not been adjudicated, information as to whether the department has identified the basin or basins as overdrafted or has projected that the basin will become overdrafted if present management conditions continue, in the most current official departmental bulletin that characterizes the condition of the groundwater basin, and a detailed description of the efforts being undertaken by the urban water supplier to eliminate the long-term overdraft condition.

(3) A detailed description and analysis of the location, amount, and sufficiency of groundwater pumped by the urban water supplier for the past five years. The description and analysis shall be based on information that is reasonably available, including, but not limited to, historic use records.

(4) A detailed description and analysis of the amount and location of groundwater that is projected to be pumped by the urban water supplier. The description and analysis shall be based on information that is reasonably available, including, but not limited to, historic use records.

(c) Describe the reliability of the water supply and vulnerability to seasonal or climatic shortage, to the extent practicable, and provide data for each of the following:

(1) An average water year.
(2) A single dry water year.
(3) Multiple dry water years.

For any water source that may not be available at a consistent level of use, given specific legal, environmental, water quality, or climatic factors, describe plans to supplement or replace that source with alternative sources or water demand management measures, to the extent practicable.

(d) Describe the opportunities for exchanges or transfers of water on a short-term or long-term basis.

(e)

(1) Quantify, to the extent records are available, past and current water use, over the same five-year increments described in subdivision (a), and projected water use, identifying the uses among water use sectors including, but not necessarily limited to, all of the following uses:

(A) Single-family residential.
(B) Multifamily.
(C) Commercial.
(D) Industrial.
(E) Institutional and governmental.
(F) Landscape.
(G) Sales to other agencies.
(H) Saline water intrusion barriers, groundwater recharge, or conjunctive use, or any combination thereof.
(I) Agricultural.

(2) The water use projections shall be in the same five-year increments described in subdivision (a).

(f) Provide a description of the supplier's water demand management measures. This description shall include all of the following:

(1) A description of each water demand management measure that is currently being implemented, or scheduled for implementation, including the steps necessary to implement any proposed measures, including, but not limited to, all of the following:

(A) Water survey programs for single-family residential and multifamily residential customers.

(B) Residential plumbing retrofit.

(C) System water audits, leak detection, and repair.

(D) Metering with commodity rates for all new connections and retrofit of existing connections.

(E) Large landscape conservation programs and incentives.

(F) High-efficiency washing machine rebate programs.

(G) Public information programs.

(H) School education programs.

(I) Conservation programs for commercial, industrial, and institutional accounts.

(J) Wholesale agency programs.

(K) Conservation pricing.

(L) Water conservation coordinator.

(M) Water waste prohibition.

(N) Residential ultra-low-flush toilet replacement programs.

(2) A schedule of implementation for all water demand management measures proposed or described in the plan.

(3) A description of the methods, if any, that the supplier will use to evaluate the effectiveness of water demand management measures implemented or described under the plan.

(4) An estimate, if available, of existing conservation savings on water use within the supplier's service area, and the effect of the savings on the supplier's ability to further reduce demand.

(g) An evaluation of each water demand management measure listed in paragraph (1) of subdivision (f) that is not currently being implemented or scheduled for implementation. In the course of the evaluation, first consideration shall be given to water demand management measures, or combination of measures, that offer lower incremental costs than expanded or additional water supplies. This evaluation shall do all of the following:

(1) Take into account economic and noneconomic factors, including environmental, social, health, customer impact, and technological factors.

(2) Include a cost-benefit analysis, identifying total benefits and total costs.

(3) Include a description of funding available to implement any planned water supply project that would provide water at a higher unit cost.

(4) Include a description of the water supplier's legal authority to implement the measure and efforts to work with other relevant agencies to ensure the implementation of the measure and to share the cost of implementation.

(h) Include a description of all water supply projects and water supply programs that may be undertaken by the urban water supplier to meet the total projected water use as established pursuant to subdivision (a) of Section 10635. The urban water supplier shall include a detailed description of expected future projects and programs, other than the demand management programs identified pursuant to paragraph (1) of subdivision (f), that the urban water supplier may implement to increase the amount of the water supply available to the urban water supplier in average, single-dry, and multiple-dry water years. The description shall identify specific projects and include a description of the increase in water supply that is expected to be available from each project. The description shall include an estimate with regard to the implementation timeline for each project or program.

(i) Describe the opportunities for development of desalinated water, including, but not limited to, ocean water, brackish water, and groundwater, as a long-term supply.

(j) Urban water suppliers that are members of the California Urban Water Conservation Council and submit annual reports to that council in accordance with the "Memorandum of Understanding Regarding Urban Water Conservation in California," dated September 1991, may submit the annual reports identifying water demand management measures currently being implemented, or scheduled for implementation, to satisfy the requirements of subdivisions (f) and (g).

(k) Urban water suppliers that rely upon a wholesale agency for a source of water, shall provide the wholesale agency with water use projections from that agency for that source of water in five-year increments to 20 years or as far as data is available. The wholesale agency shall provide information to the urban water supplier for inclusion in the urban water supplier's plan that identifies and quantifies, to the extent practicable, the existing and planned sources of water as required by subdivision (b), available from the wholesale agency to the urban water supplier over the same five-year increments, and during various water-year types in accordance with subdivision (c). An urban water supplier may rely upon water supply information provided by the wholesale agency in fulfilling the plan informational requirements of subdivisions (b) and (c), including, but not limited to, ocean water, brackish water, and groundwater, as a long-term supply.

10631.5. The department shall take into consideration whether the urban water supplier is implementing or scheduled for implementation, the water demand management activities that the urban water supplier identified in its urban water management plan, pursuant to Section 10631, in evaluating applications for grants and loans made available pursuant to Section 79163. The urban water supplier may submit to the department copies of its annual reports and other relevant documents to assist the department in determining whether the urban water supplier is implementing or scheduling the implementation of water demand management activities.

10632. The plan shall provide an urban water shortage contingency analysis which includes each of the following elements which are within the authority of the urban water supplier:

(a) Stages of action to be undertaken by the urban water supplier in response to water supply shortages, including up to a 50 percent reduction in water supply, and an outline of specific water supply conditions which are applicable to each stage.

(b) An estimate of the minimum water supply available during each of the next three water years based on the driest three-year historic sequence for the agency's water supply.

(c) Actions to be undertaken by the urban water supplier to prepare for, and implement during, a catastrophic interruption of water supplies including, but not limited to, a regional power outage, an earthquake, or other disaster.

(d) Additional, mandatory prohibitions against specific water use practices during water shortages, including, but not limited to, prohibiting the use of potable water for street cleaning.

(e) Consumption reduction methods in the most restrictive stages. Each urban water supplier may use any type of consumption reduction methods in its water shortage contingency analysis that would reduce water use, are appropriate for its area, and have the ability to achieve a water use reduction consistent with up to a 50 percent reduction in water supply.

(f) Penalties or charges for excessive use, where applicable.

(g) An analysis of the impacts of each of the actions and conditions described in subdivisions (a) to (f), inclusive, on the revenues and expenditures of the urban water supplier, and proposed measures to overcome those impacts, such as the development of reserves and rate adjustments.

(h) A draft water shortage contingency resolution or ordinance.

(i) A mechanism for determining actual reductions in water use pursuant to the urban water shortage contingency analysis.

10633. The plan shall provide, to the extent available, information on recycled water and its potential for use as a water source in the service area of the urban water supplier. The preparation of the plan shall be coordinated with local water, wastewater, groundwater, and planning agencies that operate within the supplier's service area, and shall include all of the following:

(a) A description of the wastewater collection and treatment systems in the supplier's service area, including a quantification of the amount of wastewater collected and treated and the methods of wastewater disposal.

(b) A description of the quantity of treated wastewater that meets recycled water standards, is being discharged, and is otherwise available for use in a recycled water project.

(c) A description of the recycled water currently being used in the supplier's service area, including, but not limited to, the type, place, and quantity of use.

(d) A description and quantification of the potential uses of recycled water, including, but not limited to, agricultural irrigation, landscape irrigation, wildlife habitat enhancement, wetlands, industrial reuse, groundwater recharge, and other appropriate uses, and a determination with regard to the technical and economic feasibility of serving those uses.

(e) The projected use of recycled water within the supplier's service area at the end of 5, 10, 15, and 20 years, and a description of the actual use of recycled water in comparison to uses previously projected pursuant to this subdivision.

(f) A description of actions, including financial incentives, which may be taken to encourage the use of recycled water, and the projected results of these actions in terms of acre-feet of recycled water used per year.

(g) A plan for optimizing the use of recycled water in the supplier's service area, including actions to facilitate the installation of dual distribution systems, to promote recirculating uses, to facilitate the increased use of treated wastewater that meets recycled water standards, and to overcome any obstacles to achieving that increased use.

10634. The plan shall include information, to the extent practicable, relating to the quality of existing sources of water available to the supplier over the same five-year increments as described in subdivision (a) of Section 10631, and the manner in which water quality affects water management strategies and supply reliability.

Article 2.5 Water Service Reliability

10635.

(a) Every urban water supplier shall include, as part of its urban water management plan, an assessment of the reliability of its water service to its customers during normal, dry, and multiple dry water years. This water supply and demand assessment shall compare the total water supply sources available to the water supplier with the total projected water use over the next 20 years, in five-year increments, for a normal water year, a single dry water year, and multiple dry water years. The water service reliability assessment shall be based upon the information compiled pursuant to Section 10631, including available data from state, regional, or local agency population projections within the service area of the urban water supplier.

(b) The urban water supplier shall provide that portion of its urban water management plan prepared pursuant to this article to any city or county within which it provides water supplies no later than 60 days after the submission of its urban water management plan.

(c) Nothing in this article is intended to create a right or entitlement to water service or any specific level of water service.

(d) Nothing in this article is intended to change existing law concerning an urban water supplier's obligation to provide water service to its existing customers or to any potential future customers.

Articl 3. Adoption and Implementation of Plans

10640. Every urban water supplier required to prepare a plan pursuant to this part shall prepare its plan pursuant to Article 2 (commencing with Section 10630).

The supplier shall likewise periodically review the plan as required by Section 10621, and any amendments or changes required as a result of that review shall be adopted pursuant to this article.

10641. An urban water supplier required to prepare a plan may consult with, and obtain comments from, any public agency or state agency or any person who has special expertise with respect to water demand management methods and techniques.

10642. Each urban water supplier shall encourage the active involvement of diverse social, cultural, and economic elements of the population within the service area prior to and during the preparation of the plan. Prior to adopting a plan, the urban water supplier shall make the plan available for public inspection and shall hold a public hearing thereon. Prior to the hearing, notice of the time and place of hearing shall be published within the jurisdiction of the publicly owned water supplier pursuant to Section 6066 of the Government Code. The urban water supplier shall provide notice of the time and place of hearing to any city or county within which the supplier provides water supplies. A privately owned water supplier shall provide an equivalent notice within its service area. After the hearing, the plan shall be adopted as prepared or as modified after the hearing.

10643. An urban water supplier shall implement its plan adopted pursuant to this chapter in accordance with the schedule set forth in its plan.

10644.

(a) An urban water supplier shall file with the department and any city or county within which the supplier provides water supplies a copy of its plan no later than 30 days after adoption. Copies of amendments or changes to the plans shall be filed with the department and any city or county within which the supplier provides water supplies within 30 days after adoption.

(b) The department shall prepare and submit to the Legislature, on or before December 31, in the years ending in six and one, a report summarizing the status of the plans adopted pursuant to this part. The report prepared by the department shall identify the outstanding elements of the individual plans. The department shall provide a copy of the report to each urban water supplier that has filed its plan with the department. The department shall also prepare reports and provide data for any legislative hearings designed to consider the effectiveness of plans submitted pursuant to this part.

10645. Not later than 30 days after filing a copy of its plan with the department, the urban water supplier and the department shall make the plan available for public review during normal business hours.

CHAPTER 4. MISCELLANEOUS PROVISIONS

10650. Any actions or proceedings to attack, review, set aside, void, or annul the acts or decisions of an urban water supplier on the grounds of noncompliance with this part shall be commenced as follows:

(a) An action or proceeding alleging failure to adopt a plan shall be commenced within 18 months after that adoption is required by this part.

(b) Any action or proceeding alleging that a plan, or action taken pursuant to the plan, does not comply with this part shall be commenced within 90 days after filing of the plan or amendment thereto pursuant to Section 10644 or the taking of that action.

10651. In any action or proceeding to attack, review, set aside, void, or annul a plan, or an action taken pursuant to the plan by an urban water supplier on the grounds of noncompliance with this part, the inquiry shall extend only to whether there was a prejudicial abuse of discretion. Abuse of discretion is established if the supplier has not proceeded in a manner required by law or if the action by the water supplier is not supported by substantial evidence.

10652. The California Environmental Quality Act (Division 13 (commencing with Section 21000) of the Public Resources Code) does not apply to the preparation and adoption of plans pursuant to this part or to the implementation of actions taken pursuant to Section 10632. Nothing in this part shall be interpreted as exempting from the California Environmental Quality Act any project that would significantly affect water supplies for fish and wildlife, or any project for implementation of the plan, other than projects implementing Section 10632, or any project for expanded or additional water supplies.

10653. The adoption of a plan shall satisfy any requirements of state law, regulation, or order, including those of the State Water Resources Control Board and the Public Utilities Commission, for the preparation of water management plans or conservation plans; provided, that if the State Water Resources Control Board or the Public Utilities Commission requires additional information concerning water conservation to implement its existing authority, nothing in this part shall be deemed to limit the board or the commission in obtaining that information. The requirements of this part shall be satisfied by any urban water demand management plan prepared to meet federal laws or regulations after the effective date of this part, and which substantially meets the requirements of this part, or by any existing urban water management plan which includes the contents of a plan required under this part.

10654. An urban water supplier may recover in its rates the costs incurred in preparing its plan and implementing the reasonable water conservation measures included in the plan. Any best water management practice that is included in the plan that is identified in the "Memorandum of Understanding Regarding Urban Water Conservation in California" is deemed to be reasonable for the purposes of this section.

10655. If any provision of this part or the application thereof to any person or circumstances is held invalid, that invalidity shall not affect other provisions or applications of this part which can be given effect without the invalid provision or application thereof, and to this end the provisions of this part are severable.

10656. An urban water supplier that does not prepare, adopt, and submit its urban water management plan to the department in accordance with this part, is ineligible to receive funding pursuant to Division 24 (commencing with Section 78500) or Division 26 (commencing with Section 79000), or receive drought assistance from the state until the urban water management plan is submitted pursuant to this article.

10657.

(a) The department shall take into consideration whether the urban water supplier has submitted an updated urban water management plan that is consistent with Section 10631, as amended by the act that adds this section, in determining whether the urban water supplier is eligible for funds made available pursuant to any program administered by the department.

(b) This section shall remain in effect only until January 1, 2006, and as of that date is repealed, unless a later enacted statute, that is enacted before January 1, 2006, deletes or extends that date.

Appendix B

2005 Urban Water Management Plan Checklist Form

Central Basin Municipal Water District
2005 Urban Water Management Plan Checklist Form

Water Code Section	Location in Guide	Items to Address	Location in Plan
10620 (d)(1)	Page 2	Participate in area wide, regional, watershed or basin wide urban water management planning	Page 1-3
10620 (d)(2)	Page 2	Describe the coordination of the plan preparation with other appropriate agencies in the area and anticipated benefits	Page 1-2-1 3
10620 (f)	Page 2	Describe how water management tools and/or options to maximize resources & minimize need to import water	Page ES-1-ES-7
10621 (a)	Page 4	Update plan every five years on or before December 31, in years ending in five and zero	Page 1-1
10621 (b)	Page 4	Notify any city or county within service area of UWMP of plan review & revision	Page 4-5
	Page 4	Consult and obtain comments from cities and counties within service area	Page 1-2
10631 (a)	Page 8	Provide current and projected population for water service area in 5-year increments to 20 or 25 years	Page 2-3
	Page 8	Identify source of population data	Page 2-3
	Page 8	Describe climate characteristics that affect water management	Page 2-1-2 2
	Page 8	Describe other demographic factors that affect water management	Page 2-2-2 3
10631 (b)	Page 10	Identify existing and planned water supply sources	Page 3-2
	Page 4	Provide current water supply quantities in 5-year increments to 20 or 25 years	Page 4-5
	Page 4	Provide planned water supply quantities in 5-year increments to 20 or 25 years	Page 4-5
10631 (b)(1)	Page 12	Attach copy of any groundwater management plans adopted, including plans adopted pursuant to Part 2.75 or any other specific authorization for groundwater management	N/A
10631 (b)(2)	Page 12	A description of any groundwater basins or basin from which the urban water supplier pumps groundwater	N/A
	Page 12	If the groundwater basin is adjudicated attach a copy of the order or decree	N/A
	Page 12	For basins that are not adjudicated, state whether basins are in overdraft	N/A
	Page 12	If basin is in overdraft or projected to be in overdraft describe plan to eliminate overdraft	N/A
	Page 12	Quantify legal pumping amounts from basin	Page 3-5
10631 (b)(3)	Page 12	Detailed description and analysis of location, amount, and sufficiency of water pumped for past five years	Page 3-6
10631 (b)(4)	Page 12	Detailed description and analysis of location, amount, and sufficiency for 20 or 25 year projection of water to be pumped	Page 3-7
10631 (c)(1)	Page 14	Describe the reliability of the water supply and vulnerability to seasonal or climatic shortage for normal water year	Page 4-5
10631 (c)(2)	Page 14	Describe the reliability of the water supply and vulnerability to seasonal or climatic shortage for single-dry water year	Page 4-5
10631 (c)(3)	Page 14	Describe the reliability of the water supply and vulnerability to seasonal or climatic shortage for multiple-dry water years	Page 4-6
10631 (c)	Page 14	Describe the reliability of the water supply due to seasonal or climatic shortages	N/A

	Page 14	Describe the vulnerability of the water supply to seasonal or climatic shortages	N/A
	Page 14	Participate in area wide, regional, watershed or basin wide urban water management planning	N/A
10631 (d)	Page 16	Describe opportunities for exchanges or water transfers on a short term or long term basis	Page 3-9
10631 (e)(1-3)	Page 18	Identify and quantify past water use by sector	Page 2-6
	Page 18	Identify and quantify current water use by sector	Page 2-6
	Page 18	Identify and quantify projected water use by sector in five-year increments to 20 or 25 years	Page 2-8
	Page 20	Identify and quantify past, current, and projected water use over five-year increments by sales to other agencies to 20 or 25 years	Page 2-6 and 2-8
	Page 20	Identify and quantify past, current, and projected water use over five-year increments by additional water uses and losses to 20 years	N/A
10631 (f)	Page 24	See (i)	Appendix F
10631 (g)	Page 40	See (j)	Appendix F
10631 (h)	Page 42	Description of water supply projects and water supply programs that may be undertaken to meet total projected water use with a timeline for each project	Page 3-5-3 12
		Quantify each proposed project's normal-year supply, single dry-year supply, and multi-dry year supply	Page 4-5-4 6
10631 (i)	Page 44	Describe opportunities for development of desalinated water (ocean, brackish water)	Page 3-9
10631 (j)	Page 22	Provide annual report from CUWCC identifying water demand management measures being implemented or scheduled for implementation to satisfy requirements (f) and (g)	Appendix F
10631 (k)	Page 46	Provide wholesale agency with water use projections for that source of water in five-year increments to 20 or 25 years	N/A
	Page 46	Wholesaler provided information identifying and quantifying existing and planned sources of water available to supplier over five-year increments to 20 or 25 years	N/A
	Page 46	Information from wholesaler describing reliability of wholesale supplies and amount to be delivered during normal, single-dry, and multiple-dry years, including factors resulting in inconsistency and information or plans to supplement or replace water sources that are not reliable	N/A
10631.5	Page 24	Include 2003-2004 or 2005 Annual Report submitted to CUWCC and CUWCC coverage report	Appendix F
10632 (a)	Page 50	Provide an urban water shortage contingency plan analysis with stages of action to be taken in response to a water supply shortage	Page 4-7-4 9
	Page 50	Provide water supply conditions for each stage	Page 4-8
	Page 50	Provide in plan a 50% supply shortage	Page 4-7
10632 (b)	Page 52	Estimate the minimum water supply available for each of the next three years based on the driest three-year historical sequence by source	Page 4-7

10631 (c)	Page 54	Provide a catastrophic supply interruption plan for non-drought related events looking at vulnerability of each source, delivery and distribution systems and actions to minimize impacts of supply interruption	Page 4-9
10632 (d)	Page 56	List mandatory prohibitions against specific water use practices during water shortages and stage when they become mandatory	Page 4-8
10632 (e)	Page 56	List the consumption reduction methods the water supplier will use to reduce water use in the most restrictive stages with up to a 50% reduction	Page 4-8
10632 (f)	Page 56	List excessive use charges or penalties for excessive use	Page 4-8
10632 (g)	Page 58	Describe how actions and conditions impact revenues	Page 4-8
	Page 58	Describe how action and conditions impact expenditures	Page 4-8
	Page 58	Describe measures to overcome the revenue and expenditure impacts	Page 4-8
10632 (h)	Page 60	Provide a draft Water Shortage Contingency resolution or ordinance	Appendix E
10632 (i)	Page 60	Describe mechanisms to determine actual reductions	Page 4-8
10633	Page 62	Identify coordination of the recycled water plan with other agencies	Page 8-10
10633 (a)	Page 64	Describe wastewater collection and treatment systems in supplier's service area including amount collected and treated and quantify volumes	Page 8-1-8 3
10633 (b)	Page 64	Describe methods of wastewater disposal and treatment levels and quantify amount meeting recycled water standards	N/A
10633 (c)	Page 64	Describe current uses of recycled water, including type, place and quantities	Page 8-4-8 6
10633 (d)	Page 66	Describe and quantify potential uses of recycled water and explain technical and economic feasibility	Page 8-8
10633 (e)	Page 66	Describe projected use of recycled water in surface area at 5-year intervals to 20 or 25 years	Page 8-8
	Page 66	Compare UWMP 2000 projections with UWMP 2005 actual use	Page 8-6
10633 (f)	Page 66	Describe actions that might be taken to encourage recycled water use and projected results	Page 8-8
10633 (g)	Page 66	Provide recycled water use optimization plan that includes actions to facilitate the use of recycled water	Page 8-9
10634	Page 68	Analyze and describe how water quality affects water management strategies and supply reliability for each source of water	Page 5-4
10632 (e)	Page 70-74	Compare projected normal water supply to projected normal water use over the next 20 or 25 years, in five-year increments	Page 4-5
	Page 70-74	Compare projected single-dry year supply to projected single-dry year water use over the next 20 or 25 years, in 5-year increments	Page 4-5
	Page 70-74	Compare projected multiple-dry year supply to projected multiple-dry year demand over the next 20 to 25 years, in 5-year increments (for following five year periods: 2006-2010, 2013-2015, 2018-2020, 2023-2025, 2028-2030)	Page 4-6-4 7

10635 (b)	Page 74	Provide Water Service Reliability section of UWMP to cities and counties within which it provides water supplies within 60 days of UWMP submission to DWR	N/A
10642	Page 78	Attach copy of adopted resolution to UWMP	Appendix C
	Page 78	Encourage involvement of social, cultural and economic community groups	Appendix C
	Page 78	Plan available for public inspection	Appendix C
	Page 78	Provide proof of public hearing	Appendix C
	Page 78	Provided meeting notice to any city or county it supplies water within	Appendix C
10643	Page 78	Review recycled water plan in 2000 UWMP and discuss whether it is being implemented as planned	Page 8-6
	Page 78	Discuss whether BMPs in CUWCC BMP Annual Reports submitted in 2000 UWMP were implemented as planned	Page 6-2
10644	Page 78	Provide 2005 UWMP to DWR and cities and counties within supplier area within 30 days of adoption	N/A
10645	Page 78	Provide documentation showing where plan will be available for public review during normal business hours 30 days after submittal to DWR	Appendix C

Appendix C

Notice of Public Hearing and Resolution for UWMP Adoption

LEGAL NOTICE

Notice of Public Hearing

Central and West Basin Municipal Water Districts

PLEASE TAKE NOTICE that the Board of Directors of Central and West Basin Municipal Water Districts will conduct a Public Hearing on **December 19, 2005** at the hours of **11:00 a.m.** and **1:00 p.m.**, respectfully; or as soon thereafter as the matter can be heard; in the board room of the District's office located at 17140 S. Avalon Blvd. Carson, California to consider adoption of its 2005 Urban Water Management Plans. This planning document assesses the Districts' water resources, demands, and strategies over the next 25 years, as a requirement set forth by the State Department of Water Resources. The Final Draft 2005 Urban Water Management Plan can be found on the Districts' website at www.westbasin.org and www.centralbasin.org or a copy can be requested from the Districts for review. Interested parties are invited to present oral or written comments.

Dated November 30, 2005

Charlene Jensen
Secretary

Publish: December 5, 12, 2005
Whittier Daily News Ad No.

Daily Breeze

DB 12-21
Notice of Public Hearing

Central and West Basin
Municipal Water Districts

PLEASE TAKE NOTICE that the Board of Directors of Central and West Basin Municipal Water Districts will conduct a Public hearing on **December 19, 2005** at the hours of **11:00 a.m. and 1:00 p.m.**, respectfully; or as soon thereafter as the matter can be heard in the board room of the District's office located at 17140 S. Avalon Blvd. Carson, California to consider adoption of its 2005 Urban Water Management Plans. This planning document assesses the Districts' water resources, demands, and strategies over the next 25 years, as a requirement set forth by the State Department of Water Resources. The Final Draft 2005 Urban Water Management Plan can be found on the Districts' website at www.westbasin.org and www.centralbasin.org or a copy can be requested from the Districts for review. Interested parties are invited to present oral or written comments.

Dated November 30, 2005

Charlene Jensen
Secretary

Pub.: December 5, 12, 2005.

CERTIFICATION

State of California)
County of Los Angeles) SS
Central Basin Municipal)
Water District)

I, Charlene Jensen, Board Secretary of Central Basin Municipal Water District and of the Board of Directors thereof, do hereby certify that the foregoing is a full, true and correct copy of Resolution No. 12-05-71 "A RESOLUTION OF THE BOARD OF DIRECTORS OF THE CENTRAL BASIN MUNICIPAL WATER DISTRICT APPROVING THE 2005 URBAN WATER MANAGEMENT PLAN", which was adopted at a meeting held on December 19, 2005 by the Board of Directors of the Central Basin Municipal Water District.

Dated: December 20, 2005

Charlene T. Jensen

Charlene T. Jensen
Board Secretary, Central Basin
Municipal Water District and to
the Board of Directors thereof

f:\users\charlene\certifycb

RESOLUTION NO. 12-05-716

A RESOLUTION OF THE BOARD OF DIRECTORS OF CENTRAL BASIN MUNICIPAL WATER DISTRICT APPROVING THE 2005 URBAN WATER MANAGEMENT PLAN

BE IT RESOLVED, by the BOARD OF DIRECTORS that the Board of Directors hereby adopt and sign a Resolution approving the 2005 Urban Water Management Plan, and

BE IT RESOLVED, that the Central Basin Municipal Water District hereby agrees and further authorizes that the aforementioned document complies with all applicable requirements set forth in the California Urban Water Management Planning Act of 1983, as amended, and

BE IT FURTHER RESOLVED, that the President of the Board of Directors of the Central Basin Municipal Water District is hereby authorized to sign the 2005 Urban Water Management Plan.

PASSED, APPROVED, AND ADOPTED on the 19th ___ ___ day, December 2005.

Robert Apodaca
President

ATTEST.

Charlene Jensen
Secretary

(SEAL)

G:\director\resos\cb716

Appendix D

Notice of Preparation / Draft 2005 UWMP

Central Basin Municipal Water District

17140 S. Avalon Blvd • Suite 210 • Carson, CA 90746-1256

telephone 310-217-2222 • fax 310-217-2414

July 8, 2005

To Whom It May Concern:

This letter serves as notification that the Central Basin Municipal Water District is currently preparing a 2005 update of its Urban Water Management Plan, pursuant to the Urban Water Management Planning Act (Act) of the California Water Code. The Act requires urban water suppliers to update their Urban Water Management Plans and submit a complete plan to the California Department of Water Resources every five years.

A draft of Central Basin's Plan is currently available for review and comments. A Final Draft will be available for review prior to the scheduled public hearing in October 2005.

Please contact us if you would like to receive a draft Plan. If you would like more information or have any questions, please contact Harvey De La Torre at (310) 660-6233 or via email at harveyd@wcbwater.org.

Thank you,

Art Aguilar
Co-General Manager

Rich Nagel
Co-General Manager

CHRONO FILE

Central Basin
Municipal Water District
[illegible]

West Basin
Municipal Water District
[illegible]

June 29, 2005

Dear Central/West Basin Customer Agencies:

2005 Urban Water Management Plan

As you are aware, all California agencies providing water to more than 3,000 customers or supplying more than 3,000 acre-feet of water a year are required to update their Urban Water Management Plans (UWMP) every five years, according to California Water Code Section 10621(a). Central Basin MWD (CBMWD) and West Basin MWD (WBMWD) hosted its 2005 Urban Water Management Plan workshop with the Metropolitan Water District of Southern California and the California Urban Water Conservation Council on June 28 2005.

Enclosed you will find the District's DRAFT 2005 UWMP, which will assist you in updating your agency's UWMP. We will be meeting with each agency to discuss our Plan and answer any questions you may have throughout the months of July and August. Staff will be contacting you soon to schedule a date and time. The District anticipates completing its FINAL UWMP by September and taking it to the Board for adoption in October. All UWMPs are due to the Department of Water Resources by December 31, 2005.

If you have any questions, please feel free to contact Harvey De La Torre at (310) 660-6233 or Leighanne Reeser at (310) 660-6225.

Sincerely,

Art Aguilar
Co-General Manager

Rich Nagel
Co-General Manager

Enclosures

17140 S Avalon Blvd • Suite 210 • Carson, CA 90746-1296
fax [illegible]

Appendix E

Water Shortage Contingency Plan Resolution

---DRAFT---

Resolution No. _____

A RESOLUTION OF THE BOARD OF DIRECTORS OF THE CENTRAL BASIN MUNCIPAL WATER DISTRICT FINDING THE EXISTENCE OF A WATER SHORTAGE, ORDERING THE IMPLEMENTATION OF STAGE __ OF THE WATER SHORTAGE CONTINGENCY PLAN

WHEREAS, the Central Basin Municipal Water District (District), a member agency to Metropolitan Water District of Southern California (MWD), has implemented a mandatory reduction program; and

WHEREAS, the Board of Directors has established Stages of Action contingent upon the MWD Water Surplus and Drought Management (WSDM) Plan, which provides for stages of action and an allocation methodology; and

WHEREAS, the WSDM Plan allocation methodology has yet to be determined and the District has established and will follow the following stages of action:

a) Minimum Shortage Stage: Request a voluntary effort among the District customers to reduce imported water deliveries. Pursue an aggressive Public Awareness Campaign to encourage residents and industries to reduce their usage of water.

b) Moderate Shortage Stage: In addition to the Minimum Shortage Stage actions, the District will work with its customer agencies to promote and adopt waste water prohibition and ordinances to discourage unnecessary water usage.

c) Severe Shortage Stage: In addition to the Minimum and Moderate Shortage Stage actions, the District will seek to adopt a rate structure that penalized increased water usage among its customer agencies.

d) Extreme Water Shortage Stage: In addition to the Minimum, Moderate, and Severe Shortage Stage actions, the District will call for the discontinuance of imported water based upon an allocation methodology similar to MWD for each of its customer agencies; and

WHEREAS, the Board of Directors may, upon finding that a water shortage exists, order implementation of a plan which it deems appropriate to address such water shortage and shall establish the Stage if action that it is implementing.

NOW, THEREFORE, BE IT RESOLVED BY THE BOARD OF DIRECTORS OF THE CENTRAL BASIN MUNICIPAL WATER DISTRICT AS FOLLOWS:

—-DRAFT—-

1. That, for the reasons hereinabove set forth, the Board of Directors hereby finds and determines that a Water Shortage exists in the Central Basin Water District service area.
2. That the Board of Directors hereby orders implementation of the Water Shortage Contingency Plan, ____________Stage, as set forth above.
3. That reasonable action shall be taken to ensure compliance by the District's customer agencies.

THE FOREGOING RESOLUTION is approved and adopted by the Board of Directors of the Central Basin Municipal Water District this __ day of _________, 20__

PRESIDENT, CENTRAL BASIN MWD

ATTEST:

BOARD SECRETARY, CENTRAL BASIN MWD

Appendix F

Best Management Practices Report 2003-2004

Reported as of 8/2

BMP 03: System Water Audits, Leak Detection and Repair

Reporting Unit:	BMP Form Status:	Year:
Central Basin MWD	**100% Complete**	**2003**

A. Implementation

1. Has your agency completed a pre-screening system audit for this reporting year?	no
2. If YES, enter the values (AF/Year) used to calculate verifiable use as a percent of total production:	
a. Determine metered sales (AF)	
b. Determine other system verifiable uses (AF)	
c. Determine total supply into the system (AF)	
d. Using the numbers above, if (Metered Sales + Other Verifiable Uses) / Total Supply is < 0.9 then a full-scale system audit is required.	0.00
3. Does your agency keep necessary data on file to verify the values used to calculate verifiable uses as a percent of total production?	no
4. Did your agency complete a full-scale audit during this report year?	no
5. Does your agency maintain in-house records of audit results or the completed AWWA audit worksheets for the completed audit?	no
6. Does your agency operate a system leak detection program?	no
a. If yes, describe the leak detection program:	

B. Survey Data

1. Total number of miles of distribution system line.	0
2. Number of miles of distribution system line surveyed.	0

C. System Audit / Leak Detection Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures	0	0
2. Actual Expenditures	0	

D. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP?	No
a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."	

E. Comments

As a water wholesaler, we do not actually own potable water piping. We do however provide support to our water retailers as stated in BMP 10. We have provided them with requested information on how to conduct system audits and leak detection. We do have manuals provided by DWR.

Reported as of 8/2

BMP 07: Public Information Programs

Reporting Unit:	BMP Form Status:	Year:
Central Basin MWD	**100% Complete**	**2003**

A. Implementation

1. Does your agency maintain an active public information program to promote and educate customers about water conservation? yes

a. If YES, describe the program and how it's organized.

The Public Information Program consists of a variety of programs and practices that are used to educate the public about water conservation. Conservation literature is provided to the public at the various one-day ultra-low-flush (ULF) toilet programs, and at community events. A quarterly newsletter is provided to approximately 20,000 residents. Information is provided at the quarterly Public Information Committee (PIC) meeting, and at the annual "Water Harvest" festival. Information is also provided at various speaking engagements, the web site, and on the telephone. Opportunities are sought to educate the public about the importance of water conservation. Marketing is also conducted to promote the District's rebate programs.

2. Indicate which and how many of the following activities are included in your public information program.

Public Information Program Activity	Yes/No	Number of Events
a. Paid Advertising	yes	21
b. Public Service Announcement	yes	1
c. Bill Inserts / Newsletters / Brochures	yes	2
d. Bill showing water usage in comparison to previous year's usage	no	
e. Demonstration Gardens	no	
f. Special Events, Media Events	yes	5
g. Speaker's Bureau	yes	5
h. Program to coordinate with other government agencies, industry and public interest groups and media	yes	

B. Conservation Information Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures	174617	160000
2. Actual Expenditures	80000	

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

Reported as of 8/2

BMP 08: School Education Programs

Reporting Unit:	BMP Form Status:	Year:
Central Basin MWD	**100% Complete**	**2003**

A. Implementation

1.Has your agency implemented a school information program to promote water conservation? yes

2. Please provide information on your school programs (by grade level):

Grade	Are grade-appropriate materials distributed?	No. of class presentations	No. of students reached	No. of teachers' workshops
Grades K-3rd	yes	7	190	0
Grades 4th-6th	yes	24	830	0
Grades 7th-8th	yes	3	105	0
High School	no	0	0	0

3. Did your Agency's materials meet state education framework requirements? yes

4. When did your Agency begin implementing this program? 9/10/1995

B. School Education Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures	49737	38208
2. Actual Expenditures	20000	

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

Reported as of 8/2

BMP 10: Wholesale Agency Assistance Programs

Reporting Unit:	BMP Form Status:	Year:
Central Basin MWD	**100% Complete**	**2003**

A. Implementation

1. Financial Support by BMP

BMP	Financial Incentives Offered?	Budgeted Amount	Amount Awarded	BMP	Financial Incentives Offered?	Budgeted Amount	Amount Awarded
1	No			8	yes	49737	20000
2	No			9	yes	5500	5500
3	No			10	yes	0	0
4	No			11	No	0	0
5	yes	1500000	1500000	12	yes	66000	66000
6	yes	15000	15000	13	No	0	0
7	yes	174817	174817	14	yes	350500	350000

2. Technical Support

a. Has your agency conducted or funded workshops addressing CUWCC procedures for calculating program savings, costs and cost-effectiveness?	No
b. Has your agency conducted or funded workshops addressing retail agencies' BMP implementation reporting requirements?	No
c. Has your agency conducted or funded workshops addressing:	
1) ULFT replacement	No
2) Residential retrofits	No
3) Commercial, industrial, and institutional surveys	No
4) Residential and large turf irrigation	No
5) Conservation-related rates and pricing	No

3. Staff Resources by BMP

BMP	Qualified Staff Available for BMP?	No. FTE Staff Assigned to BMP	BMP	Qualified Staff Available for BMP?	No. FTE Staff Assigned to BMP
1	yes	1	8	yes	1
2	yes	1	9	yes	1
3	yes	1	10	yes	1
4	yes	1	11	yes	1
5	yes	1	12	yes	1
6	yes	1	13	yes	1
7	yes	1	14	yes	1

4. Regional Programs by BMP

BMP	Implementation/ Management Program?	BMP	Implementation/ Management Program?
1	No	8	yes
2	No	9	yes
3	No	10	yes
4	No	11	yes
5	No	12	yes
6	yes	13	yes
7	yes	14	yes

B. Wholesale Agency Assistance Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures	720254	720254
2. Actual Expenditures	660254	

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

In reference to BMP 5, the District spends $1.5 million on O&M for its recycled water system. This system benefits large landscape customers by utilizing recycled water instead of imported or potable water. A1 of BMP 5 includes funding for recycled water operations and maintenance. Recycled water is 100% water conservation.

D. Comments

BMP #9 - Central Basin participates in MWD's region-wide CII. MWD pays vendor to implement and market program on behalf of the Member Agencies. Central Basin budgeted $5,000 to help market the program. The District has moved its recycled water budget dollars from BMP #9 into BMP #5 - Large Landscape. It is more appropriate in this BMP than in prior reporting in BMP 9. BMP #6 - Central Basin receives a $110 rebate incentive from MWD. Central Basin budgets an additional $15,000 for marketing the program. ($15 per rebate x 1,000 rebates)

Reported as of 8/2

BMP 11: Conservation Pricing

Reporting Unit:	BMP Form Status:	Year:
Central Basin MWD	**100% Complete**	**2003**

A. Implementation

Rate Structure Data Volumetric Rates for Water Service by Customer Class

1. Residential	
a. Water Rate Structure	Uniform
b. Sewer Rate Structure	Service Not Provided
c. Total Revenue from Volumetric Rates	$34686195.64
d. Total Revenue from Non-Volumetric Charges, Fees and other Revenue Sources	$4556948.46
2. Commercial	
a. Water Rate Structure	
b. Sewer Rate Structure	
c. Total Revenue from Volumetric Rates	$
d. Total Revenue from Non-Volumetric Charges, Fees and other Revenue Sources	$
3. Industrial	
a. Water Rate Structure	
b. Sewer Rate Structure	
c. Total Revenue from Volumetric Rates	$
d. Total Revenue from Non-Volumetric Charges, Fees and other Revenue Sources	$
4. Institutional / Government	
a. Water Rate Structure	
b. Sewer Rate Structure	
c. Total Revenue from Volumetric Rates	$
d. Total Revenue from Non-Volumetric Charges, Fees and other Revenue Sources	$
5. Irrigation	
a. Water Rate Structure	
b. Sewer Rate Structure	
c. Total Revenue from Volumetric Rates	$
d. Total Revenue from Non-Volumetric Charges, Fees and other Revenue Sources	$
6. Other	
a. Water Rate Structure	Decreasing Block

b. Sewer Rate Structure	Service Not Provided
c. Total Revenue from Volumetric Rates	$1445258.18
d. Total Revenue from Non-Volumetric Charges, Fees and other Revenue Sources	$3199559.55

B. Conservation Pricing Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures	0	0
2. Actual Expenditures	0	

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

Reported as of 8/2

BMP 12: Conservation Coordinator

Reporting Unit:	BMP Form Status:	Year:
Central Basin MWD	**100% Complete**	**2003**

A. Implementation

1. Does your Agency have a conservation coordinator?	yes
2. Is this a full-time position?	no
3. If no, is the coordinator supplied by another agency with which you cooperate in a regional conservation program ?	yes
4. Partner agency's name:	West Basin Municipal Water District
5. If your agency supplies the conservation coordinator:	
a. What percent is this conservation coordinator's position?	50%
b. Coordinator's Name	Gus Meza
c. Coordinator's Title	Conservation Coordinator
d. Coordinator's Experience and Number of Years	5 Years Conservation Related Experience
e. Date Coordinator's position was created (mm/dd/yyyy)	4/17/1991
6. Number of conservation staff, including Conservation Coordinator.	1

B. Conservation Staff Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures	68000	68000
2. Actual Expenditures	68000	

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? no

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

Central Basin MWD shares staff with West Basin MWD on a 50/50 basis. So conservation staff time is one-half person for each Water District.

Reported as of 8/2

BMP 03: System Water Audits, Leak Detection and Repair

Reporting Unit:	BMP Form Status:	Year:
Central Basin MWD	**100% Complete**	**2004**

A. Implementation

1. Has your agency completed a pre-screening system audit for this reporting year?	no
2. If YES, enter the values (AF/Year) used to calculate verifiable use as a percent of total production:	
a. Determine metered sales (AF)	
b. Determine other system verifiable uses (AF)	
c. Determine total supply into the system (AF)	
d. Using the numbers above, if (Metered Sales + Other Verifiable Uses) / Total Supply is < 0.9 then a full-scale system audit is required.	0.00
3. Does your agency keep necessary data on file to verify the values used to calculate verifiable uses as a percent of total production?	no
4. Did your agency complete a full-scale audit during this report year?	no
5. Does your agency maintain in-house records of audit results or the completed AWWA audit worksheets for the completed audit?	no
6. Does your agency operate a system leak detection program?	no
a. If yes, describe the leak detection program:	

B. Survey Data

1. Total number of miles of distribution system line.	0
2. Number of miles of distribution system line surveyed.	0

C. System Audit / Leak Detection Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures	0	0
2. Actual Expenditures	0	

D. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP?	No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

E. Comments

As a water wholesaler, we do not actually own potable water piping. We do however provide support to our water retailers as stated in BMP 10. We have provided them with requested information on how to conduct system audits and leak detection. We do have manuals provided by DWR.

Reported as of 8/2

BMP 07: Public Information Programs

Reporting Unit:	BMP Form Status:	Year:
Central Basin MWD	**100% Complete**	**2004**

A. Implementation

1. Does your agency maintain an active public information program to promote and educate customers about water conservation? yes

a. If YES, describe the program and how it's organized.

The Public Information Program consists of a variety of programs and practices that are used to educate the public about water conservation. Conservation literature is provided to the public at the various one-day ultra-low-flush (ULF) toilet programs, and at community events. A quarterly newsletter is provided to approximately 20,000 residents. Information is provided at the quarterly Public Information Committee (PIC) meeting, and at the annual "Water Harvest" festival. Information is also provided at various speaking engagements, the web site, and on the telephone. Opportunities are sought to educate the public about the importance of water conservation. Marketing is also conducted to promote the District's rebate programs.

2. Indicate which and how many of the following activities are included in your public information program.

Public Information Program Activity	Yes/No	Number of Events
a. Paid Advertising	yes	21
b. Public Service Announcement	yes	1
c. Bill Inserts / Newsletters / Brochures	yes	2
d. Bill showing water usage in comparison to previous year's usage	no	
e. Demonstration Gardens	no	
f. Special Events, Media Events	yes	5
g. Speaker's Bureau	yes	5
h. Program to coordinate with other government agencies, industry and public interest groups and media	yes	

B. Conservation Information Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures	168000	213000
2. Actual Expenditures	180000	

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

Reported as of 8/2

BMP 08: School Education Programs

Reporting Unit:	BMP Form Status:	Year:
Central Basin MWD	**100% Complete**	**2004**

A. Implementation

1. Has your agency implemented a school information program to promote water conservation? yes

2. Please provide information on your school programs (by grade level)

Grade	Are grade-appropriate materials distributed?	No. of class presentations	No. of students reached	No. of teachers' workshops
Grades K-3rd	yes	14	350	0
Grades 4th-6th	yes	34	1190	0
Grades 7th-8th	yes	2	60	0
High School	no	0	0	0

3. Did your Agency's materials meet state education framework requirements? yes

4. When did your Agency begin implementing this program? 9/10/1995

B. School Education Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures	68208	68208
2. Actual Expenditures	26000	

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

Reported as of 8/2

BMP 10: Wholesale Agency Assistance Programs

Reporting Unit:	BMP Form Status:	Year:
Central Basin MWD	**100% Complete**	**2004**

A. Implementation

1. Financial Support by BMP

BMP	Financial Incentives Offered?	Budgeted Amount	Amount Awarded	BMP	Financial Incentives Offered?	Budgeted Amount	Amount Awarded
1	No			**8**	yes	58208	26000
2	No			**9**	No	0	0
3	No			**10**	yes	0	0
4	No			**11**	No		
5	No			**12**	yes	65000	65000
6	yes	15000	15000	**13**	No	0	0
7	yes	158000	158000	**14**	yes	360500	360500

2. Technical Support

a. Has your agency conducted or funded workshops addressing CUWCC procedures for calculating program savings, costs and cost-effectiveness?	No
b. Has your agency conducted or funded workshops addressing retail agencies' BMP implementation reporting requirements?	No
c. Has your agency conducted or funded workshops addressing:	
1) ULFT replacement	No
2) Residential retrofits	No
3) Commercial, industrial, and institutional surveys	No
4) Residential and large turf irrigation	No
5) Conservation-related rates and pricing	No

3. Staff Resources by BMP

BMP	Qualified Staff Available for BMP?	No. FTE Staff Assigned to BMP	BMP	Qualified Staff Available for BMP?	No. FTE Staff Assigned to BMP
1	yes	1	8	yes	1
2	yes	1	9	yes	1
3	yes	1	10	yes	1
4	yes	1	11	yes	1
5	yes	1	12	yes	1
6	yes	1	13	yes	1
7	yes	1	14	yes	1

4. Regional Programs by BMP

BMP	Implementation/ Management Program?	BMP	Implementation/ Management Program?
1	No	8	yes
2	No	9	yes
3	No	10	yes
4	No	11	yes
5	No	12	yes
6	yes	13	yes
7	yes	14	yes

B. Wholesale Agency Assistance Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures	679208	623708
2. Actual Expenditures	679208	

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

In reference to BMP 5, the District spends $1.5 million on O&M for its recycled water system. This system benefits large landscape customers by utilizing recycled water instead of imported or potable water. A1 of BMP 5 includes funding for recycled water operations and maintenance. Recycled water is 100% water conservation.

D. Comments

BMP #9 - Central Basin participates in MWD's region-wide CII. MWD pays vendor to implement and market program on behalf of the Member Agencies. Central Basin budgeted $5,000 to help market the program. The District has moved its recycled water budget dollars from BMP #9 into BMP #5 - Large Landscape. It is more appropriate in this BMP than in prior reporting in BMP 9. BMP #6 - Central Basin receives a $110 rebate incentive from MWD. Central Basin budgets an additional $15,000 for marketing the program. ($15 per rebate x 1,000 rebates)

Reported as of 8/2

BMP 11: Conservation Pricing

Reporting Unit:	BMP Form Status:	Year:
Central Basin MWD	**100% Complete**	**2004**

A. Implementation

Rate Structure Data Volumetric Rates for Water Service by Customer Class

1. Residential	
a. Water Rate Structure	Uniform
b. Sewer Rate Structure	Service Not Provided
c. Total Revenue from Volumetric Rates	$36835420.8
d. Total Revenue from Non-Volumetric Charges, Fees and other Revenue Sources	$4477917.3625
2. Commercial	
a. Water Rate Structure	
b. Sewer Rate Structure	
c. Total Revenue from Volumetric Rates	$
d. Total Revenue from Non-Volumetric Charges, Fees and other Revenue Sources	$
3. Industrial	
a. Water Rate Structure	
b. Sewer Rate Structure	
c. Total Revenue from Volumetric Rates	$
d. Total Revenue from Non-Volumetric Charges, Fees and other Revenue Sources	$
4. Institutional / Government	
a. Water Rate Structure	
b. Sewer Rate Structure	
c. Total Revenue from Volumetric Rates	$
d. Total Revenue from Non-Volumetric Charges, Fees and other Revenue Sources	$
5. Irrigation	
a. Water Rate Structure	
b. Sewer Rate Structure	
c. Total Revenue from Volumetric Rates	$
d. Total Revenue from Non-Volumetric Charges, Fees and other Revenue Sources	$
6. Other	
a. Water Rate Structure	Decreasing Block

b. Sewer Rate Structure	Service Not Provided
c. Total Revenue from Volumetric Rates	$1534809.2
d. Total Revenue from Non-Volumetric Charges, Fees and other Revenue Sources	$3144069.6375

B. Conservation Pricing Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures	0	0
2. Actual Expenditures	0	

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

Reported as of 8/2

BMP 12: Conservation Coordinator

Reporting Unit:	BMP Form Status:	Year:
Central Basin MWD	**100% Complete**	**2004**

A. Implementation

1. Does your Agency have a conservation coordinator?	yes
2. Is this a full-time position?	no
3. If no, is the coordinator supplied by another agency with which you cooperate in a regional conservation program ?	yes
4. Partner agency's name:	West Basin Municipal Water District
5. If your agency supplies the conservation coordinator:	
a. What percent is this conservation coordinator's position?	50%
b. Coordinator's Name	Gus Meza
c. Coordinator's Title	Conservation Coordinator
d. Coordinator's Experience and Number of Years	5 Years Conservation Related Experience
e. Date Coordinator's position was created (mm/dd/yyyy)	4/17/1991
6. Number of conservation staff, including Conservation Coordinator.	1

B. Conservation Staff Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures	58000	58000
2. Actual Expenditures	58000	

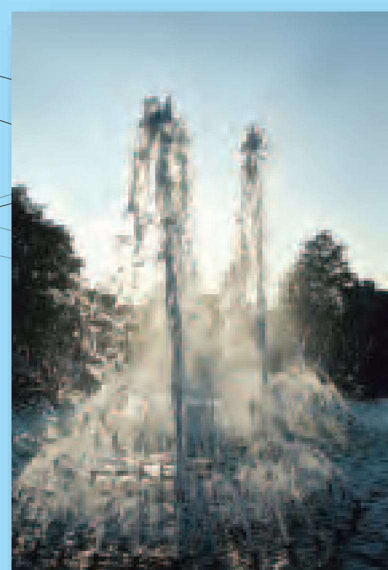
C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? no

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

Central Basin MWD shares staff with West Basin MWD on a 50/50 basis. So conservation staff time is one-half person for each Water District.



Glossary

Glossary of Abbreviations and Terms

AGENCIES

AWWARF	American Water Works Association Research Foundation
CalWater	California Water Service Company
CDHS	California Department of Health Services
Central Basin	Central Basin Municipal Water District
City	City of Los Angeles
CPUC	California Public Utilities Commission
CSDLAC	County Sanitation Districts of Los Angeles County
CUWCC	California Urban Water Conservation Council
CWAC	California Water Awareness Campaign
District	Central Basin Municipal Water District
DWR	California Department of Water Resources
Edison	Southern California Edison
EPA	United States Environmental Protection Agency
LACDPW	Los Angeles County Department of Public Works
LACFCD	Los Angeles County Flood Control District
LADWP	Los Angeles Department of Water and Power
MWD	Metropolitan Water District of Southern California
RWQCB	Regional Water Quality Control Board
SCAG	Southern California Association of Governments
USBR	United States Bureau of Reclamation
West Basin	West Basin Municipal Water District
WRD	Water Replenishment District of Southern California

FACILITIES AND LOCATIONS

Barrier	Alamitos Barrier
Basin	Central Groundwater Basin
Bay-Delta	San Francisco-San Joaquin Bay Delta
CRA	Colorado River Aqueduct
CSUDH	California State University at Dominguez Hills
CVP	Central Valley Project
Hyperion	Hyperion Treatment Plant
Ibbetson Century Project	E. Thornton Ibbetson Century Water Recycling Project
Pilot Project	West Basin's Desalination Pilot Project
Spreading Grounds	Rio Hondo and San Gabriel River Spreading Grounds
SWP	State Water Project
SWRP	Southeast Water Reliability Project
Torres Project	Esteban E. Torres Rio Hondo Water Recycling Project
WCGB	West Coast Groundwater Basin
WRP	Water Recycling Plant
WRPS	Water Reclamation Plants

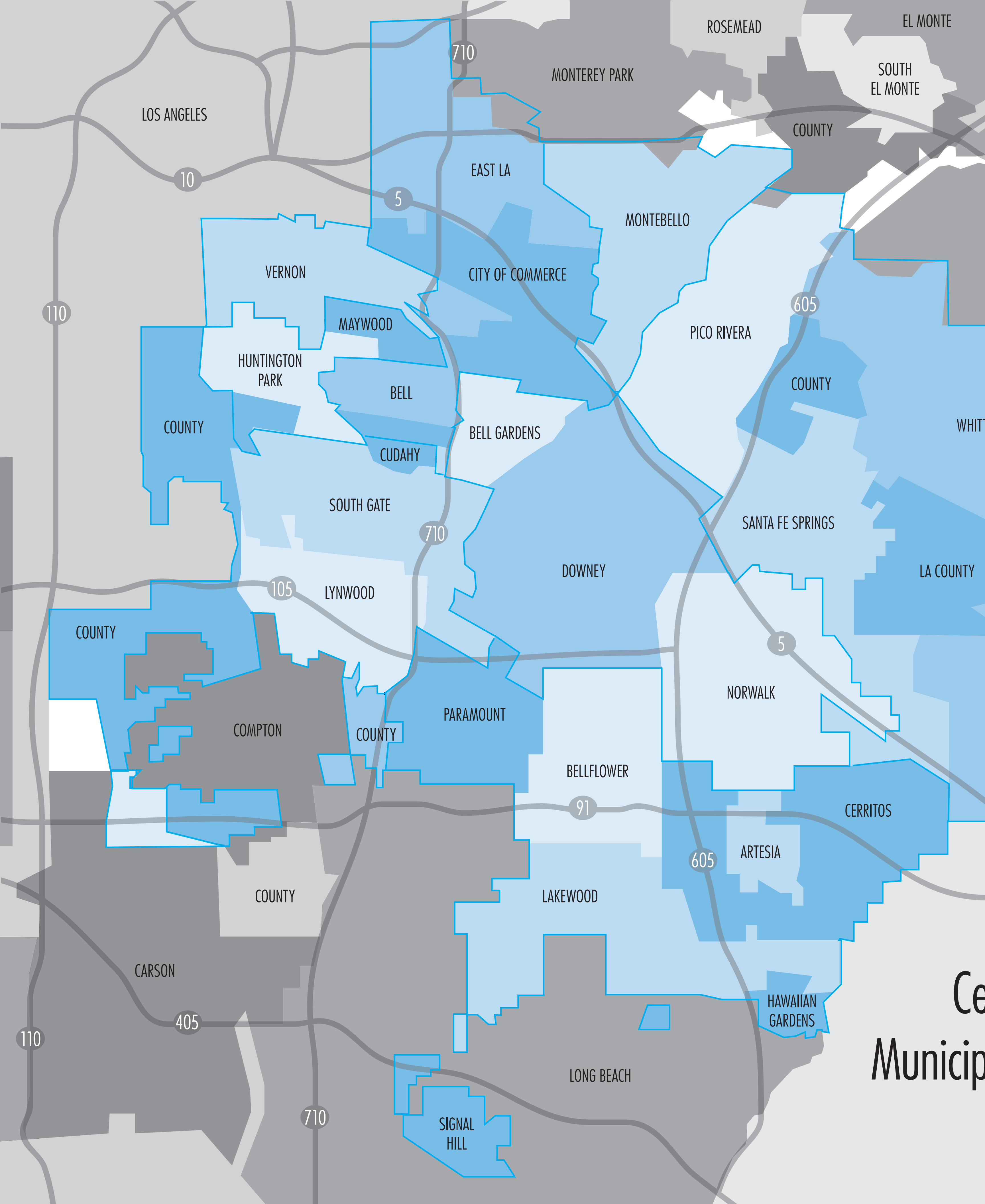
MEASUREMENTS

AFY	Acre-Feet Per Year
CFS	Cubic Feet Per Second
GPCD	Gallons Per Capita Per Day
GPM	Gallons Per Minute
MAF	Million Acre-Feet
MGD	Million Gallons Per Day
WF	Water Factor

MISCELLANEOUS

ACT	California Urban Water Management Planning Act of 1983
BMPs	Best Management Practices
CBIC	Weather-Based Irrigation Program
CII	Commercial, Industrial and Institutional
EOC	Emergency Operation Center
Harbor/South Bay	Harbor/South Bay Water Recycling Project
HECW	High-Efficiency Clothes Washer Program
HET	High-Efficiency Toilets
IRP	Integrated Resources Plan
Marketing Plan	Recycled Water Marketing Plan
Master Plan	Recycled Water Master Plan
MARS	Member Agency Response System
MOU	Memorandum of Understanding Regarding Urban Water Conservation in California
MWD-MAIN	Metropolitan Water District's Municipal and Industrial Needs
NPDES	National Pollutant Discharge Elimination System
PAC	Project Advisory Committee
PIC	Public Information Committee
Plan	Conservation Master Plan
Program	Water Audit and Leak Detection Program
QSA	Quantification Settlement Agreement
RTS	Readiness-to-Serve Charge
SDWP	Safe Drinking Water Program
Title 22	California Code of Regulations Title 22 standards
ULFT	Ultra-Low-Flush Toilet
UWMP	Urban Water Management Plan
VOCs	Volatile Organic Compounds
WBIC	Weather-Based Irrigation Controller
WQPP	Water Quality Protection Project
WSDM	Water Surplus and Drought Management Plan

www.centralbasin.org



ROSEMEAD
EL MONTE
MONTEREY PARK
SOUTH
EL MONTE
710
LOS ANGELES
COUNTY
10
EAST LA
5
MONTEBELLO
VERNON
CITY OF COMMERCE
605
110
MAYWOOD
PICO RIVERA
HUNTINGTON
PARK
COUNTY
BELL
WHIT
COUNTY
BELL GARDENS
CUDAHY
SOUTH GATE
SANTA FE SPRINGS
710
DOWNEY
LA COUNTY
105
LYNWOOD
COUNTY
5
NORWALK
PARAMOUNT
COMPTON
COUNTY
BELLFLOWER
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CERRITOS
ARTESIA
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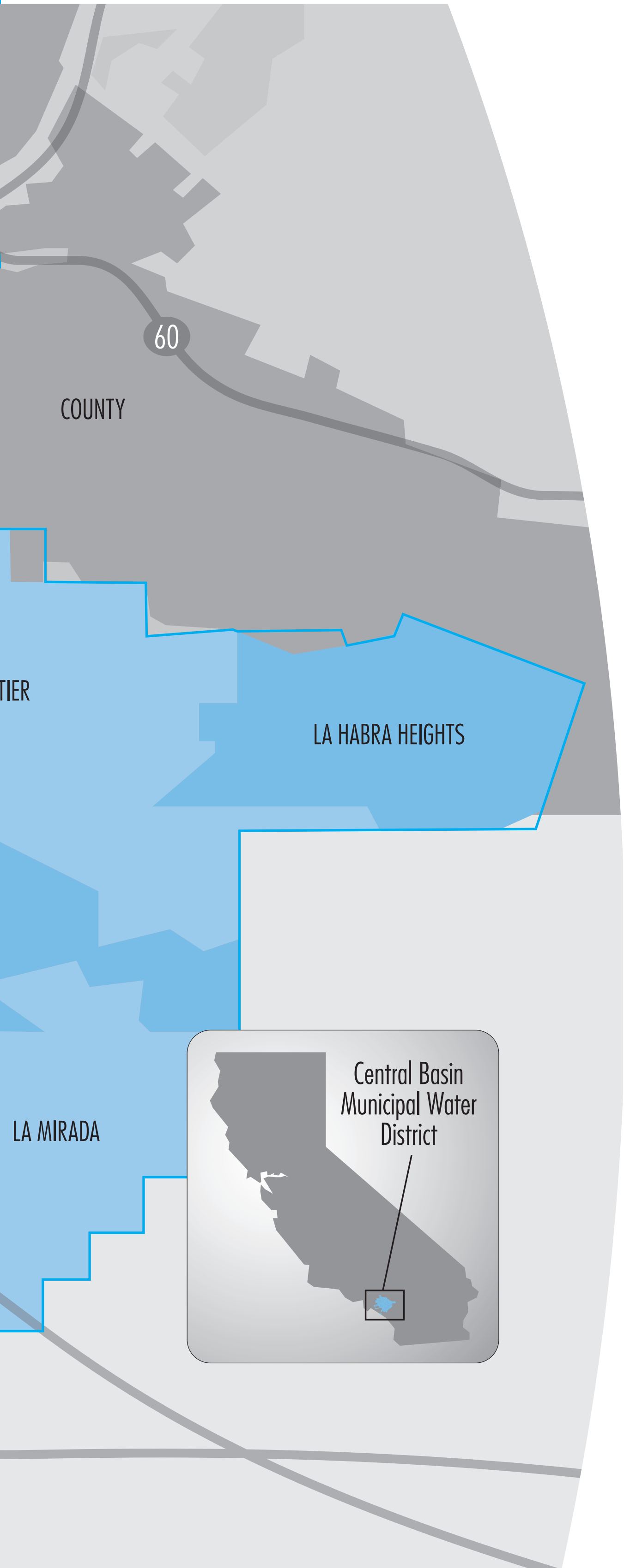

entral Basin
pal Water District

Board of Directors and Service Areas

Division I: Director Edward C. Vasquez
Bell Gardens, Downey, Montebello, Norwalk and Vernon

Division II: Director Robert Apodaca
La Habra Heights, La Mirada, Pico Rivera, Santa Fe Springs and Whittier

Division III: Director George Cole
Bell, Commerce, Huntington Park, Maywood, Walnut Park, portions of Cudahy, Monterey Park and unincorporated areas of East Los Angeles

Division IV: Director Olga E. Gonzalez
Lynwood, South Gate, portions of Cudahy, Carson, Florence-Graham and Willowbrook

Division V: Director Phillip D. Hawkins
Artesia, Bellflower, Cerritos, Hawaiian Gardens, Lakewood, Paramount and Signal Hill

West Basin
Municipal Water District

Urban Water Management Plan




Year 2005

West Basin
Municipal Water District

Message from the Board of Directors

Since the District's formation in 1947, West Basin Municipal Water District has remained steadfast in its commitment to ensure a safe and reliable water supply for the region. Through the years, the District has grown and transformed, seeking innovative and viable solutions to meet the changing needs of its communities. All of us at West Basin continue to expand our efforts to meet the growing water demand while preserving our limited and precious water resource. Through our water recycling, conservation, education, desalination, outreach and quality monitoring programs, West Basin has evolved from a potable water wholesaler to a leader safeguarding the region's water supply.

We are proud to submit this 2005 Urban Water Management Plan to the State Department of Water Resources. The Plan reports all current and projected water supplies and demands within West Basin's service area, demonstrates water reliability for the next 25 years and provides a comprehensive overview of the District's various programs.

Directors

Division I William A. Baker

Palos Verdes Estates, Rancho Palos Verdes, Rolling Hills Estates, Rolling Hills and portions of Carson

Division II Jose A. Fernandez

Inglewood, South Ladera Heights, portions of Lennox and unincorporated areas of Athens, Howard and Ross-Sexton

Division III Carol W. Kwan, President

Hermosa Beach, Lomita, Manhattan Beach, Redondo Beach and unincorporated areas of Torrance

Division IV Edward C. Little, Vice-President

Culver City, Del Aire, El Segundo, Malibu, North Ladera Heights, Topanga, View Park, West Hollywood, Windsor Hills and portions of Lennox

Division V Donald L. Dear

Gardena, Hawthorne, Lawndale and unincorporated portions of El Camino Village

Mission Statement

To obtain and provide a safe and reliable supplemental supply of high quality water to our member agencies, including the communities, businesses and residents they serve, in an efficient, effective and economical manner. In accomplishing this mission, the District shall provide adequate information and education on water issues to the public, be instrumental in guarding the integrity, safety and security of the West Coast Basin, and maintain close cooperation with the other agencies serving our area.

West Basin Municipal Water District

2005 Urban Water Management Plan

Prepared by:

West Basin Municipal Water District
17140 S. Avalon Blvd., Suite 210
Carson, CA 90746

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Executive Summary

Executive Summary

1 A Brief History

The legislative requirement to prepare an Urban Water Management Plan (UWMP) every five years provides West Basin Municipal Water District (West Basin) with an opportunity to affirm and support its primary purpose – to ensure the long-term water supply reliability of its region. Although the District's overall mission has not changed in more than five decades, techniques for meeting its objective are continuously evolving.

Colorado River
Courtesy of MWD

The history of West Basin is representative of how water resource management has evolved in Southern California during the past half a century. Ensuring that residents and businesses in Southern California have a safe and reliable supply of water requires the cooperation of local water purveyors as well as regional wholesalers.

When native groundwater supplies in the growing southeastern part of Los Angeles County became critically over-drafted in the 1940s, groundwater producers formed a regional agency, West Basin Municipal Water District, in 1947. Prior to joining Metropolitan Water District of Southern California, the District explored alternative sources of water including water recycling and even ocean water desalination. Due to the then extraordinary cost in developing these sources, West Basin joined MWD. MWD had been created in 1928 by 11 cities (13 in 1933 and now 26 member agencies in 2005) for the purpose of constructing a 240-mile aqueduct from the Colorado River. The era of "imported water" and mega-projects that began at the turn of the last century with construction of the Los Angeles Aqueduct from the Owens Valley by the City of Los Angeles, and continued with the extension of the California Aqueduct into Southern California in the 1970s, was well underway. West Basin joined this era to provide a new source of water for groundwater replenishment and to meet the needs of many cities and agencies with little or no access to groundwater.

Imported water was the fuel that drove the economic engine of Southern California for decades. Through the 1960s, 70s and 80s, imported water provided by West Basin offered the reliability enjoyed by retail water agencies across most of coastal Los Angeles County. During this time, population within West Basin's service area grew by 138% from about 320,000 in 1950 to more than 760,000 people by 1990.

2 A Different Approach to Water Management

The paradigm of ensuring reliability while continuing to provide unlimited supplies of imported water began to change with the drought of 1989-1992. Even before the near-reality of mandatory water rationing in the spring of 1992, plans had begun to enhance conservation practices and to consider the development of locally-produced sources of water that, through the long-term, would significantly reduce Southern California's reliance on supply systems subject to hydrology and environmental pressures.

West Basin was at the forefront of this change in approach to water management. By 1990, funding mechanisms were in place and designs were being drawn up for a world-class recycled water production and distribution system that would directly offset potable imported water for non-potable uses such as irrigation and industrial applications and indirect potable, such as injection into a seawater barrier system. West Basin would also become renowned for its highly successful conservation and education programs that, combined with recycled water, have helped conserve more than 63 billion gallons of potable water during the past decade.

By 1996, local water supply programs were accounted for within MWD's Southern California Integrated Resources Plan (IRP), which established a rolling 20-year roadmap for diversified supply investments in recycled water, brackish groundwater treatment, surface and groundwater storage, water transfers and exchanges, conservation practices and accessibility to imported water. A recent update of the IRP also includes ocean water desalination as an additional resource for ensuring the long-term reliability of regional water supplies.

West Basin's aggressive pursuit of the resource development targets within the IRP is bringing supply diversity to a region originally dependent on groundwater.

3 Water Demand

Total water use, or demand, within West Basin's service area includes retail demand and groundwater replenishment (i.e. Barriers). Retail demand is defined as all municipal (residential, firefighting, parks, etc.) and industrial uses, and represents the population's total direct water consumption. Replenishment includes deliveries to the West Coast and Dominguez Gap Barriers to protect the West Coast Groundwater Basin. Table ES-1 summarizes the current and projected retail and replenishment demands.

Table ES-1
West Basin's Current and Projected Water Demands
(In Acre-Feet)

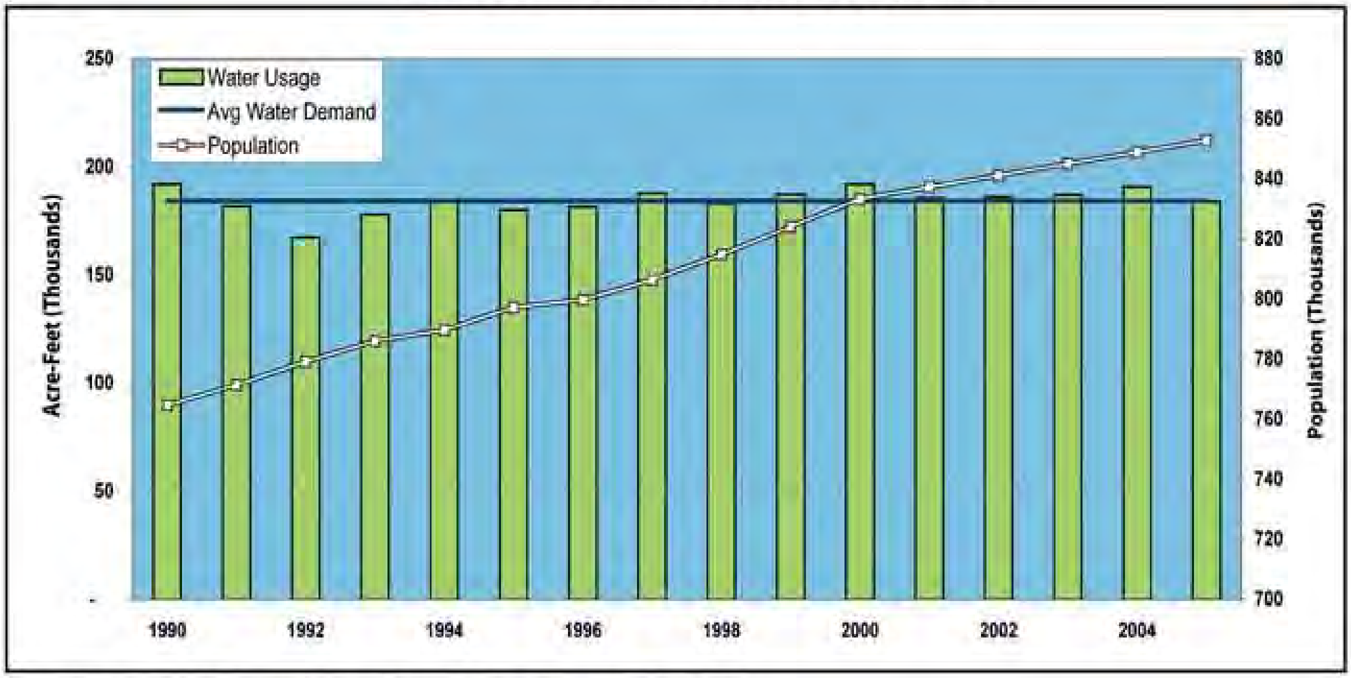
District Water Demands	2005[1]	2010	2015	2020	2025	2030
Retail Municipal & Industrial Use						
Groundwater[2]	41,535	52,000	52,000	52,000	52,000	52,000
Imported Water	129,316	123,000	97,319	98,665	100,140	101,747
Recycled Water[3]	13,065	21,848	32,500	36,250	40,000	43,750
Ocean Desalination	0	0	20,000	20,000	20,000	20,000
Total Retail Demand	**183,916**	**196,848**	**201,819**	**206,915**	**212,140**	**217,497**
Replenishment Use						
Imported Water	15,000	10,000	10,000	10,000	10,000	10,000
Recycled Water	7,500	17,500	17,500	17,500	17,500	17,500
Total Replenishment Demand	**22,500**	**27,500**	**27,500**	**27,500**	**27,500**	**27,500**
Total Demand	**206,416**	**224,348**	**229,319**	**234,415**	**239,640**	**244,997**

(1) The 2005 demands are based on the FY 2004-05, which was recorded as one of the "wettest" years on record.
(2) Groundwater demands include the amount of groundwater pumped from the West Coast and Central (avg. 2,000 AFY) groundwater basins to satisfy groundwater demands within West Basin's service area
(3) Includes M&I recycled water sales from West Basin's service area; it does not include recycled sales to Los Angeles Department of Water and Power and the City of Torrance or Replenishment sales (Barrier).

4 Impacts of Conservation and Education: Reduced Demand

Although not a traditional "wet" water supply like imported water or recycled water, water use efficiency, including conservation and education, is considered part of West Basin's water supply portfolio because it results in less retail need, or demand, for wet supplies than would otherwise be the case. Perhaps the most telling picture of the impact of conservation and education on retail demand is conveyed by Figure ES-1.

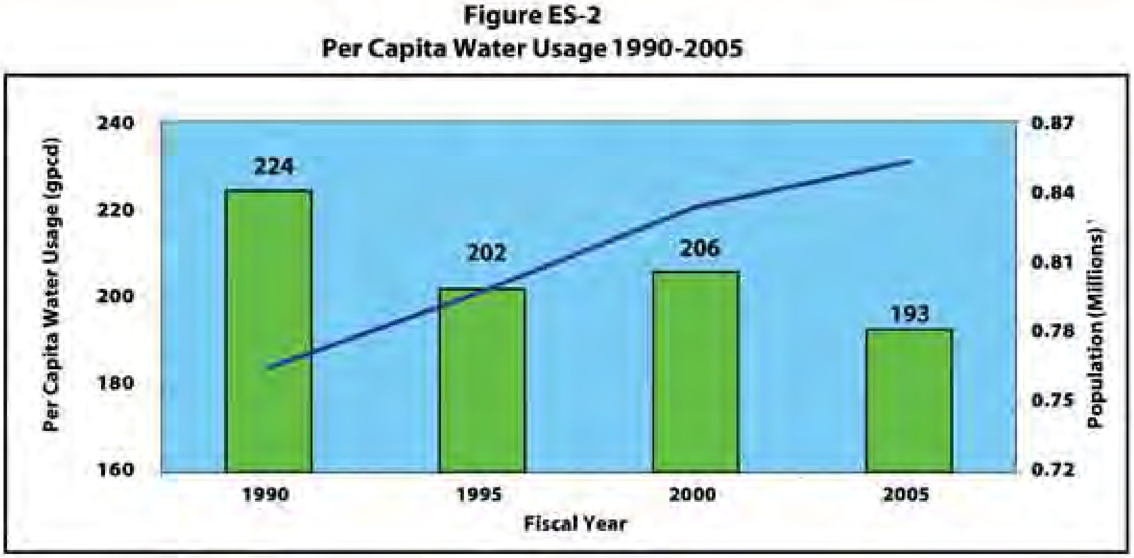
Figure ES-1
Historical Retail Demand Compared to Population



Source: Information based on WBMWD Water Use database and MWD Demographic Data, 2005.

Retail water use within West Basin's service area is largely the same today as it was 15 years ago despite the addition of more than 100,000 people. The average retail demand for the past 15 years is approximately 184,000 AFY. Clearly, residents are now using less water on an individual, or "per capita," basis, as shown in Figure ES-2, than in the past 15 years.

It is apparent that the trend of lower per capita water usage through time, with assistance from MWD and its member agencies, has been successful in continuing a water conservation ethic begun 15 years ago during the last major drought.



Source: WBMWD Water Use database.
[1] Information based on MWD Demographic Data, 2005.

5 Water Supply

West Basin currently relies on approximately 150,000 AFY of imported water from the State Water Project (SWP) and the Colorado River delivered through MWD to meet the District's retail and replenishment demands. While groundwater supplies remain a significant source of water (20%) for customer agencies in the West Basin service area, imported water supplements this resource (65%) and assists to mitigate the over-pumping of the groundwater basin. Recycled water is added to the supply mix, serving up to 7% of the area's demands, while conservation rounds out the equation at 7%.

Table ES-2 shows current (2005) and projected (2030) supplies within West Basin's service area, with imported and local supplies being provided by West Basin.

Table ES-2
Current and Projected Water Supplies
(In Acre-Feet)

District Water Supplies	2005[1]	2030
Groundwater [2]	41,535	52,000
Imported Water [3]	129,315	101,747
Recycled Water [4]	13,065	43,750
Ocean Desalination	-	20,000
Total	**183,916**	**217,497**
Conservation [5]	14,500	42,800
Total	**198,416**	**260,297**

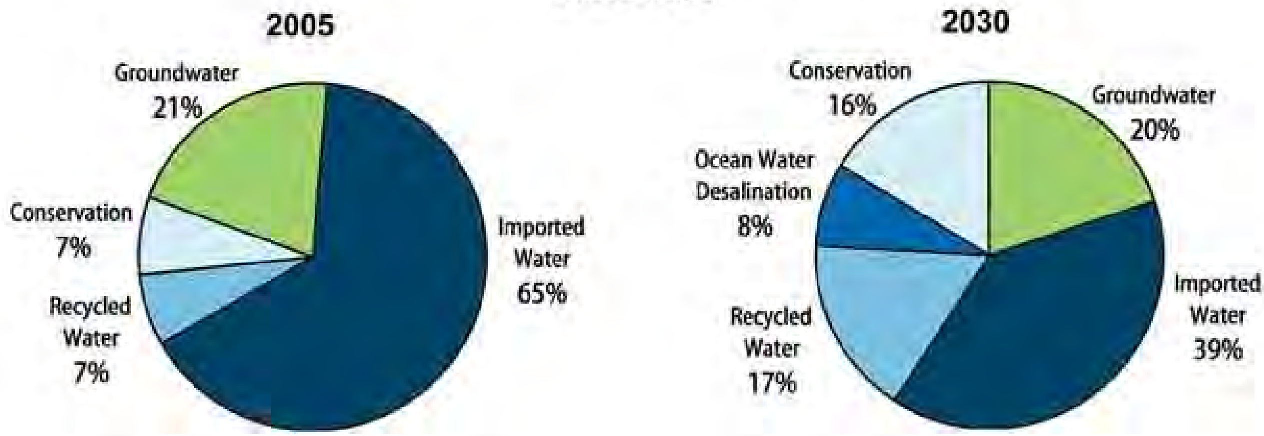
[1] 2005 demands are based on the 2004-05 year, which is also considered one of the "wettest" years on record.
[2] Groundwater production within West Basin Service area only, including imported groundwater production from California American Water Co.
[3] Imported retail uses only; does not include replenishment deliveries i.e. Barriers
[4] Recycled M&I use only; does not include projected deliveries of 17,500 AF to the Barriers
[5] Conservation consists of Active and Passive savings according to the District's projected estimates

6 Planning for Increased Diversification

Given the critical importance of water to the region's growth, economic health and quality of life, the desirable quantity and mix of supply must be planned well in advance of the actual need. Implementing water projects and changing behavior and attitudes regarding water usage are lengthy and complex endeavors. While the UWMP Act requires a 20-year planning horizon for water reliability, West Basin has used a 25-year planning horizon to ensure a minimum 20-year planning period each year until the next 5-year update of the District's UWMP.

Although implementation of supply targets is challenging, West Basin's plan is relatively simple: continue to reduce the risk of future shortage by distributing the responsibility for supply among several, well-balanced options. West Basin's projected supply portfolio for 2030, as compared to the current mix, is shown in the following figure.

Figure ES-3
Comparison of Water Supply Portfolio
2005 vs. 2030



West Basin's diversification plan includes expansion of the District's water recycling system, increased conservation efforts and groundwater storage opportunities. The District's dependence on imported water will continue to decrease with the expansion of these alternative resources. During the next 25 years, conservation is expected to have a significant dampening effect on retail water demand, lowering projected water use by roughly 42,800 AF in 2030.

West Basin's ambitious 2030 target for conservation will be directed by a Conservation Master Plan (scheduled for completion in 2006) that will identify the programs, strategies and actions that will guide policy development and commitment of resources in the future.

West Basin's increase in recycled water supply to 17% by 2030 will nearly triple recycled water use. Treatment expansions as well as distribution system extensions will provide more recycled water to meet growing demands.

Across Southern California, alternative water supplies are being explored, studied and, in some cases, implemented to enhance the area's water supply reliability. In addition to recycled water, alternative water supply projects include seawater barrier water projects, conjunctive use groundwater storage, water transfers and exchanges, and ocean and groundwater desalination. West Basin supports the ongoing efforts of all these programs.

7 Water Supply Reliability

During consecutive dry years, Southern California has historically seen demands increase by as much as 20% while supplies have decreased. Prior to recent significant improvements in water reliability, most cities and agencies were forced to mandate conservation efforts and restrict water use in some cases to maintain an adequate supply. Enormous strides made by MWD, West Basin and the entire water supply community in Southern California to increase locally-developed supplies and conservation as well as imported water storage and transfers during the past decade have increased the overall supply reliability during extended dry periods.

MWD's 2005 Regional UWMP demonstrates reliability of supply in all hydrologic conditions through the year 2030. In fact, their plan shows a surplus of supply in nearly all conditions. MWD planning initiatives to ensure water supply reliability include the IRP, the Water Surplus and Drought Management Plan (WSDM Plan) and local resource investments. These initiatives provide a framework for MWD and its member agencies to manage their water resources to meet growing demands.

Through its investments into supply diversification, support of the region's IRP and the collaborative efforts with MWD, West Basin's projections show that supplies will adequately meet service area demands in normal, single dry and multiple dry-year scenarios.

8 Water Quality

Water quality regulations are an important factor in West Basin's water management activities. Imported water quality is the responsibility of MWD to comply with State and Federal drinking water regulations. Purveyors which West Basin sells imported water are responsible for ensuring compliance in their individual distribution systems and at the customer tap. MWD maintains a rigorous water quality monitoring program and is also proactive in protecting its water quality interests in the SWP and the Colorado River. Imported water meets or exceeds all drinking water standards set by the California Department of Health Services.

Water quality of the West Coast Groundwater Basin is continually monitored by both West Basin and the Water Replenishment District. Challenges to water quality include potential contamination from seawater intrusion and the migration of shallow contamination into deeper aquifers. WRD and West Basin have several active programs to monitor, evaluate and mitigate water quality issues.

West Basin actively assists its retail agencies in meeting drinking water standards through its Cooperative Basin-Wide Title 22 Groundwater Quality Monitoring Program. West Basin offers this program to water agencies for wellhead and reservoir sample collection, water quality testing and reporting services.

Although recycled water meets Title 22 standards through tertiary treatment, West Basin's Water Recycling Facility produces five different types of water quality for various end users. The five types of recycled water include: 1) Disinfected Tertiary Water, 2) Nitrified Water, 3) Softened Reverse Osmosis Water, 4) Pure Reverse Osmosis and 5) Ultra-Pure Reverse Osmosis Water. Approximately 2,000 tests are performed monthly at the West Basin Water Recycling Facility to ensure water quality meets or exceed all State and Federal requirements.

9 Water Conservation

Since the drought of the 1990s, West Basin has been a leader in implementing aggressive water conservation programs to help limit water demand in its service area. District programs have included a strong emphasis on education and the distribution of rebate incentives and plumbing retrofit hardware. The active and passive conservation programs have resulted in significant reductions in water use. By current estimates, demand management conservation saves more than 4.5 billion gallons of imported water every year. This represents the average water use of almost 30,000 families of four in Southern California.

West Basin water conservation programs follow the recommended 14 Best Management Practices (BMPs) according to the California Urban Water Conservation Council. For fiscal year 2005-06, West Basin will complete a Conservation Master Plan that will guide the District to meet or exceed the goals of the BMPs and MWD's Conservation Strategy Plan. The plan will assess the conservation potential and incorporate local stakeholder input into a group of actions and strategies for achieving long-term targets for conservation.

10 Water Rates and Charges

In 2002, MWD adopted a new rate structure to support its strategic planning vision as a regional provider of services, incentivize the development of local supplies such as recycled water and conservation and encourage long-term planning for imported water demand. To achieve these objectives, MWD called for voluntary purchase orders from its member agencies, unbundled its water rates, established a tiered supply rate system and added a capacity charge. In all, these new rate structure components have provided a better opportunity for MWD and its member agencies to manage their water supplies.

MWD's 2002 rate structure changes were passed through to West Basin's customer agencies in a manner that preserved the water management benefits while minimizing financial impacts. With the purchase order and tiered supply rate elements, West Basin has successfully implemented a conservation-based structure that encourages agencies to stay within their annual water budget and uses revenue from agencies that exceed their water budget to fund service-area wide conservation studies and programs. West Basin also assesses a capacity charge at the retail level designed to recover the cost of MWD's capacity charge and a Readiness-to-Serve charge. In addition to the pass-through elements of MWD's rate structure, West Basin's rates include a volumetric administrative surcharge and a fixed water service charge.

Since 1995, West Basin has encouraged the maximum use of recycled water through the economic incentive of its rates and charges. West Basin commodity rates cover the operation, maintenance, labor and power costs associated with the delivery of recycled water. These rates are set up in a declining tiered structure and are wholesaled at a significant reduction to imported water so they may further encourage the use of recycled water.

11 Recycled Water

West Basin's Water Recycling Facility

Recycled water is one of the cornerstones of West Basin's efforts to augment local supplies and reduce dependence on imported water. Since the initial planning and construction of West Basin's water recycling system in the early 1990s, West Basin has become a leader in producing and marketing recycled water. This new supply of water assists in meeting the demand for non-potable applications such as landscape irrigation, commercial and industrial processes, and indirect potable such as the seawater intrusion barriers. With approximately 210 site connections, West Basin has delivered approximately 210,000 AF of recycled water during the past 10 years. During the past five years, West Basin has delivered an average 25,000 AFY to its irrigation, industrial and groundwater replenishment customers.

Although not within its service area, West Basin sells recycled water to the City of Torrance and Los Angeles Department of Water and Power. West Basin purchases secondary treated water from the City of Los Angeles' Hyperion Treatment Plant. The treated wastewater is further treated at West Basin's Water Recycling Facility, located in El Segundo, California.

West Basin anticipates recycled water use sales to increase in the future as more customers switch from potable water to recycled water due to the reliability of the supply and the economic incentives associated with the conversion. West Basin is also performing a number of expansion projects such as the Harbor/South Bay Water Recycling Project, the West Basin Water Recycling Facility Phase IV Expansion and the Madrona/Palos Verdes Lateral Extension. These three projects will increase recycled water use significantly in the coming years. Table ES-3 summarizes the current and projected demands for recycled water.

Table ES-3
Projected Recycled Water Deliveries by West Basin
(In Acre-Feet)

West Basin Water Recycling System	2005[1]	2010	2015	2020	2025	2030
Industrial & Irrigation	13,065	21,848	32,500	36,250	40,000	43,750
West Coast Barrier (Replenishment)	3,800	17,500	17,500	17,500	17,500	17,500
West Basin's Service Area Total	**16,865**	**39,348**	**50,000**	**53,750**	**57,500**	**61,250**
City Torrance	6,921	6,650	6,650	6,650	6,650	6,650
City of Los Angeles	283	1,400	1,400	1,400	1,400	1,400
Outside West Basin's Service Area Total	**7,205**	**8,050**	**8,050**	**8,050**	**8,050**	**8,050**
Total	**24,070**	**47,398**	**58,050**	**61,800**	**65,550**	**69,300**

(1) Based on West Basin MWD's actual sales for FY 2004-05

12 Ocean Water Desalination

Another important element of West Basin's supply diversification strategy is the cost-effective development of ocean desalination. Within MWD's Integrated Resources Plan, West Basin has committed to producing 20,000 AFY of potable water from the ocean beginning in 2011. West Basin is following an incremental approach to that production target, including research, pilot testing, a demonstration facility and ultimately a full-scale plant.

Since 2001, West Basin has been a leader in creating funding partnerships for research related to the application of technologies it currently uses successfully in the desalination of wastewater to produce high-purity recycled water, namely microfiltration and reverse osmosis. West Basin has successfully operated a pilot scale test facility in El Segundo using microfiltration and reverse osmosis to produce 40 gallons per minute of drinking water. These processes have demonstrated tremendous water quality and operational performance since the commissioning of the pilot project.

Recently, West Basin was awarded $1,750,000 in state grants to assist in the research and construction of the next step in its desalination program: a 500,000 gallons per day demonstration project.

Section 1

Introduction

Introduction

1.1 Purpose and UWMP Summary

An Urban Water Management Plan (UWMP or Plan) prepared by a water purveyor is to ensure the appropriate level of reliability of water service sufficient to meet the needs of its various categories of customers during normal, single dry or multiple dry years. The California Water Management Planning Act of 1983 (Act), as amended, requires urban water suppliers to develop an UWMP every five years in the years ending in zero and five.

The legislature declared that waters of the state are a limited and renewable resource subject to ever-increasing demands, that the conservation and efficient use of urban water supplies are of statewide concern, that successful implementation of plans is best accomplished at the local level, that conservation and efficient use of water shall be actively pursued to protect both the people of the state and their water resources, that conservation and efficient use of urban water supplies shall be a guiding criterion in public decisions and that urban water suppliers shall be required to develop water management plans to achieve conservation and efficient use.

West Basin Municipal Water District's (District) 2005 UWMP has been prepared in compliance with the requirements of the Act, as amended to 2005[1] (Appendix A), and includes the following:

- Water Wholesale Service Area
- Water Demands
- Water Sources and Supplies
- Water Reliability Planning
- Water Quality Information
- Water Demand Management Measures
- Water Shortage Contingency Plan
- Water Recycling
- Ocean Water Desalination

1.2 Urban Water Management Plan Update Preparation

The District's 2005 UWMP revises the 2000 UWMP prepared by the District and incorporates changes enacted by legislation, including SB 610 (2001), AB 901 (2001), SB 672 (2001), SB 1348 (2002), SB 1384 (2002), SB 1518 (2002), AB 105 (2004) and SB 318 (2004). The UWMP also incorporates water use efficiency efforts the District has implemented or is considering implementing pursuant to the *Memorandum of Understanding Regarding Urban Water Conservation in California* (MOU).[2] The District was one of the first agencies to become signatory to the MOU in September 1991.

[1] California Water Code, Division 6, Part 2.6, §10610, et. seq. Established by Assembly Bill 797 (1983).
[2] The *Memorandum of Understanding Regarding Urban Water Conservation in California* (MOU) was adopted in September 1991 by a large number of water suppliers, public advocacy organizations and other interested groups. It created the *California Urban Water Conservation Council* and established 16 Best Management Practices (BMPs) for urban water conservation, recently refined to 14 BMPs. The District became signatory to the MOU in September 1991.

The sections in this Plan correspond to the outline of the Act, specifically Article 2, Contents of Plans, Sections 10631, 10632, and 10633. The sequence used for the required information, however, differs slightly in order to present information in a manner reflecting the unique characteristics of the District. The Department of Water Resources Review for Completeness form has been completed, which identifies the location of Act requirements in this Plan and is included as Appendix B.

1.2.1 Plan Adoption

The 2005 UWMP was adopted by a resolution of the District's Board of Directors in December 2005, following a public hearing. The Plan was submitted to the California Department of Water Resources within 30 days of Board approval. Copies of the Notice of Public Hearing and the Resolution of Plan Adoption are included in Appendix C. Copies of the Plan were made available to the public within 30 days following Board approval.

1.2.2 Agency Coordination

A Notice of Preparation for the 2005 UWMP Update was prepared and sent to Metropolitan Water District of Southern California (MWD), the County of Los Angeles and all of the District's various cities and customer agencies, as shown in Table 1-1. The Notice of Preparation is included in Appendix D.

Table 1-1
Coordination with Appropriate Agencies

		Participated in UWMP Development	Commented on the Draft	Attended Public Meetings	Provided Assistance	Received Copy of Draft	Sent notice of intention to adopt
Retail Water Agencies	Metropolitan Water District of Southern California	✓	✓		✓	✓	
Customer Agencies	California American Water Company			✓	✓	✓	
	California Water Service Company	✓		✓	✓	✓	
	City of El Segundo		✓	✓	✓	✓	
	City of Inglewood			✓	✓	✓	
	City of Lomita	✓	✓	✓	✓	✓	
	City of Manhattan Beach		✓	✓	✓	✓	
	Southern California Water Company	✓	✓	✓	✓	✓	
	LA County Waterworks District 29	✓	✓	✓	✓	✓	
	Water Replenishment District	✓	✓		✓	✓	

Development of this Plan was performed by District staff in coordination with its water purveyors and MWD. District staff has met with many of its customer agencies to discuss the UWMP, answer questions related to the UWMP and/or projects occurring throughout the service area, and provide assistance when requested. Staff provided many of its agencies with conservation data that they were able to use in their conservation section of the UWMP.

The District is a water wholesaler and is fully dependent on MWD for its imported water supplies to its service area. This UWMP details the specifics as they relate to the District and it service area and will refer to MWD throughout the document. The District held two UWMP workshops, one in January 2005 for the public, in coordination with MWD and the California Urban Water Conservation Council, and the other in June 2005 for the District's water purveyors. Further, MWD held multiple UWMP information meetings for stakeholders and the public throughout its service area during the months of June and July 2005. On August 24, 2005, MWD held an additional Public Information Meeting at the Southern California Water Dialogue monthly forum. The Southern California Water Dialogue participants meet voluntarily to explore water-related issues of vital interest to the Southern California region.

The UWMP is intended to serve as a general, flexible and open-ended document that periodically can be updated to reflect changes in the region's water supply trends, as well as conservation and water use efficiency policies. This Plan, along with the District's other planning documents, will be used by District staff to guide the service area's water use and management efforts through the year 2010, when the UWMP is required to be updated.

1.3 The District's Service Area

1.3.1 Background

The District was established by a vote of the people in 1947 to help mitigate the overpumping in the West Coast Groundwater Basin (Basin). West Basin's founders realized they would have to curtail the use of pumping by providing the region with imported water. As a water supplier, MWD provides the Southern California region with a reliable supply of imported water. West Basin remains one of the largest member agencies in MWD's family of wholesalers.

Today, West Basin wholesales potable water to 17 cities, mutual water companies, investor-owned utilities, water districts and private companies in the region. In addition, the District supplies recycled water to the region for municipal, commercial and industrial use. West Basin supplies imported and recycled water to its customer agencies to help reduce their reliance on groundwater supplies.

West Basin is governed by a five member elected Board of Directors from within the service area of the District. Each Director serves a four-year term once elected. The Board of Directors guides the mission and policy of the District.

Also, West Basin's Board of Directors appoints two representatives to serve on the 37-member MWD Board of Directors. West Basin's representation on the MWD Board is critical to shaping a regional voice on water issues.

1.3.2 District's Service Area

West Basin's service area covers approximately 185-square miles and includes 17 cities and several unincorporated areas in Los Angeles County. Approximately 852,800 people are served within West Basin's service area. The cities and their associated divisions include:

Division 1:
Palos Verdes Estates, Rancho Palos Verdes, Rolling Hills, Rolling Hills Estates and Portions of Carson

Division 2:
Inglewood, South Ladera Heights, a portion of Lennox and unincorporated areas of Athens, Howard, & Ross-Sexton

Division 3:
Hermosa Beach, Lomita, Manhattan Beach, Redondo Beach and unincorporated areas of Torrance

Division 4:
Culver City, El Segundo, Malibu, West Hollywood, North Ladera Heights, Del Aire, Topanga, View Park, Windsor Hills and a portion of Lennox

Division 5:
Gardena, Hawthorne, Lawndale and unincorporated portions of El Camino Village

1.3.3 Relationship to Metropolitan Water District

West Basin became a member agency of MWD in 1947. West Basin joined MWD to purchase, on a wholesale level, potable water imported from the Colorado River and the State Water Project and then sell it to the local municipalities, investor-owned and districts. The imported water is provided to supplement existing groundwater supplies in all areas of West Basin (there are some utilities within the District service that do not receive MWD water directly but receive their drinking water through groundwater wells).

The District plays an important role in managing the imported supplies for the region. Through various programs and projects, the District ensures that its residents have a safe and reliable supply of water.

Figure 1-1 shows the supply chain, which illustrates the relationship the District plays to its customer agencies. The District is the voice and representative of its customers to MWD. As such, the District takes great pride in knowing that its retailers are receiving a safe and reliable supply of drinking water.

Figure 1-1 Imported Water Supply Chain

Section 2

Water Demands

Water Demand

2.1 Overview

Today, the total retail water demand for the 852,800 people living within West Basin's service area is approximately 183,900 acre-feet (AF) with replenishment demands adding an additional 15,200 AF. One acre-foot equals 326,000 gallons and serves the annual water needs of two families. In 1980, West Basin's population was 707,500 people and the service area's retail water demand was 162,653 AF with replenishment demands adding an additional 43,131 AF. In those 25 years, West Basin's retail water demand has grown 13.1%, while population has grown 21%. Some of the contributing factors to this growth in demand have been population, new development, land use, economic growth and persons-per-household ratios.

In the last five years West Basin's water demand has increased by only 0.4% while population has increased by more than 2%. This gradual increase in water usage is attributed to West Basin's efforts in education and promotion of water conservation as well as incentives for people to retrofit their homes and businesses with more efficient water use devices.

Despite the flattening demand trend due to conservation, water use will continue to increase. Projections show that West Basin's water usage is expected to increase roughly 0.4% per year during the next 25 years, as illustrated later in Table 2-5.

This section will explore in greater detail West Basin's population trends and historical and current water demands as well as offer some insight into expected future water demands for the next 25 years.

2.2 Climate Characteristics

West Basin's service area lies in the heart of Southern California's coastal plain. The climate is Mediterranean, characterized by typically warm, dry summers and wet, cool winters with an average precipitation level of approximately 14.9 inches per year.[1] The combination of mild climate and low rainfall makes the area a popular residential destination, which creates challenges for water agencies to provide for increased water demands with a tight water supply.

Areas with low precipitation, such as Southern California, are typically vulnerable to droughts. Historically, West Basin has been plagued with some severe dry years (Droughts of 1977-78 and 1989-92), and recently the Los Angeles region had the driest five years on record (1999-2004). In fact, anything less than the average yearly rainfall causes concern for water agencies.

[1] According to the National Weather Service

Table 2-1 illustrates the climate characteristics for the Los Angeles region, taken at both the Long Beach Station and the Los Angeles WSO Airport Station, for the period between 1944 and 2004 (60 years) including standard monthly average ETo[1] (Long Beach Station), average rainfall (Los Angeles WSO Airport Station) and average temperature (Los Angeles WSO Airport Station). In comparison to other cities with an abundant supply of precipitation each year, the low rainfall in this region invariably challenges West Basin to provide sufficient, reliable, quality water to meet the area's increasing water needs. The average precipitation for the last 60 years is approximately 12.13 inches, indicating the need for water conservation in an area with a water demand that will continue to grow as urban infiltration continues to rise.

Table 2-1
West Basin
Climate Characteristics- Los Angeles Region
Period 8/1/1944 to 12/31/2004

	Jan	Feb	Mar	Apr	May	June
Standard Monthly Average Eto	1.65	2.15	3.59	4.77	5.12	5.71
Average Rainfall (inches)	2.67	2.69	1.94	0.78	0.17	0.06
Average Temperature (Fahrenheit)	65	65.4	65.3	67.5	69.2	72

Climate (continued)

	July	Aug	Sept	Oct	Nov	Dec	Annual
Standard Monthly Average Eto	5.93	5.91	4.39	3.22	2.18	1.68	**46.3**
Average Rainfall (inches)	0.02	0.08	0.16	0.35	1.48	1.75	**12.13**
Average Temperature (Fahrenheit)	75.2	76.4	76.2	73.6	70.2	66.1	**70.2**

[1]Data taken from the California Irrigation Management Information System (CIMIS) at the Long Beach Station for the Los Angeles Region for Calendar Year 2004: http://www.cimis.water.ca.gov/cimis/welcome.jsp.
[2] Data taken from the Western Regional Climate Center's web site at the Los Angeles WSO Airport Station: http:wrcc.dri.edu/cgi-bin/cliMAIN.pl?calosa.

2.3 Demographics

West Basin's service area encompasses 185 squares miles in southwest Los Angeles County, including 17 cities, water agencies and several unincorporated areas. With the population in West Basin's service area expected to increase by 83,300 people by the year 2020, the demand on the limited existing water supplies will also increase.

Based on the Metropolitan Water District of Southern California's (MWD) demographic projections, population is expected to increase an average of roughly 3.1% every five years for the next 25 years, or 0.6% annually. Table 2-2 displays the demographic projections for the next 25 years.

[1] Evapotranspiration is the water lost to the atmosphere by two processes-evaporation and transpiration. Evaporation is the loss from open bodies of water, such as lakes and reservoirs, wetlands, bare soil and snow cover; transpiration is the loss from living-plant surfaces.

Table 2-2
Demographic Projections for West Basin's Service Area

Year	2005	2010	2015	2020	2025	2030
Population	**852,800**	**876,400**	**906,500**	**936,100**	**964,600**	**991,900**
Single-family	168,300	173,900	175,800	181,600	186,900	189,700
Multi-family	123,200	128,900	138,300	143,900	149,900	158,500
Total Household	**291,500**	**302,800**	**314,100**	**325,400**	**336,800**	**348,100**
Persons per Household	2.89	2.86	2.86	2.85	2.84	2.82
Employment	455,800	514,500	530,000	544,000	556,500	586,200

Source: Information based on MWD Demographic Data, 2005.
Note: All units are rounded to the nearest hundred; totals may not sum exactly due to rounding

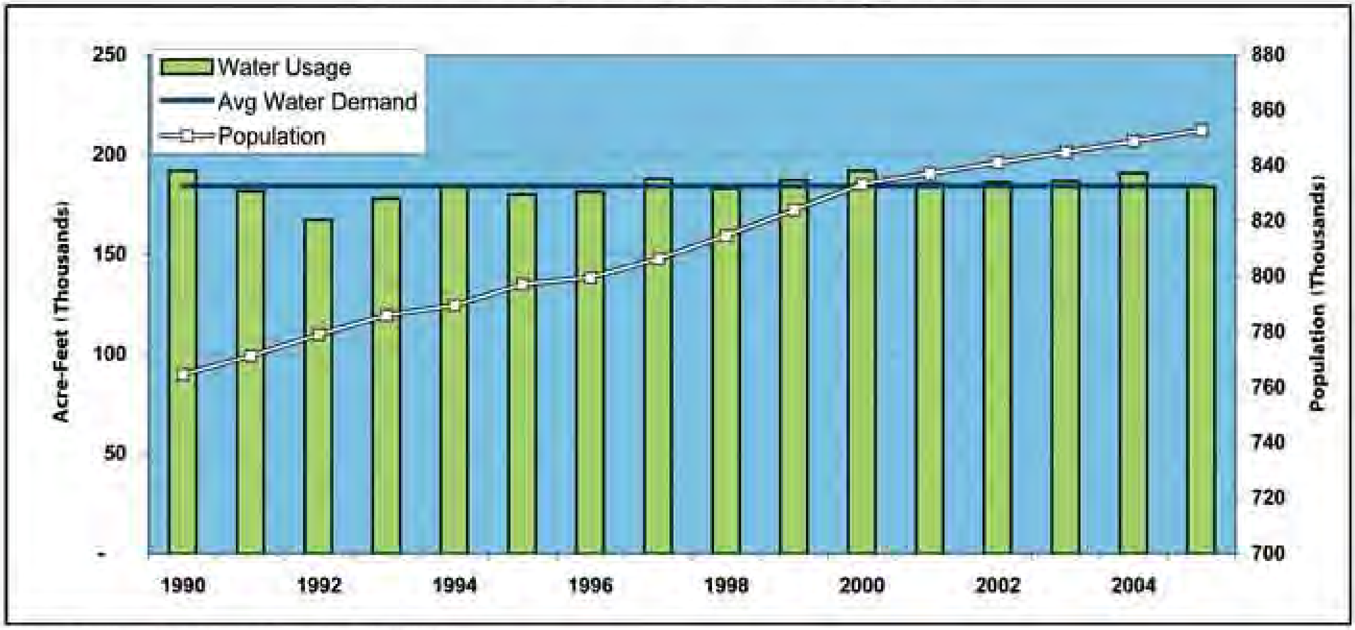
Table 2-2 displays West Basin's total households, which are expected to increase 20% by 2030, especially in the Multi-family category where households will increase by 35,300 people. As it relates to water demand, the availability of more households increases the demand on water supplies. As for employment, West Basin is expected to see a 29% increase by 2030. As urban employment grows, so does the demand on water supplies.

2.4 Historical and Current Water Demands

The key factors that affect water demands are growth in population, increases in land use development, industrial growth and hydrology. However, since the end of the 1989-1992 drought, retail water demands in West Basin's service area have remained fairly consistent. As illustrated in Figure 2-1 (on the following page), the West Basin region has not seen significant increases in water demands during the past 15 years despite population growth at an average rate of 3,875 persons per year and continued in-fill development in the service area. West Basin's FY 2004-05 retail water demand was 183,916 AF.

Total water use, or demand, within West Basin's service area includes retail demand and groundwater replenishment. Retail demand is defined as all municipal (residential, firefighting, parks, etc.) and industrial uses, and represents the population's total direct water consumption. Replenishment uses, including deliveries to the saline barriers (West Coast and Dominguez Gap Barriers), are not directly delivered to the public but enable continued groundwater production and helps to satisfy retail demand.

Figure 2-1
West Basin
Historical Total Retail Water Demand vs. Population



Source: Information based on MWD Demographic Data, 2005.
Note: The totals do not include Replenishment Sales i.e.Barrier Sales RW & Imported

Figure 2-1 displays West Basin's total retail water demand from FY 1990 to 2005. As previously discussed, retail demands have remained very consistent since 1994 following several years of increasing demands after the drought. The average retail water demand for the past 15 years is 184,295 AF.

The District averaged 187,554 AF for the past five years, which is only 1.8% above the 15 year average.

West Basin's service area is using an average amount of water as it has since 1990. This indicates that water conservation and education has significantly affected the manner in which West Basin's residents are using water today. This can be verified by reviewing West Basin's water usage per person in the "Historical Per Capita Water Usage" Section, which follows.

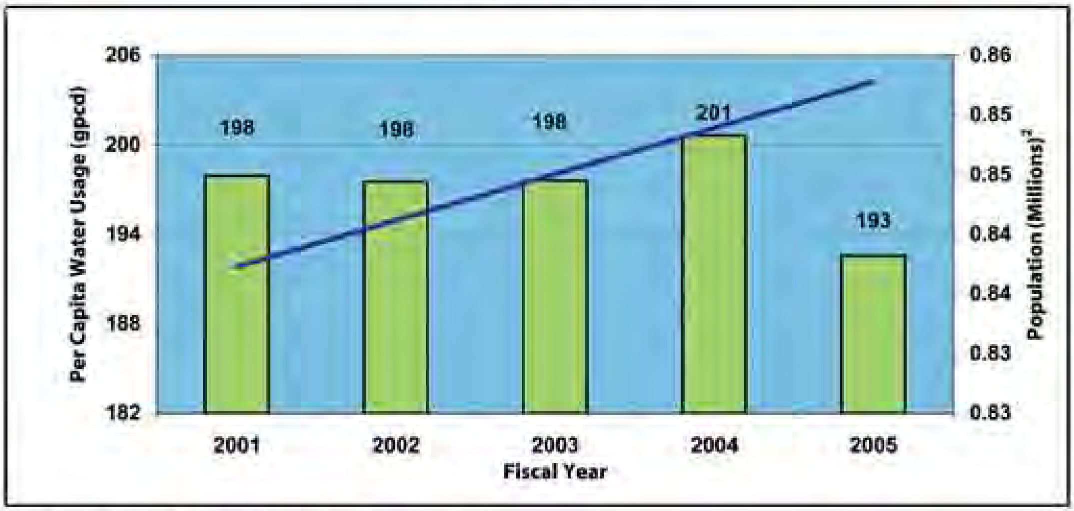
2.4.1 Historical Per Capita Water Usage

According to the Pacific Institute, the State's total water usage is equivalent to 183 gallons per capita per day (gpcd) for the nearly 34 million people living in California.[3] Through conservation measures such as Ultra-Low-Flush Toilets (ULFT), High-Efficiency Clothes Washers, low-flow showerheads and new technologies in water irrigation and education programs, West Basin has gradually reduced per capita water usage.

[3] Pacific Institute, *Waste Not, Want Not: The Potential for Urban Water Conservation in California*, 2003. pg. 4

For the last five years the usage has decreased to an average of 199 gpd. Figure 2-2 illustrates the retail water usage per capita for the last five fiscal years comparative to population in West Basin's service area.

Figure 2-2
Historical Per Capita Retail Water Usage [1]



[1] Information based on MWD Demographic Data, 2005
[2] M&I Water Usage from West Basin MWD Water Use Data

As displayed above, population has been steadily increasing from Fiscal Year 2001 - 2005 while per capita water usage remained stable at around 199 gpcd, verifying the positive impact of the District's current water resource conservation efforts.

2.4.2 Replenishment Demands

Replenishment water is defined as water that is used to refill or protect the groundwater basin. The Water Replenishment District of Southern California (WRD) is the entity responsible for maintaining and replenishing the West Coast and Central Groundwater Basins. WRD is a special district created by the State and governed by a five-member elected body to protect and replenishment these groundwater basins with imported water, storm water and recycled water. Within the West Coast (Central Basin only) Groundwater Basin (WCGB), WRD's responsibility is to protect the basin by injecting treated water at the West Coast and Dominguez Gap Barriers along the western South Bay Region.

Water Replenishment District of Southern California

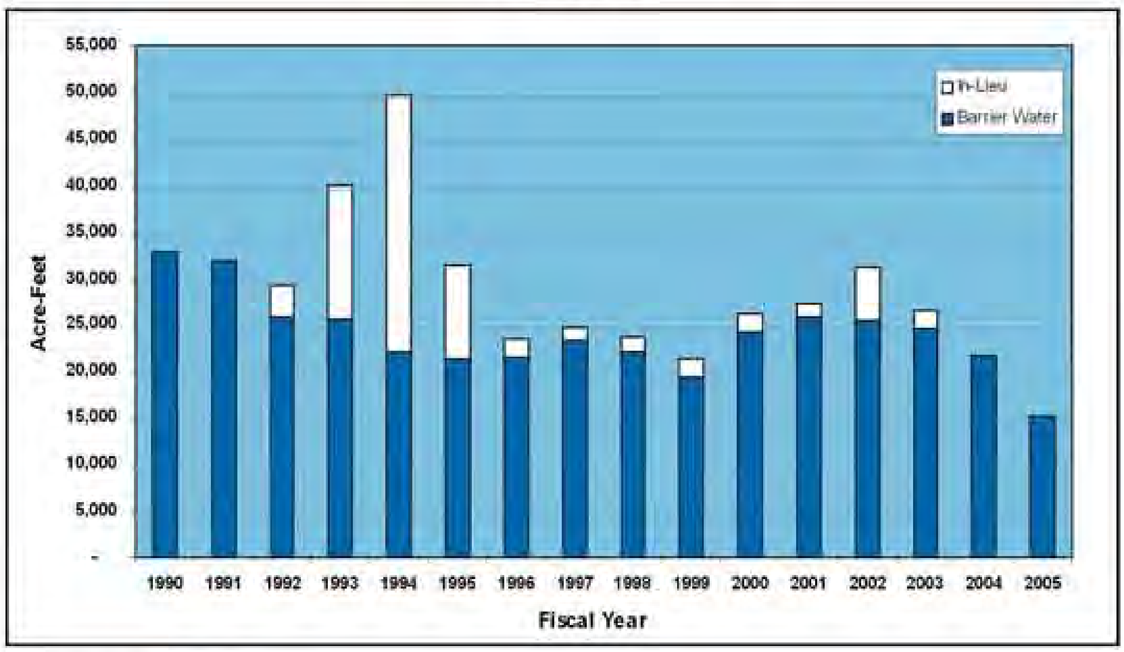
Courtesy of WRD

Barrier Demands

As groundwater is extracted annually beyond the natural level of replenishment, seawater begins to intrude into the basin along the coast. The current method in preventing seawater from contaminating the groundwater basin is to create a hydrologic barrier. The Los Angeles County Department of Public Works (LACDPW) maintains two barriers where imported and recycled water is injected on a consistent basis to protect the groundwater basins.

As the wholesaler, West Basin sells treated imported and recycled water to WRD to inject into the saltwater barriers. WRD's purchases average a total of 17,000 AFY of imported water and 5,000 AFY of recycled water from West Basin. Water demands at the barriers usually do not shift dramatically due to the limited groundwater production each customer is allowed annually. Figure 2-3 displays the total barrier demands within West Basin's service area.

Figure 2-3
Replenishment Demands[1]
in West Basin MWD's Service Area
(In Acre-Feet)



Source: WBMWD Wateruse Database, 2005

[1] Replenishment demands include both in-lieu and barrier deliveries. Barrier deliveries include both imported and recycled water. In-lieu is the practice of curtailing groundwater production and meeting those demands with imported surface water.

2.4.3 Retail Water Demand by Customer Agency

Overall, retail water demands within West Basin's service area have not seen significant increases for the past 15 years. However, individual retail customer agencies have experienced some changes in their retail demand since 1990. Table 2-3 illustrates the changes, either increases or decreases, in each retail customer agencies' average water usage during two different five year periods since 1990.

Table 2-3
Total Water Demand per West Basin Customer Agency
Average (1990-1995) vs. Average (2000-2005)
(In Acre-Feet)

Customer Agency	1990-1995 Average Total Water Use	2000-2005 Average Total Water Use	%Increase/ (Decrease)
California American Water Co.	3,261	3,834	17.6%
Cal Water Service Co.- Dominguez	33,288	35,134	5.5%
Cal Water Service Co.- Hermosa/Redondo	13,704	15,816	15.4%
Cal Water Service Co.- Palos Verde	18,479	21,684	17.3%
Cal Water Service Co.- Hawthorne	4,948	5,020	1.5%
City of El Segundo	17,802	17,296	(2.8%)
City of Inglewood	12,424	12,533	0.9%
City of Lomita	2,491	2,764	11.0%
City of Manhattan Beach	6,279	7,088	12.9%
L.A. County Waterworks District 29	8,036	9,822	22.2%
Southern California Water Co.	36,605	40,002	9.3%
Water Replenishment District	25,310	25,021	(1.1%)
Total	**182,627**	**196,014**	

Source: West basin WMD Water Use Database, 2005.

Although some agencies have seen some dramatic shifts in water demand usage during the past 15 years, the average increase for a West Basin customer agency was 9.1%. Some of the significant changes among customer agencies may be attributed to population growth, increases in industrial customers and/or further land use development.

2.5 Projected Water Demands

One of the objectives of this Plan is to provide some insight into West Basin's expected water demands for the next 25 years. The predictability of water usage is an important element in planning future water supplies. The methodology used to determine demand forecasting is a combination of historical water use analysis, population growth and commercial and residential development. West Basin, with the assistance of MWD's forecasting model known as MWD-MAIN (Municipal and Industrial Needs) Water Use Forecasting System, is able to develop some well formulated water demand projections.

The MWD-MAIN forecasting model determines expected urban water usage for the next 25 years. This model incorporates Census data, industrial growth, employment and regional development from regional planning agencies, such as SCAG (Southern California Association of Governments), to project water demands. It also features demands in sectors such as single family, multi-family, industrial, commercial and institutional usage for the region. MWD also takes into account current and future water management efforts, such as water conservation Best Management Practices (BMPs) and education programs.

Table 2-4 illustrates the current and projected retail water demands to the year 2030 for West Basin under normal demand conditions.

Table 2-4
West Basin's Service Area
Current and Projected M&I Water Demands

District Water Demands	2005[1]	2010	2015	2020	2025	2030
Retail Municipal & Industrial Use						
Groundwater[2]	41,535	52,000	52,000	52,000	52,000	52,000
Imported Water	129,316	123,000	97,319	98,665	100,140	101,747
Recycled Water[3]	13,065	21,848	32,500	36,250	40,000	43,750
Ocean Desalination	0	0	20,000	20,000	20,000	20,000
Total	**183,916**	**196,848**	**201,819**	**206,915**	**212,140**	**217,497**

[1] The 2005 demands are based on the FY 2004-05, which was recorded as one of the "wettest" years on record

[2] Groundwater demands include the amount of groundwater pumped from the West Coast and Central (avg. 2,000 AFY) groundwater basins to satisfy groundwater demands within West Basin's service area.

[3] Includes M&I recycled water sales from West Basin's service area; it does not included recycled sales to Los Angeles Department of Water and Power and the City of Torrance or Replenishment sales (Barrier)

As displayed above, the retail demand in West Basin is expected to grow approximately 0.5% each year. Groundwater will remain consistent, due to the limited amount of extractable pumping rights within the basin, but imported water is expected to decrease with the expansion of water recycling and the development of ocean water desalination meeting the growing demand during the next 25 years.

WATER FACT

"A 10-minute shower uses about 55 gallons of water."

2.5.1 Projected Per Capita Water Usage

As discussed previously, water demand is determined by the water usage per person. The future per capita usage shows how water demand is growing at a modest pace.

Table 2-5
Projected Per Capita Retail Water Usage in West Basin's Service Area

Year	Estimated Population[1]	Retail Water Usage[2] (AF)	Per Capita[3] (GPCD)
2010	876,400	196,848	201
2015	906,500	201,819	199
2020	936,100	206,915	197
2025	964,600	212,140	196
2030	991,900	217,497	196
		Avg.	198

[1] Information based on MWD Demographic Data, 2004.

[2] Retail Water usage includes recycled water but does not include replenishment sales i.e. barrier water.

Table 2-5 shows a gradual decrease in per capita usage at a time when water has become a scarce commodity in a region where population is projected to increase. Although the total retail water usage continues to increase, the amount of water used per person will decline during the next 25 years. Essentially, more people are using less water.

2.5.2 Projected Replenishment Demand

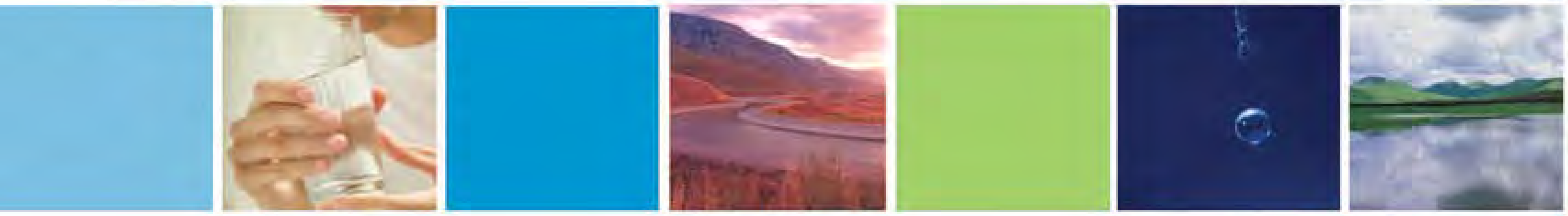
Future replenishment demands are difficult to project because of the variation in operational changes and replenishment needs. WRD expects reduced deliveries of imported water at both of the Barriers, Dominguez Gap and West Coast with increased deliveries of recycled water.

The estimated replenishment demands during the next 25 years under normal conditions are presented in Table 2-6. Although replenishment demands may fluctuate year to year, the overall demand should stay relatively the same because groundwater production is limited according to the allowable pumping rights each groundwater producer is allocated. Furthermore, groundwater production is at or around its maximum amount; therefore, replenishment demands should not significantly increase.

Table 2-6
Projected Replenishment Demands
(In Acre-Feet)

District Water Demands	2010	2015	2020	2025	2030
Replenishment					
Imported Water[1]	10,000	10,000	10,000	10,000	10,000
Recycled Water[2]	17,500	17,500	17,500	17,500	17,500
Total	**27,500**	**27,500**	**27,500**	**27,500**	**27,500**

[1] Imported water demands are based on the Water Replenishment District's projected estimate needs, although they may adjust annually depending upon groundwater production. Imported water demands are for both the West Coast and Dominguez Gap Barriers.
[2] Recycled water deliveries are only at the West Coast Barrier; with a 5,000 AF expansion in 2006. Additional Recycled water deliveries in 2010 are contingent upon a regulatory permit to expand recycled water to 100% at the West Coast Barrier.



Section 3

Water Supply

Water Supply

3.1 Overview

It is West Basin's mission to ensure a safe, adequate and reliable supply of water for the region it serves. However, with a limited supply and growing demand for water, the task of meeting this mission is becoming increasingly challenging.

Seventy years ago the average customer agency in West Basin relied completely on groundwater. Today, however, it relies on a more diverse mix of water resources: 21% groundwater, 65% imported, 7% recycled water (only Municipal & Industrial [M&I]) and 7% conservation efforts. It is projected that by 2030, the resource mix on average will be 20% groundwater, 39% imported, 17% recycled water, 8% ocean water desalination and conservation 16%. Diversification of water supplies has become one of the District's answers to ensuring a reliable supply of water for its service area.

This section provides an overview of the current and future water supplies needed to meet the expected demands of West Basin, including a review of the District's current and projected water supply mix, a description of each water source on which West Basin's customer agencies currently rely and expected future supplies that West Basin is planning and/or developing to meet the demands by year 2030.

3.2 West Basin's Water Supply Portfolio

Since its formation in 1947, West Basin has fulfilled its responsibility of providing its customer agencies with supplemental supplies to ensure reliability. Today, diversification is the key to an ample future supply of water throughout its service area. As illustrated in Figure 3-1 (on the following page), West Basin's supply portfolio has changed through the years.

Similar to creating a balanced investment portfolio to reduce risk, the District plans to further diversify the water resource mix during the next 25 years with the expansion of the District's water recycling system, increased conservation efforts and groundwater storage opportunities. The District's dependence on traditional sources of water (groundwater and imported) will continue to decrease with the expansion of these alternative resources. Figure 3-1 and Table 3-1 show the historical, current and projected water supply portfolio that the District is anticipating meeting by the year 2030.

Figure 3-1
West Basin's Service Area
Projected Water Supplies

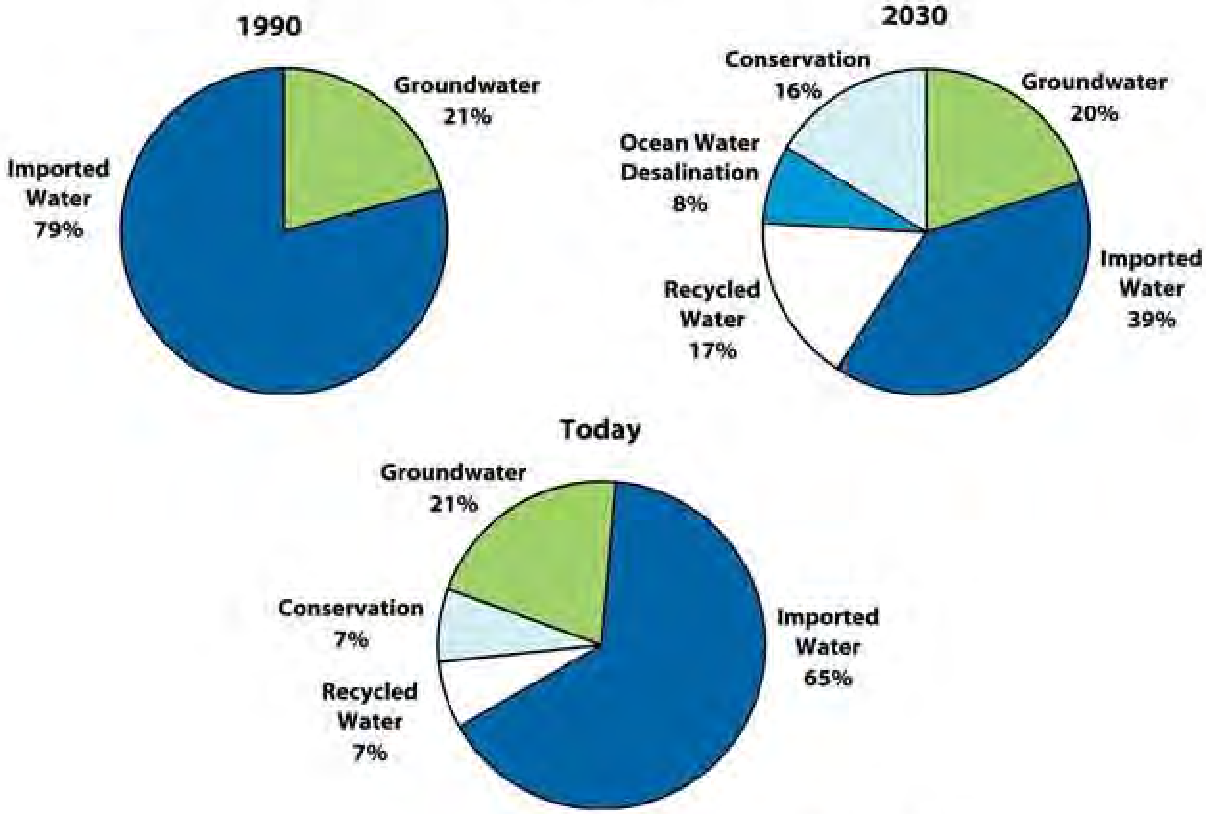


Table 3-1
West Basin
Historical & Projected Retail Water Supplies
(In Acre-Feet)

Type of Water	FY 1990	Today[1]	2030
Groundwater[2]	40,148	41,535	52,000
Imported Water[3]	151,829	129,315	101,747
Recycled Water[4]	-	13,065	43,750
Ocean Desalination[5]	-	-	20,000
Total	**191,977**	**183,916**	**217,497**
Conservation	-	14,500	42,800
Total	**191,977**	**198,416**	**260,297**

[1] Based upon actual FY 2004-05 sales.
[2] Groundwater production within West Basin Service area only, including imported groundwater production from California American Water Company (FY 1990 1,658 AF, FY 04-05 2,228 AFY, and average of 2,000 AFY for 2030).
[3] Imported retail use only; does not include replenishment deliveries i.e. Barrier.
[4] Recycled M&I use only; does not include replenishment deliveries i.e. Barrier.
[5] Conservation consists of Active and Passive savings according to the District's projected estimates.

3.3 West Basin's Water Source

3.3.1 Imported Water Supply

West Basin relies on approximately 150,000 acre-feet per year (AFY) of imported water from the Colorado River and State Water Project to meet the District's retail and replenishment demands. MWD receives this supply from these two major water systems that supplies a majority of the southern California region.[1]

Colorado River

Colorado River

MWD was established to develop a supply from the Colorado River. Its first mission was to construct and operate the Colorado River Aqueduct (CRA), which can deliver roughly 1.2 million acre-feet (MAF) per year. Under its contract with the Federal government, MWD has a basic entitlement of 550,000 AFY of Colorado River water. MWD also holds a priority for an additional 0.662 MAF per year. MWD can obtain water under this priority when the U.S. Secretary of the Interior determines that either one or both of the following exists:

- surplus water; and/or
- water is apportioned to but unused by Arizona and/or Nevada.

MWD and the State of California have acknowledged that they could obtain less water from the Colorado River in the future than they have in the past, but the lack of clearly quantified water rights hindered efforts to promote water management projects. The U.S. Secretary of Interior asserted that California's users of Colorado River water had to limit their use to a total of 4.4 MAF per year, plus any available surplus water. The resulting plan, known as "California's Colorado River Water Use Plan" or the "California Plan," characterizes how California would develop a combination of programs to allow the State to limit its annual use of Colorado River water to 4.4 MAF per year plus any available surplus water. The Quantification Settlement Agreement (QSA) among the California agencies is the critical component of the California Plan. It establishes the baseline water use for each of the agencies and facilitates the transfer of water from agricultural agencies to urban uses.

[1]The Los Angeles Aqueduct, a third aqueduct to Southern California, supplies imported water from the eastern Sierra Nevada region to the City of Los Angeles.

In the context of the QSA, MWD has identified a number of storage and transfer programs that could be used to achieve long-term development targets for a full CRA and it has entered into or is exploring agreements with a number of agencies.

State Water Project

Transport of imported supply

Courtesy of MWD

California's State Water Project (SWP), MWD's second main source of imported water, is the nation's largest state-built water and power development and conveyance system. It includes facilities—pumping and power plants, reservoirs, lakes and storage tanks, and canals, tunnels and pipelines—that capture, store, and convey water from the Lake Oroville watershed in Northern California to 29 water agencies in Central and Southern California. Planned, designed, constructed and now operated and maintained by the California Department of Water Resources, this unique facility provides water supplies for 23 million Californians and for 755,000 acres of irrigated farmland.

The original State Water Contract called for an ultimate delivery capacity of 4.2 MAF, with MWD holding a contract for 2.011 MAF. More than two-thirds of California's drinking water, including all of the water supplied by SWP, passes through the San Francisco-San Joaquin Bay-Delta (Bay-Delta). For decades, the Bay-Delta system has experienced water quality and supply reliability challenges and conflicts due to variable hydrology and environmental standards that limit pumping operations.

In 1999, MWD's Board of Directors set new goals for the SWP with the adoption of its CALFED Policy Principles. These goals committed MWD to water quality objectives, the development of 0.65 MAF minimum dry-year supply from the SWP by 2020 and average annual deliveries of 1.5 MAF (excluding transfers and storage programs along the SWP). To achieve these goals while minimizing impacts to the Bay-Delta ecosystem, MWD would maximize deliveries to storage programs during wetter years, implement a number of source water qualities and supply reliability improvements in the Delta, remove operational conflicts with the Central Valley Project (CVP) and better coordinate planning and operations between the SWP and CVP.

Types of Imported Supplies

MWD offers different types of imported water to its member agencies depending on the ultimate use. Among them, West Basin has delivered Non-Interruptible Water (treated full-service) and Seasonal Treated Replenishment Water (In-Lieu Replenishment).

Non-Interruptible Water is the treated firm supply that is available all year. West Basin delivers an average of 150,000 AF of non-interruptible water annually. It is used as the main supplemental supply of cities and water agencies, including the main supply for the Saline Barriers.

Seasonal Treated Replenishment Water, also known as the "In-Lieu" water is delivered to customer agencies that are eligible to offset groundwater production with imported water. This program incentivizes customer agencies to take imported surplus water "when available," which indirectly replenishes the groundwater basin. This surplus water is purchased at a discount rate in exchange for leaving groundwater in the basin for no less than a year so that it can be used subsequently during dry years.

3.3.2 Groundwater Supply

Groundwater has for many years represented a fifth of the District's supplies within West Basin's service area. Today, the average customer agency in West Basin relies on groundwater production for 20% of its retail demand. This is a result of the geographical location where most of West Basin's customer agencies are located. There are a few agencies within the District's service area that rely exclusively on imported water to meet all their current water needs.

Courtesy of WRD

The West Coast Groundwater Basin (WCGB) is an adjudicated basin. The extensive overpumping of the WCGB through the years led to critically low groundwater levels, resulting in seawater intrusion along the coast. This over pumping of the WCGB resulted in a legal judgment, or adjudication that limits the allowable extraction, that could occur in any given year and assigned water rights to basin pumpers. The adjudicated water rights were greater than the basin yield; therefore, the WCGB was operating with an annual overdraft. To address this overdraft, imported and recycled water sources and a means to purchase these sources were required.

In 1959, the State Legislature enacted the Water Replenishment Act, enabling the water association for the basin to secure voter approval for the formation of the "Central and West Basin Water Replenishment District" (now referred to as the Water Replenishment District of Southern California or "WRD") to be the permanent agency responsible for replenishing the basin. The State Legislature has vested in WRD the statutory responsibility to manage, regulate, replenish and protect the quality of the groundwater supplies within its boundaries for the beneficial use of the approximately 3.5 million residents and water users who rely upon those groundwater resources to satisfy all or a portion of their water needs.

Although the water rights have been bought, sold, exchanged or transferred through the years, the total amount of allowable extraction rights within the entire groundwater basin has remained virtually the same. The adjudicated pumping rights available within West Basin's service area total 54,730 AF. However, not all of these water rights holders are water retail agencies. Many of these holders are school districts, businesses, cemeteries and private entities that make up approximately 42% (23,215 AF) of the total water rights. Shown below in Table 3-2 are all of the water retailers' adjudicated groundwater rights in West Basin's service area for Fiscal Year 2003-04.

Table 3-2
Groundwater Pumping Rights 2003-2004

West Basin Retail Agencies	Adjudicated Pumping Rights in West Basin
Cal Water Service Co. (Hermosa/Redondo)	4,070
Cal Water Service Co. (Dominguez)	10,417
City of El Segundo	953
City of Hawthorne	1,882
City of Inglewood	4,450
City of Lomita	1,352
City of Manhattan Beach	1,131
Southern California Water Co.	7,260
Non-Retail Water Agencies[1]	23,215
Total	**54,730**

Source: West Basin Watermaster Report, 2004
(1) Water right holders that are not water retail agencies: ie. Nurseries, Cemeteries, industries, refineries, etc.

Although the groundwater supply is extracted from the WCGB, there is a small amount of groundwater that is imported from the Central Groundwater Basin. The Central Groundwater Basin underlies the southeastern part of the Los Angeles Coastal Plain. It is bounded on the north by the hills separating it from the San Gabriel Valley, on the east by Orange County and on the southwest by the West Coast Groundwater Basin.

The total amount of water extracted and imported within West Basin's service area is approximately 2,000 AFY. Table 3-3 below displays the water retailer and the amount produced from this adjoining basin for the past five fiscal years:

Table 3-3
Amount of Groundwater Pumped from Central Basin
(In Acre-Feet)

Water Retailer	2000	2001	2002	2003	2004
California American Water Co.	1,669	1,707	1,935	1,979	2,509
Total	**1,669**	**1,707**	**1,935**	**1,979**	**2,509**

Source: Central Basin Watermaster Report, 2004

As illustrated in Table 3-4, the total amount of groundwater produced during the past five years in the WCGB and Central Groundwater Basin has remained fairly consistent. The amount of groundwater produced ranges from 73% to 86% of the total groundwater supply available from both Basins (56,797 AF).

Table 3-4
Total Amount of Groundwater Pumped

Basin Name	2000	2001	2002	2003	2004
West Coast Basin[1]	50,295	46,867	45,367	46,555	42,421
Central Basin[2]	1,669	1,707	1,935	1,979	2,509
Total	**51,964**	**48,574**	**47,302**	**48,534**	**44,930**
% of Total Water Supply[3]	**91%**	**86%**	**83%**	**85%**	**79%**

Source: West Basin Wateruse Database, 2005

[1] Includes West Basin service area including Desalter sales

[2] Includes California American Water Co. groundwater imported from Central Basin

[3] Percentage of the available groundwater supply of both basins totaling 56,797 AFY

Courtesy of WRD

The total amount of groundwater projected to be extracted during the next 25 years will be fairly consistent due to the adjudication of both basins. The economic costs to pumped groundwater versus the purchase of imported water will pressure water retailers to maximize their groundwater rights. Therefore, the total amount of groundwater produced is projected to range in the 92nd percentile of available supply, as illustrated in Table 3-5.

Table 3-5
Total Amount of Groundwater Projected to be Pumped

Basin Name	2010	2015	2020	2025	2030
West Coast Basin[1]	50,000	50,000	50,000	50,000	50,000
Central Basin[2]	2,000	2,000	2,000	2,000	2,000
Total	**52,000**	**52,000**	**52,000**	**52,000**	**52,000**
% of Total Water Supply[3]	**92%**	**92%**	**92%**	**92%**	**92%**

[1] Includes West Basin service area including Desalter sales

[2] Includes California American Water Co. groundwater imported from Central Basin

[3] Percentage of the available groundwater supply of both basins totaling 56,797 AFY

Groundwater Recharge

To replenish the WCGB and prevent further seawater intrusion, the Los Angeles County Flood Control District (LACFCD) created the injection barriers along the West Coast and at the Dominguez Gap, located north of the Los Angeles Harbor.

For the past 42 years, WRD has accomplished its statutory replenishment objectives primarily by allowing recycled and imported water to be injected into "seawater intrusion barriers" owned and operated by the County of Los Angeles Department of Public Works (LACDPW) in the WCGB.

WRD assesses a groundwater production fee, known as their "Replenishment Assessment", to pumpers of the WCGB. This assessment provides funds that

WRD uses to purchase and produce water for both spreading and injection to replace groundwater pumped and creating hydrological barriers to seawater intrusion. Stormwater is not used in West Basin for replenishing the groundwater basin.

WRD also encourages In-Lieu replenishment of the basins. Under the "In-Lieu program" pumpers of the WCGB are encouraged through a financial incentive to purchase surplus imported water from the West Coast Groundwater Basin "in-lieu" of pumping groundwater.

Table 3-6 summarizes the historical amounts of imported water purchased to replenish the basin.

Table 3-6
Historical Imported Water Replenishment Deliveries

Fiscal Year	In-Lieu	Barrier Water[1]	Total
1990	-	32,850	**32,850**
1991	-	31,876	**31,876**
1992	3,434	25,736	**29,170**
1993	14,265	25,705	**39,970**
1994	27,656	21,958	**49,614**
1995	10,094	21,274	**31,368**
1996	1,962	21,585	**23,547**
1997	1,453	23,208	**24,661**
1998	1,593	22,088	**23,680**
1999	1,942	19,353	**21,294**
2000	2,045	24,176	**26,221**
2001	1,455	25,811	**27,265**
2002	5,726	25,414	**31,140**
2003	1,864	24,631	**26,495**
2004	-	21,672	**21,672**
2005	-	15,199	**15,199**

[1] Barrier Water includes recycled and imported water deliveries to both the west coast and Dominguez Gap Barriers

3.3.3 Recycled Water Supply

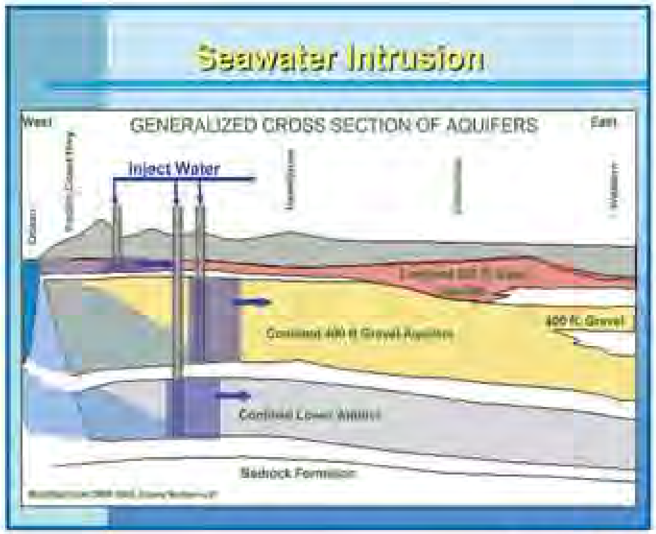
Water recycling is one of the cornerstones of West Basin's efforts to augment local supplies and reduce dependence on imported water. Since the planning and construction of West Basin's water recycling system in the early 1990s, West Basin has become a leader in producing and marketing recycled water. This new supply of water assists in meeting the demand for non-potable applications such as landscape irrigation, commercial and industrial processes, and seawater barriers.

Recycled water is a resource that is reliable and environmentally beneficial to the region. It is only limited by the infrastructure needed to deliver this source of water. With approximately 210 site connections, West Basin has delivered an average of 14,000 AF of recycled water within the District's service area.

West Basin projects on delivering 21,850 AF of recycled water by year 2010. Refer to a more detailed description of West Basin's water recycling program in Section 8 of this Plan.

3.4 Alternative Water Supply Projects

3.4.1 Seawater Barrier Water Conservation Project



Courtesy of WRD
Schematic of West Coast Seawater Injection Barrier

To prevent seawater intrusion into the WCGB, two injection barriers were created along the West Coast and at the Dominguez Gap. These barriers are a series of wells that act like a freshwater dam between the ocean and the groundwater aquifer. To ensure groundwater protection, the barriers require a reliable source of high quality water for continuous injection.

For more than a decade, West Basin has supplied a combination of 50% imported water and approximately 50% highly purified recycled water into the West Coast Barrier. To further enhance water reliability and water quality, West Basin is currently expanding the use of recycled water in the barrier to 75% for the following reasons:

- West Basin is committed to conserving imported water. A 25% increase in the amount of recycled water used for injection at the barrier represents an additional 5,000 AFY of imported water that can be used for potable purposes. Furthermore, recycled water is more reliable than imported water, which is subject to drought and changes in weather patterns.
- Since it has been treated to have impurities removed, recycled water is a higher quality water source than Colorado River water. This purified water has one-half the salt concentration of existing groundwater and one-fifth the salt of Colorado River water. This will help improve water quality in the aquifer, which is consistent with West Basin's commitment to ongoing water quality enhancement.
- Using highly purified recycled water is less expensive than imported water and helps to control water rates in West Basin's service area.

3.4.2 Ocean Water Desalination

Desalting ocean water as a source of potable water in the West Basin region is a foreseeable goal. May 2003 marked the first anniversary of West Basin's Desalination Pilot Project and research program in which 40,000 gallons per day undergo microfiltration and reverse osmosis treatment and a battery of water quality tests. It is anticipated that West Basin will be able to provide up to 20,000 AF of ocean desalinated water in 2012. A more detailed description of West Basin's desalination efforts are described in Section 9 of this Plan.

3.4.3 Conjunctive Use Groundwater Storage

Conjunctive Use can be defined as the coordinated management of surface and groundwater supplies to increase the yield of both supplies and enhance water supply reliability in an economic and environmentally responsible manner. West Basin sees the development of Conjunctive Use Storage Programs as part of the District's core responsibility to ensure a reliable supply of water for its service area. If done in a publicly responsible manner, groundwater storage can be viewed as an additional source in diversifying our water resource supply portfolio.

The potential benefits of a Conjunctive Use program include:

- Operational flexibility for groundwater production;
- Increased yield of the basin;
- More efficient use of surplus surface water during wet years;
- Financial benefits to groundwater users;
- Better distribution of water resources and
- Increased measures of reliability.

At this time there are programs available for water retailers to create groundwater storage both within and outside of the WCGB groundwater judgment. District-sponsored storage programs with MWD are available for retail agencies with imported water connections. The size of such a program would depend on retailers' total demand and the amount of groundwater they could realistically shift to imported water.

3.4.4 Water Transfers & Exchanges

Water transfers and exchanges are management tools to address increased water needs in areas of limited supply. Although transfer and exchange of water does not generate a new supply of water, these management tools distribute water from where it is abundant to where it is limited.

MWD, in recent years, has played an active role statewide in securing water transfers and exchanges as part of their IRP goals. Although West Basin is a member of MWD, there has not been a compelling reason or opportunity to pursue transfers directly.

Section 4

Water Reliability

Section 4
Water Reliability

Water Reliability

4.1 Overview

Among the future challenges of continued urbanization in Southern California are the questions of water reliability. In other words, can Southern California meet the necessary water demands of the region during times of drought? During consecutive dry years, Southern California has historically seen demands increase by as much as 20% while supplies have decreased. Prior to recent significant improvements in water reliability, most cities and agencies were forced to mandate conservation efforts and restrict water use in some cases in order to maintain an adequate supply[1].

Colorado River water at Hoover Dam in Nevada

This section will discuss how the regional supplier, MWD, in partnership with its member agencies such as West Basin, plans on ensuring future reliability through water management measures, long-term planning and investment in local resources, West Basin's projections for meeting its service area's future demands during single and multiple dry-year conditions and a review of the District's Water Shortage Contingency Plan in the event that MWD limits deliveries.

4.2 MWD Water Supply Reliability

With the experience of the droughts of 1977-78 and 1989-92, MWD has undertaken a number of planning initiatives to ensure water supply reliability. Included among them are the Integrated Resources Plan (IRP), the Water Surplus and Drought Management Plan (WSDM Plan) and local resource investments. Together these initiatives have provided the policy framework for MWD and its member agencies to manage their water resources to meet a growing population even under recurrences of the worst historical hydrologic conditions locally and in the key watersheds that supply Southern California. Below is a brief description of each water management initiative MWD has undertaken to ensure 100% reliability during the next 20 years.

4.2.1 MWD Integrated Resource Plan

To meet the challenges of the supply shortages on the State Water Project (SWP) and the Colorado River Aqueduct in spite of increases in population and growing State and Federal regulatory requirements, MWD's Board of Directors called for the development of an IRP in 1996. The IRP's objective was to determine the appropriate combination of water resources to provide 100% reliability for full service demands during the next 20 years. With the support of its member agencies, MWD developed a preferred supply mix that includes conservation,

[1]By contrast, the loss of a large portion of our Colorado River supply in 2004 during an extended dry period in Southern California did not cause hardship or require any drastic return on the part of the general population. This was a tribute to planning and investments made into water reliability during the past decade.

local supplies (recycled, brackish, desalination), SWP supplies, CRA supplies, groundwater banking and water transfers that could meet projected water demands under severe shortage conditions. The IRP identifies supply targets for each supply option and has become the blueprint for guiding investment and policy decisions for decades to come.

By design, the IRP is subject to revision when conditions and opportunities change through time. In 2003, MWD completed its first update to the IRP, which included revised projected demands and an updated resource supply mix. MWD had three clear objectives for the IRP update: (1) to review the goals and achievements of the 1996 IRP, (2) to identify changed conditions for water resource development and (3) to update the resource targets through 2025.

Among the most significant findings from the updated IRP was the increased participation of local agencies in developing local supplies such as recycled water and brackish groundwater desalination as well as promoting savings from conservation. The result of which revealed a greater source of local supply reliability than anticipated among MWD member agencies. However, it also identifies the limitations expected on the Colorado River and the need for local infrastructure improvements to provide the flexibility to manage and overcome supply risks.

Overall, the 2003 IRP Update revealed a decrease in the region's reliance on Colorado River and SWP supplies compared to the 1996 IRP while continuing to provide 100% reliability through the year 2025.

Prior to the IRP
2020

1996 IRP
2020

2003 IRP Update
2025

4.2.2 MWD Water Surplus and Drought Management Plan

In order for MWD to be 100% reliable in meeting all non-discounted non-interruptible demands in the region, MWD adopted the WSDM Plan in 1999. The WSDM Plan provides the policy guidance to manage the region's water supplies to achieve the reliability goals of the IRP. This is achieved by integrating the operating activities of surplus and shortage supplies through a series of stages and principles.

Those principles include water management actions needed to secure more imported water during times of drought by promoting efficient water usage, increasing public awareness and seeking additional water transfers and banking programs. Should supplies become limited to the point where imported supplies are truncated, the WSDM Plan would allocate water through a calculation on the basis of need, as opposed to any historical purchases through MWD. MWD and its member agencies have not yet decided on a formula for the allocation calculation.

4.2.3 MWD Local Resource Investments

A key element within MWD's IRP objectives to ensure regional reliability is to further enhance local resources. In addition to the traditional supplies of imported water and groundwater, MWD has looked to invest in numerous local resource projects including: water recycling, conservation, groundwater and surface water storage, and even ocean water desalination to meet future demands.

Since 1982, MWD has provided financial assistance to more than 75 projects in the areas of recycled water and groundwater recovery totaling approximately $124 million and $41 million, respectively.

MWD has already invested more than $290 million in water conservation, which has produced significant water savings during the last 15 years.

One of MWD's most significant investments is Diamond Valley Lake. Built in the saddle of two mountains, Diamond Valley Lake, Southern California's newest and largest reservoir, is a vital link in the regional system that has brought water to Southern California for the past 75 years. The lake nearly doubled the region's surface water storage capacity and provides additional water supplies for drought, peak summer and emergency needs. This newly created reservoir, located in southwestern Riverside County , holds

Diamond Valley Lake
Courtesy of MWD

enough water to meet the region's emergency and drought needs for six months and is an important component in MWD's plan to provide a reliable supply of water to the 18 million people in Southern California. Water began pouring into the reservoir in November 1999 and the lake was filled by early 2002. Diamond Valley Lake holds 800,000 AF, or 260 billion gallons, of water. By comparison, Lake Havasu on the Colorado River holds just 648,000 AF or 201 billion gallons.

4.3 West Basin's Water Supply Reliability

Along with MWD's reliability initiatives, West Basin has also taken important steps during the past decade to reduce the District's vulnerability to extended drought or other potential threats. The District's investments in recycled water to replace imported water for non-potable uses and the implementation of conservation devices and education have resulted in more self-reliance.

Based on the District's current water supply portfolio, as illustrated in Table 4-1, West Basin provides an adequate supply for the single dry-water year and multiple dry-water year scenarios. The Normal Water Year used in this plan is based on the average rainfall year of 2000-01. According to the National Weather Service, the recorded rainfall in FY 2000-01 was 17.94 inches - one of the closest years to the historical average of more than 100 years (16.42 inches). The Single Dry Year is based on the lowest rainfall year of 2001-02. The recorded rainfall in FY 2001-02 was at 4.42 inches - the lowest recorded year in more than 100 years. The three Multiple Dry-Water Years used below were based upon the most recent dry period - FY 2001-02, 2002-03 and 2003-04.

Table 4-1
Supply Reliability

Supplies	Normal Water Year	Single Dry-Water Year	Multiple Dry-Water Years		
	FY 2000-01	FY 2001-02	FY 2001-02	FY 2002-03	FY 2003-04
Groundwater[1]	56,797	56,797	56,797	56,797	56,797
Imported Water	126,000	129,936	129,936	130,940	135,334
Recycled Water[2]	14,000	14,000	14,000	14,000	14,000
Total Supply	**196,797**	**200,733**	**200,733**	**201,737**	**206,131**

Note: Supply Reliability covers only retail water demand; does not include replenishment deliveries such as Barrier.

[1] Based upon the total water rights for each customer agency within West Basin's service area, according to the 2004 DWR West Coast Basin Watermaster Report. Also includes groundwater rights (2,000 AFY) from the Central Groundwater Basin, which are imported in West Basin.

[2] Includes M&I Recycled Water sales from West Basin's service area; does not include recycled water sales to LADWP and Torrance or replenishment sales (Barrier).

Groundwater is shown constant in all scenarios due to the Basin's adjudication, which limits the total amount that each customer within West Basin's service area is able to extract. Recycled water, which includes only M&I sales, is also constant in all scenarios because the availability of recycled water is not subject to hydrologic variation. This leaves imported water as the only supply currently that can fluctuate under different hydrological scenarios. The supply reliability scenarios described in this section focus exclusively on municipal and industrial usage within the District's service area; it does not include replenishment water.

Looking forward, West Basin will continue to evaluate opportunities to increase its water supply portfolio within its service area. These opportunities include the expanded use of water recycling, brackish water recovery, ocean water desalination and additional conservation programs as well as the exploration of investments in groundwater storage through Conjunctive Use programs.

4.3.1 Normal-Year Reliability Comparison

As discussed in the Water Demand Section, West Basin's normal demands are projected to increase modestly during the next 25 years. Increases in recycled water use and ocean water desalination during the 25 year planning period equate to a corresponding reduction in the need for imported water.

Table 4-2
Projected Normal Water Year Supply and Demand

Supplies	2005	2010	2015	2020	2025	2030
Groundwater[1]	56,797	56,797	56,797	56,797	56,797	56,797
Imported Water	126,000	123,000	97,319	98,665	100,140	101,747
Recycled Water[2]	14,000	21,848	32,500	36,250	40,000	43,750
Ocean Desalination	0	0	20,000	20,000	20,000	20,000
Total Supply	**196,797**	**201,645**	**206,616**	**211,712**	**216,937**	**222,294**
Total Demand[3]	**183,916**	**196,848**	**201,819**	**206,915**	**212,140**	**217,497**
Surplus/(Shortage)	**12,881**	**4,797**	**4,797**	**4,797**	**4,797**	**4,797**

Note: Supply Reliability covers only retail water demand; does not include replenishment deliveries such as Barrier.

[1] Based upon the total water rights for each customer agency within West Basin's service area, according to the 2004 DWR West Coast Basin Watermaster Report. Also includes groundwater rights (2,000 AFY) from the Central Groundwater Basin, which are imported in West Basin.

[2] Includes M&I Recycled Water sales from West Basin's service area; does not include recycled water sales to LADWP and Torrance or replenishment sales (Barrier).

[3] Total Demand includes Projected Groundwater within West Basin's service area as well as Imported and Recycled M&I Demands.

4.3.2 Single Dry-Year Reliability Comparison

West Basin's projected single dry-year water supply is expected to call for additional imported supplies from MWD. According to historical demands, the total water demands in a single dry-year are projected to be 3.5% greater than normal year projections. Table 4-3 compares the dry-year supply and demand projections for the West Basin service area.

Table 4-3
Projected Single-Dry Year Water Supply and Demand*

Supplies	2005	2010	2015	2020	2025	2030
Groundwater[1]	56,797	56,797	56,797	56,797	56,797	56,797
Imported Water	129,936	125,460	99,586	101,110	102,768	104,562
Recycled Water[2]	14,000	21,848	32,500	36,250	40,000	43,750
Ocean Desalination	0	0	20,000	20,000	20,000	20,000
Total Supply	**200,733**	**204,105**	**208,883**	**214,157**	**219,565**	**225,109**
Total Demand[3]	**190,353**	**203,738**	**208,883**	**214,157**	**219,565**	**225,109**
Surplus/(Shortage)	**10,380**	**367**	**0**	**0**	**0**	**0**

Note: Supply Reliability covers only retail water demand; does not include replenishment deliveries such as Spreading.

[*] 3.5% increase in water demand from a "normal water year"

[1] Based upon the total water rights for each customer agency within West Basin's service area, according to the 2004 DWR West Coast Basin Watermaster Report. Also includes groundwater rights (2,000 AFY) from the Central Groundwater Basin, which are imported in West Basin.

[2] Includes M&I Recycled Water sales from West Basin's service area; does not include recycled water sales to LADWP and Torrance or replenishment sales (Barrier).

[3] Total Demand includes Projected Groundwater within West Basin's service area as well as Imported and Recycled M&I Demands.

4.3.3 Multiple Dry-Year Reliability Comparison

Under the multiple dry-year water scenarios, West Basin is projected to meet demands by continuing to implement conservation, water recycling and introducing ocean water desalination as a new source of potable water to replace imported water. Tables 4-4 through 4-8 illustrate the projected water supplies and demands within multiple dry-year reliability comparisons for the next 25 years.

Table 4-4
Projected Water Supply and Demand during Multiple Dry-Year

Supplies	2008	2009	2010
Groundwater[1]	56,797	56,797	56,797
Imported Water	129,936	130,940	135,334
Recycled Water[2]	21,000	21,420	21,848
Ocean Desalination	0	0	0
Total Supply	**207,733**	**209,157**	**213,979**
Total Demand[3]	**198,792**	**200,785**	**206,188**
Surplus/(Shortage)	**8,941**	**8,372**	**7,791**

Note: Supply Reliability covers only retail water demand; does not include replenishment deliveries such as Barrier.

[1] Based upon the total water rights for each customer agency within West Basin's service area, according to the 2004 DWR West Coast Basin Watermaster Report. Also includes groundwater rights (2,000 AFY) from the Central Groundwater Basin, which are imported in West Basin.

[2] Includes M&I Recycled Water sales from West Basin's service area; does not include recycled water sales to LADWP and Torrance or replenishment sales (Barrier).

[3] Total Demand includes Projected Groundwater within West Basin's service area as well as Imported and Recycled M&I Demands.

quite expensive, but market demand has helped to drive the price down. The new HECWs cost twice as much as regular inefficient models, but by providing a $100 rebate (along with other utility/store incentives), consumers are purchasing the new HECWs. In addition to saving 50% water, the HECWs also have other benefits: They save 60% electricity and use less detergent. Consumer acceptance has been very positive.

In 2004, the MWD Board of Directors, along with the support of West Basin, approved additional funding to continue the program through 2005. At the same time, MWD applied for Proposition 50 funding in an effort to maintain the program at the higher incentive level through 2006. MWD was successful in its Prop. 50 application and was awarded roughly $1.6 million from the California Department of Water Resources for the High-Efficiency Clothes Washer Rebate Program. This funding will allow MWD and West Basin to continue offering its $100 rebate to residents in an effort to encourage the purchase of high-efficient clothes washers with a Water Factor (WF) of 6.0 or less.

The Water Factor of a clothes washer can range from 13.5 to 3.6, with the lower number being more efficient. A complete list of qualifying washers can be obtained at MWD's web site www.bewaterwise.com, or by calling the District's program vendor at **1-800-442-0467**.

In 2003, the Governor of California signed Assembly Bill 1561 that would require clothes washer manufacturers to only manufacture and provide residential washers with a WF of 8.5 in 2007 and 6.0 by 2010. The legislation was adopted by the California Energy Commission and was submitted to the Federal Government for approval. The Federal Government must approve this legislation before the new standards can be applied. This process is anticipated to take 1–2 years.

As long as funding is available, MWD and West Basin will continue offering its $100 rebate to residential customers for clothes washers with a WF of 6.0 or less. Table 6-3 illustrates the number of rebates West Basin has distributed during the past two years.

Table 6-3
High-Efficiency Washing Machine

	2003	2004	Total
$ per Rebate	$100	$100	**N/A**
# of Rebates	104	602	**706**
Water Savings (AF)	1.6	9.4	**11**

In an effort to continue the successful washer rebate program, MWD along with its member agencies, applied for and received Proposition 50 funding from DWR in the amount of $1,660,000. This funding will allow West Basin to continue its program through 2006.

Table 4-5
Projected Water Supply and Demand during Multiple Dry-Year 2013-2015
(In Acre-Feet)

Supplies	2013	2014	2015
Groundwater[1]	56,797	56,797	56,797
Imported Water	129,936	130,940	135,334
Recycled Water[2]	27,500	31,000	32,500
Ocean Desalination	20,000	20,000	20,000
Total Supply	**234,233**	**238,737**	**244,631**
Total Demand[3]	**203,812**	**205,855**	**211,395**
Surplus/(Shortage)	**30,421**	**32,882**	**33,236**

Table 4-6
Projected Water Supply and Demand during Multiple Dry-Year 2018-2020
(In Acre-Feet)

Supplies	2018	2019	2020
Groundwater[1]	56,797	56,797	56,797
Imported Water	129,936	130,940	135,334
Recycled Water[2]	34,750	35,500	36,250
Ocean Desalination	20,000	20,000	20,000
Total Supply	**241,483**	**243,237**	**248,381**
Total Demand[3]	**208,959**	**211,053**	**216,733**
Surplus/(Shortage)	**32,524**	**32,184**	**31,648**

Table 4-7
Projected Water Supply and Demand during Multiple Dry-Year 2023-2025
(In Acre-Feet)

Supplies	2023	2024	2025
Groundwater[1]	56,797	56,797	56,797
Imported Water	129,936	130,940	135,334
Recycled Water[2]	38,500	39,250	40,000
Ocean Desalination	20,000	20,000	20,000
Total Supply	**245,233**	**246,987**	**252,131**
Total Demand[3]	**214,235**	**216,383**	**222,205**
Surplus/(Shortage)	**30,998**	**30,604**	**29,926**

Table 4-8
Projected Water Supply and Demand during Multiple Dry-Year 2028-2030
(In Acre-Feet)

Supplies	2028	2029	2030
Groundwater[1]	56,797	56,797	56,797
Imported Water	129,936	130,940	135,334
Recycled Water[2]	42,250	43,000	43,750
Ocean Desalination	20,000	20,000	20,000
Total Supply	**248,983**	**250,737**	**255,881**
Total Demand[3]	**219,645**	**221,847**	**227,816**
Surplus/(Shortage)	**29,338**	**28,890**	**28,065**

4.4 Water Shortage Contingency Plan

The State requires that each urban water supplier provide a water shortage contingency analysis within its UWMP. Below is a brief description of the District's plan for water shortage according to the state's water code requirements.

4.4.1 Minimum Supply

Currently, the District's water supplies are groundwater, imported water and recycled water. As it relates to the estimated minimum supply available during a severe drought, the District's groundwater supply, as stated in Section 3, is not affected by hydrology because the Basin is adjudicated. The available supply for each groundwater producer (Allowable Production Allocation), set by the Judgment, remains the same regardless of the service area's rainfall. The same relates to recycled water, where the supply is not affected by hydrology but rather through the number of service connections and production capacity. The benefit of recycled water is that it is drought-proof and the supply of recycled water remains available regardless of the rainfall. Imported water, on the other hand, is the only supply affected by hydrology. As the wholesaler of imported water to the region, the District's minimum imported water supply is based upon the recent historical demand of imported water during a dry-year sequence of fiscal years 2001-02 to 2003-04; rainfall for these three years range among the lowest on record. The estimated minimum supplies during the next three years for the District is shown in Table 4-9.

Table 4-9
Three-Year Estimated Minimum Water Supply
(In Acre-Feet)

Supplies	2006	2007	2008
Groundwater[1]	56,797	56,797	56,797
Imported Water	129,936	130,940	135,334
Recycled Water[2]	14,500	18,000	21,000
Ocean Desalination	0	0	0
Total Supply	**201,233**	**205,737**	**213,131**
Total Demand[3]	**196,819**	**198,792**	**204,142**
Surplus/(Shortage)	**4,414**	**6,945**	**8,989**

Note: Supply Reliability covers only retail water demand; does not include replenishment deliveries such as Barrier.
[1] Based upon the total water rights for each customer agency within West Basin's service area, according to the 2004 DWR West Coast Basin Watermaster Report. Also includes groundwater rights (2,000 AFY) from the Central Groundwater Basin, which are imported in West Basin.
[2] Includes M&I Recycled Water sales from West Basin's service area; does not include recycled water sales to LADWP and Torrance or replenishment sales (Barrier).
[3] Total Demand includes Projected Groundwater within West Basin's service area as well as Imported and Recycled M&I Demands.

4.4.2 Stages of Action to Reduce Imported Deliveries

As the area's wholesaler of MWD imported water, the District's stages for reduction are subject to MWD's WSDM Plan, which guide the management of water supplies for the region during shortage conditions.

According to MWD's WSDM Plan, an array of water resource management measures would take place prior to any supply reductions. Through a series of seven shortage stages, MWD will seek the steps to encourage more efficient water usage with its member agencies. Not until the last stage, under an extreme shortage condition, will MWD discontinue imported water deliveries according to an allocation formula. Currently, however, MWD has not determined the shortage allocation methodology to complete the WSDM Plan. Conversely, MWD's 2005 Regional UWMP demonstrates 100% reliability in multiple dry-years through 2030. Nevertheless given the resources described in MWD's IRP, MWD fully expects to be reliable, under the most extreme supply shortage scenarios, during the next 10 years.

However, if imported water supplies were discontinued according to MWD's WSDM Plan, the District would consider reducing supplies through a series of action stages, which would include an allocation methodology similar to MWD. Once MWD determined such an allocation, the District would work with each of its customer agencies to set a specific allocation level to cumulatively meet the District's allocation from MWD. Below is a four step stage rationing plan the District would implement to reduce imported deliveries up to 50%.

West Basin Municipal Water District Stages of Action

Minimum Shortage – The District would request for a voluntary effort among its customers to reduce imported water deliveries. In addition, the District would pursue an aggressive Public Awareness Campaign to encourage residents and industries to reduce their usage of water.

Moderate Shortage – In addition to the stage above, the District would work with its customer agencies to promote and adopt water waste prohibitions and ordinances to discourage unnecessary water usage.

Severe Shortage – In addition to the two stages above, the District would seek to adopt a rate structure that penalizes increased water usage among its customer agencies.

Extreme Shortage – In addition to all the stages above, the District would call for the discontinuance of imported water based upon an allocation methodology similar to MWD for each of its customer agencies.

Since these action stages are contingent upon MWD's WSDM Plan's allocation methodology and such a formula has yet to be determined, the District's shortage stages will remain in draft form. Until MWD completes the WSDM formula, the District's implementation of any rationing stage will be subject to a variety of conditions, among them the severity of the drought, the District allocation level and the current water supply mix available to each customer agency before the Board would apply any action stage listed above.

Once the Board determines what action is necessary, the Board will adopt, by resolution, the appropriate stage of action, which will take effect immediately and the District's customer agencies will be notified. A draft resolution is included in Appendix E.

4.4.3 Prohibitions, Penalties and Consumption Reduction Methods

Through the years the District has developed strong relationships with its customer agencies to promote community awareness of water conservation. Should water reductions become necessary, the District will work with each city, water agency or investor-owned water company within its service area to encourage the adoption of water waste prohibition measures that establish mandatory water use restrictions. Moreover, the District will provide the necessary assistance and information to apply the best suited water reducing practice(s) for each customer agency.

Additionally, the District will encourage behavioral change through the adoption of an appropriate water rate structure. As part of MWD's WSDM Plan, the District will pass through additional charges where MWD will enforce water reductions by setting a minimum amount per AF for any deliveries exceeding a member agency's allotment up to 102%

once an allocation plan is determined. Any deliveries exceeding 102% will be assessed a surcharge equal to three times MWD's full-service rate. The District will impose MWD's penalties for excess use to its customer agencies that exceed their allocation.

4.4.4 Impacts to Revenue

The District will seek to recover the shortfall of revenue caused by water reductions from its Rate Stabilization Fund as well as from any surplus revenues collected from excess penalties. Moreover, the District will closely monitor its revenue and expenditure impacts on a monthly basis and respond with any rate adjustments needed at each action stage.

Through the District's imported water invoices per connection, the District will measure each customer agencies' actual performance on a monthly basis.

4.4.5 Catastrophic Supply Interruption

In the event imported water supplies are interrupted from a catastrophic event, the District, through coordination with MWD, can respond at both a regional and a local level.

In the event that an emergency such as an earthquake, system failure or regional power outage, etc. affected the entire Southern California region, MWD would take the lead and activate its Emergency Operation Center (EOC). The EOC coordinates MWD's and the District's responses to the emergency and concentrate efforts to ensure the system can begin distributing potable water in a timely manner.

If circumstances render the Southern California's aqueducts to be out of service, MWD's Diamond Valley Lake can provide emergency storage supplies for its entire service area's firm demand for up to six months. With few exceptions, MWD can deliver this emergency supply throughout its service area via gravity, thereby eliminating dependence on power sources that could also be disrupted. Furthermore, should additional supplies be needed, MWD also has surface reservoirs and groundwater conjunctive use storage accounts that can be drawn upon to meet additional demands. The WSDM plan guides MWD's management of available supplies and resources during an emergency to minimize the impacts of a catastrophic event.

Locally, the District has the Member Agency Response System (MARS) to immediately contact its customer agencies and MWD during an emergency about potential interruption of services and the coordination of critical resources to respond to the emergency, also known as mutual aid. The MARS is a radio communication system developed by MWD and its member agencies to provide an alternative means of communication in extreme circumstances. The District is currently in the process of enhancing its communication system in order to provide a more rapid response.

Section 5

Water Quality

Water Quality

5.1 Overview

Compliance with water quality regulations within West Basin's service area is a critical water management activity. MWD is responsible for complying with State and Federal drinking water regulations on its imported water sold to West Basin. West Basin's retail customer agencies are responsible for ensuring compliance in their individual distribution systems and at the customer tap.

For groundwater quality, West Basin assists retail agencies in its service area in meeting drinking water standards through its *Cooperative Basin-Wide Title 22 Groundwater Quality Monitoring Program.* Title 22 refers to the California Code of Regulations section pertaining to both domestic drinking water and recycled water standards. West Basin offers this program to water agencies for wellhead and reservoir sample collection, water quality testing and reporting services. Sampling is conducted for compliance with the Federal Safe Drinking Water Act and Title 22 regulations. Three agencies in West Basin's service area participate in the monitoring program. Results are compiled in a published annual report called the Consumer Water Quality Report.

Gravity thickener tanks at the West Basin Water Recycling Facility

The West Basin Water Recycling Facility (WBWRF), located in El Segundo, processes and distributes water through three distinct treatment trains: Title 22, Barrier and Boilerfeed. Tertiary recycled water meeting Title 22 standards is used for a wide variety of industrial and irrigation purposes where high-quality, non-potable water is needed. The WRP also produces recycled water to meet the strict standards required for injection into the West Coast Basin Barrier Project to protect the underground aquifer from seawater intrusion and to replenish the aquifer. The Boilerfeed treatment process produces high-quality water treated through microfiltration and reverse osmosis for use in oil refinery boiler systems.

5.2 Quality of Existing Water Supplies

Providing a safe drinking water supply to consumers is a task of paramount importance to MWD and West Basin. All prudent actions are taken to ensure that water delivered throughout the service area meets or surpasses drinking water standards set by the State's primary water quality regulatory agency, the California Department of Health Services (CDHS). MWD is also proactive in its water quality efforts, protecting its water quality interests in the SWP and Colorado River through active participation in the regulatory arena and in treatment processes that provide the highest water quality from both sources.

A number of issues are considered when evaluating alternative water supply options. Of primary consideration is a project's ability to provide a safe, reliable and cost-effective drinking water supply.

5.2.1 Imported Water

West Basin's imported water comes from the SWP and Colorado River via MWD pipelines and aqueducts. MWD tests its water for microbial, organic, inorganic and radioactive contaminants as well as pesticides and herbicides. Protection of MWD's water system is a top priority. In coordination with its 26 member agencies, MWD added new security measures in 2001 and continues to upgrade and refine procedures. Changes have included an increase in the number of water quality tests conducted each year (more than 300,000) as well as contingency plans that coordinate with the Homeland Security Office's multicolored tiered risk alert system.[1] MWD also has one of the most advanced laboratories in the country where water quality staff performs tests, collects data, reviews results, prepares reports and researches other treatment technologies. Although not required, MWD monitors and samples elements that are not regulated but have captured scientific and/or public interest.

West Bain's water quality laboratory performs between 2,000-2,500 analysis per month for process control, compliance, and research development.

MWD has a strong record of identifying those water quality issues that are most of concern and have identified necessary water management strategies to minimize the impact on water supplies. Part of its strategy is to support and be involved in programs that address water quality concerns related to both the SWP and Colorado River supplies. Some of the programs and activities include:

CALFED Program – This program coordinates several SWP water feasibility studies and projects. These include:

1. A feasibility study on water quality improvement in the California Aqueduct.
2. The conclusion of feasibility studies and demonstration projects under the Southern California-San Joaquin Regional Water Quality Exchange Project.[2] This exchange project was discussed earlier as a means to convey higher quality water to MWD.
3. DWR's Municipal Water Quality Investigations Program and the Sacramento River Watershed Program. Both programs address water quality problems in the Bay-Delta and Sacramento River watershed.

Delta Improvement Package – MWD, in conjunction with DWR and the U.S. Geologic Survey, have completed modeling efforts of the Delta to determine if levee modifications at Franks Tract would reduce ocean salinity concentrations in water exported from the Delta. Currently, tidal flows trap high saline water in the track. By constructing levee breach openings and flow control structures, it is believed saline intrusion can be reduced. This would significantly reduce total dissolved solids and bromide concentrations in water from the Delta.

[1] MWD's web site, www.mwdh2o.com/mwdh2o/pages/yourwater/2005_report/protect_02.html
[2] The Metropolitan Water District of Southern California, Regional Urban Water Management Plan, 2005

Source Water Protection – In 2001, MWD completed a Watershed Sanitary Survey as required by CDHS to examine possible sources of drinking water contamination and identify mitigation measures that can be taken to protect the water at the source. CDHS requires the survey to be completed every five years. MWD also completed a Source Water Assessment (December 2002) to evaluate the vulnerability of water sources to contamination. Water from the Colorado River is considered to be most vulnerable to contamination by recreation, urban/storm water runoff, increasing urbanization in the water shed, wastewater and past industrial practices. Water supplies from SWP are most vulnerable to urban/storm-water runoff, wildlife, agriculture, recreation and wastewater.[3]

5.2.2 Groundwater

As part of West Basin's customer service, the Water Quality Department works closely with regulatory agencies to assist retail agencies in meeting State and Federal drinking water regulations through the *Cooperative Basin-Wide Title 22 Groundwater Quality Monitoring Program*. This voluntary program offers water quality testing to purveyors in the service area, funded through an annual assessment. The District's Water Quality staff coordinates a wellhead and reservoir water quality testing at approximately seven groundwater wells in the service area to ensure high quality of the local supply of drinking water. Under the program, a contract laboratory provides sampling, analytical and reporting services. Laboratory results are reported to the District, retail agencies and the CDHS. The program helps retail agencies save time and expense while providing a valuable service for public health.

West Basin's Water Recycling Facility Laboratory

Other services provided under the program are an annual report summarizing water quality throughout the basin and production of the annual Customer Water Quality report at the purveyor's request. The Customer Water Quality Report is required by State and Federal law. District water quality staff has prepared Annual Consumer Confidence Water Quality Reports for several West Basin purveyors for more than 10 years.

Water Replenishment District Programs

As the regional groundwater management agency for the Central and West Coast Groundwater Basins, WRD has several active programs to monitor, evaluate and mitigate water quality issues.

Under its Groundwater Quality Program, WRD continually evaluates current and proposed water quality compliance in agency production wells, monitoring wells and recharge/injection waters of the groundwater basins. If non-compliance is identified, WRD staff develops a recommended course of action and associated cost estimates to address the problem and to achieve compliance. WRD also monitors and evaluates the impacts of pending drinking water regulations and proposed legislation.

[3] The Metropolitan Water District of Southern California, Regional Urban Water Management Plan, 2005

WRD's Regional Groundwater Monitoring Program consists of a network of about 200 WRD and USGS-installed monitoring wells at 45 locations throughout the District. Monitoring well data is supplemented with information from production wells to capture the most accurate information available. WRD staff, comprised of certified hydrogeologists and registered engineers, provides the in-house capability to collect, analyze and report groundwater data. This information is stored in the District's GIS database and provides the basis to better understand the characteristics of the Central and West Coast Groundwater Basins.

WRD's Safe Drinking Water Program (SDWP) is intended to promote the cleanup of groundwater resources at specific well locations. Through the installation of wellhead treatment facilities at existing production wells, the District hopes to remove contaminants from the underground supply and deliver the extracted water for potable purposes. Projects implemented through the program are accomplished through direct input and coordination with well owners. The current program focuses on the removal of volatile organic compounds (VOCs) and offers financial assistance for the design and equipment of the selected treatment facility.

More information regarding these and other groundwater management programs can be found in the WRD's current Engineering and Survey Report and Regional Groundwater Monitoring Report.

WRD provides extensive information on groundwater quality in both its current Engineering and Survey Report (March 2005) and the Regional Groundwater Monitoring Report (April 2005). Both reports have a section devoted solely to groundwater quality management. The groundwater quality issues facing West Basin customers are summarized in the following sections.

5.2.3 Groundwater Recovery - Saltwater Plume

Although construction of seawater barriers was effective in halting the intrusion of seawater into the WCGB, exiting plumes of brackish water are still trapped behind the barriers. In the early 1990s, West Basin completed the C. Marvin Brewer Desalting facility in the City of Torrance area as a demonstration project for removing and treating brackish water from two existing drinking water wells. Enhancements in the Desalter's water supply and water quality in 2005 included the replacement of two wells with a new, more productive well. This well will have a design capacity of approx. 1,000 to 1,500 gallons per minute (gpm). This corresponds to approximately 1,600 to 2,400 AFY of saltwater treatment capability.

Since 2002, WRD has been operating the Robert W. Goldsworthy Desalter, located adjacent to West Basin's Brewer Desalter. Product water from the Goldsworthy Desalter is delivered for potable use to the City of Torrance's water distribution system.

5.2.4 Recycled Water

The WBWRF, in continuous operation since 1995, has conserved more than 48 billion gallons of imported water by serving reliable supplies of recycled water for a wide variety of non-potable uses. The WBWRF produces five different types of water quality from irrigation water to ultra-pure water for groundwater injection and industrial boilerfeed. Tertiary treated recycled water meeting California Title 22 regulations is produced for non-potable irrigation use through a conventional treatment process of flocculation, coagulation, filtration and disinfection. Some Title 22 recycled water is further treated in a process called nitrification for use in refinery cooling towers.

Barrier water is high-quality recycled water that undergoes lime or microfiltration pretreatment, reverse osmosis and disinfection. The resulting product is higher quality water than the Colorado River or SWP water from Northern California, with one-half the salt concentration of existing groundwater and one-fifth the salt concentration of Colorado River water. This purified water is blended with imported potable water from MWD before being injected into a series of wells that act as a barrier to protect inland fresh water supplies from sea water intrusion. Upgraded treatment facilities are being constructed that will improve the barrier water product quality, including state-of-the-art microfiltration and disinfection with ultraviolet (UV) and hydrogen peroxide.

Reverse Osmosis Units

The last two water quality types are treated with microfiltration and reverse osmosis to an ultra-pure quality for use in refinery boiler feed. More information on West Basin's water recycling efforts is included in Section 8 of this Plan.

5.2.5 West Coast Barrier Monitoring Well

The Barrier Monitoring Well was completed in June 2005. This well will monitor the quality of the groundwater down-gradient of the barrier. West Basin is committed to monitoring and maintaining the high quality of the seawater barrier and surrounding groundwater from migrating contamination sources. The monitoring well will be essential in providing critical water quality data for the surrounding groundwater. The well is located within a 3-6 month groundwater travel time from the barrier injection wells. This will serve as a first line of monitoring the blended water quality.

5.2.6 Ocean Water Desalination

West Basin's Desalination Pilot Project (Pilot Project) marked the first use of microfiltration as a pretreatment to reverse osmosis for ocean water desalination. The goal was two-fold: 1) identify optimal performance conditions and 2) evaluate the water quality. The research findings would then be shared with the rest of the industry on the suitability of microfiltration/ reverse osmosis technology for producing potable water from ocean water.

Since it first began operation, West Basin has identified the optimal operating parameters for desalination and will continue with the research, focusing primarily on water quality. Along with 500 analytical tests performed monthly, additional water quality studies will be completed under the auspices of the American Water Works Association Research Foundation (AWWARF). The Pilot Project's analytical test results indicate that the quality of the desalinated ocean water meets current State and Federal drinking water standards set by the CDHS and the EPA. West Basin's plan for the future is a full-scale desalination plant capable of providing 20,000 AFY of potable water, enough to supply 40,000 families (of four) for a year. More information on West Basin's ocean water desalination efforts is included in Section 9 of this Plan.

5.3 Effects on Water Management Strategies

Retail water agencies in densely populated Southern California are acutely aware of the economic impact of water quality on a public water system. Management strategies must be developed to maintain a safe, reliable supply at reasonable cost without jeopardizing water quality and public health. Water quality, pressure and supply are maintained through operational practices that can include wellhead treatment for contaminated groundwater sources or blending down contaminated groundwater with purchased imported surface water from MWD or high quality groundwater from adjacent purveyors.

WATER FACT

"One Acre-Foot of water equals 325,900 gallons- enough to supply two families of 4 for one year."

5.4 Effects on Supply Reliability

Poor water quality makes a water source unreliable, affects overall supply and increases the cost of serving water to the public. More importantly, it results in a loss of customer's confidence, which can be very difficult to overcome, even after water quality is restored. A water source that fails drinking water regulations must be taken out of service. The source can be restored through treatment or other management strategies.

Groundwater can become impaired through leaching of contaminants into an aquifer or by excessive concentrations of naturally-occurring constituents that impact quality, such as arsenic. Surface water sources become contaminated from human activities in the watershed or through deliberate contamination.

Section 6

Water Conservation

Water Conservation

6.1 Overview

Since the drought of the 1990s, West Basin has been a leader implementing aggressive water conservation programs to help limit water demand in its service area. District programs have included a strong emphasis on education and the distribution of rebate incentives and plumbing retrofit hardware. The results of these programs, in conjunction with passive conservation measures such as modifications to the plumbing and building codes, have resulted in significant reductions in retail water use within West Basin's service area. By current estimates, demand management conservation saves more than 4.5 billion gallons of imported water every year. This represents the average water use of almost 30,000 families (of four) in Southern California.

West Basin's conservation programs are made up of a wide array of cost-effective programs that contribute to conserving water, improving water quality, reducing imported water needs and increasing the region's water supply reliability.

Water Conservation is made of two main elements: Active and Passive. Below is a brief description of these two.

Active Conservation: Water savings produced from incentive based programs: Rebates, Giveaways, Retrofits, etc.

Passive Conservation: Water savings produced from building and plumbing codes, consumer behavioral changes and price responses.

West Basin prides itself in the partnerships it has created with Federal, State and local entities to offer these programs. By developing integrated programs with its partners, West Basin has been able to leverage funding and resources to provide effective programs throughout its region.

This section will present the past and current water conservation efforts West Basin has undertaken since 1990. In addition, this section provides a detailed analysis of West Basin's water conservation programs, implemented in accordance with the California Urban Water Conservation Council's (CUWCC) recommended Best Management Practices (BMPs), followed by a brief description of West Basin's upcoming conservation efforts and its Conservation Master Plan to promote additional water savings for the service area by the year 2030.

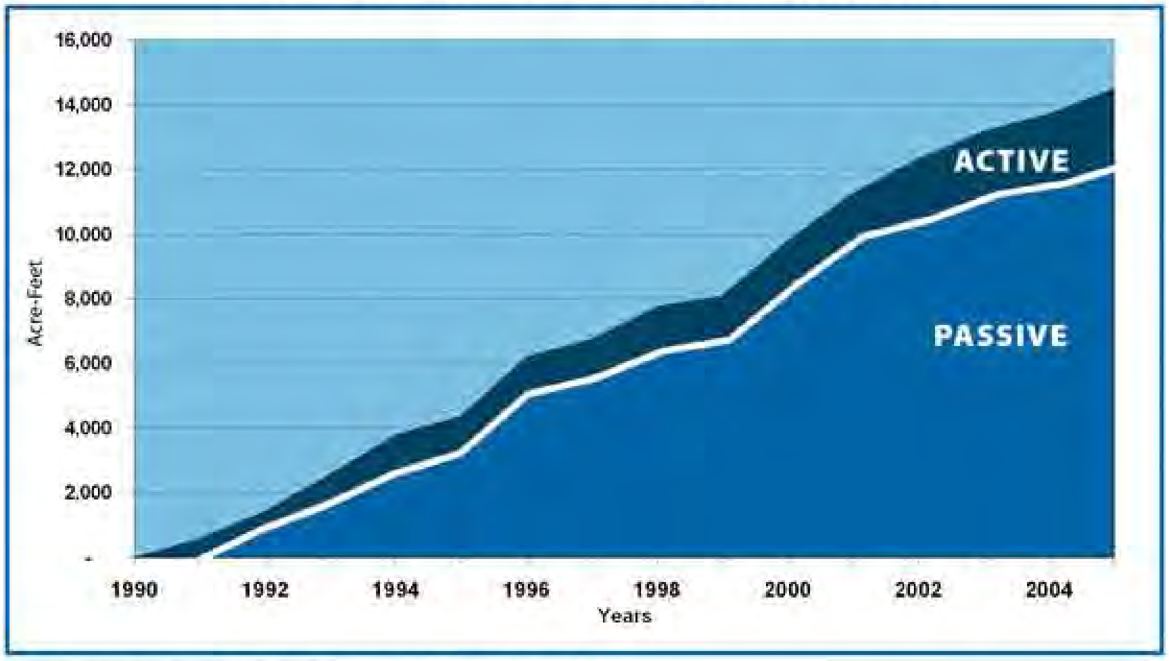
6.2 West Basin's Past and Current Water Conservation Efforts

Today, West Basin's conservation programs are made up of a wide array of cost-effective programs, which include:

- Zero Water Consumption Urinal Program
- Ultra-Low-Flush-Toilets
- High Efficiency Clothes Washer Rebate Program
- Commercial, Industrial and Institutional Rebates
- Commercial Clothes Washers
- Water Brooms
- School Education Programs
- Cooling Towers Conductivity Controllers
- Pre-Rinse Spray Nozzles
- X-Ray Machine Recirculating Devices
- Landscape Conservation Programs
- Weather-Based Irrigation Controller
- Landscape Classes
- Public Outreach

It is estimated that West Basin has distributed and installed more than 274,000 devices from 1990 to 2003. As a result, it is estimated that West Basin currently saves, from active and passive conservation combined, more than 14,500 AF (4.7 billion gallons), or 7% annually, of West Basin's total water demand. The total cumulative savings since 1990 is more than 116,000 AF.

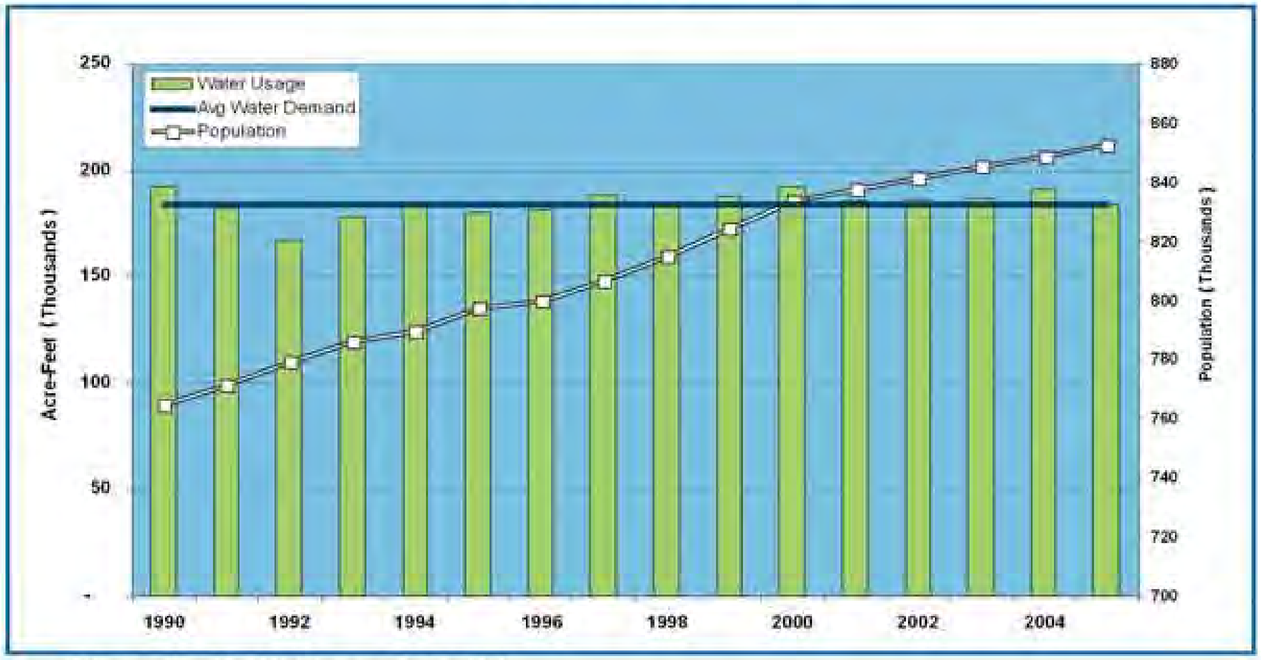
Figure 6-1
West Basin Conservation Water Savings From 1990 to 2005



Source: Estimated total water savings from conservation from MWD-MAIN Model 2004.

Conservation savings can further be verified by comparing West Basin's water usage versus population. As shown in Figure 6-2, water usage has remained relatively consistent while population has escalated an average of 1% annually.

Figure 6-2
Total Retail Water Demand vs. Population Growth
From 1990 to 2005



Source: Information based on MWD Demographic Data, 2005.
Note: The total retail demand does not include replenishment sale i.e. Barrier Sales - RW & Imported.

6.2.1 Metropolitan Water District's Conservation Goal

MWD, in adopting its 2004 IRP Update, is committed to an aggressive water conservation goal. MWD's IRP Update set water supply targets for Southern California through 2025, which includes a conservation target of 1.1 MAF during the next 20 years. MWD's strategy and approach for meeting the conservation targets is outlined in a "Conservation Strategy Plan." The Strategy Plan emphasizes three main areas of incentive based conservation: Residential, Landscape and Commercial, Industrial & Institutional (CII), and provides Board policy guidelines and action plans for the implementation of conservation under MWD's Conservation Credit Program.

6.3 California Urban Water Conservation Council

In 1991, the CUWCC was created to increase water use efficiency by integrating urban water conservation BMPs into the planning and management of California water agencies. It is a partnership of agencies and organizations concerned with water supply and conservation of natural resources in California.

To encourage water use efficiency, the CUWCC asked water agencies and organizations to sign a Memorandum of Understanding (MOU) regarding urban water conservation in California, which committed participating urban water suppliers to use their "good faith efforts" to implement the CUWCC's 14 BMPs. West Basin was one of the first urban water suppliers to become signatory to the CUWCC's MOU. In addition, West Basin has submitted a Best Management Practices Wholesaler Water Agency Report to the CUWCC every other year that details West Basin's progress in implementing the 14 BMPs as currently specified in the MOU. In Appendix F, the District has attached its 2003-04 CUWCC Report.

The BMPs are becoming increasingly important as benchmarks of agency conservation efforts throughout the State. This UWMP, for example, requires agencies that are not members of the CUWCC to describe current and future implementation efforts for all 14 BMPs (referred to as Demand Management Measures, or DMMs). Eligibility for grant funding from State agencies, such as DWR, is now contingent upon satisfactory completion of the urban water management plans and the conservation reporting within them.

6.3.1 Best Management Practices (BMPs)

The BMPs are a list of recommended conservation measures that have been proven to provide reliable savings to a given urban area. There are currently 14 BMPs that a signatory member is committed to implement. Table 6-1 lists the 14 existing BMPs.

Table 6-1
List of Best Management Practices for California Urban Water Conservation Council

1. Residential Water Surveys - Indoor and outdoor audits of residential water use and distribution of water-saving devices

2. Residential Plumbing Retrofits - Distribution or installation of water-saving devices in pre-1992 residences

3. System Water Audits - Unaccounted for water calculated annually and distribution system audits as required

4. Metering with Commodity Rates - Metering of consumption and billing by volume

5. Large-Landscape Conservation - ET-based water budget for large landscape irrigators

6. High-Efficiency Clothes Washers - Rebates for efficient washing machines

7. Public Information - Public information to promote water conservation

8. School Education - Provision of education materials and services to schools

Table 6-1 (Continued)
List of Best Management Practices for California Urban Water Conservation Council

9. Commercial, Industrial and Institutional Conservation (CII)	Programs to increase water use efficiency in CII sectors
10. Wholesale Agency Assistance	Support by wholesalers for conservation programs of retail water suppliers
11. Conservation Pricing	Uniform or increasing block rate structure, volume related water charges and service cost recovery
12. Conservation Coordinator	Designation of staff coordination of agency conservation programs
13. Water Waste Prohibition	Enforced prohibition of wasteful use of water
14. Residential Ultra-Low-Flush Toilet Replacement	Programs promoting replacement of high-water-using toilets with Ultra-Low-Flush Toilets

As a signatory to the MOU, West Basin currently implements the wholesaler BMPs, which are BMPs #3, 7, 8, 10, 11 and 12. Although only certain BMPs apply to a wholesaler, West Basin also provides additional support to its cities and water retailers (customers) through BMP #10. As a water wholesaler representing 17 cities throughout the South Bay, West Basin also supports its customers with BMPs #5, 6, 9 and 14. In order to enhance the programs, West Basin offers partnership opportunities to its customers who can add additional funding and resources in order to increase the size of the programs or rebates, which increases participation and water savings.

6.4 West Basin's Conservation Programs

West Basin's mission is to ensure a safe, reliable supply of water to its service area. Since the drought of the early 1990s, West Basin has strived to expand its role in water use efficiency. Not only is water conservation and education a method for public outreach but an essential part of West Basin's water resources portfolio to drought-proof the region.

Although West Basin is required to meet only the wholesaler BMPs, West Basin is committed to assisting its customer agencies with their conservation efforts. Described below are West Basin's efforts in each of the 14 BMPs.

6.4.1 BMP #1 - Water Survey Programs for Single-Family Residential and Multi-Family Customers

Residential surveys look to all the water using devices inside the home such as toilets, faucets and showerheads. A trained surveyor checks for leaks and tests the flow indoors and outdoors. Once the survey is completed, recommendations are provided for retrofitting certain water use devices, and educational materials are also supplied to the resident.

Because West Basin is a water wholesaler and does not have direct access to single or multi-family customer account data, West Basin can only provide support to the water retailers. MWD currently provides funding for residential survey devices, and if requested, West Basin will act as the liaison to MWD and provide retailers with funding available through MWD. It is anticipated that West Basin will review the market strategy for promoting residential water use surveys within the Conservation Master Plan.

Residential surveys provide cities and water retailers with a great opportunity to provide their customers with a program that offers customer outreach opportunities.

6.4.2 BMP #2-Residential Plumbing Retrofit

This BMP recommends the distribution and retrofit of low-flow showerheads Ultra-Low-Flush Toilets and faucet aerators as well as the adoption of enforceable ordinances.

Since 1990, it is estimated that West Basin has distributed the following number of faucet aerators and low-flow showerheads.

Table 6-2
Residential Plumbing Retrofit Devices

Devices	1990 - 2000		2000 - 2005		Total	
	# units	AF	# units	AF	# units	AF
Faucet Aerators	954	3	0	0	**954**	**3**
Low-Flow Showerheads	215,563	1,014	7,500	35	**223,063**	**1,049**

6.4.3 BMP #3 - System Water Audits, Leak Detection, and Repair

In 1996, West Basin and its sister agency, Central Basin Municipal Water District, partnered with the United States Bureau of Reclamation (USBR) and hired a consultant to develop and provide a Water Audit and Leak Detection Program (Program). The Program was offered to 40 water purveyors. Of the 40, 10 participated in the audit, and of the 10, only three agencies found their unaccounted for water to be above 10%.

According to BMP #3, water retailers shall complete an annual pre-screening system audit of its potable water system to determine the need for a full-scale system audit. This BMP is geared more toward a water retailer, but West Basin has provided support in the past. As part of its Conservation Master Plan, West Basin will seek input from its water retailers regarding support for this program.

6.4.4 BMP #4 - Metering with Commodity Rates for all New Connections and Retrofit of Existing Connections

Since West Basin is a water wholesaler, this BMP does not directly apply. However, every water agency within West Basin's service area bills their retail customers according to meter consumption. This BMP requires that agencies identify intra- and inter-agency disincentives and barriers to retrofitting mixed use commercial accounts with dedicated landscape meters and conduct a feasibility study to assess the merits of a program that provides incentives to switch mixed use accounts to dedicated landscape meters.

By encouraging the installation of dedicated landscape meters, agencies will be able to recommend the appropriate irrigation schedules through future landscape programs.

6.4.5 BMP #5 - Large Landscape Conservation Programs and Incentives

Despite the urbanization of Southern California, the region is dotted with large turf areas that require year-round irrigation to keep them green. Large turf areas include city and county parks, golf courses, schools, cemeteries and street medians. West Basin is reducing demand for imported water for irrigation purposes by providing recycled water in its service area. Virtually anywhere potable water is used to irrigate, recycled water can, and should, replace it. However, in areas where recycled water is not available, West Basin provides other programs to conserve water. Below is a list of the programs West Basin is currently implementing.

Landscape irrigation controllers installed at the City of Gardena's City Hall

Irrigation Controller Programs

In 2004, MWD was awarded a Proposition 13 grant for a new Weather-Based Irrigation Controller (WBIC) Program. MWD and its member agencies developed a Project Advisory Committee (PAC) to work on developing the program, which includes marketing, reporting, databasing and implementing. MWD allocated a limited amount of funding to each member agency for this program. West Basin has been working with the PAC to develop the program. West Basin recognizes the water savings potential and is beginning to test Weather-Based Irrigation Controllers in sites that use potable imported water. The plan is to use the new controllers in areas where recycled water is unavailable. The funding incentives provided vary based on the number of stations and acreage at each site. The funding is used to help pay for the hardware and to help motivate cities, parks and schools to participate in the program.

Protector Del Agua Irrigation Program

West Basin also partners with MWD on the "Protector Del Agua" or "Protector of Water" landscape classes. In partnership with cities, classes are offered to residents as a way to teach them about various topics that help conserve water and reduce urban runoff. Residents learn about gardening with native plants and using Weather-Based Irrigation Controllers to conserve water and reduce runoff. More than 50% of the potable water in Southern California is used for maintaining landscaping; therefore, offering these classes is an ideal way to reduce outdoor water use and waste. By educating the public on properly maintaining the irrigation system, trouble-shooting problems such as over-watering that are simple yet difficult to address can be solved without spending additional funding.

Ocean Friendly Gardens

Also in 2005, West Basin formed a partnership with the Surfrider Foundation to develop "Ocean Friendly Garden" workshops and demonstration gardens. West Basin took the lead in applying for a State grant to help finance the classes. The classes focus on planting "ocean friendly plants" and installing Weather-Based Irrigation Controllers as a way to reduce urban runoff that finds its way to the local waterways and the ocean. The installation of water efficient plants and efficient sprinkler controllers can conserve between 20%-50% of water and reduce runoff by up to 70%.

6.4.6 BMP #6 - High-Efficiency Washing Machine Rebate Programs


HECWS save 50% water and 60% electricity

Beginning in 1999, West Basin participated with MWD in a pilot program with Southern California Edison (Edison) to offer rebates to residents who replaced their existing clothes washer with a high efficiency model. The rebate from Edison varied according to the model purchased (which was tied into the total energy savings), but the amount offered by West Basin and MWD at the time was capped at $35 per washer. That pilot program ended in September 1999.

In 2003, West Basin again partnered with MWD on a new program. MWD received funding from CALFED and provided a higher rebate incentive. West Basin developed the program and offered residents a $100 rebate.

The CALFED portion of the funding expired, but the program was so successful that, at the request of the MWD member agencies, MWD continued to provide funding at the current level. The High-Efficiency Clothes Washer (HECW) Program has exceeded all expectations and continues to be one of West Basin's more successful programs. When the HECWs first hit the market, they were quite expensive, but market demand has helped to drive the price down. The new HECWs cost twice as much as regular inefficient models, but by providing a $100 rebate (along with other utility/store incentives), consumers are purchasing the new HECWs. In addition to saving 50% water, the HECWs also have other benefits: They save 60% electricity and use less detergent. Consumer acceptance has been very positive.

In 2004, the MWD Board of Directors, along with the support of West Basin, approved additional funding to continue the program through 2005. At the same time, MWD applied for Proposition 50 funding in an effort to maintain the program at the higher incentive level through 2006. MWD was successful in its Prop. 50 application and was awarded roughly $1.6 million from the California Department of Water Resources for the High-Efficiency Clothes Washer Rebate Program. This funding will allow MWD and West Basin to continue offering its $100 rebate to residents in an effort to encourage the purchase of high-efficient clothes washers with a Water Factor (WF) of 6.0 or less.

The Water Factor of a clothes washer can range from 13.5 to 3.6, with the lower number being more efficient. A complete list of qualifying washers can be obtained at MWD's web site www.bewaterwise.com, or by calling the District's program vendor at **1-800-442-0467**.

In 2003, the Governor of California signed Assembly Bill 1561 that would require clothes washer manufacturers to only manufacture and provide residential washers with a WF of 8.5 in 2007 and 6.0 by 2010. The legislation was adopted by the California Energy Commission and was submitted to the Federal Government for approval. The Federal Government must approve this legislation before the new standards can be applied. This process is anticipated to take 1–2 years.

As long as funding is available, MWD and West Basin will continue offering its $100 rebate to residential customers for clothes washers with a WF of 6.0 or less. Table 6-3 illustrates the number of rebates West Basin has distributed during the past two years.

Table 6-3
High-Efficiency Washing Machine

	2003	2004	Total
$ per Rebate	$100	$100	**N/A**
# of Rebates	104	602	**706**
Water Savings (AF)	1.6	9.4	**11**

In an effort to continue the successful washer rebate program, MWD along with its member agencies, applied for and received Proposition 50 funding from DWR in the amount of $1,660,000. This funding will allow West Basin to continue its program through 2006.

6.4.7 BMP #7 - Public Information Programs

"Public information" is a very broad term with various meanings. Since West Basin operates a strong outreach program, public information about West Basin and its mission, programs and events are constantly disseminated to many interested parties. The method by which the public receives this information is important.

- The first significant method is the Public Information Committee (PIC), formed several years ago. The Committee is made up of Public Information and Public Affairs Officers from cities and water agencies within West Basin's service area. The purpose is to share information on a variety of topics that would be of interest to customers.
- West Basin, in cooperation with MWD, also provides inspection tours of the Colorado River Aqueduct and the State Water Project to legislators, local elected officials, retail agency staff and the general public on various dates throughout the year. The purpose of the three-day trips is to give local decision-makers a better understanding and appreciation of the water supply throughout the State.
- West Basin, through its Speaker's Bureau, provides speakers to local community groups, service clubs and schools when requested. In addition, West Basin operates a very successful and aggressive school education program that promotes the importance of conservation and water recycling.
- In October 1999, West Basin began its first annual "Water Harvest Festival" located at the West Basin Water Recycling Facility in El Segundo. West Basin invites children and their parents to participate in a variety of games and to obtain information on water recycling and conservation.

West Basin's Annual Water Harvest Festival

- West Basin is also active in the California Water Awareness Campaign (CWAC), which is an association formed several years ago to coordinate efforts throughout the State during "May is Water Awareness Month." With this effort, water agencies throughout the State, large and small, can tap into a large pool of knowledge and materials to promote a water awareness message not only in May but throughout the year.
- West Basin maintains a strong link with the local news media through press releases on important subjects and periodic meetings with newspaper editorial boards.

6.4.8 BMP #8 - School Education Programs

Water and environmental education continue to be critical components of West Basin's outreach strategy. Therefore, West Basin offers a variety of elementary through high school programs free of charge to all schools within its service area. The following is a list of West Basin's current and future education programs.

Descriptions of each program can be found in Section 6.5.

- Planet Protector Water Explorations
- Think Earth It's Magic
- Conservation Connection
- Think Earth Curriculum Kits
- Water Awareness Month Poster Contest
- Water Wanderings: A Journey Through Water
- SEWER SCIENCE

School education tour at West Basin's Water Recycling Facility in El Segundo

6.4.9 BMP #9 - Conservation Programs for Commercial, Industrial and Institutional (CII) Accounts

West Basin, in partnership with MWD, participates in MWD's region-wide CII rebate program. West Basin helps promote these rebates to the businesses, schools and facilities throughout its service area. Rebates are offered for commercial clothes washers, waterbrooms, cooling tower conductivity controllers, pre-rinse spray nozzles, x-ray machine recirculating devices and commercial toilets and urinals.

In 2002, the CUWCC pursued and received a $2.3 million grant from the California Public Utilities Commission (CPUC) to purchase and install restaurant pre-rinse spray nozzle valves. The new nozzles use 1.6 gpm compared to 2 to 6 gpm valves. These valves conserve water and heating costs and reduce waste water discharge. West Basin supported CUWCC's efforts in marketing the program. The nozzles and installations were provided free of charge to the food services sector.

In 2005, West Basin entered into a 10-year agreement with MWD to help support the on-going regional marketing efforts of the CII rebate program. As a way to increase the success of this program, West Basin offers its cities and water purveyors with partnering opportunities to increase the rebate amounts. Through the years, agencies have partnered to provide higher rebate incentives in an effort to increase program participation of their customers.

6.4.10 BMP #10 - Wholesale Agency Programs

The programs provided by West Basin are done in partnership with and benefit the following retail water agencies that are located within the 17 cities serviced by West Basin: 1) California American Water Company, 2) California Water Service Company, 3) City of El Segundo, 4) City of Inglewood, 5) City of Lomita, 6) Los Angeles County Water Works #29, 7) City of Manhattan Beach and 8) Southern California Water Company.

Among the 14 BMPs West Basin provides assistance for are:

- BMP #3 - System Audits
- BMP #5 - Landscape Programs
- BMP #6 - Washing Machines
- BMP #7 - Public Information
- BMP #8 - School Education
- BMP #9 - CII Rebates
- BMP #10 - Wholesaler Incentives
- BMP #12 - Water Conservation Coordinator
- BMP #14 - ULFT Replacement

Since 2000, West Basin has acquired more than $1 million from State and local grant funding sources for program development and implementation. Furthermore, West Basin markets, designs and implements a majority of the BMPs within its service area. West Basin has also invested more than $1 million to provide conservation programs that help increase water supply reliability for the region.

West Basin plans on expanding its conservation programs and the support it provides to cities and water retailers in their conservation program efforts.

WATER FACT

"Just 3% of the world's water exists as fresh water—2% is locked in the polar ice caps; less than 1% resides in freshwater lakes and streams."

6.4.11 BMP #11 - Conservation Pricing

In 2003, West Basin passed through MWD's two-tiered rate structure to its customer agencies to promote water conservation and regional water supply reliability. This rate structure called for customer agencies, in coordination with West Basin, to develop a reasonable budget for their Tier 1 annual maximum limit for imported water. Through voluntary purchase agreements, these customers will pay a higher price (Tier 2) for purchases that exceed their Tier 1 allotment.

To help assist agencies from exceeding their Tier 1 allocation limits, West Basin works with agencies to enhance conservation, education and expand recycled water use.

6.4.12 BMP #12 - Water Conservation Coordinator

As the regional wholesaler, West Basin has a full time water conservation coordinator who not only promotes West Basin's conservation programs and devices but also works with cities and water agencies to enhance their conservation efforts. This close collaboration between West Basin's conservation coordinator and the customer agencies' staff provides for a successful execution of the BMPs. In addition, West Basin's conservation coordinator represents the service area at regional and statewide workshops and organizations.

West Basin's conservation coordinator also seeks Federal, State and local funding to develop new programs on which cities and water purveyors can partner and provide additional benefits to the end-users.

6.4.13 BMP #13 - Water Waste Prohibition

West Basin encourages its customer agencies to adopt water waste prohibition ordinances. West Basin can also assist local cities and agencies in the development of ordinances that will reduce water wasting in the area.

6.4.14 BMP #14 - Residential Ultra-Low-Flush Toilet (ULFT) Replacement Programs

Local residents inspect high efficiency toilet

One of West Basin's more successful programs has been its free ULFT distribution program. Since 1991, West Basin has provided more than 80,000 ULFTs to the public "free of charge" in an effort to conserve water. These devices have proven water savings and have contributed to the overall water reduction through the years.

In 2004, West Basin partnered with MWD on a joint-project to identify the existing opportunity within West Basin's service area for this device. Data shows that there are still many inefficient toilets that need to be replaced. Within West Basin, there is a 30%-40% saturation level in many of its cities. The saturation levels and program performance will continue to be evaluated. For the time being, West Basin plans on continuing to provide ULFTs and rebates as long as funding is available, programs continue to be cost-effective and a significant saturation level has not been met. Due to the large areas of high density and numerous multi-family facilities, there are still many older toilets that need replacing. West Basin will continue to partner with cities and water purveyors in order to implement these programs. In addition, West Basin will continue to offer its $50 rebate for the purchase and installation of ULFTs.

West Basin also provides a $70 rebate for the purchase and installation of Dual-Flush-Toilets. These new toilets have the capability of flushing at either 0.8 gallons for liquids and 1.6 gallons for solids; they average 1 gallon per flush. Also, new 1 gallon per flush High-Efficiency Toilets (HET) are beginning to enter the market place. Advances in technology continue to create new conservation devices that are more water efficient than today's products.

Tables 6-4 and 6-5 illustrate the ULFT Rebate Program and the ULFT Replacement Program for the last five years.

Table 6-4
ULFT Rebate Program

	2000	2001	2002	2003	2004	Total
$ per Rebate	$50	$50	$50	$50	$50	**N/A**
# of Rebates	564	564	377	736	581	**2,822**
Water Savings (AF)	16	16	10	21	16	**79**

Table 6-5
ULFT Replacement Program (Free ULFT Distributions to the Public)

	2000	2001	2002	2003	2004	Total
# of Devices	4,234	2,946	2,214	2,234	1,544	**13,172**
Water Savings (AF)	123	85	64	65	44	**381**

6.4.15 Additional Conservation Programs

West Basin is very active in working with MWD to develop new conservation programs that are included in the CUWCC BMPs. In 2005, MWD implemented several new programs that West Basin supports, including:

Synthetic Turf Program

MWD, in partnership with the USBR, developed and provided funding to test the effectiveness of using synthetic turf. West Basin helped promote the program by issuing press releases and forwarding information to cities, water purveyors, non-profit organizations and others.

City Makeover Program

West Basin continues to support MWD's City Makeover Program. Through a competitive application process, MWD provides funding for development of new water efficient landscapes that promote California native plants and water efficient techniques. More information about this program can be found on MWD's web site, **www.mwdh2o.com**.

Community Partnering Program

MWD, in cooperation with the Member Agencies, accepts applications from non-profit organizations and public agencies that promote discussions and educational activities for regional water quality, conservation and reliability issues. This program provides support for the following types of programs:

- after-school water education
- community water festivals
- watershed education outreach
- environmental museum exhibits
- library water resources education book drives
- public policy water conferences
- other projects that directly support water conservation or water quality education

6.5 Current and Future Education Programs

6.5.1 Current Programs

Planet Protector Water Explorations

Now in its 10th year of operation, Planet Protector Water Explorations is a collaborative water education field trip program between West Basin and the Roundhouse Marine Research Lab and Aquarium in Manhattan Beach. The

Roundhouse is operated by Oceanographic Teaching Stations, a non-profit organization, and is affiliated with the Los Angeles County Office of Education.

The objectives of Planet Protector Water Explorations are:

1. To increase the awareness of water as a valuable and limited resource.
2. To encourage water conservation efforts.
3. To introduce the concept of water recycling.
4. To introduce the concept of ocean water desalination.
5. To increase the awareness of urban runoff pollution.
6. To teach about local marine life.
7. To promote the concept of stewardship of the environment and its resources.

By the end of the 2004-2005 school year, more than 25,000 students will have experienced Planet Protector Water Explorations since the program began in September 1995. Table 6-6 displays the number of students that have been educated through the Planet Protector Water Exploration program from fiscal year 2000-01 to fiscal year 2004-05. Beginning in fiscal year 2004-05, additional programs have become available to students, therefore increasing the number of students that become educated.

Table 6-6
School Education Program

Grade Level	FY 2000-01	FY 2001-02	FY 2002-03	FY 2003-04	FY 2004-05[1]	Total
Grades K-3rd	240	250	480	690	1,014[2]	2,674
Grades 4th-6th	350	575	450	690	1,632	3,697
Grades 7th-8th	70	36	150	120	876	1,252
High School	0	70	30	30	174	304
Total	**660**	**931**	**1,110**	**1,530**	**3,696**	**7,927**

[1] Program includes *Planet Protector Water Exploration* in addition to *Think Earth It's Magic*, *Conservation Connection* and Think Earth curriculum kits for Fiscal Year 2004-05 only.

[2] Only third graders participate in this program.

Think Earth It's Magic

Through West Basin's membership as part of the Think Earth Environmental Education Foundation, Think Earth It's Magic is a collaborative program between West Basin, County Sanitation Districts of Los Angeles County and MWD. Think Earth It's Magic combines Think Earth's award winning environmental education curriculum, which is designed to promote conservation behaviors and stewardship of the environment with an environmental magic show that cleverly ties together what students learn in the classroom. By the end of the 2004-2005 school year, more than 500 elementary school students will have participated in Think Earth It's Magic.

Conservation Connection

We turn on the tap and water flows out. We turn on a lamp and light fills the room. We depend on water and energy. We need water and energy to live in this world. But where do we get the water and energy that we use? And will we always have enough to meet our needs?

Conservation Connection answers those questions, showing the connections between California, our water and energy supply, and us. But providing information is only part of Conservation Connection. The goal of the curriculum is to get students actively involved – in their homes and at school – in conserving water and energy. Within the program, students have the opportunity to survey their family's water and energy use and survey water and energy use at their school.

After gathering data, analyzing their findings and reviewing recommendations, students make, implement and monitor plans to decrease water and energy use. By participating in this action-based curriculum, students will learn to look critically at important environmental issues and take responsibility for finding solutions. By the end of the 2004-2005 school year, more than 500 middle school students will have participated in Conservation Connection.

Think Earth Curriculum Kits

Through West Basin's membership as part of the Think Earth Environmental Education Foundation, all teachers that participate in Planet Protector Water Explorations receive a grade appropriate Think Earth curriculum unit. Think Earth units are usually distributed each March so that teachers have them prior to Earth Day in April. Each Think Earth unit contains a video, two color posters, a teacher's guide and student booklets. The entire Think Earth curriculum is correlated to the California State Content Standards for the following content areas: Language Arts, Science, Social Science and Mathematics. During the past 10 years more than 25,000 students within West Basin's service area have participated in Think Earth.

Water Awareness Month Poster Contest

6th grade student Alex Oetzell from Jefferson School in the City of Redondo Beach with her parents Steve & Vicky Oetzell was honored for the winning poster, "Your Drain's in Pain," depicting the importance of water conservation.

All teachers who have or will participate in Planet Protector Water Explorations are notified each February of the "Water Is Life" Poster Contest, which is sponsored by West Basin and MWD each May. In addition, all teachers at each of West Basin's primary and secondary schools will also be notified. As in previous years, one grand-prize winner is selected and receives a fully-loaded laptop computer during an award ceremony in June. Each grand-prize winner will also have his or her artwork featured in MWD's "Water Is Life" annual calendar. During the past 10 years, more than 25,000 students within West Basin's service area have participated in this program.

6.5.2 Future Programs

Water Wanderings: A Journey Through Water

Water Wonderings is a collaborative classroom visitation program between West Basin and the S.E.A. Lab in Redondo Beach. This collaborative hands-on classroom program will take fourth graders on a 2½-hour journey through California's water. The program will be correlated to many of the fourth grade State standards for social science and science. Included in the program will also be a "touring tide pool," a van outfitted with touch tanks that will enable students to touch live marine creatures and plants. The Program schedule calls for classes to began in October and last through June for this upcoming fiscal year.

SEWER SCIENCE

Staff is currently partnering with the County Sanitation District of Los Angeles County on this exciting high school science program. SEWER SCIENCE is a hands-on laboratory program that teaches students about wastewater treatment. During a week-long lab, students create wastewater, treat it through the use of tanks employing physical, biological and chemical methods, and apply analytical procedures to test its quality. SEWER SCIENCE is correlated to the California State Content Standards for the following high school sciences: chemistry, physics and microbiology. The Program schedule calls for classes to begin in September 2005 and last through June 2006.

6.6 Funding Partnerships

In addition to partnering with MWD on programs, West Basin continually seeks State funding. In 2004 and 2005, the Department of Water Resources and the State Water Resources Control Board provided funding for programs through various chapters of Proposition 50. As a leader in water conservation, West Basin, in partnership with its cities and water retailers, developed several conservation programs and applied to the State's competitive funding process. As funding is awarded, West Basin works with its cities and water purveyors to provide programs to the local communities.

6.6.1 Proposition 50 Programs

In 2005, West Basin, with support from cities, water retailers and environmental groups, applied for and received Proposition 50 – Chapter 7 – Water Use Efficiency Grant Funding for a complete Restroom Retrofit Program in the amount of $294,834. This program will provide older commercial, industrial and institutional facilities that have inefficient devices with a complete restroom retrofit that includes: water-efficient toilets, Waterfree urinals and infrared sink sensor faucets. The program will also provide funding for installation. This new conservation program will be rolled-out in 2006.

In an effort to conserve water outdoors, West Basin also applied for Proposition 50

– Chapter 8 Funding, under the State's Integrated Regional Water Management Grant Program. West Basin partnered with various cities, water purveyors and stakeholders to develop an integrated approach at developing regional programs. Funding is being sought for the purchase and installation of Weather-Based Irrigation Controllers and for the development of "Ocean Friendly Garden" workshops. If successful, West Basin will provide education and devices that will conserve water, reduce urban runoff, reduce imported water and increase local water supply reliability.

6.7 West Basin's Conservation Master Plan

Water Conservation, along with water recycling, will be used to meet a substantial portion of West Basin's gradually increasing water demands. The goal is to minimize West Basin's need for new imported water sources and enhance this drought-proof resource that has no environmental impacts and is not subject to weather conditions.

Measures such as tiered water pricing, financial incentives for the installation of Ultra-Low-Flush Toilets, water efficient washer machines and large landscape irrigation efficiency programs are just some of the ways West Basin provides leadership and results in the conservation arena. Conservation is a key component of West Basin's water resource planning activities and will be implemented to the fullest extent practicable over the long-term.

6.7.1 Water Conservation Master Plan

West Basin is in the process of developing its own specific Conservation Master Plan (Plan) to meet and exceed the goals of the BMPs and MWD's Conservation Strategy Plan. The goal of the Plan is to assess the conservation potential within West Basin's service area and incorporate local stakeholder input into a group of actions and strategies for achieving long-term targets for conservation. The Plan will be launched and completed by the end of the 2005-06 fiscal year.

Section 7

Rates & Charges

Water Rates & Charges

7.1 Overview

The residential water bill in Southern California is most likely the least expensive of a typical household's major utility bills. In fact, tap water can be purchased for much less than a penny per gallon, which is remarkable, considering investments made by water utilities into regulatory compliance, water use efficiency, infrastructure and other reliability programs. This paradox applies to West Basin's service area as well, although residential water bills vary from one retail agency to another agency depending primarily on the mix of source water purchased and/or produced.

Retail agencies that serve exclusively groundwater, for example, tend to have water rates that are lower than those that serve all imported water or a mix of groundwater and imported water. Imported water purchased from West Basin and provided by MWD carries not only the cost of acquiring, importing, purifying (treating) and distributing the commodity throughout the region but also a long-term action plan for ensuring adequate supplies to meet growing demands through conservation, education and new locally produced supplies.

7.2 MWD Rate Structure

In 2002, the MWD Board adopted a new rate structure to support its strategic planning vision as a regional provider of services, encourage the development of local supplies such as recycled water and conservation, and ensure a reliable supply of imported water. To achieve these objectives, MWD called for voluntary purchase orders from its member agencies, unbundled its water rates, established a tiered supply rate system and added a capacity charge. In all, these new rate structure components provide a better opportunity for MWD and its member agencies to manage their water supplies and proactively plan for future demands.

7.2.1 Purchase Orders

One of the important changes in the new rate structure was the call for voluntary purchase orders among MWD's member agencies. The Purchase Order is an agreement between MWD and a member agency, whereby the member agency agrees to purchase a minimum amount (60% of their highest year's delivery of non-interruptible water times 10) of non-interruptible water during a 10-year period - "Purchase Commitment." The economic incentive for a Purchase Commitment is that it entitles the member agency to purchase annually a set amount of non-interruptible water (Tier 1 Annual Maximum) at the lower Tier 1 rate, which is 90% of it's highest year's delivery of non-interruptible water.

In the case of West Basin, the highest delivery of non-interruptible water was 174,304 AF in 1990. As shown below in Table 7-1, West Basin's Tier 1 Annual Maximum is 156,874 AF with a Purchase Commitment of 1,045,824 AF by the end of 2013.

Table 7-1
West Basin Purchase Order Terms

Initial Base Allocation	Tier 1 Annual Maximum (90% of Base)	Purchase Commitment (60% of Base x 10)
174,304 AF	156,874 AF	1,045,824 AF

Since signing a Purchase Order with MWD, West Basin has remained below its Tier 1 Annual Maximum and has been on track to meet its Purchase Commitment by the year 2013.

7.2.2 Unbundled Rates and Tier 1& 2

To clearly justify the different components of the costs of water on a per acre-foot basis, MWD unbundled its full service water rate. Among the components MWD established are:

Supply Rate Tier 1
Reflects the average supply cost of water from the Colorado River and State Water Project.

Supply Rate Tier 2
Reflects the MWD costs associated with developing new supplies, which is assessed when an agency exceeds its Tier 1 limit of firm deliveries.

System Access Rate
Recovers a portion of the costs associated with the conveyance and distribution system, including capital and operating and maintenance costs.

Water Stewardship Rate
Recovers MWD's cost of providing incentives to member agencies for conservation, water recycling, groundwater recovery and other water management programs approved by the MWD Board.

System Power Rate
Recovers MWD's electricity-related costs, such as the pumping of water through the conveyance and distribution system.

Treatment Surcharge
Recovers the treatment cost and is assessed only for treated water deliveries, whether non-intuerruptible or intuerruptible.

The unbundled MWD water rates for calendar year (CY) 2006 are displayed in Table 7-2.

Table 7-2
Metropolitan Water District
Unbundled Water Rate Components
Adopted for 2006

Category of Water	$/AF
Supply Rate Tier 1	$73
Supply Rate Tier 2	$169
System Access Rate	$152
Water Stewardship Rate	$25
System Power Rate	$81
Treatment Surcharge	$122
Total Tier 1 Treated Rate	**$453**
Total Tier 2 Treated Rate	**$549**

7.2.3 Replenishment Service

Although a majority of the MWD water sold is full service at the Tier 1 rate, there is imported water sold at a discounted rate, better known as Replenishment Service Water. This type of water is used for groundwater replenishment. There are two main types of replenishment water–treated and untreated. Because the replenishment water can be interrupted at anytime, MWD has provided a discount to the rates. However, these rates are not tied to the unbundled rate structure illustrated above. These rates are established by MWD to provide the best incentive to replenish the groundwater basins. Replenishment Service rates for 2006 are shown in Table 7-3.

Table 7-3
Metropolitan Water District
Replenishment Service Rate
Adopted for 2006

Category of Water	$/AF
Replenishment Water Rate Untreated	**$238**
Treated Replenishment Water Rate	**$335**

Within West Basin, the only replenishment water sold is the treated replenishment water for customers participating in the West Basin and WRD In-Lieu program.

7.2.4 MWD Capacity Charge

MWD's new rate structure also established a new charge labeled "Capacity Charge." This charge was developed to recover the costs of providing distribution capacity use during peak summer demands. The aim of this new charge is to encourage member agencies to reduce peak day demands during the summer months (May 1 - September 30) and shift usages to the winter months (October 1 - April 30), which will result in more efficient utilization of MWD's existing infrastructure and defers capacity expansion costs. Currently, MWD's Capacity Charge for 2006 is set at $6,800/cubic feet per second (cfs).

The Capacity Charge is assessed by multiplying West Basin's maximum usage by the rate. The maximum usage is determined by a member agency's highest daily average usage (per cfs) for the past three summer periods, as shown below for West Basin's maximum usage for 2006 – 260.5 cfs.

Table 7-4
West Basin MWD
Capacity Charge for 2006

	Peak Flow 2002	Peak Flow 2003	Peak Flow 2004	3-Year Max
West Basin	256.0 cfs	260.5 cfs	258.5 cfs	**260.5 cfs**

Note: These peak flows are based upon West Basin's coincident peak of all its MWD connections.

7.2.5 Readiness-to-Serve Charge

The Readiness-to-Serve Charge (RTS) recovers a portion of MWD's debt service costs associated with regional infrastructure improvements. The RTS charge is a fixed charge assessed to each member agency regardless of the amount of imported water delivered in the current year. Rather, it is determined by the member agencies' firm imported deliveries for the past 10 years. West Basin meets this obligation through its commodity rates.

7.3 West Basin's Imported Water Rates

As MWD adopted a new rate structure so did West Basin. In 2003, West Basin passed through MWD's Purchase Order by offering customer agencies voluntary purchase agreements and assessing MWD's new Capacity Charge. West Basin also revised the administrative surcharge to be applied uniformly to all classes of imported water sold. Described below are elements of the rate structure that West Basin applies to the delivery of imported water.

7.3.1 Purchase Agreements

In order to meet the Purchase Order commitment with MWD, West Basin established its own purchase contract policy with its customer agencies. West Basin's Imported Water Purchase Agreements mimic the MWD version in terms of an Annual Tier 1 Maximum and Total Purchase Commitment but offer more flexibility to the customer. West Basin requires only a five-year commitment as opposed to a 10-year term. Furthermore, customer agencies have the option to adjust their Tier 1 and Purchase Commitment amounts annually if certain conditions are favorable and can also reduce their commitment amounts by offsetting imported water demand with recycled water purchased from West Basin. For purchases above the Tier 1 limit, or in the absence of a Purchase Agreement, the customer agency pays the Tier 2 rate (currently $81/AF above the Tier 1 rate).

Every customer agency of West Basin signed an imported water Purchase Agreement.

7.3.2 Administrative Surcharge

One of the main revenue sources for West Basin is the Administrative Surcharge applied to all imported water sold. In 2003, West Basin revised the Administrative Surcharge to be uniformly applied to all imported water regardless of the type delivered. Revenue from the surcharge recovers West Basin's administrative costs including planning, outreach and education, and conservation efforts. As of July 1, 2005, West Basin's Administrative Surcharge is at $32/AF.

7.3.3 Readiness-to-Service Surcharge

As described above, MWD levies to West Basin a RTS charge to recover a portion of its debt service costs. Thus, a RTS surcharge is added to West Basin's commodity rates for Non-interruptible and Barrier water to cover this charge. As of January 1, 2006, West Basin's RTS surcharge will be $60/AF.

7.3.4 Water Service Charge

Water utility revenue structures benefit from a mix of fixed and variable sources. West Basin's Water Service Charge recovers a portion of the agency's fixed administrative costs but is a relatively small portion of its overall revenue from water rates. As of July 1, 2005, the Water Service Charge is $20/cfs of a customer agency's meter capacity for imported water meters.

7.3.5 West Basin's Capacity Charge

This charge, as described in Section 7.2.4, is intended to encourage customers to reduce peak day demands during the summer months, which will result in more efficient utilization of MWD's existing infrastructure. West Basin has passed this MWD charge onto its customer agencies by mimicking MWD's methodology. Each customer's Capacity Charge is determined from their highest daily average usage (per cfs) for the past three summer periods. However, because MWD assesses West Basin on the coincident daily peak of all the connections and aggregate of all its customers' daily peak is the non-coincident peak, West Basin is able to lower the Capacity Charge to its customers from $6,800/cfs to $5,700/cfs.

7.3.6 Desalter Water Charges

West Basin also sells the water produced by the Brewer Desalter at the effective MWD rate. This includes the MWD Non-interruptible base rate and an acre-foot equivalent for the Capacity Charge. Currently, the rate for desalter water is $465/AF.

7.4 Recycled Water Rates

West Basin's water recycling program is one of the largest in Southern California, delivering more than 28,000 acre-feet of highly treated recycled water to more than 200 sites annually. The West Basin Water Recycling Facility in El Segundo provides five different qualities of "designer" water to meet the needs of landscape irrigation, cooling towers, refineries and industries within the Los Angeles County South Bay region. The WBWRF also has the potential to expand its delivery up to 100,000 AF of recycled water.

Since 1995, West Basin has encouraged the maximum use of recycled water to industries, cities and landscape irrigation sites through its water quality and economic incentive of its rates and charges. Below is a description of West Basin's recycled water rates and charges.

7.4.1 Recycled Water Rates

West Basin contains seven different rates for recycled water. Each rate differs because of the treatment quality, power and location. All rates, however, are assessed to cover the operation and maintenance costs, and labor and power costs associated with the delivery of recycled water. A majority of these rates are set up in a declining tiered structure so they may further encourage the use of the recycled water, while the others are set up to service one or more customers at a uniform rate.

Most of these rates are set lower than West Basin's imported rates to encourage the usage of recycled water. Only highly treated recycled water deliver to the refineries are set above imported rates. West Basin's recycled water rates for FY 2005-06 are shown in Table 7-5.

Table 7-5
West Basin Recycled Water Rates Fiscal Year 2005-06

Volume (AF/Month)	West Basin Service Area	West Coast Barrier	Industrial R/O (WB Svc Area)	Nitrified (Ind R/O usage)	Industrial R/O Ultra (WB Svc Area)	Torrance / LADWP Service Areas	Palos Verdes Zone Rate
0-25	$312/AF	$430/AF	$568/AF	$292/AF	$750/AF	$354/AF	$548/AF
25-50	$292/AF	$430/AF	$568/AF	$292/AF	$750/AF	$334/AF	$528/AF
50-100	$272/AF	$430/AF	$568/AF	$292/AF	$750/AF	$314/AF	$508/AF
100-200	$252/AF	$430/AF	$568/AF	$292/AF	$750/AF	$294/AF	$488/AF
200+	$232/AF	$430/AF	$568/AF	$292/AF	$750/AF	$274/AF	$468/AF

The "out of service area" rate is assessed to customers outside of West Basin's service area boundaries, which pay an additional $40/AF per tier. This additional charge is applied to make up for the recycled water standby charge they are not levied on their parcels.

7.4.2 Recycled Water Standby Charge

There is a recycled water standby charge that is levied by West Basin to each parcel within the service area. An average rate of $24 per parcel is administered by West Basin to provide a source of non-potable water completely independent of drought-sensitive supplies. The revenue collected from this charge is used to pay the debt service obligations on the West Basin Water Recycling Facilities. Each year the Board holds a public hearing where they adopt West Basin's Engineer's Report and Resolution to assess this charge.

Recycled water at the Good Year Airship Station located in the City of Carson

7.5 Future Water Rate Projections

As the demand for water increases in Southern California so does the cost to administer, treat and distribute imported and recycled water. However, West Basin has worked diligently to ensure that stable and predictable rates are managed for the future. Below are discussions of imported and recycled water rate trends during the next 10 years.

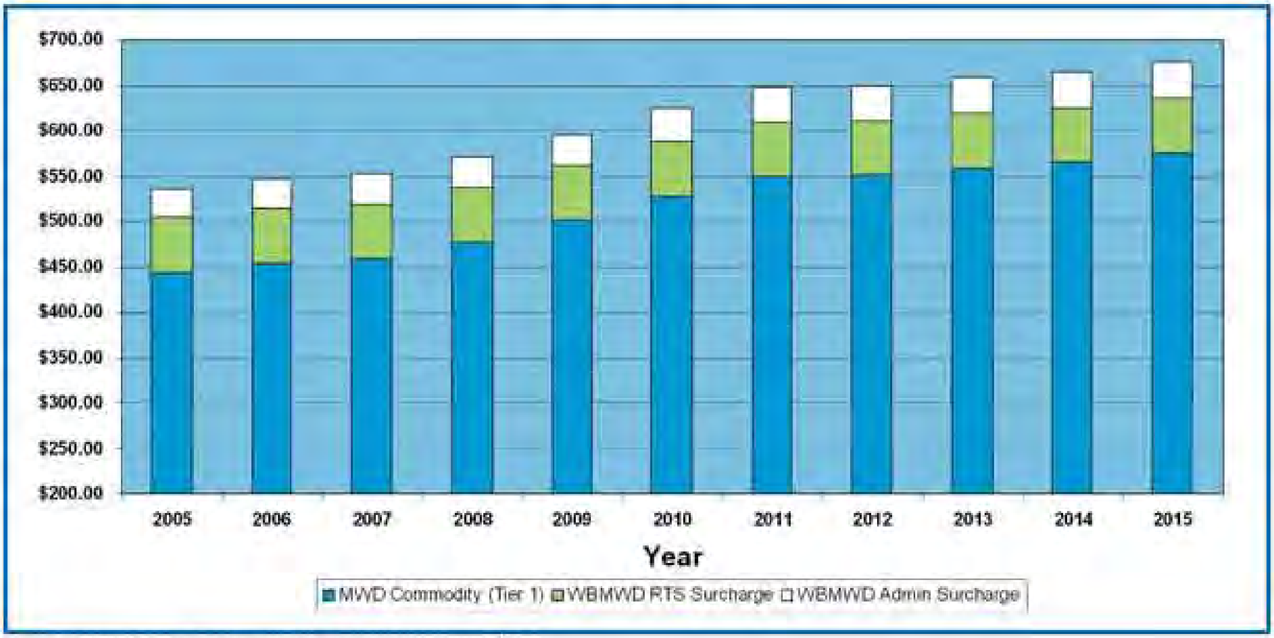
7.5.1 Imported Water Rate Projections

In 2004, the MWD Board adopted its Long Range Financial Plan. This plan was developed to forecast future costs and revenues necessary to support its operations and capital investments. Furthermore, it lays out the financial policy MWD will pursue during the next 10 years. According to projected MWD sales, with investments into local resources, MWD estimates imported water rates will increase 4-6% annually.

West Basin's Administrative Surcharge is projected to increase at an annual average rate of 3%-4%. This increase is determined by West Basin's Long Range Financial analysis and the budget's revenue requirements.

Figure 7-1 (on the following page) displays West Basin's imported water rate projections for the next 10 years.

Figure 7-1
West Basin Imported Water Rates
10-year Projections



Source: MWD 2004 Long Range Financial Plan & West Basin's Financial Plan.

7.5.2 Recycled Water Rate Projections

Similar to imported water rates, recycled water rates are expected to increase because of higher treatment, maintenance and power costs. However, West Basin believes in setting recycled water rates at a competitive level to help offset the use of imported water. To achieve this economic incentive, recycled water rates have been projected by West Basin to increase at a slightly lower level than imported water. The recommended rates are projected to increase for all types of recycled water, by an average of 3% annually. However, these rates may vary depending upon energy and chemical costs.

Section 8

Water Recycling

Water Recycling

8.1 Overview

Recycled water is a cornerstone of West Basin's efforts to augment local supplies and reduce dependence on imported water. Since planning and constructing its recycled water system in the early 1990s, West Basin has become an industry leader in water re-use. Recycled water is used for non-potable applications such as landscape irrigation, commercial and industrial processes, and indirect potable uses such as groundwater replenishment. An additional benefit of West Basin's recycled water is less ocean discharge of treated wastewater into the Santa Monica Bay.

In 2005, West Basin delivered 24,069 AF of recycled water to customer agencies inside and outside its service area. Within West Basin's service area, M&I recycled water totaled 13,065 AF, representing approximately 7% of the District's current total water supplies. According to projections, recycled water sales will represent 17% of the District's total water supplies by the year 2030.

This section will provide an overview of the District's water recycleing system, its treatment process at its El Segundo Plant and a description of its distribution systems. In addition, a description of the District's past, current and projected sales inside and outside of its service area will be discussed, concluding with a discussion of West Basin's system expansion projects and plans to encourage future recycled water use.

8.2 Recycled Water Sources and Treatment

8.2.1 Source Water

The source of West Basin's recycled water is from the City of Los Angeles's Hyperion Wastewater Treatment Plant (Hyperion). The City of Los Angeles has operated Hyperion, located adjacent to West Basin's service area, since 1894. Initially built as a raw sewage discharge plant into the Santa Monica Bay, it has been upgraded through the years to partial secondary treatment (1950) and most recently to full secondary treatment (1998). Hyperion has a dry weather capacity of 450 mgd for full secondary treatment and an 850 mgd wet weather capacity. Hyperion has a daily influent of 362 mgd, or 405,000 AFY, and secondary treatment capacity of 450 mgd. West Basin recycles approximately 24 mgd, or roughly 7.7% of the effluent from Hyperion. Ocean disposal accounts for the balance of the secondary effluent from Hyperion.

West Basin purchases secondary effluent from Hyperion prior to ocean disposal and provides, at a minimum, tertiary treatment and disinfection to meet applicable Title 22 standards. More advanced treatment is provided according to customer specifications. West Basin treats and distributes recycled water at its Water Recycling

Treatment Facility (WBWRF), located in the city of El Segundo, to customer sites in its service area as well as to sites in the City of Torrance and the City of Los Angeles. Figure 8-1 shows the WBWRF, located in the City of El Segundo in Los Angeles County.

Figure 8-1
West Basin's Water Recycling Treatment Facility

8.2.2 Treatment Process

City of Los Angeles' Hyperion Wastewater Treatment Plant

The effluent received from Hyperion is limited by the City of Los Angeles' (City) National Pollutant Discharge Elimination System permit. Although the City strives to provide West Basin with a consistent quality of secondary treated wastewater, the WBWRF has to accommodate inevitable fluctuations in influent quality. Table 8-1 illustrates the amount of historical, current and projected wastewater collected and treated at Hyperion and the amount of recycled water that West Basin treats to Title 22 standards, the minimum treatment standard at the facility. There are other qualities of water that are treated, named "Designer Water," explained in further detail on the next page.

Table 8-1
Wastewater Collected and Treated
(AF/Calendar Year)

	2000	2005	2010	2015	2020	2025	2030
Wastewater collected & treated in service area[1]	355,000	390,000	425,000	465,000	500,000	335,000	570,000
Quantity that meets recycled water standard[2]	21,900	32,500	48,000	58,100	62,000	66,000	70,000

[1] Data supplied by the Hyperion Wastewater Treatment Plant

[2] Data supplied by West Basin's Water Recycling Treatment Facility

Most of West Basin's recycled water undergoes a treatment process to clarify it to quality standards to meet California Code of Regulations Title 22 (Title 22). The level of treatment necessary is approved by the California Department of Health Services (CDHS). Title 22 addresses specific treatment requirements for recycled water and lists approved uses. Approximately 2,000 tests are performed monthly at the WBWRF to ensure water quality meets or exceeds all State and Federal requirements. West Basin's Water Recycling Program is unique in that it provides a variety of products that are developed at one or more facilities to meet specific customer specifications ("designer water"). In all, West Basin produces five different qualities of recycled water:

- *Disinfected Tertiary Water* - Tertiary recycled water is treated secondary water from Hyperion that undergoes coagulation, flocculation, filtration and disinfection to meet Title 22 standards. Tertiary water can be used for a wide variety of industrial and irrigation purposes where high-quality, non-potable water is needed.

- *Nitrified Water* - Nitrified recycled water is tertiary treated water that has been nitrified to remove ammonia, which can be corrosive to pipe material. This water is used in industrial cooling towers.

- *Softened Reverse Osmosis Water* - Softened reverse osmosis water is secondary treated water from Hyperion that has been pretreated with microfiltration and lime softeners and then treated with reverse osmosis. The water is softened because it can be corrosive to pipe material. This water is used in the seawater barrier to protect the South Bay's coastal groundwater reservoirs against saltwater intrusion from the Pacific Ocean and to replenish the groundwater supplies. Softened reverse osmosis water is superior to State and Federal drinking water standards. West Basin is currently undergoing a major capital project to add both ultraviolet light as well as advanced oxidation to the barrier system, further ensuring the quality of this water and making it the most advanced water treatment facility in the world for recycled water.

- *Pure Reverse Osmosis* - Pure reverse osmosis water is secondary treated water from Hyperion that has been pretreated with microfiltration and further treated with reverse osmosis. This water is used for low pressure boilerfeed water for large scale industrial sites such as refineries.

- *Ultra-Pure Reverse Osmosis Water* - Ultra-pure reverse osmosis water is secondary treated water that has been pretreated once with microfiltration and then treated twice with reverse osmosis. Since this water is used for high pressure boilers, it is important that no mineral buildup occurs on the equipment. This water can be used multiple times (cycles) as boilerfeed water before being discharged.

8.3 West Basin's Recycled Water System

8.3.1 Existing System

In 1995, West Basin opened its state-of-the-art water recycling facility in El Segundo, which is still one of the largest recycled water facilities of its type in the nation. West Basin's facility has a current capacity of 35 mgd with a 15 mgd expansion expecting to come online in early 2006. In 2002, West Basin was recognized by the National Water Research Institute as one of the six National Centers for Water Treatment Technologies in the country, and this past year the District celebrated the facilities 10-year anniversary of its continuous operation. To date, West Basin has saved more than 48 billion gallons of potable water that would have otherwise been imported from Northern California and the Colorado River.

Figure 8-2
West Basin Water Recycling System

As Figure 8-2 shows, West Basin's water recycling system serves the cities of Carson, El Segundo, Gardena, Hawthorne, Hermosa Beach, Inglewood, Manhattan Beach, Lawndale, Redondo Beach and unincorporated areas of Los Angeles County. The District also serves the Cities of Torrance and Los Angeles, which are both outside of the District's service area.

All recycled water is produced initially at the WBWRF where it is distributed to either end-use sites or one of several satellite facilities. In all, more than 200 sites currently use more than 8 billion gallons annually.

Victoria Golf Course, located in the City of Carson

The recycled water distribution infrastructure is separate from the drinking water system. All pipes, pumps and other equipment used to transport recycled water are clearly identified as recycled water to distinguish them from the potable drinking water system.

8.3.2 Recycled Water Use by Type

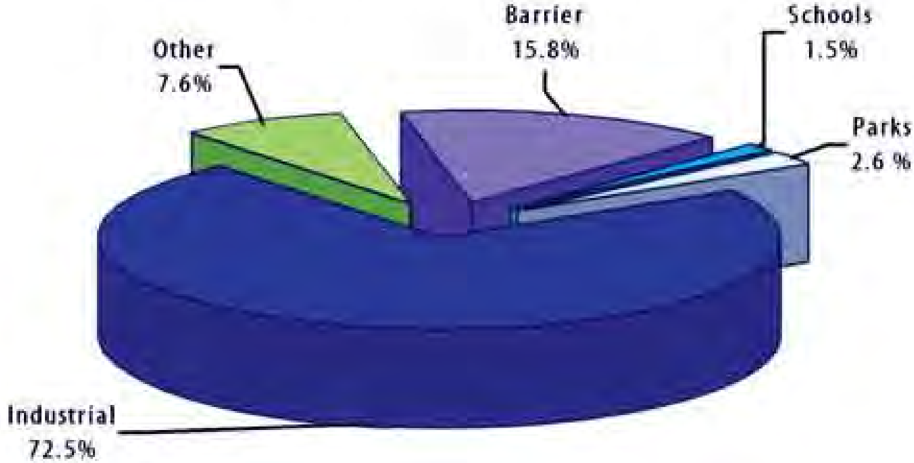
The type of customers West Basin currently delivers recycled water, as shown in Table 8-2, varies from parks and landscape medians to refineries and industries.

Table 8-2
Types of Recycled Water Customers

• Cemetery	• Multi-use
• Industries	• Parks/ Sports Fields
• Golf Courses	• Schools (irrigation)
• Replenishment (Barrier)	• Street Sweeping/ Sewer Flushing
• Landscape & Medians	• Refineries
• Cal-Trans (irrigation)	• Others

Figure 8-3 shows the distribution of West Basin's total FY 2004-05 sales by type of use. The predominate area of recycled water deliveries are to the refineries, making up roughly 72% of the total use. In the upcoming years with expanding the system, the District plans to increase deliveries in both the landscape irrigation and Barrier sector.

Figure 8-3
West Basin Recycled Water Use By Type of Site FY 2004-05

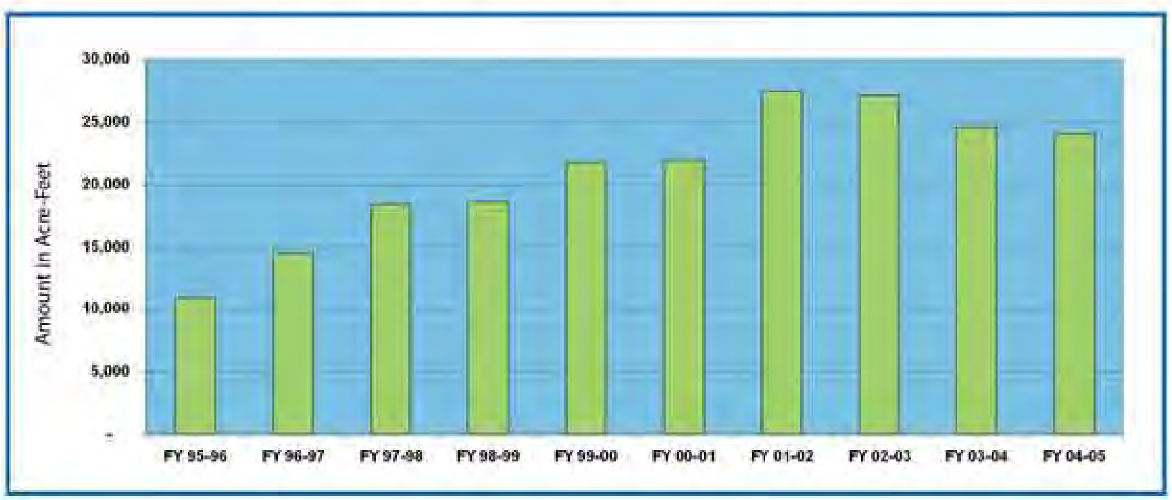


8.3.3 Historical and Current Sales

Historical Water Sales

West Basin's historical recycled water sales for the past 10 years are illustrated in Figure 8-4. Sales increased until 2002-03 and declined in subsequent years due to a change in the source water from Hyperion, which reduced the acceptability of recycled water for the West Coast Barrier Project. After identifying the source of the quality variance, West Basin designed and built a high rate clarifier treatment facility to restore the barrier water to even higher quality standards. The high rate clarifier will go online in early 2006 enabling West Basin to increase barrier use by 5,000 AFY beyond the original level.

Figure 8-4
Historical Recycled Water Sales From FY 1996-2005



The amount of recycled water the District has been able to delivery inside and outside of its service area during the last 10 years have total more than 209,000 AF, replacing enough potable water to supply the needs of approximately 418,000 families of four for an entire year. West Basin anticipates recycled water sales to increase in the future due to system expansions, new applications, increasing public acceptance and economic incentives.

Table 8-3 provides a more detailed breakdown of historical sales by showing each retail customer agency's annual purchases for the past 10 years.

Recycled water filters at West Basin's Water Recycling Facility

Table 8-3
West Basin Historical Recycled Water Sales
FY 1996-2005
(In Acre-Feet)

West Basin	FY 95-96	FY 96-97	FY 97-98	FY 98-99	FY 99-00	FY 00-01	FY 01-02	FY 02-03	FY 03-04	FY 04-05	TOTAL
CWS - Dominguez	-	-	-	4	1,317	3,297	3,165	3,101	3,639	3,616	18,139
CWS - Hawthorne	26	78	75	92	94	90	116	101	112	111	894
CWS - Hermosa Redondo	26	67	88	128	141	133	130	130	144	107	1,095
City of El Segundo	1,709	3,610	3,943	3,756	4,050	3,542	7,632	8,102	8,310	7,868	52,523
City of Inglewood	243	708	516	533	706	622	707	577	638	595	5,845
City of Manhattan Beach	181	197	177	197	230	272	307	254	301	274	2,389
Inglewood Unified School District	-	-	-	12	22	24	31	30	67	60	246
Southern California Water Co.	121	442	279	240	273	237	282	315	432	435	3,055
West Basin Inland Use	502	631	515	330	-	-	-	-	-	-	1,978
Industrial & Irrigation Subtotal	2,808	5,732	5,593	5,293	6,833	8,216	12,371	12,610	13,643	13,065	86,163
WRD (Replenishment-Barrier)	4,609	5,062	8,355	7,081	7,539	6,753	7,290	6,754	3,935	3,799	61,177
West Basin's Service Area Total	7,417	10,794	13,948	12,374	14,372	14,969	19,660	19,364	17,578	16,864	147,339
City of Torrance	-	-	-	-	22	91	117	144	196	186	757
City of Torrance - Mobil	3,466	3,653	4,334	6,157	7,030	6,558	7,212	7,328	6,385	6,735	58,858
LA Dept. of Water and Power	-	-	84	138	268	357	398	277	394	283	2,200
Outside West Basin's Service Area Total	3,466	3,653	4,418	6,295	7,321	7,006	7,727	7,750	6,975	7,205	61,815
TOTAL	10,883	14,447	18,366	18,669	21,693	21,975	27,387	27,114	24,553	24,069	209,154

As discussed above, West Basin's water recycling system services the Cities of Torrance and Los Angeles, which are located outside of the District's boundaries. Therefore, although the total usage within West Basin was 16,863 AF this past year, the total amount of recycled water delivered by West Basin was 24,068 AF.

Table 8-4
Recycled Water Uses 2000 Projections Compared with 2005 Actuals
AF/Fiscal Year

Type of Use	2000 Projection for 2005	2005 Actual Use
Irrigation/Industrial	33,000	20,268
West Coast/Dominguez Barrier	15,000	3,800
Total	**48,000**	**24,068**

In West Basin's 2000 UWMP, the District projected deliveries of recycled water within its service area to reach 33,000 by 2005. As shown in Table 8-4, actual sales in 2005 fell significantly below this target. This was mainly due to setbacks in expanding the water recycling program in the southern area of the District, which resulted in many large industrial customers not being able to connect. In addition, water quality problems at Hyperion impacted deliveries to the West Coast Barrier. However, with the recent plant expansion projected to be online, next year deliveries should place the District back on target.

8.3.4 System Expansions and Projected Sales

Harbor/South Bay Water Recycling Project

Recycled water used at California State University, Dominguez Hills

Currently, the Harbor/South Bay Water Recycling Project (Harbor/South Bay), a federally funded partnership project between West Basin and the U.S. Army Corps of Engineers, is under construction and consists of 16 component projects with 68 miles of combined pipelines. The first two laterals of the overall project, the Victoria Lateral and the California State University at Dominguez Hills (CSUDH) Mainline Extension, were successfully completed in April 2003.

Harbor/South Bay is scheduled for completion in 2010 and is expected to conserve more than 490 million gallons of potable water annually.

The $3 million Victoria Lateral Project added nearly 1.4 miles of pipeline throughout the City of Carson. The project delivers approximately 4 million gallons of recycled water daily for landscape irrigation and industrial application at local sites, which include medians along Avalon Boulevard, the Links at Victoria Golf Course and the Victoria Regional Park.

The $1.8 million California State University at Dominguez Hills (CSUDH) Mainline Extension consists of a recycled water transmission pipeline connecting to the end point of the Victoria Lateral and serving irrigation sites and cooling towers on the CSUDH campus. The pipeline also serves the newly-built Home Depot National Training Center, including the soccer stadium field.

In addition to the completion of the Victoria Lateral Project and CSUDH Mainline Extension, on-going 2005 activities of the Harbor/South Bay Project include: design and construction of the Madrona Lateral and a lateral to serve Los Angeles Southwest College and the pre-design of the Palos Verdes Extension and Lateral V. The customers served by the Palos Verdes Extension will include parks and schools in the City of Torrance along with several golf courses, parks, schools and a cemetery in the Palos Verdes Peninsula area. This project is detailed below.

West Basin Water Recycling Facility Phase IV Expansion

Undergoing its fourth expansion in 10 years, WBWRF will add an additional 5 mgd of barrier water treatment capacity by the end of 2005 and 10 mgd of Title 22 treatment capacity in 2006 to supply the Harbor/South Bay System expansion. The barrier water expansion will enable the blend of seawater barrier injection to increase to 75% recycled water (and 25% potable water) by upgrading the existing 7.5 mgd train with microfiltration pre-treatment, adding a new 5 mgd train of microfiltration and reverse osmosis, and introducing ultraviolet disinfection to the entire 12.5 mgd process. The higher blend of ultra-pure recycled water in the source water for barrier injection will not only improve the quality of the groundwater basin and conserve potable water but also lower water costs to WRD (the purchaser of the recycled water) and enhance ecosystem benefits.

Additional upgrades to the WBWRF will also be implemented, including removal of the lime clarification system, modifications to the solids de-watering system and the addition of clarifiers upstream of the Title 22 Filters.

Madrona / Palos Verdes Lateral Extension

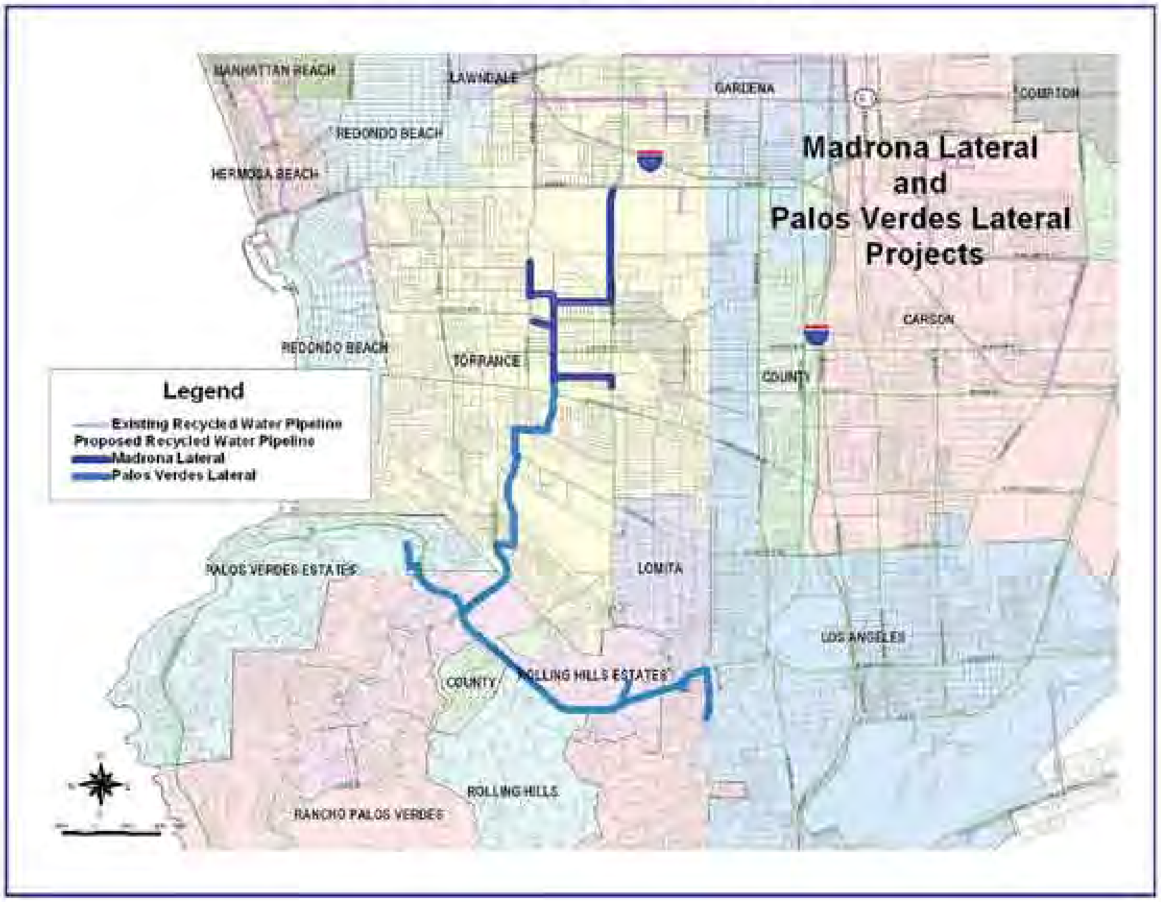
The Madrona Lateral will consist of 20,100 linear feet of pipeline, which will provide recycled water for non-potable use to several sites in the City of Torrance, including Charles Wilson Park and Madrona Middle School. This $9 million project is expected to be completed by late 2005. This lateral represents a stepping stone to the Palos Verdes Peninsula.

The Palos Verdes Lateral will serve several large irrigation customers along the north side of the Palos Verdes Peninsula such as Palos Verdes Golf Club, Rolling Hills Country Club, Los Angeles County Sanitation District landfill and Green Hills Memorial Park (cemetery). This 34,000 linear-foot pipeline is currently in its pre-design phase and is targeted to be completed in early 2007 at a cost of $17 million.

West Basin recently applied for State funding through Proposition 50 for the Madrona / Palos Verdes Lateral project. This construction project is an extension of West Basin's existing water recycling distribution system that will serve the City of Torrance and various cities throughout the Palos Verdes Peninsula. This project includes approximately 64,000 linear feet of pipeline that will ultimately serve up to 17 sites with more than 800 AFY of recycled water to public and private entities. Recycled water for this project will be provided by the WBWRF. Construction on the Madrona Lateral began in January 2005 while design for the Palos Verdes Lateral was underway. The Madrona Lateral is expected to be completed in April 2006 and operational soon thereafter. Construction of the Palos Verdes Lateral is expected to be complete by December 2006 and operational by June 2007.

West Basin will provide recycled water via the Palos Verdes Lateral to the Palos Verdes Peninsula to reduce demand on imported water. The ability for West Basin to produce and distribute this water locally means less impact on fragile ecosystems, less energy to pump water long distances and a drought-proof supply of water. As an added benefit, the cost to produce this water will be less than the cost of imported supplies. An extra 800 AFY of recycled water saves potable water for approximately 1,600 families of four every year and reduces the amount of wastewater that is discharged into the ocean. Figure 8-5 illustrates the Madrona and Palos Verdes Lateral projects in West Basin's service area.

Figure 8-5
Madrona and Palos Verdes Lateral Projects



Projected Sales

As discussed in Section 8.3.3., recycled water sales in fiscal year 2004-05 totaled 24,068 AF. The Phase IV Expansion of the WBWRF and the Harbor/South Bay System Expansion are expected to enable West Basin to add a minimum of 40,000 AF of sales by 2030. One key to further expanding the system, and increasing sales, is West Basin's partnership with the City of Los Angeles. Additional oil refineries within the harbor area of Los Angeles, but proximal to West Basin's existing system, represent a large untapped potential for high-quality recycled water sales. A proven track record with West Basin's existing refinery customers is expected to convince others that recycled water can increase reliability and reduce costs in water management. Roughly 37,500 AFY of projected recycled water sales through 2030 are attributable to the refinery/industrial sector. Table 8-5 illustrates the projected increase of recycled water during the next 25 years.

Table 8-5
Projected Recycled Water & Deliveries by West Basin
(In Acre-Feet)

	2010	2015	2020	2025	2030
Industrial & Irrigation	21,848	32,500	36,250	40,000	43,750
West Coast Barrier (Replenishment)	17,500	17,500	17,500	17,500	17,500
West Basin's Service Area Total	**39,348**	**50,000**	**53,750**	**57,500**	**61,250**
City Torrance	6,650	6,650	6,650	6,650	6,650
City of Los Angeles	1,400	1,400	1,400	1,400	1,400
Outside West Basin's Service Area Total	**8,050**	**8,050**	**8,050**	**8,050**	**8,050**
Total	**47,398**	**58,050**	**61,800**	**65,550**	**69,300**

8.3.5 Potential Recycled Water Use

West Basin is currently acting to fulfill the potential identified in its 2000 Master Plan as well as other opportunities that have emerged since that Plan was completed. Although limited to an extent by economic feasibility of reaching end users that are not near existing infrastructure, the potential for increased use of recycled water continues to grow with greater acceptance of its use in different applications. Fabric and carpet dying, for example, are areas that represent a significant opportunity for increased sales for West Basin.

West Basin will continue to pursue new cost-effective projects both within and outside its service area. Although there are challenges and limitations in connecting customers, such as in the Palos Verdes peninsula, there is great potential. The limitations in connecting customers due to their challenges dictate when and how much recycled water will be sold in the future.

The 2000 Master Plan identified and prioritized areas where recycled water has the potential to expand. In this Plan, a database was established to locate and identify future customers. The approach considered pipeline routing, hydraulic analysis and economic interests to project the growth of the system. Much of these findings evolved in the system expansion projects discussed in section 8.3.4.

8.3.6 Encouraging Recycled Water Use

West Basin's marketing efforts have been successful in changing the perception of recycled water from merely a conservation tool with minimal application to a business enhancement tool that lowers operating costs while increasing the reliability of the water supply. West Basin markets recycled water as a resource that:

- Is less expensive than potable water;
- Is more reliable than imported water in a drought and
- Is consistent with statewide goals for water supply and ecosystem improvement on both the SWP and Colorado River systems.

The target customer is expanding from traditional irrigation users such as golf courses and parks to unconventional commercial and industrial users. Through innovative marketing, recycled water is now being used by oil refineries and for cooling towers. In addition, West Basin investigating recycled water use in fabric dye houses, co-generating plants and commercial laundries.

In addition to West Basin wholesaling recycled water at a rate lower than potable water, West Basin provides other financial incentives as well to encourage recycled water use. Some potential recycled water customers do not have the financial capability to pay for onsite plumbing retrofits necessary to accept recycled water. Therefore, West Basin advances funds for retrofit expenses, which can be reimbursed through the water bills. The onsite plumbing retrofit costs are amortized over a period of time up to 10 years at West Basin's cost of funds. Repayment is made using the differential between potable and recycled water rates so that the customer never pays more than the potable rate. Once the loan is repaid, the rate reverts to the current recycled rate.

Optimizing Recycled Water Use

West Basin's plan for optimizing the use of recycled water is carried out through its Recycled Water Master Plan (Master Plan) and its Recycled Water Marketing Plan (Marketing Plan). The Master Plan is West Basin's guiding document for identifying and prioritizing potential customers in all existing and emerging types of recycled water use.

The Marketing Plan is the companion effort to the Master Plan and revisits the strategies and tools employed by West Basin's staff and consultants in generating interest in recycled water with potential customers and the cities in which they do business. The thrust of the Marketing Plan is to emphasize the benefit of recycled water as a "tool for profitability" for businesses and not just the right thing to do in terms of water conservation and the environment. The Marketing Plan will be updated in FY 2005-2006.

Coordination Efforts

Table 8-6 illustrates the District's coordinated effort among key stakeholders as well as their role in the development of West Basin's 2000 Recycled Water Master Plan.

Table 8-6
Recycled Water Master Plan Coordination

Participating Agencies	Role in Plan Development
1. Water Agencies (Purveyors)	Customer Development, Facilities, Impacts, Rates
2. Wastewater Agencies	Recycled Water Supply, Water Quality, Reliability
3. Groundwater Agencies	Rates,Customer Involvement
4. Planning Agencies	Economic Analysis, Rates, Data Assessment, Customer Assessment, Rates, Community Impacts, Customer Involvement, Conceptual Pipeline Routes, Cost Estimates

1. Water Purveyor Agencies: See Table 8-3.
2. Wastewater Agencies: Hyperion Wastewater Treatment Facility and West Basin Water Recycling Facility
3. Groundwater Agencies: Water Replenishment District of Southern California
4. Planning Agencies: Purveyors and Cities within West Basin's service area

8.3.7 Funding

Capital costs for projects planned for the future have been budgeted to average per fiscal year approximately $8.1 million. These costs will be covered by the sources identified here and other sources as they become available:

- ***MWD Local Resources Program Incentive.*** To qualify, proposed water recycling projects by member agencies must cost more than projected MWD treated non-interruptible water rates and reduce potable water needs. Since founding MWD with other municipal water utilities in 1928, West Basin has remained affiliated as a member agency and is therefore considered for the rebates for up to $250/AF of produced water offered under the program.

- ***Grant Funding.*** West Basin continuously applies for Federal and State grant funding for water recycling projects, as it becomes available. For example, in 2005, West Basin applied for a Water Recycling Construction grant for the Madrona/Palos Verdes Lateral project through Proposition 50. West Basin submitted an application to the State to fund 25% of the $27.5 million cost of the pipeline. An additional source of funding for water recycling projects is through the U.S Army Corps of Engineers Program, which affords qualified conservation programs 75% project funding.

Section 9

Desalination

Desalination

9.1 Overview

West Basin's expertise in recycled water treatment includes substantial experience in the removal of salt from recycled water supplies. West Basin currently performs extensive research and development, affording them the opportunity to refine their water production and treatment methods as well as educating the public. Desalination of ocean water is the next natural step in the development of a new water source for West Basin's service area.

Ocean water desalination is typically thought to be too expensive for large-scale use. However, due to recent advances in technology, desalination now costs less than half of what it did 10 years ago, making it an attractive and financially viable option. The cost has dropped because newer membranes last longer and are more energy efficient, thus lowering capital and operational costs.

9.2 Desalting Process and Quality of Ocean Water Desalination

A number of issues are considered when evaluating alternative water supply options. Of primary consideration is a project's ability to provide a safe, reliable and cost-effective drinking water supply. Providing a safe drinking water supply to West Basin customers is a task of paramount importance to West Basin. All prudent actions are taken to ensure that water delivered throughout the service area meets or exceeds drinking water standards set by the State's primary water quality regulatory agency, the CDHS. West Basin has performed extensive water quality research at its ocean desalination pilot facility. Test results indicate that the District's treatment approach of utilizing microfiltration pretreatment and reverse osmosis treatment provides a reliable water quality that meets all State and Federal drinking water standards.

The desalting process involves removing salt, minerals and impurities from the ocean water with the latest technologies – microfiltration and reverse osmosis. The ocean water first passes through microfiltration, which consists of thousands of strands with pores that are 5,000 times smaller than a pinhole. The water then continues on to undergo high pressure reverse osmosis. Reverse osmosis, a common method used to produce bottled water, is a pressure driven process whereby water passes through a thin film membrane that filters out impurities. The water produced at the pilot project consists of approximately 350 parts per million (ppm) of salt, lower than typical tap water in Southern California. West Basin will use the data acquired from the pilot project in the planning and development of a 0.5 MGD demonstration plant.

9.3 West Basin's Ocean Water Desalination Pilot Project

West Basin's ocean water desalination pilot project is located at the El Segundo Power Plant and marks the first use of microfiltration pretreatment and reverse osmosis for ocean water desalination. The pilot project desalts approximately 40 gallons per minute (gpm) of raw ocean water. The goal of the project is two-fold: 1) identify optimal performance conditions and 2) evaluate the water quality. The research findings are being shared among industry partners to determine the viability and suitability of producing potable desalinated ocean water.

El Segundo Power Plant

West Basin's ocean water desalination pilot project was designed to be a regional and national asset and it is an open, collaborative effort that will benefit the entire water industry. To fund the $1.5 million combined cost of the pilot project, West Basin has partnered with major agencies in the water industry, including the American Water Works Association Research Foundation, California Avocado Commission, City of Tampa Bay, Department of Water Resources, East Bay Municipal Utility District, Long Beach Water Department, Los Angeles Department of Water and Power, Metropolitan Water District, National Water Research Institute, San Diego County Water Authority South Florida Water Management District, and United States Bureau of Reclamation.

Since it first began operation, West Basin has strived to identify the optimal operational and water quality parameters utilizing a power plant's pre-condenser cooling water as the pilot plant's feed water source to allow reliable and cost efficient ocean desalination treatment. The District recognizes the environmental benefits and capital cost savings of utilizing an existing open ocean water intake substructure and outfall by co-locating the pilot project at an existing power plant site. Following in the footsteps of West Basin's vast desalting experience using advanced membrane treatment, the ocean water desalination pilot project utilizes microfiltration pretreatment and reverse osmosis treatment as the primary treatment processes. These processes have demonstrated tremendous water quality and operational performance since the commissioning of the project. Figure 9-1 illustrates the microfiltration and reverse osmosis membranes used in the pilot demonstration project.

Figure 9-1
MF-RO Research Pilot Unit

West Basin will continue to conduct piloting research to focus on meeting current and future regulatory and water quality standards utilizing post condenser water at the hosting power plant site. This research information will be used to formulate a comparative index to the cold water research to determine the most efficient and environmentally safe approach in the development of a demonstration and full scale ocean desalination treatment facility.

9.4 Future Ocean Water Desalination Projects

West Basin's next logical step in moving forward with a full scale ocean desalination treatment facility is to develop and construct a 500,000 gpd demonstration project. This demonstration project is necessary to evaluate the water quality performance and treatment stability, assess efficient energy recovery devices, optimize operational performance utilizing full scale process equipment and acquire the necessary data to achieve regulatory compliance and approval. West Basin's ocean water desalination demonstration project will be located within West Basin's service area and in close proximity to the Pacific Ocean. West Basin and its partners will perform the full battery of water quality analyses to ensure that the demonstration project meets all Federal and State Drinking Water Standards.

Additionally, West Basin will construct a research and education center to educate the public on how ocean water desalination is performed and the safe environmental benefits of developing such a precious and reliable water supply resource. In 2005, West Basin was awarded $1,750,000 in State grants administered under the Proposition 50 funds to assist in the research and construction of the District's ocean water desalination demonstration project. Table 9-1 lays out the opportunities for West Basin to desalinate ocean water.

Table 9-1
Opportunities for Desalinated Water

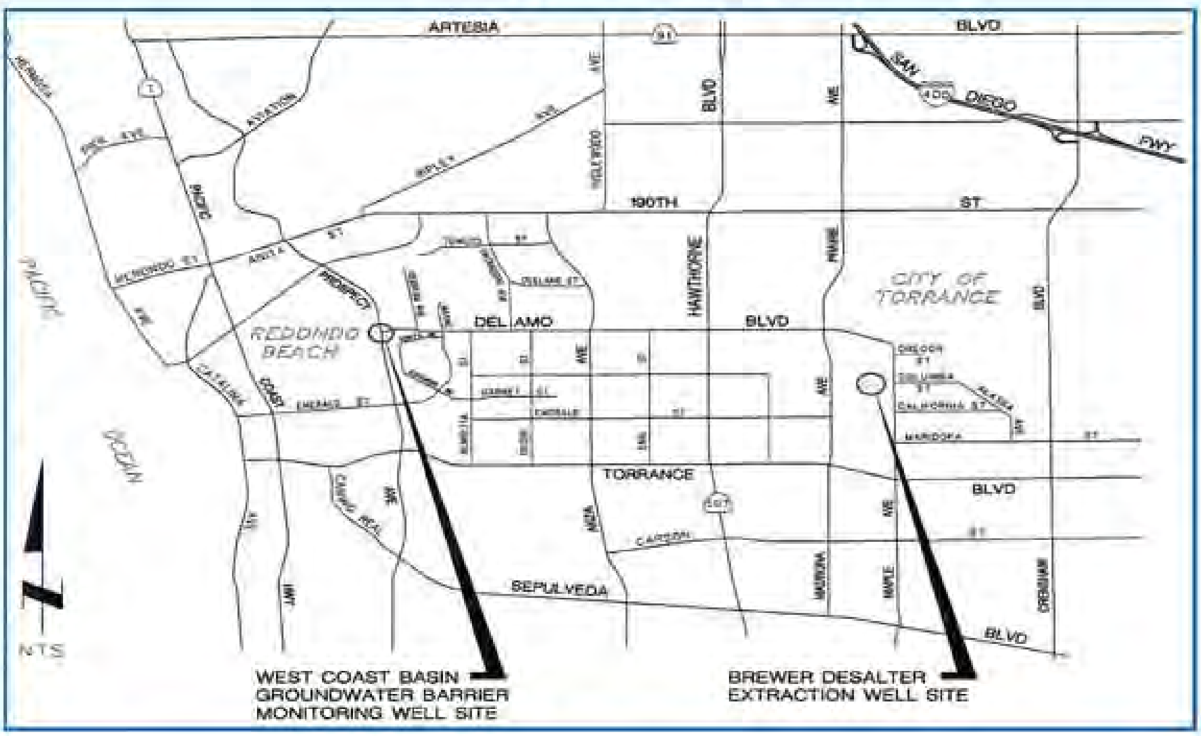
Sources of Water	Yield AFY	Start Date	Type of Use
Ocean Water	20,000	June 2011	Potable

With the knowledge gained by operating the demonstration project, West Basin expects to eventually move forward with the planning, design and construction of a full scale 20,000 AFY ocean water desalination and education facility. West Basin is currently addressing the development of the demonstration project with the Regional Water Quality Control Board and the California Coastal Commission. West Basin anticipates operating the demonstration plant for at least two years while plans are being completed and finalized for the development of a 20,000 AFY full-scale desalination treatment plant. The ultimate goal is to construct a full-scale plant that will diversify the regional water supply and ensure a safe, reliable water source for today and the future.

9.5 Brewer Desalter Treatment Facility

The Brewer Desalter Treatment Facility, located adjacent to the City of Torrance bus maintenance and storage yard, removes chloride from groundwater impacted by seawater intrusion in the WCGB. The brackish groundwater resulted from seawater intrusion prior to construction of the West Coast Basin Groundwater Barrier. The vicinity map provided in Figure 9-2 shows the location of the Brewer Desalter site.

Figure 9-2
Brewer Desalter Location Map



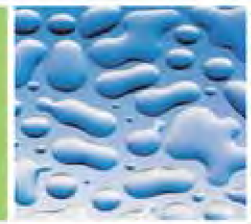
The Brewer Desalter facility treats brackish groundwater produced by an on-site well. The brackish groundwater passes through cartridge filters and finally reverse osmosis. California Water Service Company (CalWater) stores the treated water on-site in a 5-million gallon storage reservoir and ultimately delivers it to consumers for CalWater's distribution system. The Brewer Desalter facility is currently out of service until a new extraction well can be constructed. A new extraction well, located north of the reverse osmosis facility, is expected to be online in early 2006.

Figure 9-3
Brewer Desalter Facility Equipment

Brewer Extraction Well Site, looking west from atop the 5 MG reservoir

Chemical addition tanks located inside the RO building

Brewer Desalter RO treatment onsite



Appendices

Appendix A UWMP Act

Appendix B 2005 UWMP Checklist Form

Appendix C Notice of Public Hearing and Resolution for UWMP Adoption

Appendix D Notice of Preparation

Appendix E Water Shortage Contingency Plan Draft Resolution

Appendix F Best Management Practices Report

Appendix A

Established: AB 797, Klehs, 1983
Amended: AB 2661, Klehs, 1990
AB 11X, Filante, 1991
AB 1869, Speier, 1991
AB 892, Frazee, 1993
SB 1017, McCorquodale, 1994
AB 2853, Cortese, 1994
AB 1845, Cortese, 1995
SB 1011, Polanco, 1995
AB 2552, Bates, 2000
SB 553, Kelley, 2000
SB 610, Costa, 2001
AB 901, Daucher, 2001
SB 672, Machado, 2001
SB 1348, Brulte, 2002
SB 1384, Costa, 2002
SB 1518, Torlakson, 2002
AB 105, Wiggins, 2004
SB 318, Alpert, 2004

CALIFORNIA WATER CODE DIVISION 6
PART 2.6. URBAN WATER MANAGEMENT PLANNING

CHAPTER 1. GENERAL DECLARATION AND POLICY

10610. This part shall be known and may be cited as the "Urban Water Management Planning Act."

10610.2. (a) The Legislature finds and declares all of the following:

(1) The waters of the state are a limited and renewable resource subject to ever-increasing demands.

(2) The conservation and efficient use of urban water supplies are of statewide concern; however, the planning for that use and the implementation of those plans can best be accomplished at the local level.

(3) A long-term, reliable supply of water is essential to protect the productivity of California's businesses and economic climate.

(4) As part of its long-range planning activities, every urban water supplier should make every effort to ensure the appropriate level of reliability in

its water service sufficient to meet the needs of its various categories of customers during normal, dry, and multiple dry water years.

(5) Public health issues have been raised over a number of contaminants that have been identified in certain local and imported water supplies.

(6) Implementing effective water management strategies, including groundwater storage projects and recycled water projects, may require specific water quality and salinity targets for meeting groundwater basins water quality objectives and promoting beneficial use of recycled water.

(7) Water quality regulations are becoming an increasingly important factor in water agencies' selection of raw water sources, treatment alternatives, and modifications to existing treatment facilities.

(8) Changes in drinking water quality standards may also impact the usefulness of water supplies and may ultimately impact supply reliability.

(9) The quality of source supplies can have a significant impact on water management strategies and supply reliability.

(b) This part is intended to provide assistance to water agencies in carrying out their long-term resource planning responsibilities to ensure adequate water supplies to meet existing and future demands for water.

10610.4. The Legislature finds and declares that it is the policy of the state as follows:

(a) The management of urban water demands and efficient use of water shall be actively pursued to protect both the people of the state and their water resources.

(b) The management of urban water demands and efficient use of urban water supplies shall be a guiding criterion in public decisions.

(c) Urban water suppliers shall be required to develop water management plans to actively pursue the efficient use of available supplies.

CHAPTER 2. DEFINITIONS

10611. Unless the context otherwise requires, the definitions of this chapter govern the construction of this part.

10611.5. "Demand management" means those water conservation measures, programs, and incentives that prevent the waste of water and promote the reasonable and efficient use and reuse of available supplies.

10612. "Customer" means a purchaser of water from a water supplier who uses the water for municipal purposes, including residential, commercial, governmental, and industrial uses.

10613. "Efficient use" means those management measures that result in the most effective use of water so as to prevent its waste or unreasonable use or unreasonable method of use.

10614. "Person" means any individual, firm, association, organization, partnership, business, trust, corporation, company, public agency, or any agency of such an entity.

10615. "Plan" means an urban water management plan prepared pursuant to this part. A plan shall describe and evaluate sources of supply, reasonable and practical efficient uses, reclamation and demand management activities. The components of the plan may vary according to an individual community or area's characteristics and its capabilities to efficiently use and conserve water. The plan shall address measures for residential, commercial, governmental, and industrial water demand management as set forth in Article 2 (commencing with Section 10630) of Chapter 3. In addition, a strategy and time schedule for implementation shall be included in the plan.

10616. "Public agency" means any board, commission, county, city and county, city, regional agency, district, or other public entity.

10616.5. "Recycled water" means the reclamation and reuse of wastewater for beneficial use.

10617. "Urban water supplier" means a supplier, either publicly or privately owned, providing water for municipal purposes either directly or indirectly to more than 3,000 customers or supplying more than 3,000 acre-feet of water annually. An urban water supplier includes a supplier or contractor for water, regardless of the basis of right, which distributes or sells for ultimate resale to customers. This part applies only to water supplied from public water systems subject to Chapter 4 (commencing with Section 116275) of Part 12 of Division 104 of the Health and Safety Code.

CHAPTER 3. URBAN WATER MANAGEMENT PLANS
Article 1. General Provisions

10620.

(a) Every urban water supplier shall prepare and adopt an urban water management plan in the manner set forth in Article 3 (commencing with Section 10640).

(b) Every person that becomes an urban water supplier shall adopt an urban water management plan within one year after it has become an urban water supplier.

(c) An urban water supplier indirectly providing water shall not include planning elements in its water management plan as provided in Article 2 (commencing with Section 10630) that would be applicable to urban water suppliers or public agencies directly providing water, or to their customers, without the consent of those suppliers or public agencies.

(d)

(1) An urban water supplier may satisfy the requirements of this part by participation in areawide, regional, watershed, or basinwide urban water management planning where those plans will reduce preparation costs and contribute to the achievement of conservation and efficient water use.

(2) Each urban water supplier shall coordinate the preparation of its plan with other appropriate agencies in the area, including other water suppliers that share a common source, water management agencies, and relevant public agencies, to the extent practicable.

(e) The urban water supplier may prepare the plan with its own staff, by contract, or in cooperation with other governmental agencies.

(f) An urban water supplier shall describe in the plan water management tools and options used by that entity that will maximize resources and minimize the need to import water from other regions.

10621.

(a) Each urban water supplier shall update its plan at least once every five years on or before December 31, in years ending in five and zero.

(b) Every urban water supplier required to prepare a plan pursuant to this part shall notify any city or county within which the supplier provides water supplies that the urban water supplier will be reviewing the plan and considering amendments or changes to the plan. The urban water supplier may consult with, and obtain comments from, any city or county that receives notice pursuant to this subdivision.

(c) The amendments to, or changes in, the plan shall be adopted and filed in the manner set forth in Article 3 (commencing with Section 10640).

Article 2. Contents of Plans

10630. It is the intention of the Legislature, in enacting this part, to permit levels of water management planning commensurate with the numbers of customers served and the volume of water supplied.

10631. A plan shall be adopted in accordance with this chapter and shall do all of the following:

(a) Describe the service area of the supplier, including current and projected population, climate, and other demographic factors affecting the supplier's water management planning. The projected population estimates shall be based upon data from the state, regional, or local service agency population projections within the service area of the urban water supplier and shall be in five-year increments to 20 years or as far as data is available.

(b) Identify and quantify, to the extent practicable, the existing and planned sources of water available to the supplier over the same five-year increments described in subdivision (a). If groundwater is identified as an existing or planned source of water available to the supplier, all of the following information shall be included in the plan:

(1) A copy of any groundwater management plan adopted by the urban water supplier, including plans adopted pursuant to Part 2.75 (commencing with Section 10750), or any other specific authorization for groundwater management.

(2) A description of any groundwater basin or basins from which the urban water supplier pumps groundwater. For those basins for which a court or the board has adjudicated the rights to pump groundwater, a copy of the order or decree adopted by the court or the board and a description of the amount of groundwater the urban water supplier has the legal right to pump under the order or decree.

For basins that have not been adjudicated, information as to whether the department has identified the basin or basins as overdrafted or has projected that the basin will become overdrafted if present management conditions continue, in the most current official departmental bulletin that characterizes the condition of the groundwater basin, and a detailed description of the efforts being undertaken by the urban water supplier to eliminate the long-term overdraft condition.

(3) A detailed description and analysis of the location, amount, and sufficiency of groundwater pumped by the urban water supplier for the past five years. The description and analysis shall be based on information that is reasonably available, including, but not limited to, historic use records.

(4) A detailed description and analysis of the amount and location of groundwater that is projected to be pumped by the urban water supplier. The description and analysis shall be based on information that is reasonably available, including, but not limited to, historic use records.

(c) Describe the reliability of the water supply and vulnerability to seasonal or climatic shortage, to the extent practicable, and provide data for each of the following:

(1) An average water year.
(2) A single dry water year.
(3) Multiple dry water years.

For any water source that may not be available at a consistent level of use, given specific legal, environmental, water quality, or climatic factors, describe plans to supplement or replace that source with alternative sources or water demand management measures, to the extent practicable.

(d) Describe the opportunities for exchanges or transfers of water on a short-term or long-term basis.

(e)

(1) Quantify, to the extent records are available, past and current water use, over the same five-year increments described in subdivision (a), and projected water use, identifying the uses among water use sectors including, but not necessarily limited to, all of the following uses:

(A) Single-family residential.
(B) Multifamily.
(C) Commercial.
(D) Industrial.
(E) Institutional and governmental.
(F) Landscape.
(G) Sales to other agencies.
(H) Saline water intrusion barriers, groundwater recharge, or conjunctive use, or any combination thereof.
(I) Agricultural.

(2) The water use projections shall be in the same five-year increments described in subdivision (a).

(f) Provide a description of the supplier's water demand management measures. This description shall include all of the following:

(1) A description of each water demand management measure that is currently being implemented, or scheduled for implementation, including the steps necessary to implement any proposed measures, including, but not limited to, all of the following:

(A) Water survey programs for single-family residential and multifamily residential customers.

(B) Residential plumbing retrofit.

(C) System water audits, leak detection, and repair.

(D) Metering with commodity rates for all new connections and retrofit of existing connections.

(E) Large landscape conservation programs and incentives.

(F) High-efficiency washing machine rebate programs.

(G) Public information programs.

(H) School education programs.

(I) Conservation programs for commercial, industrial, and institutional accounts.

(J) Wholesale agency programs.

(K) Conservation pricing.

(L) Water conservation coordinator.

(M) Water waste prohibition.

(N) Residential ultra-low-flush toilet replacement programs.

(2) A schedule of implementation for all water demand management measures proposed or described in the plan.

(3) A description of the methods, if any, that the supplier will use to evaluate the effectiveness of water demand management measures implemented or described under the plan.

(4) An estimate, if available, of existing conservation savings on water use within the supplier's service area, and the effect of the savings on the supplier's ability to further reduce demand.

(g) An evaluation of each water demand management measure listed in paragraph (1) of subdivision (f) that is not currently being implemented or scheduled for implementation. In the course of the evaluation, first consideration shall be given to water demand management measures, or combination of measures, that offer lower incremental costs than expanded or additional water supplies. This evaluation shall do all of the following:

(1) Take into account economic and noneconomic factors, including environmental, social, health, customer impact, and technological factors.

(2) Include a cost-benefit analysis, identifying total benefits and total costs.

(3) Include a description of funding available to implement any planned water supply project that would provide water at a higher unit cost.

(4) Include a description of the water supplier's legal authority to implement the measure and efforts to work with other relevant agencies to ensure the implementation of the measure and to share the cost of implementation.

(h) Include a description of all water supply projects and water supply programs that may be undertaken by the urban water supplier to meet the total projected water use as established pursuant to subdivision (a) of Section 10635. The urban water supplier shall include a detailed description of expected future projects and programs, other than the demand management programs identified pursuant to paragraph (1) of subdivision (f), that the urban water supplier may implement to increase the amount of the water supply available to the urban water supplier in average, single-dry, and multiple-dry water years. The description shall identify specific projects and include a description of the increase in water supply that is expected to be available from each project. The description shall include an estimate with regard to the implementation timeline for each project or program.

(i) Describe the opportunities for development of desalinated water, including, but not limited to, ocean water, brackish water, and groundwater, as a long-term supply.

(j) Urban water suppliers that are members of the California Urban Water Conservation Council and submit annual reports to that council in accordance with the "Memorandum of Understanding Regarding Urban Water Conservation in California," dated September 1991, may submit the annual reports identifying water demand management measures currently being implemented, or scheduled for implementation, to satisfy the requirements of subdivisions (f) and (g).

(k) Urban water suppliers that rely upon a wholesale agency for a source of water, shall provide the wholesale agency with water use projections from that agency for that source of water in five-year increments to 20 years or as far as data is available. The wholesale agency shall provide information to the urban water supplier for inclusion in the urban water supplier's plan that identifies and quantifies, to the extent practicable, the existing and planned sources of water as required by subdivision (b), available from the wholesale agency to the urban water supplier over the same five-year increments, and during various water-year types in accordance with subdivision (c). An urban water supplier may rely upon water supply information provided by the wholesale agency in fulfilling the plan informational requirements of subdivisions (b) and (c), including, but not limited to, ocean water, brackish water, and groundwater, as a long-term supply.

10631.5. The department shall take into consideration whether the urban water supplier is implementing or scheduled for implementation, the water demand management activities that the urban water supplier identified in its urban water management plan, pursuant to Section 10631, in evaluating applications for grants and loans made available pursuant to Section 79163. The urban water supplier may submit to the department copies of its annual reports and other relevant documents to assist the department in determining whether the urban water supplier is implementing or scheduling the implementation of water demand management activities.

10632. The plan shall provide an urban water shortage contingency analysis which includes each of the following elements which are within the authority of the urban water supplier:

(a) Stages of action to be undertaken by the urban water supplier in response to water supply shortages, including up to a 50 percent reduction in water supply, and an outline of specific water supply conditions which are applicable to each stage.

(b) An estimate of the minimum water supply available during each of the next three water years based on the driest three-year historic sequence for the agency's water supply.

(c) Actions to be undertaken by the urban water supplier to prepare for, and implement during, a catastrophic interruption of water supplies including, but not limited to, a regional power outage, an earthquake, or other disaster.

(d) Additional, mandatory prohibitions against specific water use practices during water shortages, including, but not limited to, prohibiting the use of potable water for street cleaning.

(e) Consumption reduction methods in the most restrictive stages. Each urban water supplier may use any type of consumption reduction methods in its water shortage contingency analysis that would reduce water use, are appropriate for its area, and have the ability to achieve a water use reduction consistent with up to a 50 percent reduction in water supply.

(f) Penalties or charges for excessive use, where applicable.

(g) An analysis of the impacts of each of the actions and conditions described in subdivisions (a) to (f), inclusive, on the revenues and expenditures of the urban water supplier, and proposed measures to overcome those impacts, such as the development of reserves and rate adjustments.

(h) A draft water shortage contingency resolution or ordinance.

(i) A mechanism for determining actual reductions in water use pursuant to the urban water shortage contingency analysis.

10633. The plan shall provide, to the extent available, information on recycled water and its potential for use as a water source in the service area of the urban water supplier. The preparation of the plan shall be coordinated with local water, wastewater, groundwater, and planning agencies that operate within the supplier's service area, and shall include all of the following:

(a) A description of the wastewater collection and treatment systems in the supplier's service area, including a quantification of the amount of wastewater collected and treated and the methods of wastewater disposal.

(b) A description of the quantity of treated wastewater that meets recycled water standards, is being discharged, and is otherwise available for use in a recycled water project.

(c) A description of the recycled water currently being used in the supplier's service area, including, but not limited to, the type, place, and quantity of use.

(d) A description and quantification of the potential uses of recycled water, including, but not limited to, agricultural irrigation, landscape irrigation, wildlife habitat enhancement, wetlands, industrial reuse, groundwater recharge, and other appropriate uses, and a determination with regard to the technical and economic feasibility of serving those uses.

(e) The projected use of recycled water within the supplier's service area at the end of 5, 10, 15, and 20 years, and a description of the actual use of recycled water in comparison to uses previously projected pursuant to this subdivision.

(f) A description of actions, including financial incentives, which may be taken to encourage the use of recycled water, and the projected results of these actions in terms of acre-feet of recycled water used per year.

(g) A plan for optimizing the use of recycled water in the supplier's service area, including actions to facilitate the installation of dual distribution systems, to promote recirculating uses, to facilitate the increased use of treated wastewater that meets recycled water standards, and to overcome any obstacles to achieving that increased use.

10634. The plan shall include information, to the extent practicable, relating to the quality of existing sources of water available to the supplier over the same five-year increments as described in subdivision (a) of Section 10631, and the manner in which water quality affects water management strategies and supply reliability.

Article 2.5 Water Service Reliability

10635.

(a) Every urban water supplier shall include, as part of its urban water management plan, an assessment of the reliability of its water service to its customers during normal, dry, and multiple dry water years. This water supply and demand assessment shall compare the total water supply sources available to the water supplier with the total projected water use over the next 20 years, in five-year increments, for a normal water year, a single dry water year, and multiple dry water years. The water service reliability assessment shall be based upon the information compiled pursuant to Section 10631, including available data from state, regional, or local agency population projections within the service area of the urban water supplier.

(b) The urban water supplier shall provide that portion of its urban water management plan prepared pursuant to this article to any city or county within which it provides water supplies no later than 60 days after the submission of its urban water management plan.

(c) Nothing in this article is intended to create a right or entitlement to water service or any specific level of water service.

(d) Nothing in this article is intended to change existing law concerning an urban water supplier's obligation to provide water service to its existing customers or to any potential future customers.

Articl 3. Adoption and Implementation of Plans

10640. Every urban water supplier required to prepare a plan pursuant to this part shall prepare its plan pursuant to Article 2 (commencing with Section 10630).

The supplier shall likewise periodically review the plan as required by Section 10621, and any amendments or changes required as a result of that review shall be adopted pursuant to this article.

10641. An urban water supplier required to prepare a plan may consult with, and obtain comments from, any public agency or state agency or any person who has special expertise with respect to water demand management methods and techniques.

10642. Each urban water supplier shall encourage the active involvement of diverse social, cultural, and economic elements of the population within the service area prior to and during the preparation of the plan. Prior to adopting a plan, the urban water supplier shall make the plan available for public inspection and shall hold a public hearing thereon. Prior to the hearing, notice of the time and place of hearing shall be published within the jurisdiction of the publicly owned water supplier pursuant to Section 6066 of the Government Code. The urban water supplier shall provide notice of the time and place of hearing to any city or county within which the supplier provides water supplies. A privately owned water supplier shall provide an equivalent notice within its service area. After the hearing, the plan shall be adopted as prepared or as modified after the hearing.

10643. An urban water supplier shall implement its plan adopted pursuant to this chapter in accordance with the schedule set forth in its plan.

10644.

(a) An urban water supplier shall file with the department and any city or county within which the supplier provides water supplies a copy of its plan no later than 30 days after adoption. Copies of amendments or changes to the plans shall be filed with the department and any city or county within which the supplier provides water supplies within 30 days after adoption.

(b) The department shall prepare and submit to the Legislature, on or before December 31, in the years ending in six and one, a report summarizing the status of the plans adopted pursuant to this part. The report prepared by the department shall identify the outstanding elements of the individual plans. The department shall provide a copy of the report to each urban water supplier that has filed its plan with the department. The department shall also prepare reports and provide data for any legislative hearings designed to consider the effectiveness of plans submitted pursuant to this part.

10645. Not later than 30 days after filing a copy of its plan with the department, the urban water supplier and the department shall make the plan available for public review during normal business hours.

CHAPTER 4. MISCELLANEOUS PROVISIONS

10650. Any actions or proceedings to attack, review, set aside, void, or annul the acts or decisions of an urban water supplier on the grounds of noncompliance with this part shall be commenced as follows:

(a) An action or proceeding alleging failure to adopt a plan shall be commenced within 18 months after that adoption is required by this part.

(b) Any action or proceeding alleging that a plan, or action taken pursuant to the plan, does not comply with this part shall be commenced within 90 days after filing of the plan or amendment thereto pursuant to Section 10644 or the taking of that action.

10651. In any action or proceeding to attack, review, set aside, void, or annul a plan, or an action taken pursuant to the plan by an urban water supplier on the grounds of noncompliance with this part, the inquiry shall extend only to whether there was a prejudicial abuse of discretion. Abuse of discretion is established if the supplier has not proceeded in a manner required by law or if the action by the water supplier is not supported by substantial evidence.

10652. The California Environmental Quality Act (Division 13 (commencing with Section 21000) of the Public Resources Code) does not apply to the preparation and adoption of plans pursuant to this part or to the implementation of actions taken pursuant to Section 10632. Nothing in this part shall be interpreted as exempting from the California Environmental Quality Act any project that would significantly affect water supplies for fish and wildlife, or any project for implementation of the plan, other than projects implementing Section 10632, or any project for expanded or additional water supplies.

10653. The adoption of a plan shall satisfy any requirements of state law, regulation, or order, including those of the State Water Resources Control Board and the Public Utilities Commission, for the preparation of water management plans or conservation plans; provided, that if the State Water Resources Control Board or the Public Utilities Commission requires additional information concerning water conservation to implement its existing authority, nothing in this part shall be deemed to limit the board or the commission in obtaining that information. The requirements of this part shall be satisfied by any urban water demand management plan prepared to meet federal laws or regulations after the effective date of this part, and which substantially meets the requirements of this part, or by any existing urban water management plan which includes the contents of a plan required under this part.

10654. An urban water supplier may recover in its rates the costs incurred in preparing its plan and implementing the reasonable water conservation measures included in the plan. Any best water management practice that is included in the plan that is identified in the "Memorandum of Understanding Regarding Urban Water Conservation in California" is deemed to be reasonable for the purposes of this section.

10655. If any provision of this part or the application thereof to any person or circumstances is held invalid, that invalidity shall not affect other provisions or applications of this part which can be given effect without the invalid provision or application thereof, and to this end the provisions of this part are severable.

10656. An urban water supplier that does not prepare, adopt, and submit its urban water management plan to the department in accordance with this part, is ineligible to receive funding pursuant to Division 24 (commencing with Section 78500) or Division 26 (commencing with Section 79000), or receive drought assistance from the state until the urban water management plan is submitted pursuant to this article.

10657.

(a) The department shall take into consideration whether the urban water supplier has submitted an updated urban water management plan that is consistent with Section 10631, as amended by the act that adds this section, in determining whether the urban water supplier is eligible for funds made available pursuant to any program administered by the department.

(b) This section shall remain in effect only until January 1, 2006, and as of that date is repealed, unless a later enacted statute, that is enacted before January 1, 2006, deletes or extends that date.

Appendix B

West Basin Municipal Water District
2005 Urban Water Management Plan Checklist Form

Water Code Section	Location in Guide	Items to Address	Location in Plan
10620 (d)(1)	Page 2	Participate in area wide, regional, watershed or basin wide urban water management planning	Page 1-2
10620 (d)(2)	Page 2	Describe the coordination of the plan preparation with other appropriate agencies in the area and anticipated benefits	Page 1-2
10620 (f)	Page 2	Describe how water management tools and/or options to maximize resources & minimize need to import water	Page ES-1-ES-9
10621 (a)	Page 4	Update plan every five years on or before December 31, in years ending in five and zero	Page 1-1
10621 (b)	Page 4	Notify any city or county within service area of UWMP of plan review & revision	Page 1-2
	Page 4	Consult and obtain comments from cities and counties within service area	Page 1-2
10631 (a)	Page 8	Provide current and projected population for water service area in 5-year increments to 20 or 25 years	Page 2-3
	Page 8	Identify source of population data	Page 2-3
	Page 8	Describe climate characteristics that affect water management	Page 2-1-2-2
	Page 8	Describe other demographic factors that affect water management	Page 2-2
10631 (b)	Page 10	Identify existing and planned water supply sources	Page 3-2
	Page 10	Provide current water supply quantities in 5-year increments to 20 or 25 years	Page 4-5
	Page 10	Provide planned water supply quantities in 5-year increments to 20 or 25 years	Page 4-5
10631 (b)(1)	Page 12	Attach copy of any groundwater management plans adopted, including plans adopted pursuant to Part 2.75 or any other specific authorization for groundwater management	N/A
10631 (b)(2)	Page 12	A description of any groundwater basins or basin from which the urban water supplier pumps groundwater	N/A
	Page 12	If the groundwater basin is adjudicated attach a copy of the order or decree	N/A
	Page 12	For basins that are not adjudicated, state whether basins are in overdraft	N/A
	Page 12	If basin is in overdraft or projected to be in overdraft describe plan to eliminate overdraft	N/A
	Page 12	Quantify legal pumping amounts from basin	Page 3-6
10631 (b)(3)	Page 12	Detailed description and analysis of location, amount, and sufficiency of water pumped for past five years	Page 3-7
10631 (b)(4)	Page 12	Detailed description and analysis of location, amount, and sufficiency for 20 or 25 year projection of water to be pumped	Page 3-7
10631 (c)(1)	Page 14	Describe the reliability of the water supply and vulnerability to seasonal or climatic shortage for normal water year	Page 4-4
10631 (c)(2)	Page 14	Describe the reliability of the water supply and vulnerability to seasonal or climatic shortage for single-dry water year	Page 4-4

West Basin Municipal Water District
2005 Urban Water Management Plan Checklist Form

10631 (c)(3)	Page 14	Describe the reliability of the water supply and vulnerability to seasonal or climatic shortage for multiple-dry water years	Page 4-4
10631 (c)	Page 14	Describe the reliability of the water supply due to seasonal or climatic shortages	N/A
	Page 14	Describe the vulnerability of the water supply to seasonal or climatic shortages	N/A
	Page 14	Describe plans to supplement or replace inconsistent sources with alternative sources or DMMs	N/A
10631 (d)	Page 16	Describe opportunities for exchanges or water transfers on a short term or long term basis	Page 3-10
10631 (e) (1-3)	Page 18	Identify and quantify past water use by sector	Page 2-7
	Page 18	Identify and quantify current water use by sector	Page 2-7
	Page 18	Identify and quantify projected water use by sector in five-year increments to 20 or 25 years	Page 2-8
	Page 20	Identify and quantify past, current, and projected water use over five-year increments by sales to other agencies to 20 or 25 years	Page 2-7-2-8
	Page 20	Identify and quantify past, current, and projected water use over five-year increments by additional water uses and losses to 20 years	N/A
10631 (f)	Page 24	See (i)	Appendix F
10631 (g)	Page 40	See (j)	Appendix F
10631 (h)	Page 42	Description of water supply projects and water supply programs that may be undertaken to meet total projected water use with a timeline for each project	Page 8-8-8-10, 9-3-9-4
		Quantify each proposed project's normal-year supply, single dry-year supply, and multi-dry year supply	Page 4-5-4-8
10631 (i)	Page 44	Describe opportunities for development of desalinated water (ocean, brackish water)	Page 3-9 and 9-3 - 9-4
10631 (j)	Page 22	Provide annual report from CUWCC identifying water demand management measures being implemented or scheduled for implementation to satisfy requirements (f) and (g)	Appendix F
10631 (k)	Page 46	Provide wholesale agency with water use projections for that source of water in five-year increments to 20 or 25 years	N/A
	Page 46	Wholesaler provided information identifying and quantifying existing and planned sources of water available to supplier over five-year increments to 20 or 25 years	N/A
	Page 46	Information from wholesaler describing reliability of wholesale supplies and amount to be delivered during normal, single-dry, and multiple-dry years, including factors resulting in inconsistency and information or plans to supplement or replace water sources that are not reliable	N/A
10631.5	Page 48	Include 2003-2004 or 2005 Annual Report submitted to CUWCC and CUWCC coverage report	Appendix F
10632 (a)	Page 50	Provide an urban water shortage contingency plan analysis with stages of action to be taken in response to a water supply shortage	Page 4-8-4-11
	Page 50	Provide water supply conditions for each stage	Page 4-10

West Basin Municipal Water District
2005 Urban Water Management Plan Checklist Form

	Page 50	Provide in plan a 50% supply shortage	Page 4-9
10632 (b)	Page 52	Estimate the minimum water supply available for each of the next three years based on the driest three-year historical sequence by source	Page 4-8-4-9
10631 (c)	Page 54	Provide a catastrophic supply interruption plan for non-drought related events looking at vulnerability of each source, delivery and distribution systems and actions to minimize impacts of supply interruption	Page 4-11
10632 (d)	Page 56	List mandatory prohibitions against specific water use practices during water shortages and stage when they become mandatory	Page 4-10
10632 (e)	Page 56	List the consumption reduction methods the water supplier will use to reduce water use in the most restrictive stages with up to a 50% reduction	Page 4-10
10632 (f)	Page 56	List excessive use charges or penalties for excessive use	Page 4-10
10632 (g)	Page 58	Describe how actions and conditions impact revenues	Page 4-11
	Page 58	Describe how action and conditions impact expenditures	Page 4-11
	Page 58	Describe measures to overcome the revenue and expenditure impacts	Page 4-11
10632 (h)	Page 60	Provide a draft Water Shortage Contingency resolution or ordinance	Appendix E
10632 (i)	Page 60	Describe mechanisms to determine actual reductions	Page 4-11
10633	Page 62	Identify coordination of the recycled water plan with other agencies	Page 8-14
10633 (a)	Page 64	Describe wastewater collection and treatment systems in supplier's service area including amount collected and treated and quantify volumes	Page 8-1-8-4
10633 (b)	Page 64	Describe methods of wastewater disposal and treatment levels and quantify amount meeting recycled water standards	N/A
10633 (c)	Page 64	Describe current uses of recycled water, including type, place and quantities	Page 8-5-8-6
10633 (d)	Page 66	Describe and quantify potential uses of recycled water and explain technical and economic feasibility	Page 8-12
10633 (e)	Page 66	Describe projected use of recycled water in surface area at 5-year intervals to 20 or 25 years	Page 8-11-8-12
	Page 66	Compare UWMP 2000 projections with UWMP 2005 actual use	Page 8-8
10633 (f)	Page 66	Describe actions that might be taken to encourage recycled water use and projected results	Page 8-12
10633 (g)	Page 66	Provide recycled water use optimization plan that includes actions to facilitate the use of recycled water	Page 8-13
10634	Page 68	Analyze and describe how water quality affects water management strategies and supply reliability for each source of water	Page 5-1-5-6
10635 (a)	Page 70-74	Compare projected normal water supply to projected normal water use over the next 20 or 25 years, in five-year increments	Page 4-5
	Page 70-74	Compare projected single-dry year supply to projected single-dry year water use over the next 20 or 25 years, in 5-year increments	Page 4-6

	Page 70-74	Compare projected multiple-dry year supply to projected multiple-dry year demand over the next 20 to 25 years, in 5-year increments (for following five year periods: 2006-2010, 2011-2015, 2016-2020, 2021-2025)	Page 4-6-4-8
10635 (b)	Page 74	Provide Water Service Reliability section of UWMP to cities and counties within which it provides water supplies within 60 days of UWMP submission to DWR	N/A
10642	Page 78	Attach copy of adopted resolution to UWMP	Appendix C
	Page 78	Encourage involvement of social, cultural and economic community groups	Appendix C
	Page 78	Plan available for public inspection	Appendix C
	Page 78	Provide proof of public hearing	Appendix C
	Page 78	Provided meeting notice to any city or county it supplies water within	Appendix C
10643	Page 78	Review recycled water plan in 2000 UWMP and discuss whether it is being implemented as planned	Page 8-12
	Page 78	Discuss whether BMPs in CUWCC BMP Annual Reports submitted in 2000 UWMP were implemented as planned	Page 6-5
10644	Page 78	Provide 2005 UWMP to DWR and cities and counties within supplier area within 30 days of adoption	N/A
10645	Page 78	Provide documentation showing where plan will be available for public review during normal business hours 30 days after submittal to DWR	Appendix C

Appendix C

LEGAL NOTICE

Notice of Hearing

Central and West Basin Municipal Water Districts

PLEASE TAKE NOTICE that the Board of Directors of Central and West Basin Municipal Water Districts will conduct a Public Hearing on **December 19, 2005** at the hours of **11:00 a.m. and 1:00 p.m.,** respctfully; or as soon thereafter as the matter can be heard, in the board room of the District's office located at 17140 S. Avalon Blvd., Carson, California to consider adoption of its 2005 Urban Water Management Plans. This planning document assesses the Districts' water resources, demands, and strategies over the next 25 years, as a requirement set forth by the State Department of Water Resources. The Final Draft 2005 Urban Water Management Plan can be found on the Districts' website at www.westbasin.org or a copy can be requested from the Districts for review. Interested parties are invited to present oral or written comments.

Dated November 30, 2005

Charlene Jenson
Secretary

Publish: December 5, 12, 2005
Whittier Daily News

Ad. No.

Daily Breeze

DB 12-21
Notice of Hearing

Central and West Basin
Municipal Water Districts

PLEASE TAKE NOTICE that the Board of Directors of Central and West Basin Municipal Water Districts will conduct a Public Hearing on December 19, 2005 at the hours of 11:00 a.m. and 1:00 p.m., respctfully; or as soon thereafter as the matter can be heard, in the board room of the District's office located at 17140 S. Avalon Blvd., Carson, California to consider adoption of its 2005 Urban Water Management Plans. This planning document assesses the Districts' water resources, demands, and strategies over the next 25 years, as a requirement set forth by the State Department of Water Resources. The Final Draft 2005 Urban Water Management Plan can be found on the Districts' website at www.westbasin.org or a copy can be requested from the Districts for review. Interested parties are invited to present oral or written comments.

Dated November 30, 2005

Charlene Jenson
Secretary

Pub: December 5, 12, 2005.

CERTIFICATION

State of California)
County of Los Angeles) SS
West Basin Municipal)
Water District)

I, Charlene Jensen, Board Secretary of West Basin Municipal Water District and of the Board of Directors thereof, do hereby certify that the foregoing is a full, true and correct copy of Resolution No. 12-05-835 "A RESOLUTION OF THE BOARD OF DIRECTORS OF THE WEST BASIN MUNICIPAL WATER DISTRICT APPROVING THE 2005 URBAN WATER MANAGEMENT PLAN", which was adopted at a Board meeting held on December 19, 2005 by the Board of Directors of the West Basin Municipal Water District.

Dated: December 20, 2005

Charlene T. Jensen

Charlene T. Jensen
Board Secretary, West Basin
Municipal Water District and to
the Board of Directors thereof

G:\directors\boardmisc\certifications\certifywb resolution

RESOLUTION NO. 12-05-835

A RESOLUTION OF THE BOARD OF DIRECTORS OF WEST BASIN MUNICIPAL WATER DISTRICT APPROVING THE 2005 URBAN WATER MANAGEMENT PLAN

BE IT RESOLVED, by the BOARD OF DIRECTORS that the Board of Directors hereby adopt and sign a Resolution approving the 2005 Urban Water Management Plan, and

BE IT RESOLVED, that the West Basin Municipal Water District hereby agrees and further authorizes that the aforementioned document complies with all applicable requirements set forth in the California Urban Water Management Planning Act of 1983, as amended, and

BE IT FURTHER RESOLVED, that the President of the Board of Directors of the West Basin Municipal Water District is hereby authorized to sign the 2005 Urban Water Management Plan.

PASSED, APPROVED, AND ADOPTED on the 19th day, December 2005.

President

ATTEST:

Secretary

(SEAL)

G:\director\resos\wb835

Appendix D

West Basin Municipal Water District
17140 S. Avalon Blvd • Suite 210 • Carson, CA 90746-1296
telephone 310-217-2411 • fax 310-217-2414

July 8, 2005

To Whom it May Concern:

This letter serves as notification that the West Basin Municipal Water District is currently preparing a 2005 update of its Urban Water management Plan, pursuant to the Urban Water Management Planning Act (Act) of the California Water Code. The Act requires urban water suppliers to update their Urban Water management Plans and submit a complete plan to the California Department of Water Resources every five years.

A draft of West Basin's Plan is currently available for review and comment. A Final Draft will be available for review prior to the scheduled public hearing in October 2005.

Please contact us if you would like to receive a draft Plan. If you would like more information or have any questions, please contact Harvey De La Torre at (310) 660-6233 or via email at harveyd@wcbwater.org.

Thank you,

Art Aguilar, Co-General Manager

Rich Nagel, Co-General Manager

West Basin Municipal Water District

17140 S. Avalon Blvd • Suite 210 • Carson, CA 90746-1296

telephone 310-217-2411 • fax 310-217-2414

June 29, 2005

Dear Central/West Basin Customers Agencies:

2005 Urban Water Management Plan

As you are aware, all California agencies providing water to more than 3,000 customers or supplying more than 3,000 acre-feet of water a year are required to update their Urban Water Management Plans (UWMP) every five years, according to California Water Code Section 10621(a). Central Basin MWD (CBMWD) and West Basin MWD (WBMWD) posted its 2005 Urban Water Management Plan workshop with the Metropolitan Water District of Southern California and California Urban Water Conservation Council on June 28, 2005.

Enclosed you will find the District's DRAFT 2005 UWMP, which will assist you in updating your agency's UWMP. We will be meeting with each agency to discuss our Plan and answer any questions you may have throughout the months of July and August. Staff will be contacting you soon to schedule a date and time the District anticipates completing its FINAL UWMP by September and taking it to the Board for adoption in October. All UWMP's are due to the Department of Water Resources by December 31, 2005.

If you have any questions, please feel free to contact Harvey De La Torre at (310) 660-6233 or Leighanne Reeser at (310) 660-6225.

Sincerely,

Art Aguilar, Co-General Manager

Rich Nagel, Co-General Manager

Enclosures

Appendix E

West Basin Municipal Water District
17140 S. Avalon Blvd • Suite 210 • Carson, CA 90746-1296
telephone 310-217-2411 • fax 310-217-2414

Resolution No. _____

A RESOLUTION OF THE BOARD OF DIRECTORS OF
THE WEST BASIN MUNCIPAL WATER DISTRICT FINDING THE
EXISTENCE OF A WATER SHORTAGE,
ORDERING THE IMPLEMENTATION OF STAGE __ OF
THE WATER SHORTAGE CONTINGENCY PLAN

WHEREAS, the West Basin Municipal Water District (District), a member agency to Metropolitan Water District of Southern California (MWD), has implemented a mandatory reduction program; and

WHEREAS, the Board of Directors has established Stages of Action contingent upon the MWD Water Surplus and Drought Management (WSDM) Plan, which provides for stages of action and an allocation methodology; and

WHEREAS, the WSDM Plan allocation methodology has yet to be determined and the District has established and will follow the following stages of action:

a) Minimum Shortage Stage: Request a voluntary effort among the District customers to reduce imported water deliveries. Pursue an aggressive Public Awareness Campaign to encourage residents and industries to reduce their usage of water.

b) Moderate Shortage Stage: In addition to the Minimum Shortage Stage actions, the District will work with its customer agencies to promote and adopt waste water prohibition and ordinances to discourage unnecessary water usage.

c) Severe Shortage Stage: In addition to the Minimum and Moderate Shortage Stage actions, the District will seek to adopt a rate structure that penalized increased water usage among its customer agencies.

d) Extreme Water Shortage Stage: In addition to the Minimum, Moderate, and Severe Shortage Stage actions, the District will call for the discontinuance of imported water based upon an allocation methodology similar to MWD for each of its customer agencies; and

WHEREAS, the Board of Directors may, upon finding that a water shortage exists, order implementation of a plan which it deems appropriate to address such water shortage and shall establish the Stage if action that it is implementing.

West Basin Municipal Water District
17140 S. Avalon Blvd • Suite 210 • Carson, CA 90746-1296
telephone 310-217-2411 • fax 310-217-2414

NOW, THEREFORE, BE IT RESOLVED BY THE BOARD OF DIRECTORS OF THE WEST BASIN MUNICIPAL WATER DISTRICT AS FOLLOWS:

1. That, for the reasons hereinabove set forth, the Board of Directors hereby finds and determines that a Water Shortage exists in the West Basin Water District service area.
2. That the Board of Directors hereby orders implementation of the Water Shortage Contingency Plan, ___________Stage, as set forth above.
3. That reasonable action shall be taken to ensure compliance by the District's customer agencies.

THE FOREGOING RESOLUTION is approved and adopted by the Board of Directors of the West Basin Municipal Water District this __ day of ________, 20__

____
PRESIDENT, WEST BASIN MWD

ATTEST:

____
BOARD SECRETARY, WEST BASIN MWD

Appendix F

BMP 03: System Water Audits, Leak Detection and Repair

Reporting Unit:	BMP Form Status:	Year:
West Basin MWD	**100% Complete**	**2003**

A. Implementation

1. Has your agency completed a pre-screening system audit for this reporting year?	no
2. If YES, enter the values (AF/Year) used to calculate verifiable use as a percent of total production:	
a. Determine metered sales (AF)	
b. Determine other system verifiable uses (AF)	
c. Determine total supply into the system (AF)	
d. Using the numbers above, if (Metered Sales + Other Verifiable Uses) / Total Supply is < 0.9 then a full-scale system audit is required.	0.00
3. Does your agency keep necessary data on file to verify the values used to calculate verifiable uses as a percent of total production?	no
4. Did your agency complete a full-scale audit during this report year?	no
5. Does your agency maintain in-house records of audit results or the completed AWWA audit worksheets for the completed audit?	no
6. Does your agency operate a system leak detection program?	no
a. If yes, describe the leak detection program:	

B. Survey Data

1. Total number of miles of distribution system line.	0
2. Number of miles of distribution system line surveyed.	0

C. System Audit / Leak Detection Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures	0	0
2. Actual Expenditures	0	

D. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP?	No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

E. Comments

As a water wholesaler, West Basin does not own potable water pipes. We do however provide support to our water retailers as stated in BMP #10. Upon request, we provide DWR's literature on system audits and leak detection.

BMP 07: Public Information Programs

Reporting Unit:	BMP Form Status:	Year:
West Basin MWD	**100% Complete**	**2003**

A. Implementation

1. Does your agency maintain an active public information program to promote and educate customers about water conservation? — yes

a. If YES, describe the program and how it's organized.

The Public Information Program consists of a variety of programs and practices that are used to educate the public about water conservation. Conservation literature is provided to the public at the various one-day ultra-low-flush toilet programs, and at community events. A quarterly newsletter is provided to approximately 20,000 residents. Information is provided at the quarterly Public Information Committee (PIC) meeting, and at the annual "Water Harvest" festival. Information is also provided at various speaking engagements, the web site, and on the telephone. Opportunities are sought to educate the public about the importance of water conservation. Conservation literature is also provided to the retail water agencies upon request.

2. Indicate which and how many of the following activities are included in your public information program.

Public Information Program Activity	Yes/No	Number of Events
a. Paid Advertising	yes	21
b. Public Service Announcement	yes	1
c. Bill Inserts / Newsletters / Brochures	yes	2
d. Bill showing water usage in comparison to previous year's usage	no	
e. Demonstration Gardens	yes	1
f. Special Events, Media Events	yes	5
g. Speaker's Bureau	yes	3
h. Program to coordinate with other government agencies, industry and public interest groups and media	yes	

B. Conservation Information Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures	510850	475550
2. Actual Expenditures	200850	

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? — No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

The Budget is made up of several programs including,Education, Public Information Committee Meetings, web-site development and hosting.

BMP 08: School Education Programs

Reporting Unit:	BMP Form Status:	Year:
West Basin MWD	**100% Complete**	**2003**

A. Implementation

1.Has your agency implemented a school information program to promote water conservation? yes

2. Please provide information on your school programs (by grade level):

Grade	Are grade-appropriate materials distributed?	No. of class presentations	No. of students reached	No. of teachers' workshops
Grades K-3rd	yes	16	345	0
Grades 4th-6th	yes	15	505	0
Grades 7th-8th	yes	5	160	0
High School	yes	1	35	0

3. Did your Agency's materials meet state education framework requirements? yes

4. When did your Agency begin implementing this program? 9/10/1995

B. School Education Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures	62500	115500
2. Actual Expenditures	20000	

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

BMP 10: Wholesale Agency Assistance Programs

Reporting Unit:	BMP Form Status:	Year:
West Basin MWD	**100% Complete**	**2003**

A. Implementation

1. Financial Support by BMP

BMP	Financial Incentives Offered?	Budgeted Amount	Amount Awarded	BMP	Financial Incentives Offered?	Budgeted Amount	Amount Awarded
1	No			**8**	yes	62500	20000
2	No			**9**	yes	5000	5000
3	No			**10**	yes	0	0
4	No			**11**	No		
5	yes	15000000	15000000	**12**	yes	65000	65000
6	yes	5000	5000	**13**	yes	0	0
7	yes	510850	200850	**14**	yes	327350	327350

2. Technical Support

a. Has your agency conducted or funded workshops addressing CUWCC procedures for calculating program savings, costs and cost-effectiveness?	No
b. Has your agency conducted or funded workshops addressing retail agencies' BMP implementation reporting requirements?	No
c. Has your agency conducted or funded workshops addressing:	
1) ULFT replacement	No
2) Residential retrofits	No
3) Commercial, industrial, and institutional surveys	No
4) Residential and large turf irrigation	No
5) Conservation-related rates and pricing	No

3. Staff Resources by BMP

BMP	Qualified Staff Available for BMP?	No. FTE Staff Assigned to BMP	BMP	Qualified Staff Available for BMP?	No. FTE Staff Assigned to BMP
1	yes	1	**8**	yes	1
2	yes	1	**9**	yes	1
3	yes	1	**10**	yes	1
4	yes	1	**11**	yes	1
5	yes	1	**12**	yes	1
6	yes	1	**13**	yes	1
7	yes	1	**14**	yes	1

4. Regional Programs by BMP

BMP	Implementation/ Management Program?	BMP	Implementation/ Management Program?
1	No	**8**	yes
2	No	**9**	yes
3	No	**10**	yes
4	No	**11**	No
5	No	**12**	yes
6	yes	**13**	yes
7	yes	**14**	yes

B. Wholesale Agency Assistance Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures	665700	680700
2. Actual Expenditures	665700	

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? yes

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

In reference to BMP 5, the District spends roughly $15 Million on maintaining its water recycling system. Recycled water is 100% water conservation. This system benefits large landscape customers by utilizing recycled water instead of imported or potable water. A1 BMP 5 includes funding for recycled water operations and maintenance. Sections B1 & B2 exclude the budgets for the recycled water program. We consider this program as wholesale agency assistance because we are providing the region with a new source of water, and that the cities and retail water agencies can use to purchase less expensive water.

D. Comments

BMP #6 - MWD provides a $110 incentive per rebate. West Basin budgets $5,000 to further promote program. BMP $9 - MWD funds a region-wide CII rebate program. District budgets $5,000 to further promote program.

BMP 11: Conservation Pricing

Reporting Unit:	BMP Form Status:	Year:
West Basin MWD	**100% Complete**	**2003**

A. Implementation

Rate Structure Data Volumetric Rates for Water Service by Customer Class

1. Residential

a. Water Rate Structure	Uniform
b. Sewer Rate Structure	Service Not Provided
c. Total Revenue from Volumetric Rates	$65219297
d. Total Revenue from Non-Volumetric Charges, Fees and other Revenue Sources	$9924917

2. Commercial

a. Water Rate Structure	
b. Sewer Rate Structure	
c. Total Revenue from Volumetric Rates	$
d. Total Revenue from Non-Volumetric Charges, Fees and other Revenue Sources	$

3. Industrial

a. Water Rate Structure	
b. Sewer Rate Structure	
c. Total Revenue from Volumetric Rates	$
d. Total Revenue from Non-Volumetric Charges, Fees and other Revenue Sources	$

4. Institutional / Government

a. Water Rate Structure	
b. Sewer Rate Structure	
c. Total Revenue from Volumetric Rates	$
d. Total Revenue from Non-Volumetric Charges, Fees and other Revenue Sources	$

5. Irrigation

a. Water Rate Structure	
b. Sewer Rate Structure	
c. Total Revenue from Volumetric Rates	$
d. Total Revenue from Non-Volumetric Charges, Fees and other Revenue Sources	$

6. Other

a. Water Rate Structure

b. Sewer Rate Structure

c. Total Revenue from Volumetric Rates $

d. Total Revenue from Non-Volumetric Charges, Fees and other Revenue Sources $

B. Conservation Pricing Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures	0	0
2. Actual Expenditures	0	

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

BMP 12: Conservation Coordinator

Reporting Unit:	BMP Form Status:	Year:
West Basin MWD	**100% Complete**	**2003**

A. Implementation

1. Does your Agency have a conservation coordinator?	yes
2. Is this a full-time position?	no
3. If no, is the coordinator supplied by another agency with which you cooperate in a regional conservation program ?	yes
4. Partner agency's name:	Central Basin Municipal Water District
5. If your agency supplies the conservation coordinator:	
a. What percent is this conservation coordinator's position?	50%
b. Coordinator's Name	Gus Meza
c. Coordinator's Title	Conservation Coordinator
d. Coordinator's Experience and Number of Years	5 Years Water Conservation Experience
e. Date Coordinator's position was created (mm/dd/yyyy)	4/17/1991
6. Number of conservation staff, including Conservation Coordinator.	1

B. Conservation Staff Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures	65000	68000
2. Actual Expenditures	57680	

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP?	no

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

West Basin MWD shares staff with its sister agency Central Basin MWD on a 50/50 basis. So conservation staff time is one-half person for each Water District.

BMP 03: System Water Audits, Leak Detection and Repair

Reporting Unit:	BMP Form Status:	Year:
West Basin MWD	**100% Complete**	**2004**

A. Implementation

1. Has your agency completed a pre-screening system audit for this reporting year?	no
2. If YES, enter the values (AF/Year) used to calculate verifiable use as a percent of total production:	
a. Determine metered sales (AF)	
b. Determine other system verifiable uses (AF)	
c. Determine total supply into the system (AF)	
d. Using the numbers above, if (Metered Sales + Other Verifiable Uses) / Total Supply is < 0.9 then a full-scale system audit is required.	0.00
3. Does your agency keep necessary data on file to verify the values used to calculate verifiable uses as a percent of total production?	no
4. Did your agency complete a full-scale audit during this report year?	no
5. Does your agency maintain in-house records of audit results or the completed AWWA audit worksheets for the completed audit?	no
6. Does your agency operate a system leak detection program?	no
a. If yes, describe the leak detection program:	

B. Survey Data

1. Total number of miles of distribution system line.	0
2. Number of miles of distribution system line surveyed.	0

C. System Audit / Leak Detection Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures	0	0
2. Actual Expenditures	0	

D. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP?	No
a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."	

E. Comments

As a water wholesaler, West Basin does not own potable water pipes. We do however provide support to our water retailers as stated in BMP #10. Upon request, we provide DWR's literature on system audits and leak detection.

BMP 07: Public Information Programs

Reporting Unit:	BMP Form Status:	Year:
West Basin MWD	**100% Complete**	**2004**

A. Implementation

1. Does your agency maintain an active public information program to promote and educate customers about water conservation? — yes

a. If YES, describe the program and how it's organized.

The Public Information Program consists of a variety of programs and practices that are used to educate the public about water conservation. Conservation literature is provided to the public at the various one-day ultra-low-flush toilet programs, and at community events. A quarterly newsletter is provided to approximately 20,000 residents. Information is provided at the quarterly Public Information Committee (PIC) meeting, and at the annual "Water Harvest" festival. Information is also provided at various speaking engagements, the web site, and on the telephone. Opportunities are sought to educate the public about the importance of water conservation. Conservation literature is also provided to the retail water agencies upon request.

2. Indicate which and how many of the following activities are included in your public information program.

Public Information Program Activity	Yes/No	Number of Events
a. Paid Advertising	yes	21
b. Public Service Announcement	yes	1
c. Bill Inserts / Newsletters / Brochures	yes	2
d. Bill showing water usage in comparison to previous year's usage	no	
e. Demonstration Gardens	no	
f. Special Events, Media Events	yes	5
g. Speaker's Bureau	yes	3
h. Program to coordinate with other government agencies, industry and public interest groups and media	yes	

B. Conservation Information Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures	475550	475550
2. Actual Expenditures	353700	

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? — No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

The Budget is made up of several programs including,Education, Public Information Committee Meetings, web-site development and hosting,

BMP 08: School Education Programs

Reporting Unit:	BMP Form Status:	Year:
West Basin MWD	**100% Complete**	**2004**

A. Implementation

1.Has your agency implemented a school information program to promote water conservation? yes

2. Please provide information on your school programs (by grade level):

Grade	Are grade-appropriate materials distributed?	No. of class presentations	No. of students reached	No. of teachers' workshops
Grades K-3rd	yes	23	477	0
Grades 4th-6th	yes	23	767	0
Grades 7th-8th	yes	4	140	0
High School	yes	1	30	0

3. Did your Agency's materials meet state education framework requirements? yes

4. When did your Agency begin implementing this program? 9/10/1995

B. School Education Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures	115500	115500
2. Actual Expenditures	26000	

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? No

   a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

BMP 10: Wholesale Agency Assistance Programs

Reporting Unit:	BMP Form Status:	Year:
West Basin MWD	**100% Complete**	**2004**

A. Implementation

1. Financial Support by BMP

BMP	Financial Incentives Offered?	Budgeted Amount	Amount Awarded	BMP	Financial Incentives Offered?	Budgeted Amount	Amount Awarded
1	No			**8**	yes	115500	26000
2	No			**9**	yes	5000	5000
3	No			**10**	yes	0	0
4	No			**11**	No		
5	No			**12**	yes	65000	65000
6	yes	15000	15000	**13**	yes	0	0
7	yes	475550	200850	**14**	yes	321500	321500

2. Technical Support

a. Has your agency conducted or funded workshops addressing CUWCC procedures for calculating program savings, costs and cost-effectiveness?	No
b. Has your agency conducted or funded workshops addressing retail agencies' BMP implementation reporting requirements?	No
c. Has your agency conducted or funded workshops addressing:	
1) ULFT replacement	No
2) Residential retrofits	No
3) Commercial, industrial, and institutional surveys	No
4) Residential and large turf irrigation	No
5) Conservation-related rates and pricing	No

3. Staff Resources by BMP

BMP	Qualified Staff Available for BMP?	No. FTE Staff Assigned to BMP	BMP	Qualified Staff Available for BMP?	No. FTE Staff Assigned to BMP
1	yes	1	**8**	yes	1
2	yes	1	**9**	yes	1
3	yes	1	**10**	yes	1
4	yes	1	**11**	yes	1
5	yes	1	**12**	yes	1
6	yes	1	**13**	yes	1
7	yes	1	**14**	yes	1

4. Regional Programs by BMP

BMP	Implementation/ Management Program?	BMP	Implementation/ Management Program?
1	No	**8**	yes
2	No	**9**	yes
3	No	**10**	yes
4	No	**11**	No
5	No	**12**	yes
6	yes	**13**	yes
7	yes	**14**	yes

B. Wholesale Agency Assistance Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures	680700	680700
2. Actual Expenditures	680700	

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? yes

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

In reference to BMP 5, the District spends roughly $16 Million on maintaining its water recycling system. Recycled water is 100% water conservation. This system benefits large landscape customers by utilizing recycled water instead of imported or potable water. A1 BMP 5 includes funding for recycled water operations and maintenance. Sections B1 & B2 exclude the budgets for the recycled water program. We consider this program as wholesale agency assistance because we are providing the region with a new source of water, and that the cities and retail water agencies can use to purchase less expensive water.

D. Comments

BMP #6 - MWD provides a $110 incentive per rebate. West Basin budgets $5,000 to further promote program. BMP $9 - MWD funds a region-wide CII rebate program. District budgets $5,000 to further promote program.

BMP 11: Conservation Pricing

Reporting Unit: **West Basin MWD**	BMP Form Status: **100% Complete**	Year: **2004**

A. Implementation

Rate Structure Data Volumetric Rates for Water Service by Customer Class

1. Residential	
a. Water Rate Structure	Uniform
b. Sewer Rate Structure	Service Not Provided
c. Total Revenue from Volumetric Rates	$68006966
d. Total Revenue from Non-Volumetric Charges, Fees and other Revenue Sources	$10658770
2. Commercial	
a. Water Rate Structure	
b. Sewer Rate Structure	
c. Total Revenue from Volumetric Rates	$
d. Total Revenue from Non-Volumetric Charges, Fees and other Revenue Sources	$
3. Industrial	
a. Water Rate Structure	
b. Sewer Rate Structure	
c. Total Revenue from Volumetric Rates	$
d. Total Revenue from Non-Volumetric Charges, Fees and other Revenue Sources	$
4. Institutional / Government	
a. Water Rate Structure	
b. Sewer Rate Structure	
c. Total Revenue from Volumetric Rates	$
d. Total Revenue from Non-Volumetric Charges, Fees and other Revenue Sources	$
5. Irrigation	
a. Water Rate Structure	
b. Sewer Rate Structure	
c. Total Revenue from Volumetric Rates	$
d. Total Revenue from Non-Volumetric Charges, Fees and other Revenue Sources	$
6. Other	
a. Water Rate Structure	

b. Sewer Rate Structure

c. Total Revenue from Volumetric Rates $

d. Total Revenue from Non-Volumetric Charges, Fees and other Revenue Sources $

B. Conservation Pricing Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures	0	0
2. Actual Expenditures	0	

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

BMP 12: Conservation Coordinator

Reporting Unit:	BMP Form Status:	Year:
West Basin MWD	**100% Complete**	**2004**

A. Implementation

1. Does your Agency have a conservation coordinator?	yes
2. Is this a full-time position?	no
3. If no, is the coordinator supplied by another agency with which you cooperate in a regional conservation program ?	yes
4. Partner agency's name:	Central Basin Municipal Water District
5. If your agency supplies the conservation coordinator:	
a. What percent is this conservation coordinator's position?	50%
b. Coordinator's Name	Gus Meza
c. Coordinator's Title	Conservation Coordinator
d. Coordinator's Experience and Number of Years	6 Years Water Conservation Experience
e. Date Coordinator's position was created (mm/dd/yyyy)	4/17/1991
6. Number of conservation staff, including Conservation Coordinator.	1

B. Conservation Staff Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures	68000	68000
2. Actual Expenditures	57680	

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? no

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

West Basin MWD shares staff with its sister agency Central Basin MWD on a 50/50 basis. So conservation staff time is one-half person for each Water District.

Glossary

Glossary of Abbreviations and Terms

Agencies

AWWARF	American Water Works Association Research Foundation
CalWater	California Water Service Company
CDHS	California Department of Health Services
Central Basin	Central Basin Municipal Water District
City	City of Los Angeles
CPUC	California Public Utilities Commission
CSDLAC	County Sanitation Districts of Los Angeles County
CUWCC	California Urban Water Conservation Council
CWAC	California Water Awareness Campaign
District	West Basin Municipal Water District
DWR	California Department of Water Resources
Edison	Southern California Edison
EPA	United States Environmental Protection Agency
LACDPW	Los Angeles County Department of Public Works
LACFCD	Los Angeles County Flood Control District
LADWP	Los Angeles Department of Water and Power
MWD	Metropolitan Water District of Southern California
RWQCB	Regional Water Quality Control Board
SCAG	Southern California Association of Governments
USBR	United States Bureau of Reclamation
West Basin	West Basin Municipal Water District
WRD	Water Replenishment District of Southern California

Facilities and Locations

Barrier	Alamitos Barrier
Bay-Delta	San Francisco- San Joaquin Bay Delta
CGB	Central Groundwater Basin
CRA	Colorado River Aqueduct
CSUDH	California State University at Dominguez Hills
CVP	Central Valley Project
EOC	Emergency Operation Center
Hyperion	Hyperion Wastewater Treatment Plant
Pilot Project	West Basin's Desalination Pilot Project
SWP	State Water Project
WBWRF	West Basin Water Recycling Treatment Facility
WCGB	West Coast Groundwater Basin
WRP	Water Recycling Plant

Measurements

AFY	Acre-Feet Per Year
CFS	Cubic Feet Per Second
GPCD	Gallons Per Capita Per Day
GPM	Gallons Per Minute
MAF	Million Acre-Feet
MGD	Million Gallons per Day
TAF	Thousand Acre-Feet
WF	Water Factor

Miscellaneous

BMPs	Best Management Practices
CBIC	Weather0Based Irrigation Program
CII	Commercial, Industrial & Institutional
Harbor/South Bay	Harbor/South Bay Water Recycling Project
HECW	High-Efficiency Clothes Washer Program
HET	High-Efficiency Toilets
IRP	Integrated Resources Plan
Marketing Plan	Recycled Water Marketing Plan
Master Plan	Recycled Water Master Plan
MOU	Memorandum of Understanding
MWD-MAIN	Metropolitan Water District's Municipal and Industrial Needs
NPDES	National Pollutant Discharge Elimination System
PAC	Project Advisory Committee
PIC	Public Information Committee
Plan	Conservation Master Plan
Program	Water Audit and Leak Detection Program
QSA	Quantification Settlement Agreement
RTS	Readiness-to-Serve Charge
SDWP	Safe Drinking Water Program
Title 22	California Code of Regulations Title 22 standards
ULFT	Ultra-Low Flush Toilet
UWMP	Urban Water Management Plan
VOCs	Volatile Organic Compounds
WBIC	Weather-Based Irrigation Controller
WQPP	Water Quality Protection Project
WSDM Plan	Water Surplus and Drought Management Plan




Prepared by: West Basin Municipal Water District - 17140 South Avalon Boulevard, Suite 210 - Carson, CA 90746
www.westbasin.org

Ventura County
Watershed Protection District
Water & Environmental Resources Division

MEMORANDUM

DATE: June 3, 2014

FROM: Ewelina Mutkowska, Engineering Manager
David Kirby, Water Quality Engineer

SUBJECT: Summary of Stormwater Runoff Volume Estimation
El Rio Retrofit for Groundwater Recharge Project Selected for 2014 Drought IRWM Implementation Grant Program Funding Application

Introduction
The County of Ventura is proposing to install stormwater capture system in El Rio, CA for groundwater recharge of Oxnard Plain Forebay Basin for funding application under the 2014 Drought IRWM Implementation Grant Program. This retrofit project is designed to capture "first flush" stormwater runoff during each storm event and all dry weather flows for treatment and recharge. In order to quantify groundwater recharge volumes, it was essential to estimate how much and how frequently storm events will occur. This memo presents estimates based on most recent 10 years of rainfall data.

Historical Rainfall Data Analysis
Daily rainfall totals collected between 10/01/1992 and 10/01/2013 at the gauge station 239 located at El Rio-UWCD Spreading Grounds were used to estimate future project stormwater capture volumes for groundwater recharge.

The project groundwater recharge system is designed to capture 99,273 cubic feet (2.3 acre feet) of runoff from 64 acre residential area per storm event equal or greater than 0.85". For rainfall events smaller than 0.85" and for dry weather flows, the captured volume will be respectively less depending on amount of runoff generated. Utilizing preliminary on-site testing infiltration rates for the project footprint, it is estimated that at a minimum 99,273 cubic feet (2.3 acre feet) of water will be infiltrated recharging the Oxnard Forebay Groundwater basin which is equivalent to approximately 0.85" of every rain event. Infiltration testing was completed at the El Rio project area in May/June 2014. Preliminary results indicated average infiltration rates of 165 in/hr at 4 feet below ground surface and 238 in/hr at 12 feet below ground surface. Laboratory testing of the soils as well as the final infiltration testing results are being compiled within a final memorandum.

Monitoring Year	Calculated Total Stormwater Volume* (AFY)
2013	14
2012	23
2011	38
2010	36
2009	23
2008	26
2007	13
2006	32
2005	57
2004	21
2003	32
2002	16
2001	31
2000	34
1999	25
1998	68
1997	27
1996	25
1995	53
1994	28
1993	48
Average	**32**

* The calculated volume represent volume would be captured and infiltrated for groundwater recharge by the proposed retrofit project based on the design total storage capacity of the system and conservative soil infiltration rates.

Stormwater Capture Estimate and Comments

Based on the over 20 years of rainfall data collected at El Rio area and the design storage capacity of the system, the average stormwater capture volume by the proposed retrofit project is 32 AFY during wet weather.

Ventura County
Watershed Protection District
Water & Environmental Resources Division

MEMORANDUM

DATE: June 2, 2014

FROM: Bram Sercu, Water Resources Specialist

TO: Ewelina Mutkowska, Engineering Manager

CC: David Kirby, Water Quality Engineer

SUBJECT: Summary of Dry-weather Urban Runoff Volume Estimation
El Rio Retrofit for Groundwater Recharge Project Selected for 2014 Drought IRWM Implementation Grant Program Funding Application

Introduction

The County of Ventura is proposing to install a stormwater capture system in El Rio, CA for groundwater recharge of Oxnard Plain Forebay Basin for funding application under the 2014 Drought IRWM Implementation Grant Program. In addition to stormwater volumes this retrofit project is designed to capture during wet-weather, it is anticipated that 100% of the dry-weather nuisance runoff will be also captured for treatment and recharge. In order to quantify groundwater recharge volumes, it was essential to estimate how much dry-weather runoff is generated within the residential land area of the project. This memo presents my best dry-weather volume estimate based on monitoring data generated for storm drain outfalls in the residential area of Oak Park, CA during the County's Malibu Creek Bacteria TMDL special study in summer of 2013.

Oak Park Study Results

The County of Ventura (County) performed a dry-weather microbial source identification study in Oak Park during the summer of 2013. The study involved measuring dry-weather flow in storm drain outfalls. Flow measurements occurred in the morning, on between 1 and 5 occasions at each outfall location. Average daily volumes per acre were calculated assuming continuous flow during 24 hours. The table below summarizes outfall flow monitoring data and land-use information relevant for the County's El Rio Retrofit for Groundwater Recharge project. The average daily runoff volume per acre across all locations was 31 cf/acre/day.

Outfall	Dominant land uses	Urban drainage area (acres)	Average flow (gpm)	Average volume (cf/acre/day)
L3	Single family residential Apartments, condos and townhouses	295	89	57

Outfall	Dominant land uses	Urban drainage area (acres)	Average flow (gpm)	Average volume (cf/acre/day)
TL1	Single family residential Multiplexes, condos and townhouses Commercial	71	20	53
TL6D	Multiplexes, condos and townhouses	13	1.27	19
M1	Single family residential Multiplexes, condos and townhouses	23	2.2	18
M2	Single family residential	18	1.2	12
M5	Single family residential	31	3.4	21
M8	Single family residential Apartments, condos and townhouses	47	2.4	10
M31	Single family residential Apartments, condos and townhouses Park	113	35.3	59

Estimate for the proposed project drainage area

The annual dry-weather runoff volume (acre-ft/yr) from the El Rio drainage area was estimated by multiplying the average daily volume per acre (31 cf/acre/day) measured in the Oak Park study with the El Rio drainage area.

Area	Project drainage area (acres)	Estimated annual runoff volume (cf/day)	Estimated annual runoff volume (acre-ft/yr)
El Rio	64	1973	17

While dry-weather runoff volumes can vary based on local conditions, the Oak Park data are expected to be representative for the El Rio area, because the latter drainage area is well within the range of those monitored in Oak Park, and because land use in all drainage areas is highly similar. The El Rio drainage area is predominantly single family residential (and one school), while the Oak Park drainage areas are mostly single-family residential, with some apartments, multiplexes, condos and townhouses, and to a lesser extent schools and parks (excluding undeveloped areas which do not contribute during dry-weather).

GROUNDWATER AND SURFACE WATER CONDITIONS REPORT - 2013

United Water Conservation District
Open-File Report 2014-02

PREPARED BY

GROUNDWATER RESOURCES DEPARTMENT
MAY 2014

UWCD OFR 2014-02

GROUNDWATER AND SURFACE WATER CONDITIONS REPORT - 2013

United Water Conservation District
Open-File Report 2014-02

Groundwater Resources Department
May 2014

THIS REPORT IS PRELIMINARY AND IS SUBJECT TO MODIFICATION

BASED UPON FUTURE ANALYSIS AND EVALUATION

Cover Photo: Sunrise at El Rio Spreading Grounds. By John Carman.

Preferred Citation:

United Water Conservation District, 2014, Groundwater and Surface Water Conditions Report - 2013, United Water Conservation District Open-File Report 2014-02.

GROUNDWATER AND SURFACE WATER CONDITIONS REPORT - 2013

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LIST OF FIGURES AND TABLES

EXECUTIVE SUMMARY / ABSTRACT

United Water Conservation District is a public agency that encompasses nearly 213,000 acres of central and southern Ventura County. The District covers the downstream (Ventura County) portion of the valley of the Santa Clara River, as well as the Oxnard Plain. The District serves as the steward for managing the surface water and groundwater resources within all or portions of eight groundwater basins. This report includes data and records from the 2013 calendar year, including basic information and discussion on the operation of the District's facilities, weather and hydrologic information, groundwater levels and available storage within the basins, and the quality of surface water and groundwater.

Major water resource issues and concerns are the driving impetus for the District's projects and programs. Projects and programs are implemented to manage, mitigate, or eliminate those issues or concerns that threaten the water resources. Those issues and concerns include, but are certainly not limited to, groundwater overdraft and the intrusion of saline water in the Oxnard Plain and Pleasant Valley basins, the gradual, long-term declining water levels in the Santa Paula Basin, water quality of the Oxnard Forebay basin and the Piru basin, and concerns related to the management of the Piru and Fillmore basin water resources.

To address those issues and concerns, United implements a wide variety of activities. Some of the activities are District-wide, for example: water levels are monitored in an extensive network of water wells thorough the District and a significant number of these wells are sampled as a part of a water quality monitoring program. In addition, stream gauging is performed periodically to quantify surface water volumes and flow rates under various hydrologic conditions. These data are important to United's habitat conservation efforts and the facilitation of fish passage at the Vern Freeman Diversion, as well as optimizing various District operations (e.g., annual conservation release, diversion of water to recharge basins or for use in-lieu of groundwater pumping by agricultural operations on the Oxnard Plain and in Pleasant Valley basin). Currently, the largest District-wide project underway by the groundwater department is the update of the Ventura County Regional Groundwater Flow Model. This is a multi-year, multi-faceted project that requires the expertise of several groundwater science specialties and relies on the District's long record of water-level, water quality, and stream gauging data. When completed, the groundwater flow model will be a primary evaluative tool for various proposed water management scenarios and will assist stakeholders with enhancing the sustainability and reliability of local water resources.

Issue-specific projects are also implemented by United to assist local stakeholders in the management of local water resources (e.g., AB3030 Piru/Fillmore Groundwater Management Plan, analyses of groundwater conditions in the Santa Paula basin as a part of the Technical Advisory Committee) or the pursuit of grant funds (e.g., Local Groundwater Assistance Program grants from CA Department of Water Resources, Fox Canyon Groundwater Management Agency Groundwater

Supply Enhancement Assistance Program) to help defray the costs of some of the groundwater projects.

The benefits of the surface water and groundwater projects and programs operated by United are shared by the many groundwater pumping entities in the District and those who receive those waters. Many of the benefits are in the background and not readily recognized or apparent to individual water users, however, the positive impacts of the District's activities are significant to the agricultural, municipal, and industrial economies of Ventura County.

4 ANNUAL HYDROLOGIC CONDITIONS

This section details the range of hydrologic conditions observed throughout United's district boundaries in the year 2013. While the emphasis is placed on surface water and groundwater conditions over the past year, some discussion is devoted to the comparison of recent conditions to conditions documented in the historical record. Rainfall totals were well below normal in both 2012 and 2013, and significant storms have not visited the region since March 2011. The basins of the district have responded to these unusually dry conditions.

4.1 PRECIPITATION AND EVAPOTRANSPIRATION

United participates in data collection in partnership with the Ventura County Watershed Protection District's three rainfall gages, two of which are also evaporation stations. The VCWPD maintains approximately 125 gages around the county (Figure 4.1-1). United's gages are located at the field offices in Saticoy, El Rio, and at the guard station at the Lake Piru. United also maintains records from the gage at the office in Santa Paula for its own use. United's monitoring stations showed that precipitation was about 136% of normal for the 2011 water year, with December and March accounting for 65% of the rainfall. Lake Piru recorded 28.48 inches of rainfall, approximately 8.6 inches more that the average received at that location, and in the top 20% in terms of rainfall totals for this station. In contrast, 2013 precipitation was about 38% of normal within the district with an average rainfall of just 6.6 inches across the district. The rainfall measured at the Santa Paula site for 2013 represents the second driest year measured since 1890. Table 4-1 and Figure 4.1-2 show the precipitation across the districts monitoring sites for 2011 through 2013.

Table 4-1 Monthly Precipitation for water years 2011-2013

Rainfall at UWCD Stations (Inches)			
WY	El Rio #239	Lake Piru # 160	Santa Paula # 245
2011	19.41	28.48	23.79
2012	9.7	13.07	10.18
2013	5.7	7.55	6.53

4.2 SURFACE WATER

The Santa Clara River Watershed is extensively monitored by multiple agencies for rainfall, daily stream discharge and flood flows. Data for many of the monitoring sites goes back to the early 1900s giving a long period of record for comparison purposes. The year 2011 overall would fall in the normal to wet category in terms of both precipitation and run-off. Below is a brief discussion of how 2011 compares to the historical record. Daily and monthly data for all the sites discussed can be obtained on-line at websites maintained by the USGS and VCWPD.

4.2.1 SANTA CLARA RIVER SYSTEM

The Santa Clara River is the largest river system in southern California remaining in a relatively natural state. The headwaters start on the northern slopes of the San Gabriel Mountains and the river flows approximately 84 miles to an estuary and river mouth at the Pacific Ocean near Ventura Harbor on the northern Oxnard Plain. The major tributaries include Castaic Creek and San Francisquito Creek in Los Angeles County, and Sespe, Piru and Santa Paula creeks in Ventura County. While the Los Angeles portion of the watershed accounts for 40% of the total area, it only produces about 20% of the total river flow, with dry-season base flows sustained by discharges from wastewater treatment plants and rising groundwater from the Eastern groundwater basin. As mentioned in other sections of this report, even though 2011 was wetter than most years, large sections of the main stem of the Santa Clara River remained dry for most of the year.

4.2.1.1 FLOW IN THE SANTA CLARA RIVER WATERSHED

Surface water flows in the Santa Clara River system were well above normal for the 2011 calendar year. The season started out wet with an early storm in December 2010. The storm peaked Sespe flows over 3,000 cfs a couple of times before runoff subsided in late February. Two smaller storms were then followed by a large March storm where the Sespe's peak flow exceeded 35,000 cfs. Flows in the Sespe were over 1,000 cfs for the next 10 days. In contrast to 2012 and 2013, the maximum runoff measured at the Sespe gage was 2,300 cfs for 2012 and just 77cfs for 2013. Base flows in these years went down to 2-3 cfs measured at the gage.

The USGS station 111090000, Santa Clara River near Piru, measures the entire contribution from Los Angeles County's portion of the watershed that flows into Ventura County. This station recorded a peak flow of nearly 9,000 cfs in the March storm. Flows subsided to a little over 300 cfs within a couple of days after the peak. A large release from Castaic Lake in the month of April brought the average flow up to 11,000 AF that month. In contrast peak flows for 2012 reached 1,520 cfs and 893 cfs in 2013. Due to the effluent dominating the low flows, all years experienced base flows as low as 10 -12 cfs during the summer months.

Table 4-2 Total Discharge for various stream flow stations

USGS/VCWPD Stream flow Stations	2011	2012	2013
	AF	AF	AF
Santa Clara River Near Piru USGS Sta. 11109000	69,813	31,582	23,271
Piru Creek Above Santa Felicia Dam USGS Sta. 11109600	69,885	13,081	6,605
Piru Creek Below Santa Felicia Dam USGS Sta. 1110900	41,989	39,893	22,765
Sespe Near Fillmore USGS Sta. 1111300	158,271	15,104	4,307
Santa Paula Creek VCWPD 709	32,811	4,408	1,164

Table 4-2 shows the annual water year runoff for the monitoring sites above the Freeman Diversion. The Sespe, Piru Creek above Santa Felicia Dam and Santa Paula Creek in general represent the natural runoff produced by rainfall. Because Pyramid above Lake Piru has adopted an inflow = outflow flow regime this gage can be included as a more natural flow regime. Both the Piru Creek below Santa Felicia Dam and The Santa Clara River Near Piru sites represent a more regulated stream flow with SFD on Piru Creek and the Los Angeles County effluent discharge upstream of the other site. As a result of the more regulated flows the dry year of 2013 has less of an effect on the flows when compared to the more natural watersheds. In 2013 the natural watersheds produced a total of 261,000 AF of runoff in 2011 and only 12,000 AF of runoff in 2013. The dry year of 2013 represents only 5% of the total runoff produced in 2011. In contrast the regulated flows in Piru and the County Line dry year represents 33% of the total runoff produced in 2011. Figure 4.2-1 shows the discharge measured at the above mentioned USGS sites for 2011 through 2013.

4.2.1.2 WATER QUALITY

United maintains a surface water quality monitoring program and collects samples from a number locations at frequencies ranging from quarterly to every two weeks. Sampling sites are generally located on the Santa Clara River near groundwater basin boundaries and at the major tributaries near the confluence with the river. Additional water quality sampling sites include the Santa Clara River at the Freeman Diversion and the weir where surface water arrives at United's El Rio recharge basins. Sample analysis commonly consists of either a full inorganic general mineral suite or several key constituents such as TDS, chloride and nitrate. This surface water quality monitoring provides documentation of variations in surface water quality and information on the quality of water that is recharging the groundwater basins of the District. Sampling is conducted every three months at most of the sites, but more frequently at some key locations (Santa Clara River: every month near County Line and every two weeks at Freeman Diversion).

Water quality at the various sampling sites throughout the District tends to vary seasonally, with the lowest annual mineral concentrations commonly recorded in the winter and spring when flow is higher. Results from United's 2013 surface water sampling are shown on Figures 4.2-2 and 4.2-3, where the annual recorded maximum concentrations of chloride and TDS, respectively, are displayed over the annual minimum values. The range in values is from four seasonal samples at most locations, so the true range in quality in the water bodies is likely greater than what is documented. In 2013 several sites had dry channel conditions at the time of scheduled sampling, so less than four annual samples were collected at those locations. With the dry conditions in the watershed this year, the mineral content of surface waters tended to be higher at some locations. At locations when rising groundwater is a primary component of surface flow, dry season water quality tends to be fairly stable year-to-year.

Water quality in Piru Creek is influenced by Pyramid Lake located higher in the Piru Creek watershed, which receives large volumes of water from the State Water Project. Water in middle Piru Creek is a blend of State Water and local runoff from the upper Piru Creek watershed. When chloride concentrations in State Water are high, the chloride in middle Piru Creek (below Pyramid dam) and Lake Piru can be much higher than what would occur naturally. In 2013 the maximum-recorded chloride in Lake Piru was 63 mg/l. Chloride concentrations as high as 135 mg/l were recorded flowing into the lake, but the 2013 flows associated with these high chloride concentrations were minor.

Chloride concentrations in the Santa Clara River near the Los Angeles County line are also influenced by chloride in imported State Water, as Castaic Lake Water Agency delivers State Water to water retailers in the greater Santa Clarita area. Nearly 50% of the chloride load in wastewater discharges is from the chloride load in delivered water (LACSD, 2008). Additional chloride loading occurs during beneficial use of the delivered water, but loading has been significantly reduced in recent years as the Los Angeles County Sanitation District has managed a successful campaign to remove thousands of self-regenerating water softeners from the community. The Sanitation Districts are trying to satisfy regulatory requirements for the quality of their effluent, but the approach to be taken is not yet clear as community residents have resisted funding a chloride TMDL proposed by the Sanitation Districts and approved by the Los Angeles Regional Water Quality Control Board in December 2008.

Over the past few decades chloride concentrations in the Santa Clara River have varied considerably near the Los Angeles County line as water quality at this location is heavily influenced by discharges from the Valencia Water Reclamation Plant. From the late 1990s through 2003 the discharges from the Valencia plant increased steadily in both volume and chloride, with chloride concentrations exceeding 200 mg/l near the end of this period. Since 2003 chloride concentrations in the discharges have fallen somewhat: however, chloride in the river commonly exceeds the 100 mg/l surface water objective during months without significant rainfall (Figure 4.2-4). The lower chloride concentrations in the Santa Clara River in recent years are largely related to lower chloride in wastewater discharges from the Valencia WRP (Figure 4.3-4). This is likely the result of lower chloride levels in State Water Project imports and a successful ban of self-regenerating water softeners in City of Santa Clarita area homes. Prior to 1970 the discharge of oilfield brines significantly impaired water quality in the river at this location, but flows associated with this poor water quality were likely minor.

Beginning in January 1999, United has sampled the Santa Clara River near the Los Angeles County line each month for chloride and other analytes. Sampling in 2013 documented chloride concentrations ranging from 112 to 135 mg/l. Chloride concentrations in the water released from Lake Piru ranged from 61 to 63 mg/l over the same time period (Figure 4.2-2).

Sespe Creek at times has high chloride concentrations, historically and in recent years. Low chloride concentrations are also commonly measured in the runoff from the Sespe watershed, and the source of chloride has not been determined.

In recent years both the City of Fillmore and the City of Santa Paula have eliminated discharges of treated wastewater to the Santa Clara River. Santa Paula's new treatment plant came on line in 2010 and now utilizes percolation basins for wastewater disposal. Fillmore completed a new plant in 2009 and now distributes reclaimed water to both percolation basins near the plant site and a network of subsurface irrigation systems constructed in parks and school fields throughout the City. The City of Fillmore has banned installation of self-regenerating water softeners as part of its efforts to reduce chloride loading to the watershed. There are now no Ventura County water reclamation plants discharging flow to the Santa Clara River. Continuous river flow from Los Angeles County line to the Freeman Diversion is uncommon, but when there is connection, flows are usually high in the lower watershed and the recycled water component sourcing from Los Angeles County is very minor. The maximum-recorded chloride concentration in the Santa Clara River at Freeman Diversion in 2013 was 140 mg/l (Figure 4.2-2). In the summer and fall of 2013 when chloride in the Santa Clara River was recorded at concentrations greater than 100 mg/l, flow in the river was approximately one cfs or less.

United frequently monitors water quality in the Santa Clara River at the Freeman Diversion, the point where water is diverted from the river for either direct deliveries to agricultural users or groundwater recharge in the Oxnard Forebay. Samples are collected at the Freeman Diversion approximately every two weeks to confirm that the water is acceptable for use in both aquifer recharge and for irrigation deliveries. The TDS and chloride content of water in the river at this location exhibits a strong negative correlation with flow, with higher flows being less mineralized (Figure 4.2-5 and Figure 4.2-6). Under dry watershed conditions groundwater discharge (rising water) from the Fillmore basin comprises a large portion of the river flow at the Freeman Diversion. Under wetter conditions tributary flow, most notably from Sespe and Santa Paula Creeks, contribute flow to the lower river and improves water quality compared to low-flow conditions. High river flows resulting from the direct runoff of precipitation commonly has the lowest dissolved mineral content, as does the recession limb of hydrographs from large flow events (Figure 4.2-5). United commonly diverts large volumes of water from the river for groundwater recharge during these periods of high flow and good water quality. Recorded TDS concentrations at the Freeman Diversion ranged from 1110 to 1570 mg/l in 2013 (Figure 4.2-3). As with chloride concentrations at this location, poor quality is associated with low flows in the river, and this water is generally used for irrigation deliveries rather than groundwater recharge.

Nitrate concentrations in the Santa Clara River at Freeman Diversion show some negative correlation with flow but concentrations are routinely low in the river during both high and low flows (Figure 4.2-6). A weak seasonal signature has been observed, with nitrate concentrations rising slightly in the fall (UWCD, 2008). For the 27 samples collected at Freeman Diversion in 2013 the maximum-recorded nitrate concentration was 7.7 mg/l, well below the CA DPH health standard of 45 mg/l.

The County of Ventura maintains and operates composite sampling device at the Freeman Diversion, and samples storm flow and dry weather base flows several times per year. These samples are analyzed for a broad suite of organic contaminants and metals as part of a storm water quality program required by the Los Angeles Regional Water Quality Control Board. Detections of organic contaminants such as pesticides are uncommon and generally of low concentration (VCWPD, 2010)

4.2.2 CALLEGUAS CREEK

United does not actively gage or sample surface water in the Calleguas Creek watershed. Much of the monitoring activity in the Calleguas Creek watershed is currently associated with the Salts TMDL under development for the watershed.

4.3 GROUNDWATER

Groundwater is utilized extensively for municipal and agricultural use throughout the boundaries of United Water Conservation District, as imported water supplies are unavailable over much of this area. United has a responsibility to monitor conditions in the basins throughout the District so that the basins are understood and managed as needed. Many small water supply projects are completed without United's direct involvement, but proponents of most large water projects engage United's support in some way (e.g., data sets, technical support, financial assistance, etc.).

The following sections detail 2013 basin conditions within the eight groundwater subbasins which fall wholly or partially within United's District boundaries. Groundwater elevations have fallen considerably in a number of areas since 2011, the last year with significant local rainfall. In 2013 rainfall and streamflow were well below average, which limited the amount of recharge to the basins. For the first time since 1990 there was no conservation release from Lake Piru. Some discussion in the following section is devoted to comparing current conditions to past periods of abundant rainfall or drought, or periods pre-dating some major water supply projects within the District.

4.3.1 PIRU BASIN

The unconfined Piru basin has the capacity to rapidly accept water from the channel of the Santa Clara River and tributary streams. Groundwater in storage within the basin is slowly discharged to the downstream Fillmore basin, so in some ways the Piru basin acts as a "forebay" to downstream groundwater basins in the Santa Clara River Valley. Surface water flow resulting from the discharge of rising groundwater at the west end of the basin is greater when groundwater elevations are higher in the downstream portions of the basin. Groundwater elevations remain above historic lows, but over the past decade chloride impacts sourcing from Los Angeles County have migrated down past the midpoint of the basin.

4.3.1.1 WATER LEVELS

Historical groundwater elevations for United's Piru basin key well, located northwest of the confluence of Piru Creek and the Santa Clara River are shown on the hydrograph in Figure 4.3-1. The historical record for this well shows that groundwater elevations in the Piru basin fluctuate dramatically, and that the basin is capable of rapid recovery of water levels following periods of drought. Water level recovery at this location is largely related to channel recharge associated with high and prolonged flow in the Santa Clara River and in Piru Creek, such as that which occurs during reservoir releases or large winter storms.

The basin fills in wet years such as 1998 and 2005, as shown by the flat-topping of groundwater elevations at 620 feet (Figure 4.3-1). The winter of 2011 was moderately wet but the basin did not fill to historical highs. Water levels in this key well recovered by about 13 feet in response to United's fall 2012 conservation release, but have fallen continuously since that time. Water levels in this well have fallen 80 feet since the spring of 2011, to a level within 20 feet of the level recorded in the drought conditions of 1991.

Piru basin groundwater levels have benefited from the recharge of recycled water discharged to the Santa Clara River by water reclamation plants in Los Angeles County. Historically the Santa Clara River has maintained perennial flow in the vicinity of Blue Cut and the County line, with the flow sustained by groundwater discharge from the Eastern groundwater basin. The City of Santa Clarita began importing State Water in 1980, and steady growth in that community resulted in steady increases in wastewater discharges until recent years, when discharge has diminished slightly. United's fall conservation releases from Lake Piru provide an additional source of recharge to the basin. Release volumes vary year-to-year, and variable channel conditions affect the percentage of the released water that percolates in the Piru basin. Recharge through the channel of Hopper Creek is likely another source of significant recharge during wet years. Reclaimed water from the community of Piru is distributed to recharge ponds near the confluence of Hopper Creek and the Santa Clara River.

Groundwater elevation contours were interpreted from measured groundwater elevation highs from the spring of 2013 and groundwater elevation lows from the fall of 2013, and are shown in Figures

4.3-2 and 4.3-3 respectively. Groundwater flow is consistently from east to west, roughly following the land surface gradient of the river channel. In the eastern portion of the Piru basin, groundwater flow paths angle north towards areas of groundwater pumping north of the Santa Clara River. Depths to water are greater along the northern portions of the basin where alluvial fan deposits elevate the land surface.

The tight contours shown in the eastern Piru basin, just west of United's District boundary, indicate that this eastern portion of the basin is an area of significant recharge. This is the area where surface water sourcing from the Santa Clara River watershed in Los Angeles County infiltrates to groundwater and the river often goes dry. Spring 2013 measured groundwater elevations were approximately 30 feet higher than in the fall in this area.

Groundwater rises near the constriction at the downstream west end of the basin, contributing flow to the Santa Clara River. Groundwater elevations near the constriction at the west end of the basin are historically more stable than those in the central and eastern portions of the basin. Recorded groundwater elevations were about the same in this area in spring and fall of 2013. Near Hopper Creek, water levels were about 20 feet lower in the fall than they were in the spring. The contours also show groundwater flow from the Piru basin to the Fillmore basin to the west.

4.3.1.2 GROUNDWATER EXTRACTIONS

Reported groundwater extractions from 107 active wells in the Piru Basin totaled 12,800 acre-feet for the 2013 calendar year. This is about 420 acre-feet more than the historical average for the period 1980 to 2013, the period of available records. A portion of the Piru basin extends east of United's District boundary and any pumping from this portion of the basin is not reported to United. The historical annual extractions for the Piru basin are shown in the histogram in Figure 4.3-4. Only a small percentage of groundwater pumping in the Piru basin is for municipal and industrial use, consistent with agriculture being the dominant land use within the basin.

Figure 4.3-5 is a map showing reported groundwater extractions from individual wells in the Piru Basin for the 2013 calendar year. Pumping magnitude is indicated by dot size and color. Agriculture is the predominant land use within the Piru basin, and pumping is shown to be distributed throughout the basin. Few active wells exist along the southeastern margin of the basin, and some crops here are irrigated with water piped in from other areas. Two private mutual water companies operate within the basin. The Piru Mutual Water Company diverts water from Piru Creek for agricultural use in the north-central portion of the basin, and Warring Water Company pumps water primarily for domestic use in the town of Piru.

In some canyon and upland areas, orchards are irrigated with groundwater pumped from lower areas of the basin and lifted to higher elevations. Additional development of hillside areas surrounding the alluvial basin floor results in increased groundwater demand on the basin. Over the past decade a large number of orange orchards have been removed and replaced by row crops or box tree nurseries.

The primary losses of groundwater from the Piru basin are the result of discharge of groundwater to the Santa Clara River at the western boundary of the basin, the subsurface outflow of groundwater at the western boundary of the basin and extraction of groundwater by wells.

4.3.1.3 WATER QUALITY

Over the past fifteen years the main water quality concern in the Piru basin has been impacts associated with high chloride concentrations in the Santa Clara River flows sourcing from Los Angeles County. Discharge from the Valencia Water Reclamation Plant located next to the river at Interstate 5 significantly influences the flow and water quality of this reach of the river, which normally percolates completely in the eastern Piru basin (UWCD, 2006; CH2M Hill, 2006). The chloride concentration of plant discharges began to increase in the late 1990s and peaked at over 210 mg/l in 2003 (Figure 4.3-6). The chloride plume associated with these discharges has made a steady advance with groundwater flow down the Piru basin. The extent of chloride impacts now reaches Hopper Creek in the western third of the basin (Figure 4.3-7). Irrigation of salt-sensitive crops such as strawberries and avocado with water over 100 mg/l chloride is generally not recommended, and growers in Ventura County remain concerned about the westward progression of these impacts. More recently, chloride concentrations in Los Angeles County wastewater discharges are improving, the result of a successful campaign to remove self-regenerating water softeners from Santa Clarita residences and lower chloride concentrations in imported State Water Project deliveries. The Sanitation Districts of Los Angeles County have recently indicated their intention to construct a desalter and maintain chloride concentrations of less than 100 mg/l in their discharges. In the western portion of the basin chloride concentrations are generally less than 70 mg/l, indicative of background levels within the basin (DWR, 1989).

The Piru basin generally does not have problems with nitrate contamination, and samples collected in 2013 show only two wells exceeding the MCL of 45 mg/l. Many wells record TDS concentrations of 1,200 mg/l or less, but some wells near Highway 126 west of Hopper Creek record TDS concentrations approaching twice this value (VCWPD, 2014). Water quality of the Piru basin is characterized more thoroughly in the revised Groundwater Management Plan for the Piru and Fillmore basins (Piru/Fillmore Groundwater Management Council, 2011).

4.3.2 FILLMORE BASIN

The City of Fillmore overlies the northeast portion of the Fillmore basin, and relies entirely on groundwater for water supply. Sespe Creek is the largest tributary to the Santa Clara River and enters the Fillmore basin from the north. Sespe Creek is an important source of recharge to the basin, providing high-quality water from a largely undeveloped watershed draining the southern slopes of the Pine Mountain complex in the Los Padres National Forest. Groundwater supports extensive acreage of agriculture in the basin, ranging from row crops and nursery stock near the valley floor to citrus and avocado plantings at both low and high elevations. Groundwater discharge to the downstream Santa Paula basin is thought to be significant, and the extensive wetlands near this basin boundary are supported by rising groundwater. This groundwater discharge to the Santa Clara River in this vicinity commonly sustains surface flow downstream in the Santa Paula basin.

4.3.2.1 WATER LEVELS

Many water levels in the Fillmore basin behave in a manner similar to the Piru basin. Water levels from a key well in the Bardsdale area shows that water levels rise to a threshold elevation in significant wet years, as evidenced by the flat topping of groundwater elevations in 1998 and 2005 (Figure 4.3-8). In this vicinity south of the confluence of Sespe Creek and the Santa Clara River, groundwater elevations do not fluctuate as dramatically as those in the Piru basin.

Groundwater elevations at United's key well for the basin show that in 2011, a moderately wet year, the basin did not fill completely. In 2013 the recorded high groundwater elevation at United's key well was approximately six feet lower that the 2005 recorded high groundwater elevation, and approximately 23 feet higher than the recorded low groundwater elevation during the 1987 to 1991 drought.

Fillmore basin groundwater levels benefit from increased discharge from the Piru basin as that basin has sustained fairly high water levels in recent decades. The Fillmore basin also benefits from United's fall conservation release from Lake Piru which helps stabilize groundwater elevations. The unconfined Fillmore basin receives most of its recharge from the Santa Clara River and Sespe Creek. The upland areas in the northern portion of the basin likely receive relatively more recharge from direct precipitation and mountain front recharge.

Groundwater elevation contours are shown for spring and fall 2013 in Figures 4.3-2 and 4.3-3. Groundwater flow is predominantly east-to-west in the area of the Santa Clara River alluvium. In the Pole Creek fan area underlying the City of Fillmore, groundwater flow is generally westerly, but also is interpreted to trend northerly towards the City's active wells. Well control in the Sespe Upland area is relatively poor, but groundwater flow here is thought to be predominantly north-to-south. Along the valley floor groundwater gradients are quite uniform and are similar for the spring and fall of 2013. Groundwater flow converges near the west end of the basin where the groundwater flow aligns with the orientation of the river valley. Groundwater elevations in wells located in the Sespe Upland area and in the Pole Creek fan area of the basin generally exhibit more variability than wells along the valley floor.

The relatively tight contours shown in the eastern Fillmore Basin near the basin boundary reflect a steeper gradient as groundwater moves from the constriction of the Piru narrows and moves into the basin. In this area surface water commonly infiltrates to groundwater, resulting in diminished surface flow and a greater component of flow as groundwater. As in Piru basin, groundwater is forced to the surface near the downstream end of the Fillmore basin as geologic structure constricts the main aquifer units of the Fillmore basin. In this area groundwater elevations are more stable than elsewhere in the basin. At this discharge area of the basin contouring shows that spring and fall 2013 groundwater elevations are approximately the same (Figures 4.3-2 and 4.3-3). Extensive wetlands in this area are clearly visible on aerial imagery.

4.3.2.2 GROUNDWATER EXTRACTIONS

Reported groundwater extractions from 287 wells in the Fillmore Basin totaled approximately 50,400 acre-feet for the 2013 calendar year. This is 6,100 acre-feet more than the historical average from 1980 to 2013. The historical annual extractions for the Fillmore basin are shown in the histogram in Figure 4.3-9. Recently and historically, agriculture has been the predominant user of groundwater in the basin.

Figure 4.3-5 is a map depicting reported groundwater extractions from individual wells in the Fillmore Basin for the 2013 calendar year. This graphic shows that: 1) the City of Fillmore pumps from three wells located in the north Pole Creek fan area near Sespe Creek and no longer pumps from wells located near the Santa Clara River; 2) there are numerous wells in the Bardsdale area pumping small volumes of water, as there is no mutual water company distributing potable water in this area; 3) there are few active wells in the Sespe Upland area and most active wells are located at lower elevations; and 4) Groundwater extractions from wells at the Fillmore Fish Hatchery located at the eastern boundary of the basin accounts for a significant portion of the groundwater extractions of the basin. In 2013 Fillmore Fish Hatchery wells reported pumping of 7,500 acre-feet (15% of the total groundwater extractions from the basin). In 2012 Farmers Irrigation Company constructed a new well near the western boundary of the Fillmore basin. This well pumped 4,400 AF in 2013, supplying irrigation water to growers in the Santa Paula basin.

Twelve mutual water companies operate in the Fillmore Basin, serving water primarily for irrigated agriculture. Fillmore Irrigation operates a surface water diversion on Sespe Creek, supplying water to nearby agricultural lands. Several water companies operate wells near the valley floor and pump water to higher elevation where groundwater is not as plentiful. Plantings in Timber Canyon and many areas of the Sespe Uplands are served by such arrangements. In recent years many orange orchards at lower elevations have been removed and replaced by row crops or box tree nurseries. Plantings of citrus and avocado remain the primary agricultural land use at higher elevations.

Discharge of groundwater to the Santa Clara River at the western boundary of the basin, subsurface outflow of groundwater to the Santa Paula Basin and extraction of groundwater by wells are the three primary losses of groundwater from the basin. The extensive wetlands and stands of *Arundo donax* (an invasive giant cane) at the west end of basin likely transpire large volumes of water. By some estimates *Arundo donax* may transpire up to six times the amount of water as native vegetation (CA Invasive Plant Council, 2011).

4.3.2.3 WATER QUALITY

The Fillmore basin is not known for having any pervasive water quality problems. TDS concentrations can be somewhat elevated in some locations, as in other groundwater basins along the Santa Clara River Valley. The City of Fillmore no longer uses wells near the Santa Clara River, favoring locations near Sespe Creek where TDS tends to be lower. Naturally-occurring boron sourcing from the Sespe watershed, however, is sometimes a concern for citrus growers and the City of Fillmore. Deeper aquifer units may have elevated concentrations of iron and manganese, a common occurrence throughout Ventura County.

Chloride concentrations from samples collected in 2013 are shown on Figure 4.3-7. Recorded chloride concentrations exceeding 80 mg/l are uncommon, and the highest concentrations are observed along the southern edge of the basin. Concentrations in the 40s and 50s in the downstream/discharge portion of the basin are likely indicative of background chloride concentrations in the basin. While elevated chloride concentrations are sometimes observed in surface water in Sespe Creek, wells near the channel of Sespe Creek record chloride levels common to the rest of the basin.

4.3.3 SANTA PAULA BASIN

Groundwater storage in the Santa Paula basin is generally less dynamic than in surrounding basins, as recharge appears to be limited by confined aquifer conditions in some portions of the basin. Pumping in the Santa Paula basin is managed by a stipulated Judgment which assigns pumping allocations to each basin pumper that restricts the amount or groundwater each pumper can extract (on a seven-year rolling average). The City of Santa Paula occupies the eastern portion of the basin and relies entirely on groundwater for its water supply. Extensive water delivery systems have long existed in the basin, delivering water to agricultural users areas of the basin with poor water quality or areas that are not readily recharged.

4.3.3.1 WATER LEVELS

Long-term records of groundwater elevations in the Santa Paula Basin indicate that water levels do not recover as readily as in the Piru and Fillmore basins. The channel of the Santa Clara River is located south of the Oakridge fault in the central portion of the basin, and overlies older sedimentary units of low permeability. The basin likely receives significant recharge as underflow from the Fillmore basin. Recent gauging of surface water flows at various locations along Santa Paula Creek and the Santa Clara River suggests the amount of recharge the basin receives from these sources, at least during low-flow conditions, is limited. An extensive flood control project on lower Santa Paula Creek, completed in the late 1990s, may have negatively affected the amount of recharge derived from the watershed of Santa Paula Creek.

Historical groundwater elevations dating from 1923 to present are shown in a hydrograph for United's key well for the basin (Figure 4.3-10). The well is located near Peck Road and Highway 126 in the eastern portion of the basin. In contrast to the key wells from the Piru and Fillmore basins, this Santa Paula basin well shows a long-term decline in water levels. The hydrograph shows that the recorded high groundwater elevation for 2011 was approximately 8 feet lower than the recorded high groundwater elevation in 1998. The low water level measured in fall 2013 was within 5.5 feet of the February 1991 historic low for this well.

Evaluation of the key well hydrograph and other the hydrographs for other wells located throughout the basin show that water levels in many of the wells (43 of 57 wells) in both the eastern and western portions of the Santa Paula basin failed to fully recover to 1998 levels after near-record precipitation in 2005. This lack of complete recovery is consistent with an observed long-term, gradual decline in basin groundwater elevations (UWCD, 2009; Santa Paula Basin Technical Advisory Committee, 2011).

Figure 4.3-11 and Figure 4.3-12 show groundwater elevation contours in the Santa Paula Basin for spring and fall 2011, respectively. The spring contours represent the annual basin high groundwater elevations and the fall contours represent the annual basin low groundwater elevations. The difference between the spring high groundwater elevations and the fall low groundwater elevations is approximately 10 feet throughout the basin.

The contours show a general east-to-west flow direction with groundwater underflow from the Fillmore basin to the Santa Paula Basin and groundwater underflow from the Santa Paula Basin to the Mound basin. The relatively tight contours just west of the Santa Paula-Fillmore boundary show an area of recharge to the basin. The complex subsurface geology related to extensive faulting in the most western portion of the basin complicates the interpretation of groundwater flow in this area.

4.3.3.2 GROUNDWATER EXTRACTIONS

A histogram of reported basin pumping from 1980 to 2013 is shown in Figure 4.3-13. In recent years municipal pumping has accounted for more than 20% of the total pumping from the basin. The total reported groundwater extractions from 129 active wells in the Santa Paula Basin totaled nearly 26,700 acre-feet for the 2013 calendar year. A new Farmers Irrigation Company well located in the Fillmore basin immediately east of the Santa Paula basin Settlement Boundary pumped an additional 4,400 AF for delivery to the western Santa Paula basin. A 2003 basin study titled "Investigation of Santa Paula Basin Yield" was conducted by experts from the City of Ventura, Santa Paula Basin Pumpers Association and United. The study suggested that the yield of Santa Paula basin is probably near the historic average pumping of about 26,000 acre-feet per year. Additional study of the safe yield of the Santa Paula basin is planned, as modest declines in water levels have been observed in recent years when annual extractions have averaged about 26,000 acre-feet per year.

Figure 4.3-14 is a map showing groundwater extractions by wells in the Santa Paula Basin in year 2013. The map shows significant pumping within the Santa Paula city limits and near the Fillmore basin boundary. Numerous wells report pumping in agricultural areas in the central portion of the basin. Few active wells exist north, west and south of this vicinity. In the western third of the basin, significant pumping is reported south of Highway 126 and west of Ellsworth Barranca, and in the area north of Highway 126 and west of Brown Barranca.

Several private irrigation companies are active in the Santa Paula basin, operating wells and delivery pipelines that distribute large quantities of water around the basin. Farmers Irrigation Company pumps groundwater primarily from the eastern portion of the basin and distributes the water by pipeline for agricultural use in areas of the central and western basin. Also affiliated with Farmers Irrigation Company are Canyon Irrigation Company and Thermal Belt Mutual Water Company. Canyon Irrigation operates the Harvey Diversion on Santa Paula Creek, and some wells in the eastern basin, delivering water to agriculture in the area of Santa Paula Canyon. Thermal Belt Mutual pumps groundwater from the east basin for pipeline distribution for agriculture in the Foothill Road area and upland area of the north central basin. Alta Mutual Water Company extracts water from the Saticoy area in the west basin, and delivers water primarily to agricultural areas north of Telegraph Road. These extensive water delivery systems were largely established to deliver water to areas of the Santa Paula basin having poor quality groundwater. In the canyons and foothills along the northern flank of the basin, both well production and water quality are generally poor.

4.3.3.3 WATER QUALITY

Water quality is fairly variable throughout the Santa Paula basin, but water quality is generally worse in the western portion of the basin. The maximum recorded TDS concentrations for Santa Paula basin wells in calendar year 2013 are shown in Figure 4.3-15, with the highest concentrations recorded in the west. In these wells sulfate is commonly a large contributor to TDS. Deeper wells in the basin tend to have elevated iron and manganese concentrations, and both the City of Santa Paula and City of Ventura operate treatment facilities to reduce these constituents in delivered municipal water. Recorded nitrate concentrations from wells within the basin are generally low, but two irrigation wells recorded nitrate concentrations slightly over the MCL of 45 mg/l in 2013.

United conducts groundwater quality monitoring at the two nested monitoring well sites in the Santa Paula Basin, and in several production wells in the basin. Mineral concentrations are observed to vary with groundwater elevation in some wells. More thorough characterizations of groundwater quality in the Santa Paula basin can be found in other publications (DWR, 1989; Santa Paula Basin TAC, 2011).

4.3.4 MOUND BASIN

The Mound Basin is located in the westerly portion of the District and has experienced over time a progression of groundwater use that was historically dominated by agriculture, followed by a period of time when municipal and industrial pumping was dominant, and most recently a return to greater pumping by agriculture than by municipal and industrial users. The City of Ventura overlies much of the Mound basin, although some areas of agricultural land use remain.

4.3.4.1 WATER LEVELS

Historical groundwater levels for a key monitoring well in the Mound Basin are shown in Figure 4.3-16. Measured water levels have varied over about a 90-foot range over the period of record for this well, located in the eastern portion of the basin near Kimball Road. An extended period of low water levels was recorded in the late 1980s and early 1990s when water levels declined to below sea level. Water levels recovered in the 1990s and generally have remained more than 15 feet above sea level over the past decade, except when falling below sea level in 2004.

Recharge of the aquifers in this basin comes from multiple sources such as direct precipitation, mountain-front recharge, and subsurface flow from adjoining basins (e.g., Santa Paula, Oxnard Forebay, and Oxnard Plain). Recharge from the Oxnard Forebay and Oxnard Plain is thought to be significant, most notably during periods of high water levels in these adjacent basins (GTC, 1972; UWCD, 2012b). The aquifers utilized for groundwater production are confined.

Groundwater elevation records exist for nearly 60 active and historic wells located within the Mound Basin. A number of important wells have water levels dating to the late 1920s, allowing an evaluation of long-term water level trends within the basin. However, the distribution of wells is heavily skewed towards the southern half of the basin, with relatively few wells existing north of Telephone Road. In the western portion of the basin wells are concentrated along Olivas Park Drive and near the railroad tracks south of Highway 101. This poor distribution of active and historic wells complicates the assessment of potential mountain-front recharge to the basin from the north. The southern and eastern boundaries of the basin are defined by structural features, and water level records from adjacent areas help assess the nature of the basin boundaries in these areas. Water level trends for many wells within the basin are similar, with evidence of recharge from adjacent basins to the east and south (UWCD, 2012b). The main groundwater flow pattern is down the axis of the basin from east-to-west. The slope of the potentiometric surface within the basin is quite flat during dry periods and the gradient increases somewhat following periods of above-average rainfall. During dry periods, groundwater elevations in many wells fall below sea level.

The contouring of past water level conditions is complicated at times by sparse data. Available groundwater elevation data for the spring and fall of 2013 are presented in Figures 4.3-17 and 4.3-18. Increased collection of water level records is recommended in this basin to better define groundwater gradients between this basin and adjacent basins. The recent installation of monitoring wells north of the Santa Clara River near the northwestern margin of the Forebay should be helpful in better defining the flow of groundwater from the Oxnard Forebay to areas north of the Montalvo anticline (see Section 2.1.8). Relatively few wells, however, exist along the southeastern portion of the Mound basin, an area of sparse well records and known structural complexity.

4.3.4.2 GROUNDWATER EXTRACTIONS

The City of Ventura is the major municipal and industrial groundwater pumper in the Mound basin, with its wells concentrated in the area near the Ventura County Government Center. Agricultural pumping was historically the majority use of groundwater in the Mound Basin, but municipal and industrial use exceeded or approximately equaled agricultural use for the period 1999 through about 2006 (Figure 4.3-19). Municipal pumping peaked in 2003 and declined fairly steadily through 2011. Since the mid-1980s agricultural pumping has averaged nearly 4,100 acre-feet per year with a peak annual production of 5,850 acre-feet recorded in 1990. Over the past two years municipal pumping has increased again, and reported pumping in 2013 totaled 7,000 AF, equally divided between agriculture and urban use.

4.3.4.3 WATER QUALITY

While the quality of the groundwater produced by most wells within the Mound Basin is suitable for municipal and agricultural uses, the basin is not known for the high quality of its groundwater. Water quality is variable between wells, and many records indicate somewhat elevated concentrations of TDS, sulfate, hardness and other analytes. Water quality appears to be relatively stable among many of the Mound basin wells having long-term water quality records, although some municipal production wells (e.g., Victoria 1 and 2) in the central portion of the basin have been experiencing declining water quality (i.e., increasing TDS values) that currently reach about 1,800 mg/L. Available records from wells nearest the coast do not show evidence of saline intrusion.

A map showing recorded TDS concentrations in Mound basin wells from 2013 is shown as Figure 4.3-20. The map plots TDS (by summation) from production well samples collected by the Groundwater Section of the Ventura County Watershed Protection District, as well as TDS (by total filterable residue) as sampled by United Water and the City of Ventura. TDS in the production wells ranged from 1,050 to nearly 3,000 mg/l. Sulfate commonly contributes roughly half the TDS in these samples, and water quality results are often variable among nearby wells.

Records from existing monitoring wells within the basin reveal very poor quality water at depths up to several hundred feet in the central portion of the basin. Water from these wells is thought to be connate or perched waters that are not utilized for groundwater supply. The three 2013 samples recording TDS greater than 3,000 mg/l are from monitoring wells with screened intervals shallower than 510 feet below the land surface.

4.3.5 OXNARD FOREBAY

The Oxnard Forebay basin is an area of critical importance to the water resources of the Oxnard Plain. This is the unconfined portion of the Oxnard Plain where units of low permeability are generally absent or discontinuous, allowing water to percolate deep into the ground and recharge the aquifers which extend from the Forebay to the Oxnard Plain. The basin readily accepts large volumes of recharge water in wet years when abundant surface water is available for recharge. A time series of estimated changes in available groundwater storage within the Forebay is shown in Figure 4.3-21. The graphic shows that storage in the basin can change rapidly. In the dry conditions that have prevailed since spring 2011, groundwater storage in the Forebay has fallen by about 87,500 AF.

Coarse gravel deposits deposited by high flows of the ancestral Santa Clara River are common in the Oxnard Forebay. These gravels have historically been extensively mined, both within the river channel and in nearby upland areas. The high permeability of these coarse alluvial deposits also comprise an ideal substrate for groundwater recharge. Groundwater recharge occurs naturally where water percolates through the bed of the Santa Clara River, and in upland areas near the river where United distributes diverted river water to a series of recharge basins. United's recharge activities are sometimes termed "artificial recharge" because the activities augment the recharge that would naturally occur in this area. The term "managed aquifer recharge" has become more popular in recent years.

Groundwater recharge to the Forebay serves to raise groundwater elevations in this up-gradient area of the groundwater flow system for the Oxnard Plain. High water levels in the Forebay increase the hydrostatic pressure in the confined aquifers extending from the margins of the Forebay to the coastal and offshore portions of these continuous aquifer units. While the physical movement of groundwater out of the Forebay is fairly slow, the pressure response in the confined aquifers distant from the Forebay responds more rapidly to significant recharge events in the Forebay. During wet climatic years the Forebay has the ability to quickly accept large volumes of water, allowing storage of surface water that otherwise would be lost from the watershed. Water stored in the Forebay slowly bleeds out to the outlying areas, flowing naturally from areas of high elevation to areas of lower elevation on the Oxnard Plain and near the coast, which serves to raise or sustain groundwater elevations in wells in down-gradient areas. Groundwater extraction by wells, both in the Forebay and in the confined aquifers of the Oxnard Plain, hastens the decline of Forebay water levels as water is removed from the system. Under drought conditions, groundwater elevations in the Forebay may approach sea level, resulting in flattened groundwater gradients and only minor groundwater flow out of the Forebay. These conditions now exist for the first time since completion of the Freeman Diversion in 1991. While there have been very wet years in the past where groundwater storage in the Forebay has recovered greatly, United's ability to divert and recharge water is now more constrained by regulatory requirements relating to fish migration opportunities. Significant recovery of groundwater storage in the Forebay can still be expected in future wet years, but the degree of recovery may well be less than what has been observed in the past.

4.3.5.1 WATER LEVELS

Groundwater elevation contours for the Upper Aquifer System (UAS) in the spring of 2013 are shown in Figure 4.3-22. Less than 100 AF of water was recharged through United's Saticoy Spreading Grounds in early 2013, as diversions from the Santa Clara River were minor and available surface water was delivered elsewhere. Recorded groundwater elevations at the northern portion of the Forebay were only 50 feet above sea level in spring 2013. Despite a lack of significant recharge activities, a flatter but familiar pattern of groundwater flow radiating from the up-gradient portion of the Forebay to surrounding areas is readily apparent. Groundwater elevations near the southern boundary of the Forebay were less than 25 feet above sea level in spring 2013.

Figure 4.3-23 displays UAS groundwater elevation contours for the Oxnard Forebay and Plain in fall 2013. Groundwater elevations near the Saticoy Spreading Grounds remain about 50 feet above sea level, but elevations fall quickly to less than 10 feet near the midpoint of the basin. A pumping depression associated with the O-H well field at the El Rio Spreading Grounds is apparent, where water levels are below sea level. With low water levels around the perimeter of the Forebay there is the potential for shallow groundwater of the semi-perched zone on the Oxnard Plain to drain into the Forebay. This reverse flow out of this semi-perched zone would be difficult to document without additional wells, but there is some concern about the potential water quality impacts to the Oxnard aquifer.

Historical water level hydrographs from selected wells in the Forebay are shown in Figure 4.3-24. UAS water levels in the Forebay fluctuate by as much as 100 feet, with groundwater elevations dropping below sea level in drought periods and recovering during wet periods. Historic highs were recorded in a number of wells in recent years, following a number of consecutive wet years and the expansion of United's recharge facilities. Extremely dry conditions in the Santa Clara River watershed since spring 2011 have resulted in significant declines among some key wells in the Forebay: in less than three years the water level in United's key well near the Saticoy Spreading Grounds has fallen more than 90 feet and another well in the down-gradient portion of the basin has fallen more than 50 feet.

4.3.5.2 GROUNDWATER EXTRACTIONS

Reported 2013 groundwater extractions from the Forebay totaled nearly 23,500 acre-feet. Figure 4.3-25 shows reported extractions for the basin since 1980. The 2013 reported pumping from the Forebay was less than the average annual extraction rate of 25,000 AF. Pumping from the Forebay is often more variable than in other basins within the District, resulting the variable amount of groundwater pumping for delivery to the Oxnard Plain and Pleasant Valley basins. United's O-H well field is the largest pumping center in the basin, delivering water to coastal areas as part of a management strategy to move pumping away from coastal areas vulnerable to saline intrusion. The City of Oxnard is the largest O-H customer. The City's other two sources of water are their own wells on the Oxnard Plain and State Water imported by and purchased from Calleguas Municipal Water District.

In the 2013 calendar year only 2,400 AF were spread for groundwater recharge at the El Rio Spreading grounds (in contrast to 2011 when some 37,800 AF of water was diverted for recharge at El Rio). Over this same period 12,850 AF was pumped from UAS wells at El Rio for deliveries to the O-H system. In most years United recharges more water at El Rio than is pumped for delivery to O-H customers.

The distribution of UAS pumping for calendar year 2013 is shown in Figure 4.3-26. Significant pumping is apparent surrounding the El Rio Spreading Grounds, where municipal pumping in the basin is centered. The majority of the pumping in the up-gradient areas of the Forebay is for irrigation purposes, including the pumping on the south side of United's Saticoy Spreading Grounds. Wells screened in units of the Lower Aquifer System are relatively uncommon in the Oxnard Forebay, and 2013 pumping from LAS wells is shown in Figure 4.3-27.

4.3.5.3 WATER QUALITY

Water quality records from Forebay basin wells near the Santa Clara River and United's recharge facilities show that groundwater quality in these areas is generally similar to that of the Santa Clara River. The most recharge from the river takes place when flows are high, when water quality in the river is best. Some characterization of Santa Clara River water quality is included in Section 4.2 of this report. During the dry season when river flows are lower and mineral content is generally higher, much of the diverted surface water is blended with well water and used for irrigation in areas served by the PTP and Pleasant Valley pipelines.

Occasional high nitrate concentrations in UAS wells has historically been the water quality issue causing concern in the Forebay. A definitive evaluation of sources of nitrate and flow paths to area wells has proven difficult, but septic systems and fertilizer from irrigated agriculture are commonly believed to be major contributors of nitrate to the groundwater flow system (UWCD, 1998). The highest nitrate concentrations are often observed during drought periods, when nitrogen inputs continue but the diluting influence of natural and artificial recharge is reduced. High nitrate has also been documented in wells as water levels rise following periods of drought, as nitrogen stored in the vadose zones is mobilized as sediments become saturated by a rising water table. Installation of additional monitoring wells in the Forebay has contributed to the understanding that the highest nitrate concentrations are often observed in the shallowest wells (UWCD, 2008). Once high-nitrate water enters the groundwater flow system its movement is likely very complex. An incomplete understanding of nitrate inputs to the Forebay basin and the complexity of water movement in the unsaturated and saturated zones of the subsurface make predictions of future nitrate impacts to area wells impractical.

Maximum-recorded nitrate concentrations from wells in the Forebay and northern Oxnard Plain in 2011 are shown in Figure 4.3-28. With dry conditions prevailing in both 2012 and 2013, nitrate concentrations have increased in a number of production and monitoring wells in the Forebay. Five of the nine active O-H (UAS) wells recorded annual-maximum nitrate concentrations over the health standard. Other public supply wells in the El Rio community recorded high nitrate concentrations, but purchased water from the O-H system so as to not deliver water which exceeded the MCL for nitrate. Near United's Saticoy Spreading Grounds UAS nitrate concentrations ranged from four to nine mg/l, values that match the range of nitrate concentrations recorded for diverted Santa Clara River water spread nearby.

A major effort to sewer the El Rio community was recently completed, significantly reducing nitrate loading in this areas of shallow unconfined groundwater. Residents and regulators are hopeful that significant nitrate impacts will be avoided in future droughts, but a cautionary statement from a recent UC Davis report on nitrate contamination is repeated here as a reminder that flow paths to production wells are often not well understood, and may be longer and more complex than many might imagine: "Travel times of nitrate from source to wells range from a few years to decades in domestic wells, and from years to many decades and even centuries in deeper production wells. This means that nitrate source reduction actions made today may not affect sources of drinking water for years to many decades" (Harter and Lund, 2012).

4.3.6 OXNARD PLAIN BASIN

Early newspaper accounts suggest that the confined aquifers of the Oxnard Plain were first drilled for water supply wells in the early 1870s. Artesian conditions existed on the Oxnard Plain at this time, and the well installations that received press coverage were wells providing impressive flow at the land surface without a pump in the well. Artesian conditions are believed to have persisted through the late 1800s. The town of Oxnard was established in 1897, and in 1899 a large sugar beet processing facility began operations. The large water demands associated with irrigation of beets and other crops on the Oxnard Plain, along with the growing population and industrial uses, lowered the pressure in the Oxnard aquifer. By the turn of the century widespread artesian conditions were generally absent, requiring wells to be fitted with pumps to lift water from elevations below the land surface (Freeman, 1968).

Over the approximately 110 years since the initial depressuring of the Oxnard Aquifer in the late 1800s, artesian conditions have periodically returned to the Oxnard Plain during wet climatic cycles. Documentation of water levels in the aquifers of the Oxnard Plain are sparse until the early 1930s, but artesian conditions were documented in Oxnard City well #9 in the winters of 1917, 1919, 1922 and 1923 (CA Division of Water Rights, 1928). The early 1940s was a wet period, and widespread artesian conditions likely existed at that time. The year 1945 marked the beginning of a long dry period during which water levels fell across the plain and problems with saline intrusion intensified in coastal areas. These alarming developments at a time of urban and economic growth in Ventura County prompted significant investments in water resource projects, including the O-H well field at El Rio and a pipeline delivery system to urban areas on the coastal plain. In subsequent years pumping patterns continued to change as the City of Oxnard grew. The city once had water supply wells distributed throughout its service area, but now pumping is centralized in two primary well fields. As farmland around the city margins has converted to urban areas, pumping has generally been transferred to the City of Oxnard's main well field in the northern Oxnard Plain. Much of the population growth in the cities of Oxnard and Port Hueneme has been supported by State Water Project supplies, imported and delivered by Calleguas Municipal Water District.

Widespread artesian conditions were again present on the Oxnard Plain in the late 1990s following the completion of the Freeman Diversion and high precipitation totals in 1993, 1995 and 1998. More recently, artesian conditions periodically existed in coastal areas surrounding Port Hueneme, and are more common in UAS wells than in wells with deeper screened intervals. Near Point Mugu in the southernmost portion of the Oxnard Plain, water levels have remained below sea level for decades in both the UAS and LAS.

Following a period of drought in the 1970s and expansion of the areas impacted by saline intrusion, the Fox Canyon Groundwater Management Agency (FCGMA) was established in 1982 as a local agency with regulatory authority to bring overdraft conditions under control in southern Ventura County. The agency has successfully implemented a number of mandatory cutbacks for production from public supply wells, and agricultural pumpers are required to demonstrate the use of efficient irrigation practices. One early strategy was a shift of pumping from the Upper Aquifer System to the Lower Aquifer System on the Oxnard Plain. This shift in pumping resulted in improved conditions in the UAS but considerable overdraft of deeper aquifers. An update to the FCGMA's management plan was completed in 2007, and describes a number of projects and strategies that might be employed to bring pumping in the Oxnard Plain, Pleasant Valley and Las Posas basins into balance with recharge to the aquifers of these highly-developed basins (FCGMA, 2007).

The primary water quality concern on the Oxnard Plain is water quality degradation associated with the intrusion of saline waters. The direct lateral intrusion of seawater remains the primary threat in coastal areas, with the near-shore submarine canyons at Port Hueneme and Point Mugu exposing aquifer beds to the sea. The vertical movement of deep brines and shallow water of poor quality has also been documented. This movement of poor-quality groundwater is also related to overdraft conditions, but is not limited to coastal areas. Nitrate problems have been documented periodically in specific Oxnard Plain wells. In some cases this nitrate problem is likely related to the downward movement of poor-quality water, in other locations it may be related to nitrate contamination sourcing from the Oxnard Forebay (UWCD, 2008).

4.3.6.1 WATER LEVELS

As discussed in the groundwater basin descriptions of the Oxnard Forebay and Oxnard Plain, large volumes of groundwater flow from the Oxnard Forebay to the Oxnard Plain. Contouring of recorded UAS water levels from wells shows that groundwater flows radially from recharge areas in the Forebay to surrounding areas (Figures 4.3-22 and 4.3-23). Recharge from the Forebay serves to raise or sustain water levels in wells on the Oxnard Plain, countering the decline in groundwater elevations resulting from groundwater extractions. When water levels are high across the basin groundwater may flow past the coastline to the offshore extension of the aquifers of the plain, or exit the system at near-shore canyons as discharge to the sea.

Precipitation totals for the 2012-13 water year were only about a third of average. Only about six inches of rain was measured in Santa Paula, and no single day recorded rainfall greater than one inch. The lack of any significant storm event resulted in very low flows in the Santa Clara River throughout the year, limiting the amount of water available for artificial recharge in the Forebay. Recorded high water levels on the Oxnard Plain in spring 2013 were similar to those measured in fall 2012.

Selected hydrographs for UAS wells on the Oxnard Plain are shown in Figure 4.3-29. It is typical for water levels in the confined aquifers of the Oxnard Plain to exhibit a distinct annual signature, with increased pumping stresses and reduced recharge in the summer and fall resulting in water level declines of ten feet or more, followed by some degree of recovery the following winter and spring. The absence of notable recharge to the basin in winter 2013 resulted in a continuous water level decline in most wells over the past two years. Fall 2013 water levels are below sea level in all the well hydrographs shown in Figure 4.3-29. Contours of fall 2013 water levels across the basin are shown in Figure 4.3-24. The zero elevation (sea level) contour is mapped in an arc extending northeast from Port Hueneme to an area north of Fifth Street near downtown Oxnard. Approximately half the area of the Oxnard Plain is below sea level, including an area in the northeastern portion of the basin.. In the southern Oxnard Plain groundwater elevations in Oxnard aquifer wells in some areas are more than 20 feet below sea level. In the area south of Hueneme Road, piezometric heads in the Mugu aquifer of the UAS are commonly at least 20 feet lower than those in the Oxnard aquifer.

Groundwater elevations from Lower Aquifer System wells are contoured for the spring and fall of 2013 for the Oxnard Forebay, Oxnard Plain and Pleasant Valley basins (Figures 4.3-30 and 4.3-31). In the spring of 2013 a pumping depression centered near the Oxnard Plain/ Pleasant Valley basin was clearly visible. By fall 2013 the depression is much deeper and broader. Groundwater elevations in the central plain south of the Camarillo Hill are more than 130 feet below sea level, and 80 feet below sea level at the coast near the Mugu submarine canyon. Available records suggest that only small portions of the basin near the recharge areas (northern Oxnard Forebay, northern Pleasant Valley) remain above sea level.

These contours show a revised interpretation for LAS groundwater flow in the central and western Oxnard Plain. Evaluation of well construction, interpretation of geophysical well logs and construction of stratigraphic cross-sections for the area indicate that a number of wells in the Oxnard Forebay and north Oxnard Plain, utilized in the past for LAS contours, and previously classified as LAS wells, are likely influenced by higher heads in the UAS. Some of these wells may be screened in both the LAS and UAS. South of a certain point these "shallow LAS" wells are absent, and wells are screened much deeper due to structural and stratigraphic changes in the subsurface. The inclusion of the "shallow LAS" wells in earlier contouring resulted in a steep break in groundwater elevations that was thought to be indicative of a structural barrier to groundwater flow. The newer interpretation of LAS groundwater elevations functionally expands the pumping depression seen along the eastern Oxnard Plain and western portions of the Pleasant Valley basin north into the Forebay. LAS groundwater elevations above sea level near the Saticoy Spreading Grounds, however, indicates that the LAS pumping depression does not extend north to this area of the Forebay. Water level records and associated contouring shows that in the aquifers of the LAS, groundwater flows from the Oxnard Forebay to the large pumping depression in the eastern Oxnard Plain and the Pleasant Valley basin.

Also notable in this interpretation (of deeper LAS wells) is higher LAS heads along the coast in the western Oxnard Plain than in most other areas of the basin. Maps showing LAS pumping locations within the basin (next section) are consistent with the contouring. The LAS contouring presented here is somewhat preliminary and subject to modification in the future as work on the hydrogeology in this area is ongoing.

In the northwestern Oxnard Plain, LAS groundwater flow is likely from the Oxnard Forebay towards the coast. Few LAS wells exist in this area (Figure 4.3-27), as recharge to the Oxnard Forebay is very effective in sustaining groundwater elevations in this area (UWCD, 2010). LAS wells near Victoria Avenue and the northern boundary of the Oxnard Plain record groundwater elevations similar to nearby UAS wells (UWCD, 2010). The exclusion of "shallow LAS" groundwater elevations from Figures 4.3-30 and 4.3-31 provides an incomplete representation of LAS heads in the northwestern Oxnard Plain.

Historical water level records from selected LAS wells on the Oxnard Plain are shown on Figure 4.3-32. Periods of drought (notably ~1989-1991) are clearly evident in some of the wells, with measured water level declines exceeding 100 feet in some wells. Annual water level fluctuations of greater than thirty feet are common in the confined conditions of the LAS. As shown in the figure, the LAS hydrographs show fall 2013 water levels at more than 100 feet below sea level in Pleasant Valley and in the east-central Oxnard Plain. Water levels in wells near the coast are more muted, as recharge by seawater prevents heads from falling as low as they do in inland areas.

While the occurrence of land subsidence is not well documented in Pleasant Valley and on the Oxnard Plain, concern about increased subsidence is justified as water levels in the LAS approach historic lows.

4.3.6.2 GROUNDWATER EXTRACTIONS

The groundwater resources of the Oxnard Plain are heavily utilized to support overlying land uses. The area is famous for its highly productive agriculture, supporting year-round production of a wide variety of agricultural products. Groundwater supports much of the agriculture on the Oxnard Plain, but surface water is available in some areas. The area also supports an extensive urban population. The Cities of Oxnard and Ventura maintain active wells on the Oxnard Plain, but also rely on other sources of water. The City of Port Hueneme and other coastal communities generally maintain wells in reserve status and import water from inland areas given their location near the coast and vulnerabilities with respect to seawater intrusion.

The distribution of reported UAS pumping shown in Figure 4.3-26 is typical of pumping patterns in recent years. The City of Oxnard operates several wells at its main well field near Third Street and Oxnard Blvd., and at a smaller facility some distance to the northeast. Aside from these locations UAS pumping is uncommon in the urban areas of the Oxnard Plain. Agricultural interests pump extensively from the UAS in the northwest Oxnard Plain, as well as in the northeastern portion of the basin near the Oxnard Forebay. Additional pumping is scattered across the central Plain east of the City of Oxnard, where a number of wells reporting minor pumping are small domestic wells. Few UAS wells are active south of Hueneme Road on the southern Oxnard Plain.

The distribution of LAS pumping on the Oxnard Plain is concentrated in the eastern half of the basin, as shown in Figure 4.3-27. Near the basin boundary in the northwestern Oxnard Plain the City of Ventura operates two wells at the Ventura Municipal Golf Course, and exports water for municipal use in the Mound basin. LAS extractions are common for irrigation in the northeastern Oxnard Plain, as they are in the east-central portion of the basin. South of Hueneme Road LAS aquifers are pumped extensively for irrigation, in contrast to the UAS which is pumped very little in this area. Also notable is the near-absence of LAS pumping in the northwest portion of the basin.

A histogram of historical extractions from the Oxnard Plain are shown in Figure 4.3-33. Reported pumping for agricultural and municipal uses were greater in 2013 than in any year since 1990. The percentage of agricultural pumping is typically slightly greater in dry years, as less of the irrigation demand for various crops is satisfied by rainfall.

Some 60,900 acre-feet of pumping reported on the Oxnard Plain in 2013, about 10,000 AF more than was reported in 2011 and 2012. In the years 1985-1990, annual extractions totaling more than 70,000 AF were not uncommon. The Freeman Diversion was completed in 1991, which improved the quantity and reliability of surface water delivered to the Oxnard Plain. Municipal and Industrial (M&I) pumping has been subject to cutbacks mandated by the FCGMA, beginning with 5% in 1992 and currently at 25%. Municipal pumping has not actually been reduced by this amount: pumping allocations have been transferred to the Cities of Oxnard and Camarillo, as these cities have expanded into agricultural areas. As noted in earlier sections, large volumes of potable water are imported from both the Oxnard Forebay and from northern California, so the extraction totals represented in Figure 4.3-33 are less than the total demand for agricultural and M&I water in the area.

4.3.6.3 WATER QUALITY

Seawater intrusion was first recognized on the Oxnard Plain in the 1930s and since that time this issue has dominated water quality concerns in southern Ventura County (CA DWR, 1971; FCGMA, 2007). In areas not impacted by saline intrusion, groundwater quality is somewhat variable among wells but generally is adequate for most agricultural and municipal/industrial uses. Water in the confined aquifers of the Oxnard Plain tends to be somewhat mineralized due the marine deposition of many of the aquifers (TDS, sulfate, iron, manganese), but contamination by organic contaminants is uncommon (Burton et al, 2011). Nuisance concentrations of iron and manganese are most commonly associated with LAS wells where reducing conditions are present.

In the northern portion of the Oxnard Plain samples for some wells in 2013 show elevated concentrations of nitrate. The provenance of the high nitrate detected in these wells is generally difficult to determine, but high and variable concentrations are likely related to the downward leakage of near-surface waters (Izbicki, 1992, Zohdy et al, 1993). On the southern Oxnard Plain nitrate concentrations in wells are not commonly detected, and the rare detects are likely related to damaged or improperly constructed wells.

Recorded chloride concentrations across the central Oxnard Plain were consistently low in 2013, as shown in Figure 3.4-34. These values are similar to native chloride concentrations in the basins of the Santa Clara River Valley. South of Hueneme Road some wells record chloride concentrations of greater than 16,000 mg/l, concentrations similar to seawater.

4.3.6.3.1 SALINE INTRUSION

Since the 1930s the southern Oxnard Plain in Ventura County has been subject to seawater intrusion. The Oxnard, Mugu, Fox Canyon, and Grimes Canyon aquifers are believed to be geologically vulnerable, to varying degrees, to seawater intrusion by their exposure in offshore outcrop in the walls of submarine canyons and along the broader offshore shelf. Concerns related to the expansion of intruded areas in the 1970s and 1980s helped motivate local funding for cooperative studies with the U.S. Geological Survey.

In 1989 the U.S. Geological Survey initiated the Regional Aquifer-System Analysis (RASA) study in the Santa Clara-Calleguas groundwater basin. As part of this project a series of fourteen nested monitoring well sites were installed in coastal areas. Extensive sampling was conducted, and a number of advanced analytical techniques were used to provide a much better understanding of the nature and extent of saline intrusion on the Oxnard Plain. The USGS studies concluded that some areas classified as seawater intrusion in the past were in fact subject to increased chloride concentrations from connate saline water squeezed from fine-grained sediments within and separating the aquifers (Izbicki, 1992). The USGS mapped areas of high salinity in the major aquifer units of the southern Oxnard Plain, and classified sources of salinity as either seawater intrusion or saline intrusion from local sediments. A major product of the RASA study for the Santa Clara-Calleguas study area was a calibrated groundwater flow model. A solute transport component of the model was proposed in the scoping of the study, but this component was later abandoned after initial efforts proved unsuccessful.

United continues to sample the network of monitoring wells on the southern Oxnard Plain. In all of the recent samples from the southern Oxnard Plain, calcium or sodium are the dominant cations. Among samples not affected by high salinity, sulfate and bicarbonate are the dominant anions. For most samples impacted by saline waters, sodium and chloride are the dominant ions (UWCD, 2007). Major ion analysis is helpful in determining chemical conditions and changes over time, but not necessarily the source of brine causing water quality degradation. Researchers from the USGS have advanced methods for determining whether high chloride is sourcing from direct seawater intrusion or rather from deep or stranded brines (Izbicki, 1992 and Izbicki et al, 2005a). The minor ions iodide and bromide, along with the trace elements boron and barium, are useful indicators for delineating the source of brines impacting fresh aquifers. Analysis of minor ion concentrations and trace element ratios from coastal monitoring wells suggest that some wells are impacted by the recent intrusion of seawater via the near-shore submarine canyons at Port Hueneme and Point Mugu. Other wells are likely impacted by inland brines, such as those expelled from buried fine-grained marine deposits. Clays within these deposits compact over time in response to regional pumping stresses, allowing the brines to enter adjacent permeable beds within the aquifer system (UWCD, 2007).

Over the past decade the sampling of coastal monitoring wells has indicated that near Port Hueneme chloride conditions have generally improved as heads in most aquifers have remained near or above sea level. United's sampling of wells and contouring of groundwater elevations in this area suggest the chloride plumes associated with past periods of drought are now migrating southeast towards the Mugu area, most notably in the UAS (UWCD, 2004). Figure 4.3-35 displays chloride records for selected UAS monitoring wells in coastal areas of the southern Oxnard Plain. The figure shows well A1-195 located north of Port Hueneme has totally recovered from chloride impacts in the early 1990s. The chloride plume shown east of Hueneme Harbor likely extended north from Hueneme Canyon during the drought (chloride spike in well A1-195), and since that time the plume has slowly shifted towards the southeast (groundwater flow is perpendicular to the groundwater elevation contours shown on Figure 4.3-23). Within the plume of displaced seawater, samples from well CM4-275 remain above 6,000 mg/l, and chloride continues to rise in well CM7-190 some 20 years after the drought ended. In the Mugu area, however, saline groundwater would likely flow out from the groundwater basin if a significant seaward groundwater gradient could be maintained, but such conditions have not existed for many years. In inland areas surrounding Mugu Lagoon aquifers of the UAS remain impaired by high chloride. One well in the western portion of this area has shown some improvement in recent years, but chloride is still over 2,000 mg/l (Figure 4.3-35). Other UAS wells show continued degradation by either brines or direct intrusion of seawater (UWCD, 2007). With depressed water levels in the basin, another period of active seawater intrusion is now underway. While seawater is believed to be entering the aquifers of the UAS in the areas surrounding Hueneme and Mugu Canyons, high chloride concentrations from this new episode of seawater intrusion has not yet reached the coastal monitoring wells.

Selected chloride time series for Lower Aquifer System monitoring wells on the southern Oxnard Plain are shown in Figure 4.3-36. Near Hueneme Canyon few wells show chloride impacts, but well CM2-760 shows increasing chloride at concentrations greater than 10,000 mg/l. In the greater Mugu area chloride degradation is severe in a number of wells, and chloride is trending upwards in many wells. Degradation by brines continues unabated in LAS monitoring wells at the Q2 well site, located about two miles north of Mugu Canyon. Degradation in these wells is related to chronically depressed water levels in the area, allowing brines to migrate into the aquifers from surrounding sediments or deeper zones hosting poor-quality groundwater (UWCD, 2007). These trends are expected to continue as water levels remain severely depressed in the LAS in both coastal and inland areas.

Given the chronic groundwater depression existing north and northeast of the Mugu area, basin managers wish to better understand the extent of existing chloride impacts and the potential for further degradation. While additional monitoring wells allow the ability to sample discrete zones within an aquifer and identify vertical head gradients, expansion of the network of monitoring wells is fairly expensive. In recent years United has conducted geophysical studies to gain some information on chloride conditions in areas where wells are not available.

In 2010 United conducted a Time Domain Electromagnetic (TDEM) geophysical survey on the southern Oxnard Plain to assess the lateral extent of saline water intrusion over four different depth ranges (UWCD, 2012a). The survey was designed to replicate a study performed by the USGS in the early 1990s, conducted as part of the RASA project (Zohdy et al, 1993). United's field survey area was approximately 35 square miles and extended along the coast between Port Hueneme and Point Mugu (approximately 7 miles) and inland for approximately 5 miles. One hundred twenty five soundings were collected throughout the study area and the data were forward and inverse modeled for each sounding. The model data were used to construct resistivity maps, at four depth ranges typical of the UAS and LAS.

United's TDEM investigation was successful at delineating earth resistivity values that are typical of saline and brackish water in both the Upper and Lower Aquifer Systems. Resistivities typical of saline water occurred along the coast and extended farther inland near Point Mugu with brackish water inferred at various locations inland. An image of contoured resistivity values at depths approximating the lower portions of the UAS are shown in Figure 4.3-37. A second image of contoured resistivity values for the shallower portions of the LAS are shown in Figure 4.3-38. Groundwater salinity estimates from the TDEM surveys generally correlated well samples from areas monitoring wells. The work suggested that geologic features such as paleochannels may affect groundwater flow and the migration of chloride, particularly in deposits of the UAS (UWCD, 2012a).

Local water managers share a common desire to better understand the extent of saline water impacts on the southern Oxnard Plain and how rapidly it might be migrating toward pumping depressions that exist within the basin . There are relative few monitoring wells in the coastal areas of the southern Oxnard Plain and the extent of saline impacts is not precisely known, but it is well understood that elimination of groundwater overdraft conditions will largely mitigate the worsening of chloride impacts on the southern Oxnard Plain. Prevention of additional water quality degradation is a common goal for all stakeholders as degraded aquifers can negatively affect land values. Restoration of degraded aquifers is also a difficult and expensive prospect, especially in areas already suffering from groundwater overdraft. United recently retained an engineering firm to study the feasibility and expense of desalting brackish groundwater in coastal areas and delivering the treated water to growers on the Oxnard Plain.

4.3.7 PLEASANT VALLEY BASIN

The Pleasant Valley basin lies adjacent and east of the Oxnard Plain, occupying the area south of the Camarillo Hills. The entire area of the basin falls within the Calleguas Creek watershed. Aquifers of the Upper Aquifer System are poorly developed in this basin and dominated by fine-grained deposits. This change in UAS deposits forms the basis for the basin boundary with the Oxnard Plain. Aquifers of the Lower Aquifer System are continuous with areas to the west on the Oxnard Plain. The City of Camarillo occupies the northern portion of the basin and operates public supply wells located outside of United's boundaries. Agriculture is the predominant land use in the remainder of the basin, where the Pleasant Valley County Water District (PVCWD) operates an extensive water delivery system. United has delivered surface water from the Santa Clara River to PVCWD since 1958. Completion of the Conejo Creek Diversion in 2002 brought additional surface water to the Pleasant Valley area.

4.3.7.1 WATER LEVELS

Most wells in the Pleasant Valley basin area are completed in units of the Lower Aquifer System. Some wells are perforated in coarse basal units of the UAS, but pumping and water level measurements from UAS wells are uncommon as the UAS in the Pleasant Valley basin is predominantly comprised of fine-grained sediments (UWCD, 2003). United does not attempt to contour UAS water levels in the Pleasant Valley basin.

Groundwater elevation hydrographs for selected LAS wells are shown in Figure 4.3-39. The LAS well located in the northeast corner of the Pleasant Valley basin near Las Posas Road and Lewis Road recorded groundwater elevations approximately 140 feet below sea level in the early 1990s. Since the early 1990s water levels in this well have increased dramatically, reaching levels of about 140 feet above sea-level in 2011. This recovery is related to increased surface water flow in Arroyo Las Posas and the associated groundwater recharge in the northern portion of the basin. Since the 1990s flow in the Arroyo Las Posas has increased dramatically, largely due to population growth in upstream areas and related water imports and wastewater discharges (LPUG, 2011). This recharge in recent years has lead to the recognition that the basin is unconfined in this area and may be considered a forebay area for the Pleasant Valley basin (Hopkins, 2008). Some recovery in this well is likely related to the relatively wet period the area has experienced since the drought period ending in 1991. The degree to which this recharge has influenced water levels in the central portion of the basin remains a topic worthy of further study.

The groundwater elevation hydrograph for the LAS well located at the intersection of Las Posas Road and Pleasant Valley Road shows a clear decline during the drought conditions of the late 1980s, with water levels reaching approximately 180 feet below sea level in 1991. Since that time, with the onset of a relatively wet period, groundwater elevations increased steadily except for a slight decline during a dry period from 2002 to 2004. From 2005 through 2011 groundwater elevations remained below sea level but higher than the water levels recorded in the late 1980s and early 1990s. This recovery is likely related to the utilization of surface water diverted from Conejo Creek and delivered to agricultural users in the basin. Camrosa Water District constructed the Conejo Creek Diversion in 2002 and has negotiated agreements to provide water to Pleasant Valley County Water District (PVCWD), a major supplier of agricultural water in the Pleasant Valley basin. From 2004 to 2011, diversions from Conejo Creek have averaged approximately 5,600 acre-feet per year. Use of this water for irrigation has reduced pumping demands on the basin. Despite the general water level recovery in this well over the past twenty years, records from fall 2013 show levels have fallen to about 90 feet below sea level.

The groundwater elevation hydrograph for a well in the southern Pleasant Valley area, located along Laguna Road, shows a 1991 drought groundwater elevation of 174 feet below sea level. Since 1993, groundwater levels have returned to pre-drought levels and annual high water levels have remained fairly stable. Annual variability in groundwater elevation appears to be greater following the drought, which could be the influence of a nearby well. Unlike some wells in the northern portion of the basin, spring high water levels recorded in this well are not appreciably higher than they were in the 1980s. The highest recorded groundwater elevation for this well is approximately twenty feet below sea level.

Groundwater elevation contours for LAS wells measured in spring and fall 2013 are shown in Figures 4.3-30 and 4.3-31. The spring LAS contours on the maps show the significant pumping depression that exists in western Pleasant Valley and the eastern Oxnard Plain, where groundwater elevations are well below sea level over a broad area. The fall map shows a pumping depression over several square miles with groundwater elevations more than 120 feet below sea level. The severely depressed water levels in the basin promote the upwelling of brines from deeper formations, the compaction of both aquifers and aquitards, and land subsidence.

The contours for both spring and fall indicate groundwater flow from the west Oxnard Plain and from the Oxnard Forebay to the north. A steep groundwater gradient likely exists between the main pumping depression and the recharge area along Calleguas Creek in the northern part of the basin, but this area is not contoured due to sparse well control and the unknown influence of faulting in the northern basin.

4.3.7.2 GROUNDWATER EXTRACTIONS

Maps showing reported groundwater pumping from LAS wells in the Pleasant Valley basin and on the Oxnard Plain are shown in Figure 4.3-27. The northern and eastern portions of the basin fall outside of United's district boundary, and pumping in those areas is not shown on figures in this report. Pumping from the LAS within United's district boundaries is concentrated along the western portion of the basin, and aligns with the areas where water levels are deepest in the basin. Pumping of the UAS is limited, and skewed towards the eastern portion of the basin (Figure 4.3-26). A majority of the UAS wells report minor pumping and are likely used for domestic supply.

Reported Pleasant Valley basin pumping for the area within United's boundaries is shown in Figure 4.3-40. In 2013 pumping was the greatest since 1991, totaling 18,700 AF. Pumping from the Pleasant Valley basin is fairly variable, in large part due to the significant surface water deliveries that are possible during years of above-average precipitation.

4.3.7.3 WATER QUALITY

The map showing the maximum groundwater chloride concentrations recorded in 2013 is shown as Figure 4.3-34. Samples from wells in the Pleasant Valley basin are distinctly higher than those from the Oxnard Plain to the west (except for the intruded areas near the coast). Many wells in the Pleasant Valley Basin had chloride concentrations well over 100 mg/l, a common advisory chloride level for sensitive agricultural crops. A number of the samples are from wells operated by Pleasant Valley County Water District, which blends well water with surface water diverted from Conejo Creek and the Santa Clara River before delivery to areas growers.

During the RASA study in the early 1990s USGS investigators recognized high chloride in some Pleasant Valley basin wells. Innovative sampling techniques were employed to profile flow and chloride concentrations in deep production wells. It was recognized that the highest chloride and TDS concentrations were commonly sourcing from the deepest portions of these deep LAS wells, and that these zones contributed little water to the well. In 2001 United sought and was awarded an AB303 grant from the California Department of Water Resources to study the nature of the inland saline intrusion problem in the Pleasant Valley basin (UWCD, 2003). A major part of this study was depth dependent sampling and flow profiling of eight deep production wells in the basin. The USGS was contracted to perform this work, which included chemical analysis of major ions and trace elements as well as specific isotopes and chemical tracers. The report concluded that chloride increased with pumping during past period of drought, and that increased delivery of surface water to the area of the Pleasant Valley Basin pumping depression would help groundwater levels recover and likely decrease chloride concentrations in water produced from deep wells in the basin.

In 2005 the USGS published technical papers detailing the results of their sampling of Pleasant Valley wells, which included depth-dependent groundwater sampling, flow profiling, and analysis of isotopic and chemical tracers (Izbicki et al, 2005a; Izbicki et al, 2005b). The results detailed by the USGS included that: 1) high chlorides were entering wells from various sources at different depths; 2) concentrations of chlorides in the upper portion of some wells influenced by irrigation return flow were as high as 220 mg/L; 3) concentrations of chlorides in wells with depths greater than 1400 feet were as high as 500 mg/L and had the chemical and isotopic composition trending toward oil field production water in the area; 4) higher chloride concentrations occurred in deep wells near faults that bound the valley such as the Camarillo fault in the north basin and the Bailey Fault on the south side of the basin; and 5) chlorides increase with increased pumping during droughts.

A recommendation by the USGS was that sealing off the low-yield and poor-quality lower portions of some deep wells would act to improve water quality in many production wells without sacrificing appreciable yield. The 2013 chloride concentrations shown in Figure 4.3-34 suggests that a majority of the wells in the basin are impacted by elevated chloride concentrations. These impacts are likely to continue as chronic overdraft conditions persist in the basin and deep brines migrate upward in response to the hydraulic gradients produced by over-pumping. Figure 4.3-41 displays maximum chloride concentrations from calendar year 1990, a year when extensive sampling was conducted by the USGS as part of the RASA study. In this drought year few wells recorded chloride less than 100 mg/l. Comparison of chloride records from 1990 to 2013 reveals that recent samples from a number of wells record higher chloride now than they did in a past period of drought.

Recharge water sourcing from Arroyo Las Posas in the northern portion of the Pleasant Valley basin is another significant chloride input to the basin. Chloride loading associated with this recharge is currently under evaluation as part of a proposed desalter project for this area. The effort is being lead by the City of Camarillo. Calleguas MWD has constructed an ocean outfall and brine line ("Salinity Management Pipeline") to inland areas along Calleguas Creek. This pipeline is a tremendous development for the region, as a number of desalters are expected to be built to improve the quality of water delivered to both municipal and agricultural users.

4.3.8 WEST LAS POSAS BASIN

The West Las Posas basin is the western-most of a series of three subbasins that are referred to collectively as the Las Posas basin. The other subbasins of the Las Posas basin are the East Las Posas basin and South Las Posas basin. The West Las Posas basin is bounded to the north by South Mountain, to the south by the Camarillo Hills, to the west by the Oxnard Plain and to the east by the East Las Posas basin. Only approximately the western one-third of the West Las Posas basin is included within the boundaries of United Water Conservation District (Figure 1-1).

The Los Posas Basin Users Group (LPUG) is currently in the process of formulating a Basin Specific Groundwater Management Plan for the Las Posas Basin. The portion of the basin within the District, however, is excluded from the Plan. Del Norte Mutual Water Company made a formal request of the LPUG to be excluded from the current Las Posas basin plan on the basis of groundwater conditions, groundwater source, and political jurisdiction. LPUG agreed that the District's portion of the Las Posas basin does not have to be managed under the Las Posas basin plan, because groundwater users pay pump charges for groundwater recharge and management activities conducted by United (LPUG, 2011). Although the United portion of the West Las Posas basin will not be managed by the LPUG plan, it will be monitored because it is hydraulically connected to the remainder of the West Las Posas subbasin.

4.3.8.1 WATER LEVELS

Groundwater levels have been monitored for nearly a century in the Las Posas Valley. Groundwater elevations in the West Las Posas Basin are monitored by UWCD and Ventura County

Watershed Protection District (VCWPD) with private entities also providing data. Fewer wells are monitored in this basin than for most other basins within the District.

In the West Las Posas basin, piezometric heads range from approximately 100 feet below mean sea level (msl) near the Central Las Posas fault to approximately 50 feet above msl near the Oxnard Plain, indicating a general northwest to southeast flow direction (LPUG, 2011). The flow pattern in the West Las Posas basin suggests the aquifer is receiving inflow from the Oxnard Plain and recharge along the northern flank of the valley. Groundwater moves across the subbasin toward an area of focused pumping near Bradley Road where there has been a long history of depressed water levels (LPUG, 2011).

4.3.8.2 GROUNDWATER EXTRACTIONS

During calendar year 2013, a reported 4,000 acre-feet of groundwater were pumped from the portion of West Las Posas basin that lies within United's boundaries. The areal distribution of pumping in the UAS and LAS in 2013 is shown in Figures 4.3-26 and 4.3-27. Reported groundwater extraction from the basin has generally been increasing in recent years (Figure 4.3-42). The Del Norte Water Company pumps water from its well yard located near Highway 118 and Santa Clara Avenue on the Oxnard Plain, and delivers this water for agricultural use in northern portions of the West Las Posas Basin within United's District boundary. In 2013 Del Norte pumped and exported nearly 3,000 acre-feet from the Oxnard Plain to the West Las Posas Basin.

4.3.8.3 WATER QUALITY

Water quality samples from wells in the West Las Posas basin indicate groundwater quality is generally adequate for agricultural and municipal use, however, localized exceedances of the MCL for TDS, nitrates, and sulfates have been reported.

Ventura County Watershed Protection District (2014) reports that for the average TDS among the ten wells sampled in 2013 was 874 mg/l, and two wells had nitrate concentrations above the MCL for nitrate. Groundwater with this degree of mineralization is common throughout United's service area. In the West Las Posas basin TDS and chloride concentrations tend to be higher in the northern and western portions of this basin compared to other areas, suggesting that mountain front recharge along the southern flank of South Mountain and inflow from the Oxnard Plain Basin are the sources of higher TDS and chloride concentrations (LPUG, 2011).

5 SUMMARY

With two years of below-average rainfall in 2012 and 2013, the basins within United's service area are showing signs of stress. Groundwater elevations have fallen in all basins, and water levels across much of the coastal plain are now below sea level. A renewed period of active saline intrusion is now underway. Water quality problems associated with reduced rainfall and recharge are also apparent in some inland areas where nitrate, chloride and TDS concentrations are causing problems for some users of groundwater. Groundwater conditions are expected to deteriorate further over the summer and fall of 2014. Dry weather is expected for these months and there will not be a conservation release from Lake Piru in fall 2014. Much of United's current infrastructure is designed to maximize the use of surface water from the watershed of the Santa Clara River, but these projects are of limited use when the river is dry. Even when wet conditions do return to the area, the recovery of groundwater storage in the coastal basins is expected to be slower than it was in 1991-1995. United's ability to divert water at the Freeman Diversion is likely to be less than in prior years due to regulatory constraints associated with endangered species issues, and multiple wet years may not occur again following this period of drought.

United Water continues to evaluate various strategies to best manage and protect the surface and groundwater resources within the District. Current and on-going considerations include: the characterization of groundwater conditions, the most-efficient use of existing infrastructure and the need for additional or modified facilities, current and future water demands, current and anticipated water quality issues, and effective utilization of existing allocations of imported State Water Project water. United Water's goal is to identify the best use of local water resources and infrastructure, and to work with other agencies to implement these strategies, while honoring a coherent strategy and set of priorities that guides all future infrastructure and water management decisions.

The District's groundwater and surface water projects and programs are keyed to the issues and concerns that impact or potentially impact the water resources of the region. These issues and concerns evolve over time and United Water strives to adjust, modify, or devise new projects or programs in response to changing water resource challenges. Many of the projects and programs undertaken by United Water have long-term implementation schedules (e.g., District-wide groundwater level measurements, conservation releases), however, these types of efforts provide the critical data needed to make sound water resource management decisions that provide for the maintenance of reliable, sustainable, local water resources for the benefit of both agricultural and municipal and industrial water users in central and southern Ventura County. United is encouraged by the desalters and advanced water treatment plants that are either planned or under construction in the region, and it hopeful that these facilities will serve to lessen long-term demands on the groundwater basins.

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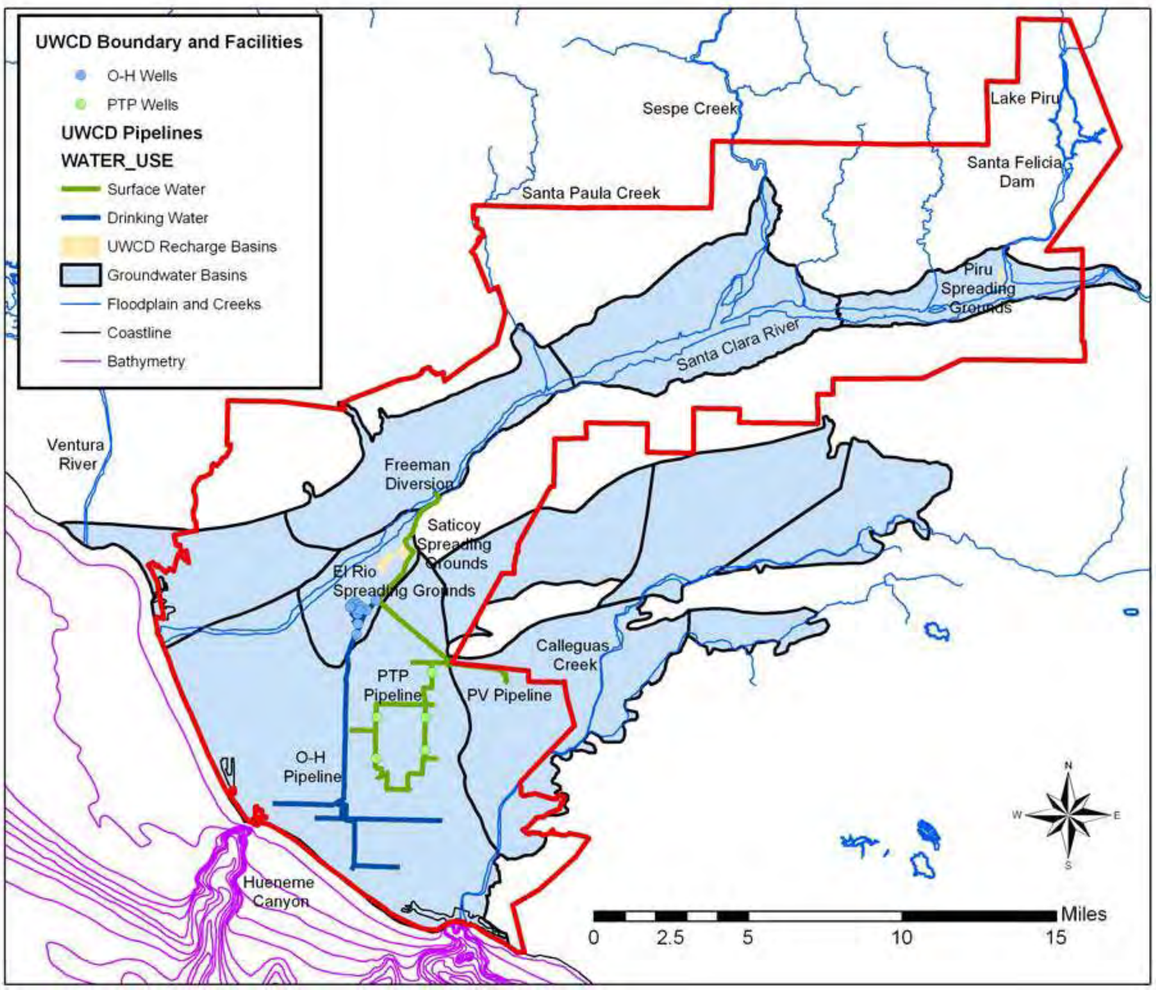
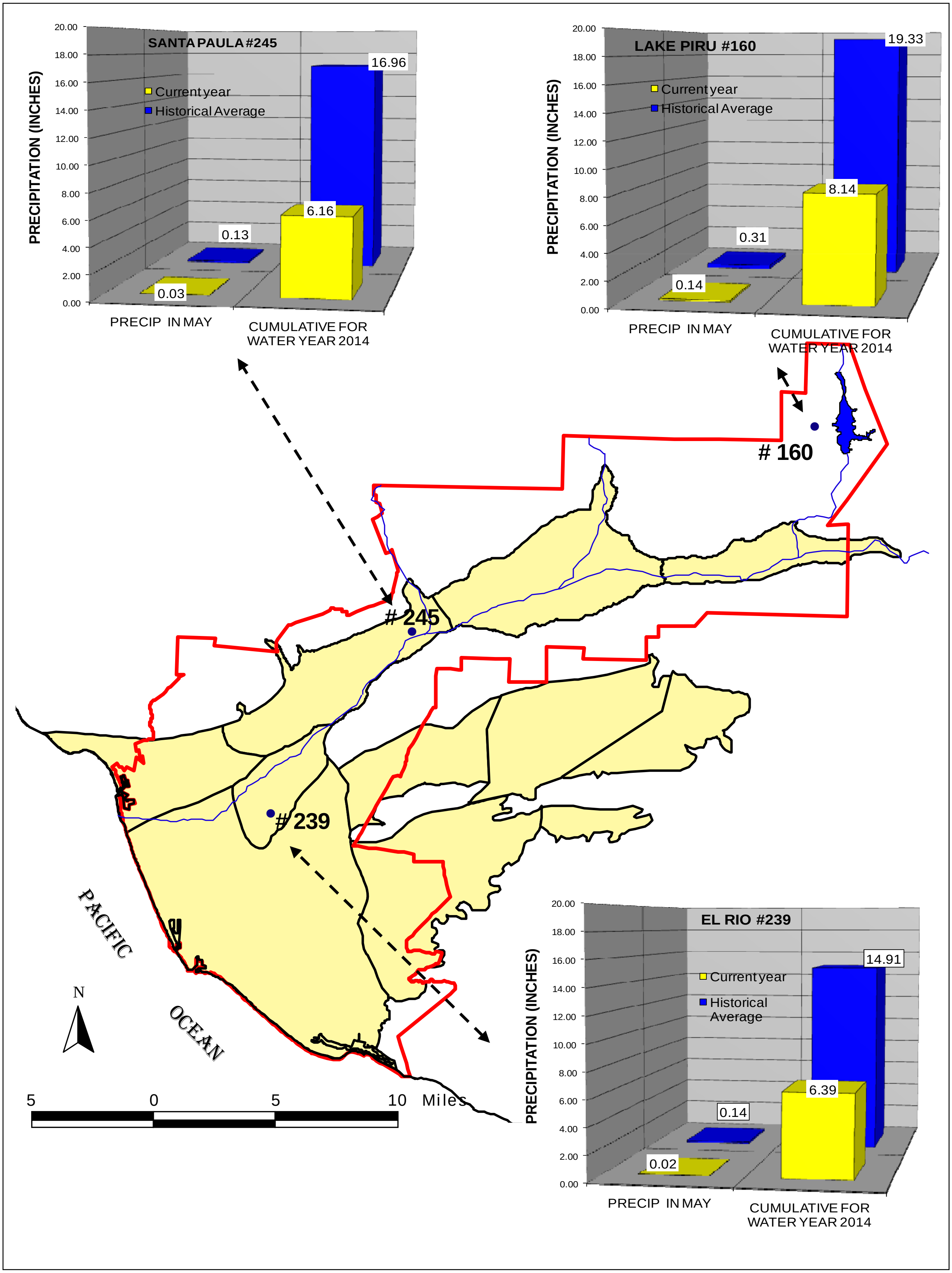
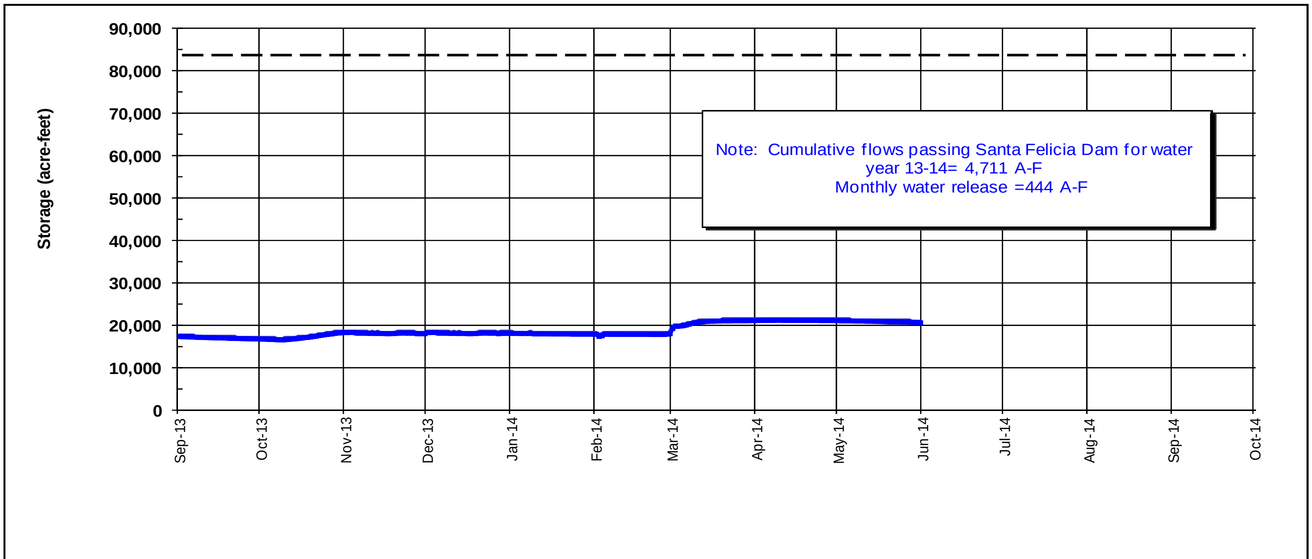
United Water Conservation District
May 2014 Hydrologic Conditions Report
2014 Water Year

June 4, 2014



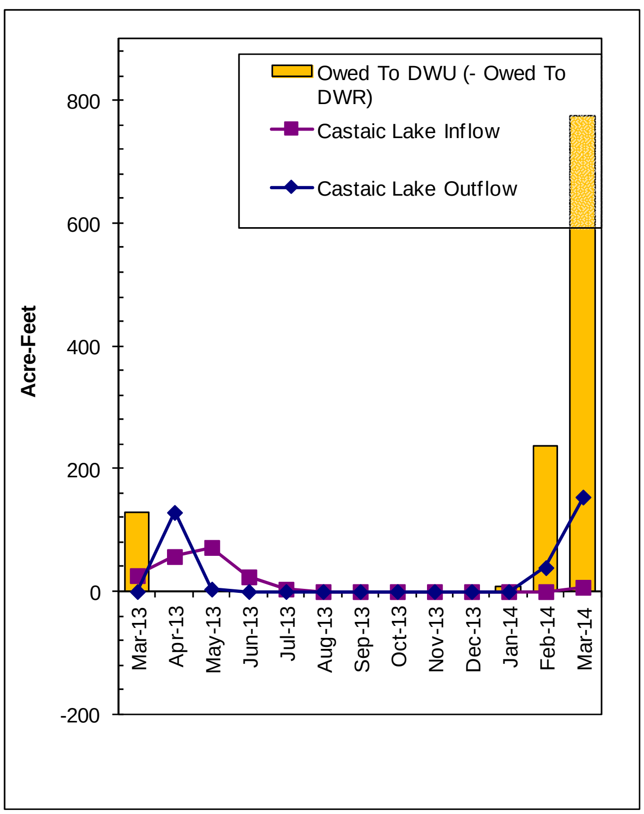


District-wide percent of normal precipitation = 40%

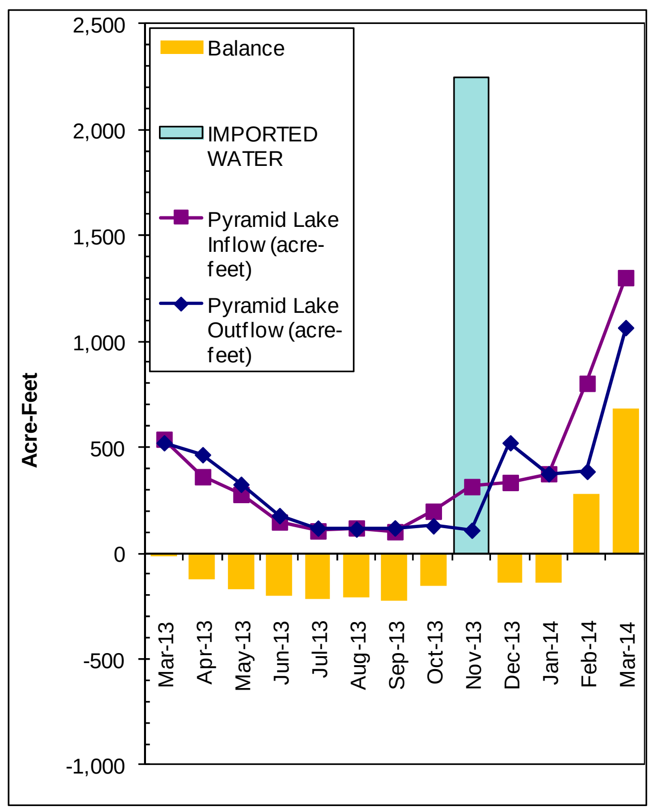


			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Hydro Plant Outflow (Acre-Feet)			0	0	0	0	0	0	0	0				
Cumulative Hydro Plant Outflow (A-F)			0	0	0	0	0	0	0	0				

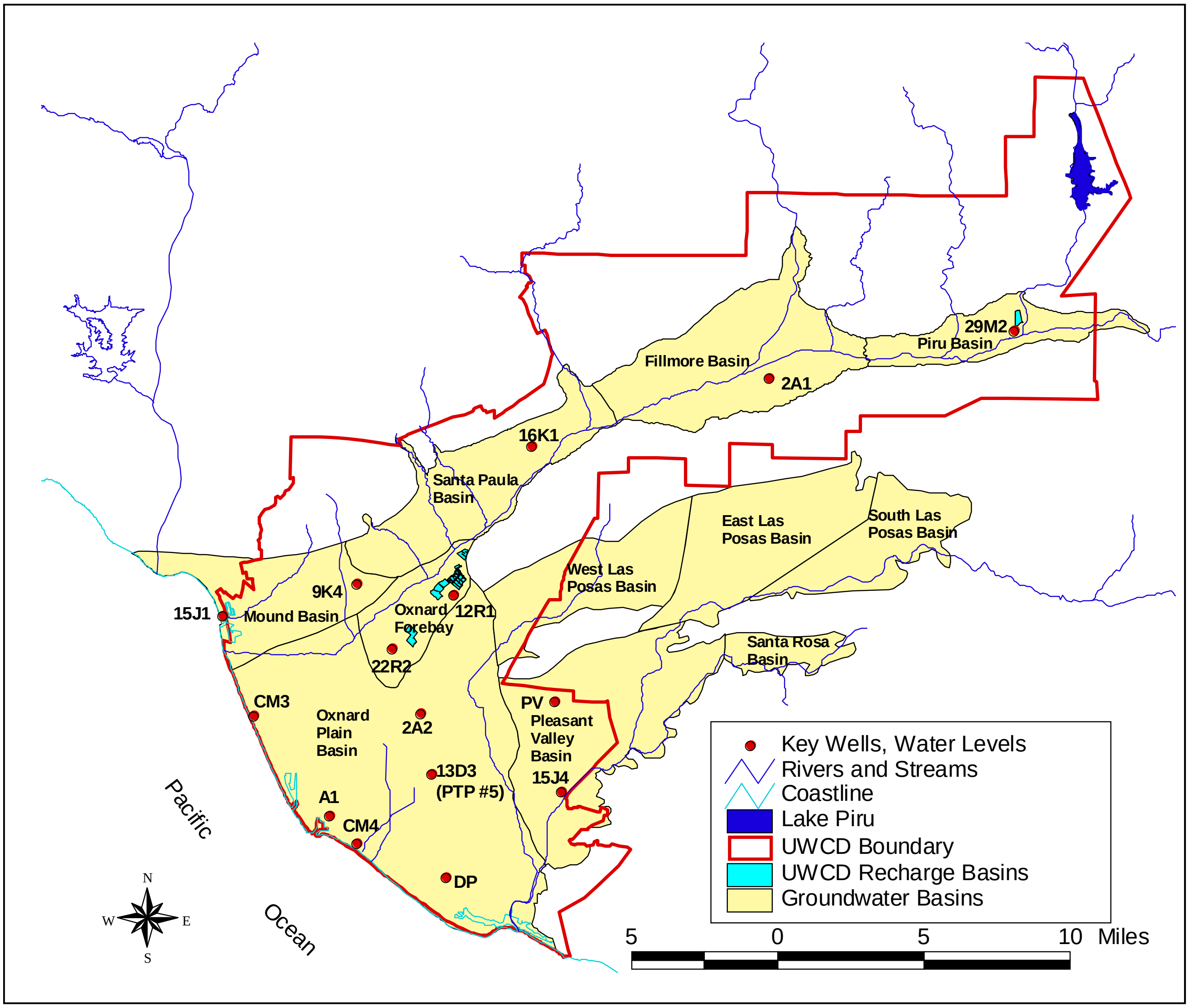
Lake Piru storage and outflow



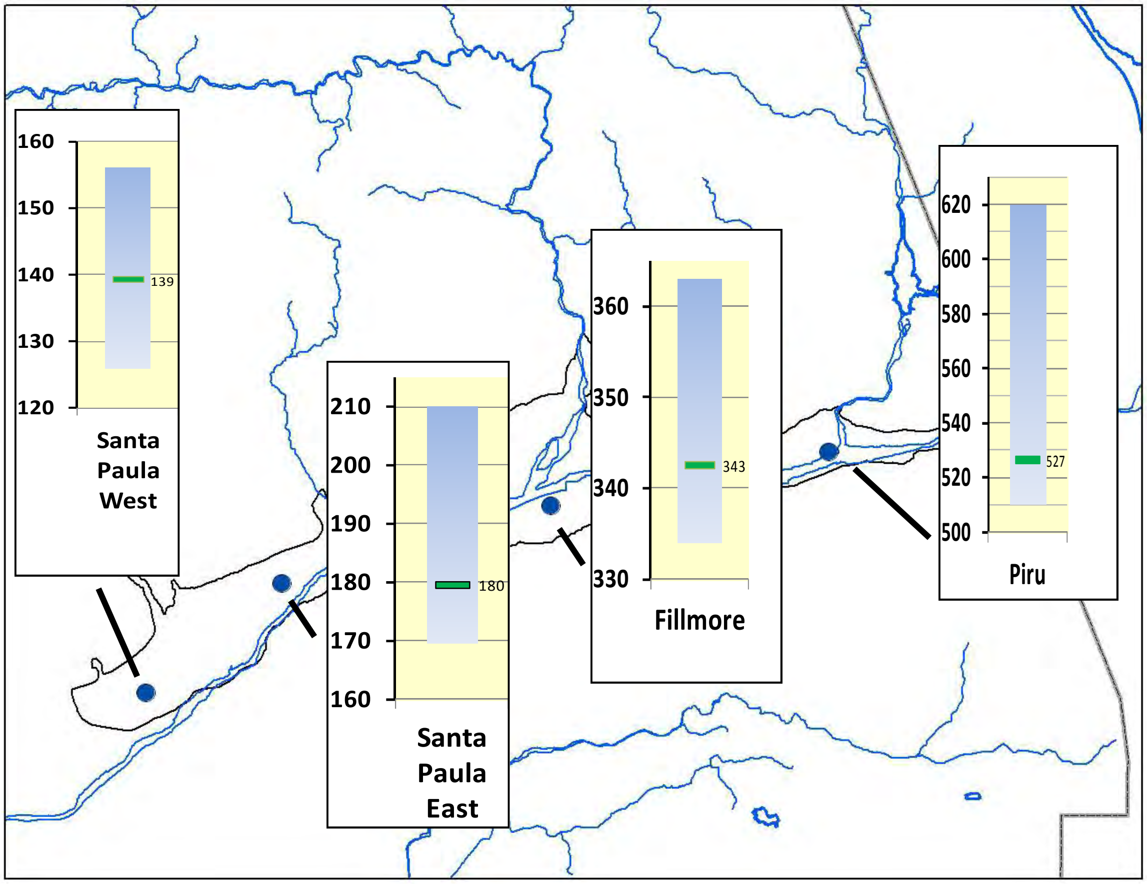
Castaic Lake releases to downstream users



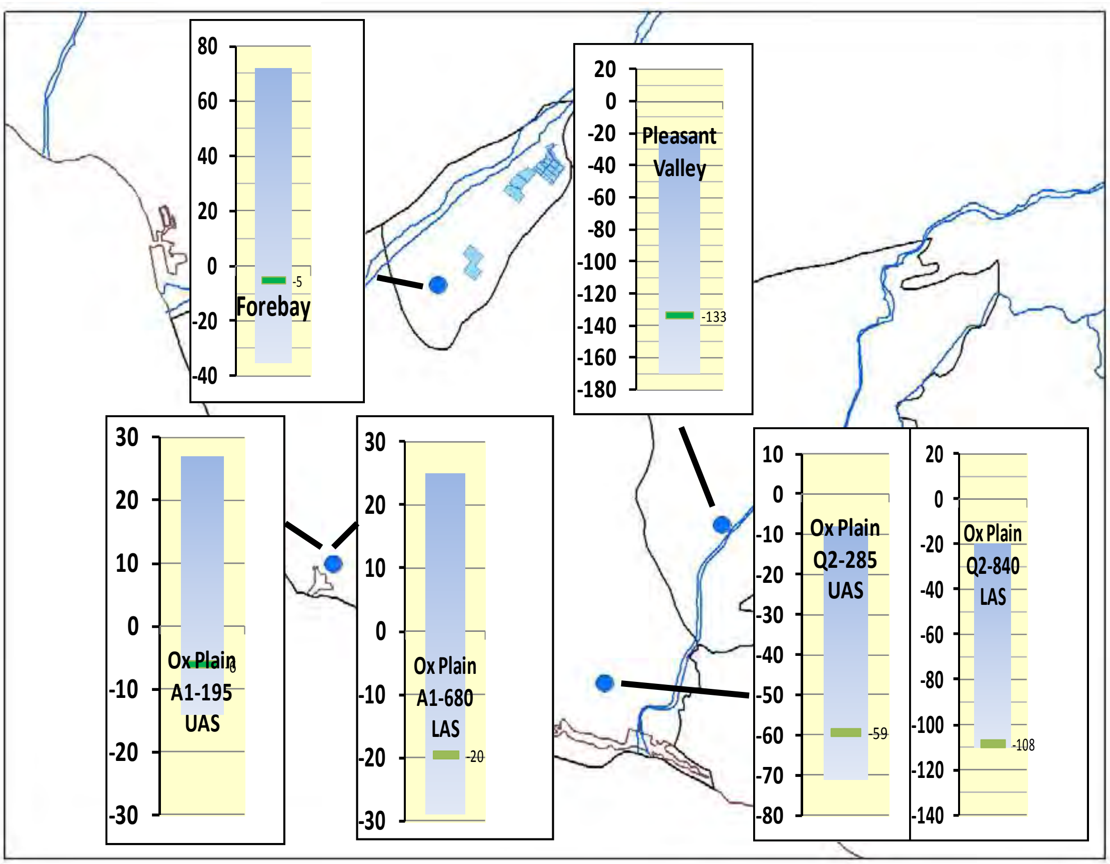
Pyramid Lake releases to UWCD

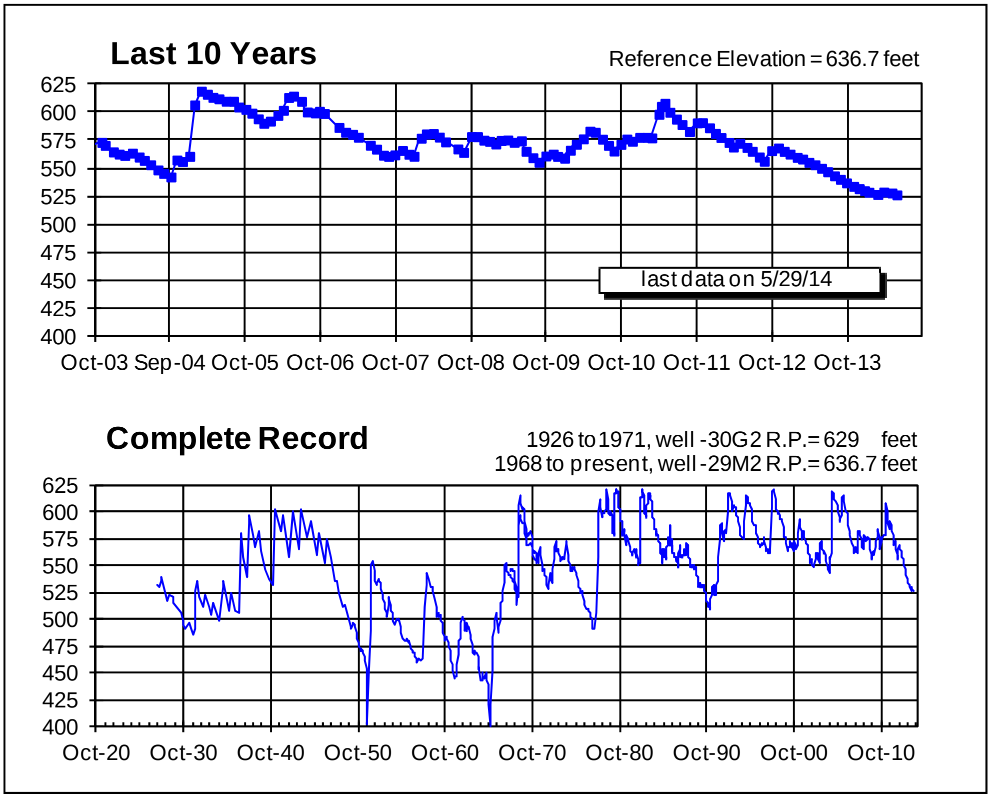


Locations of key wells, monthly groundwater elevation monitoring

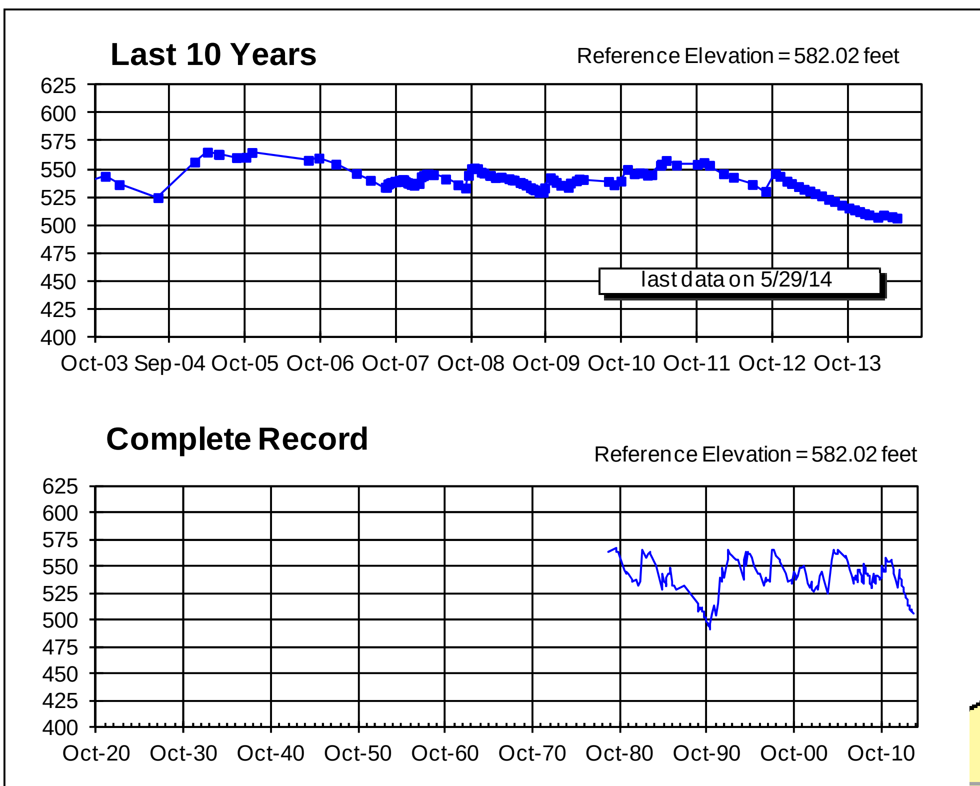


Recent water level elevations, compared to high-low range since 1990

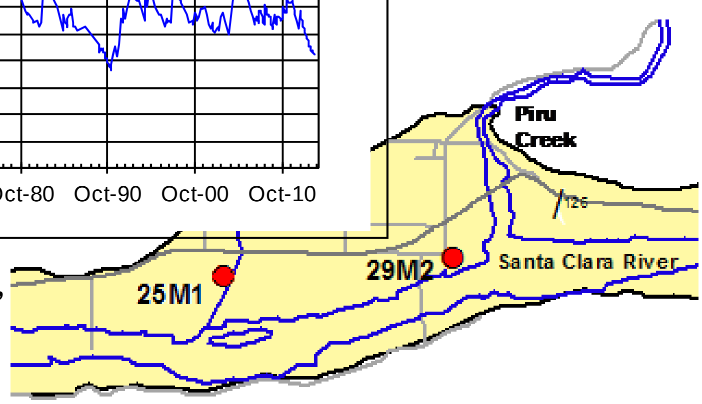


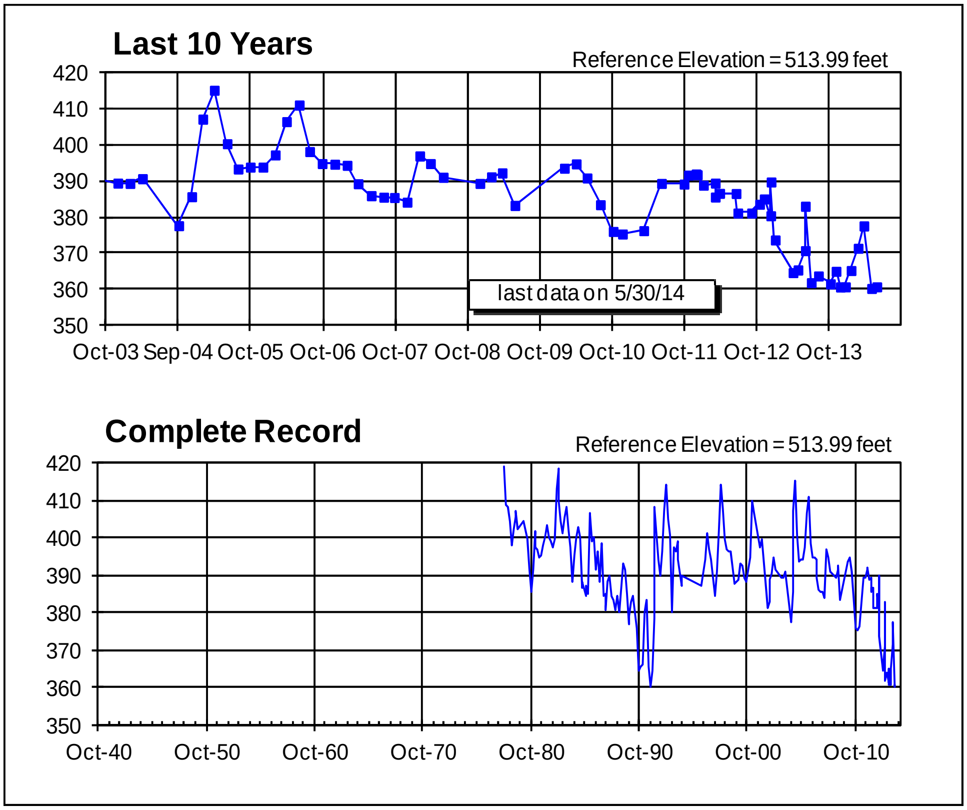


Historic groundwater elevation records, well 04N18W29M02S, Piru basin

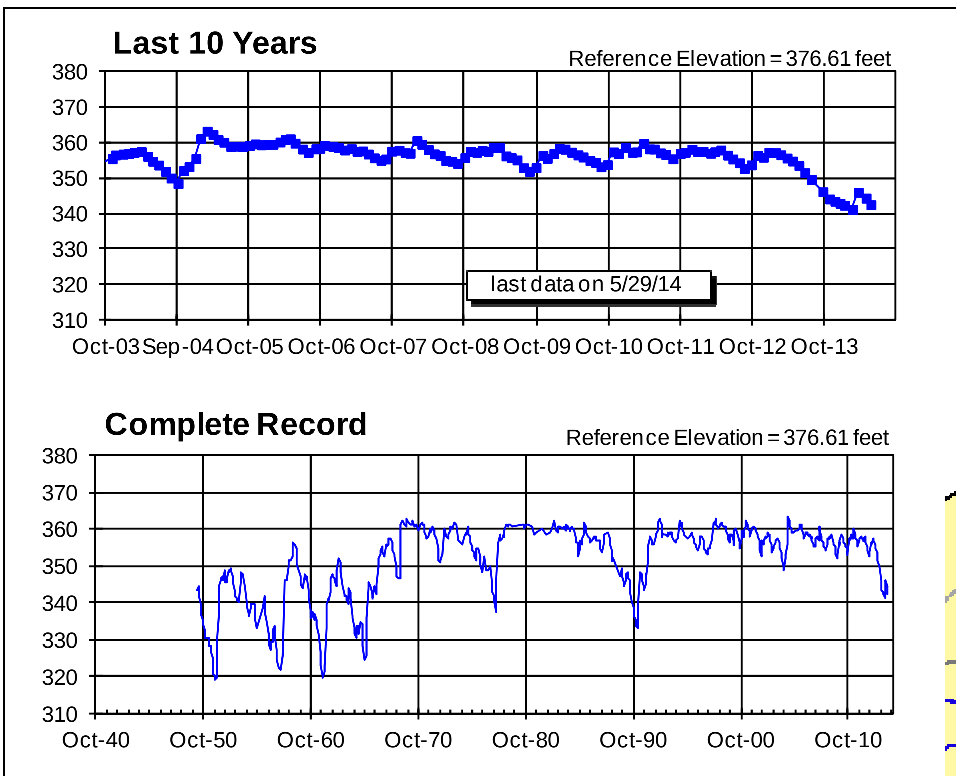


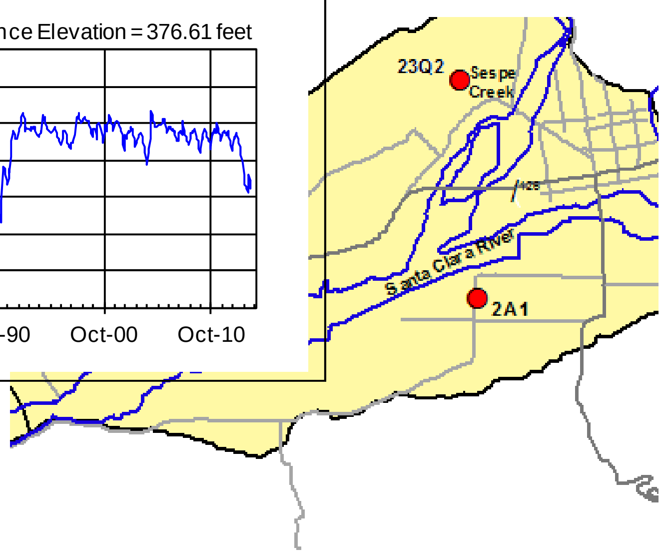
Historic groundwater elevation records, well 04N19W25M01S, Piru basin



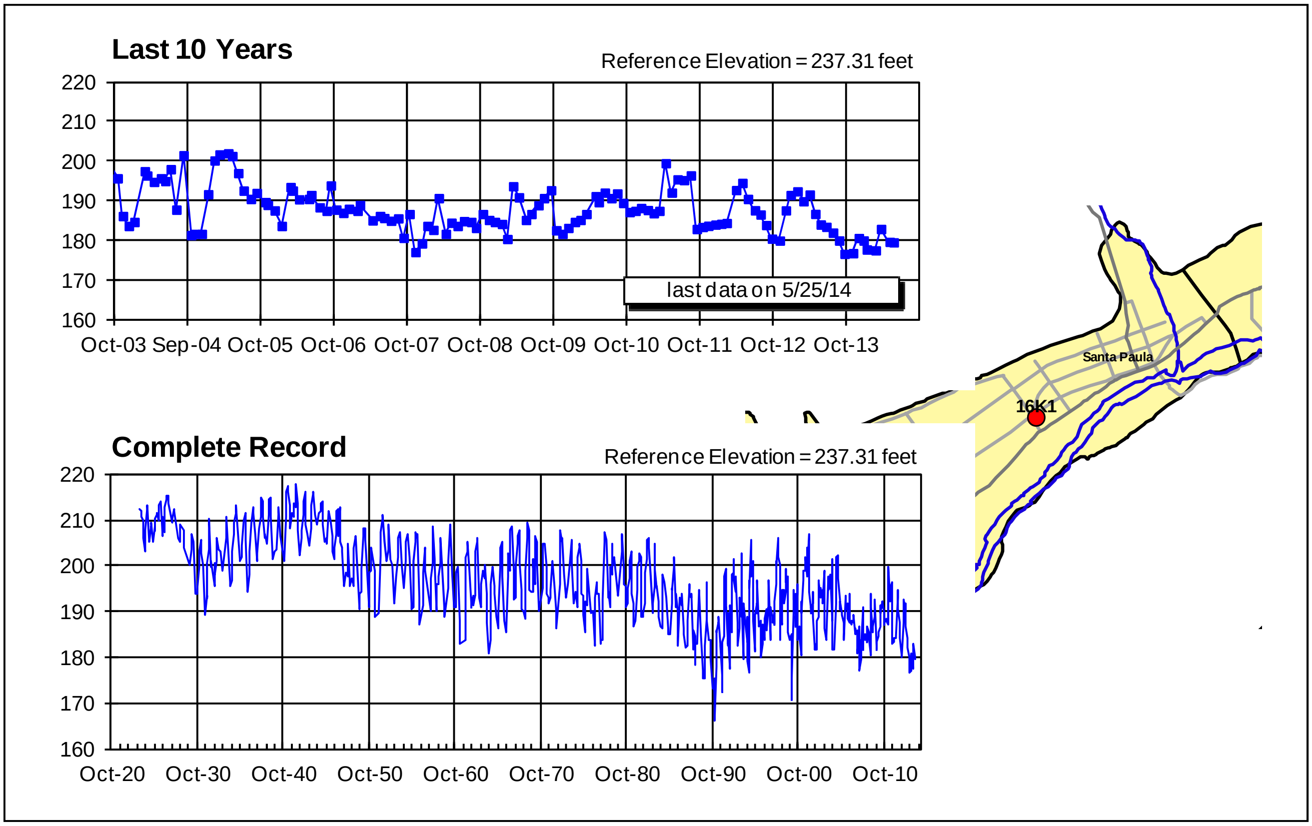


Historic groundwater elevation records, well 04N20W23Q02S, Fillmore basin

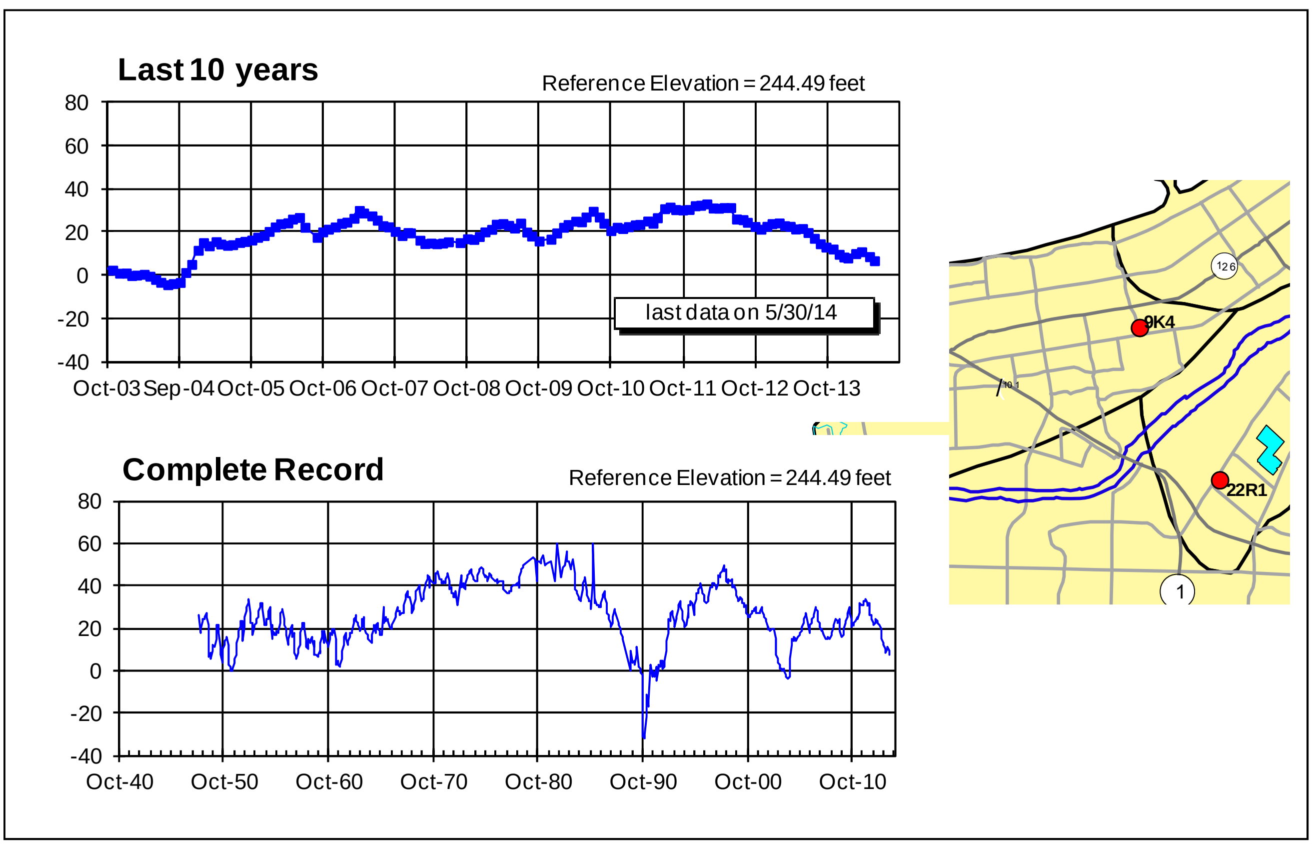




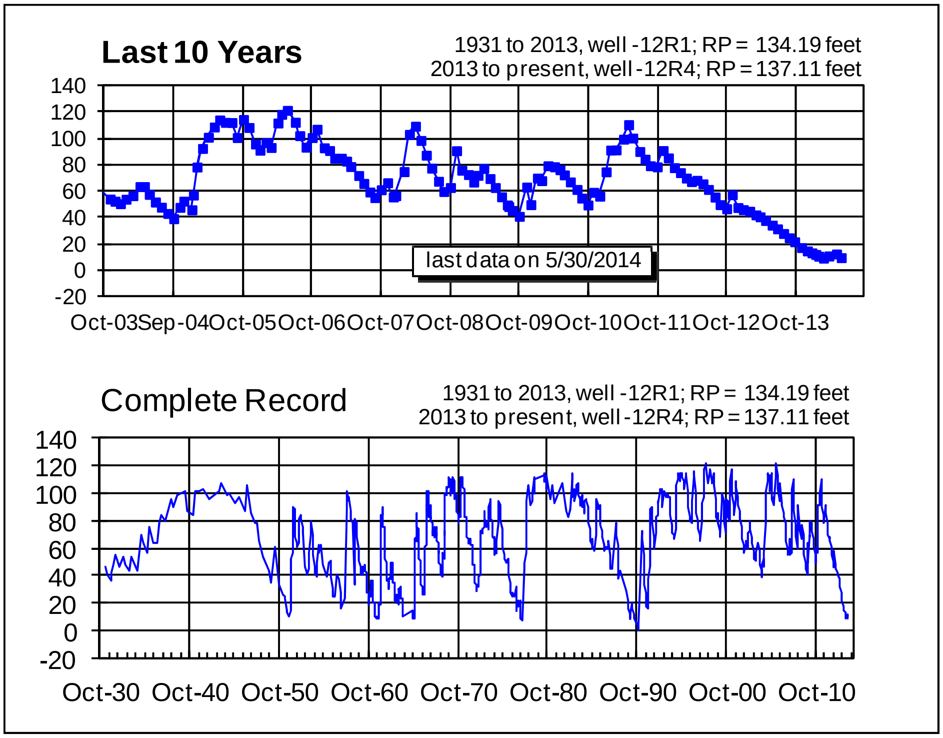
Historic groundwater elevation records, well 03N20W02A01S, Fillmore basin



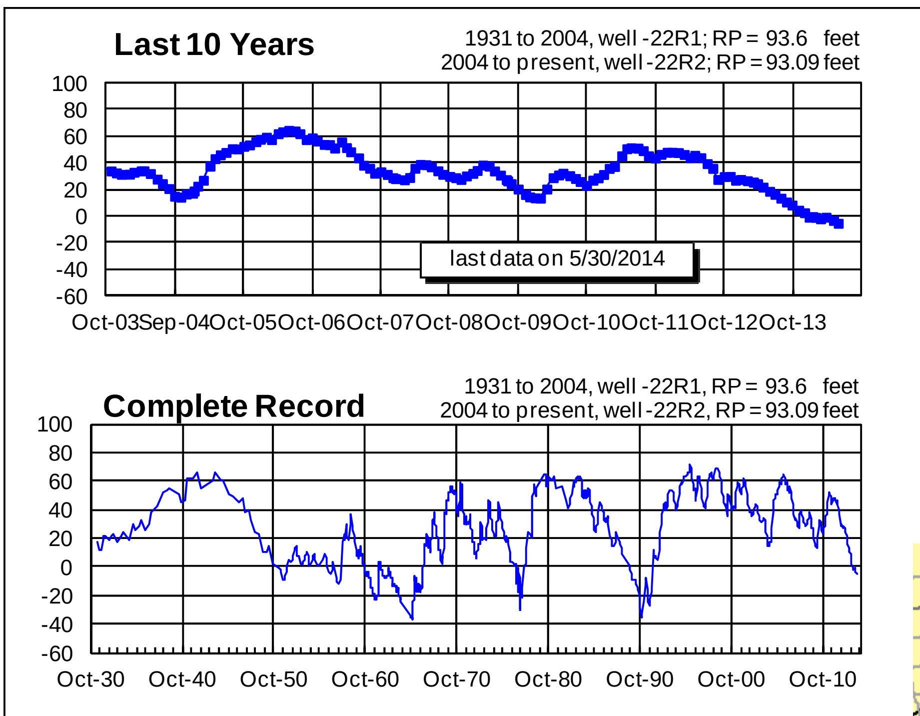
Historic groundwater elevation records, well 03N21W16K01S, Santa Paula basin

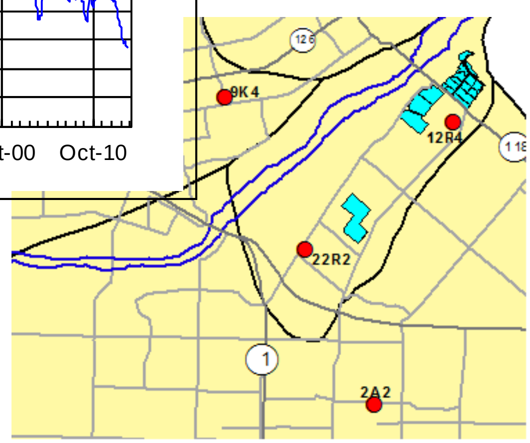


Historic groundwater elevation records, well 02N22W09K04S, Mound basin

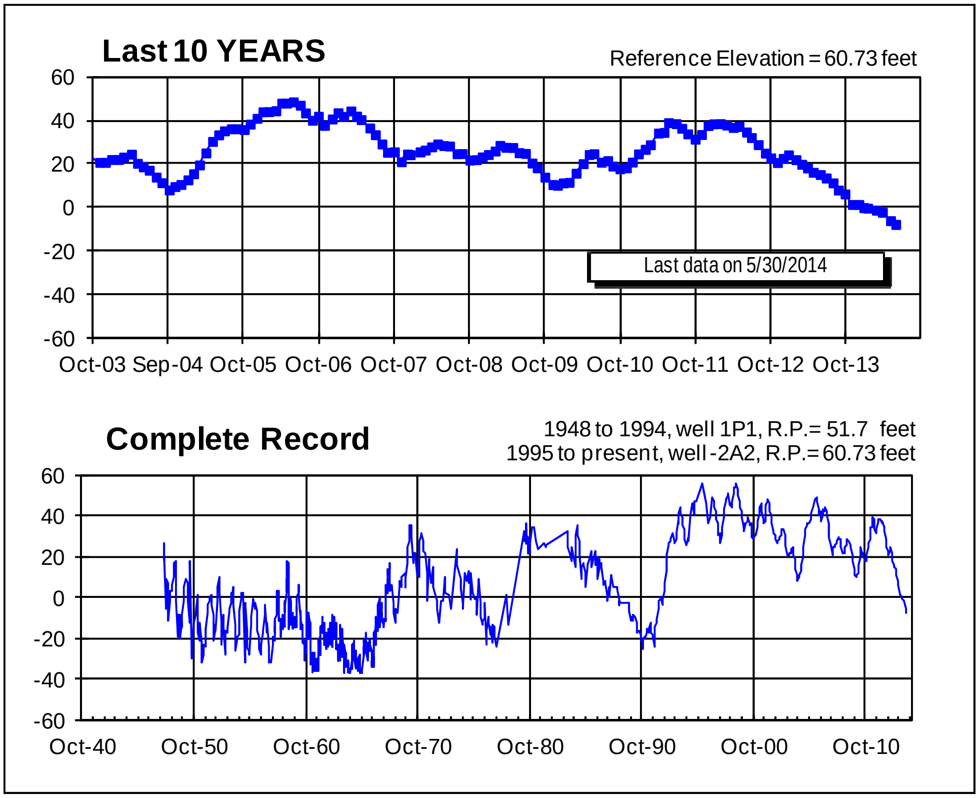


Historic groundwater elevation records, well 02N22W12R04S, Oxnard Forebay basin

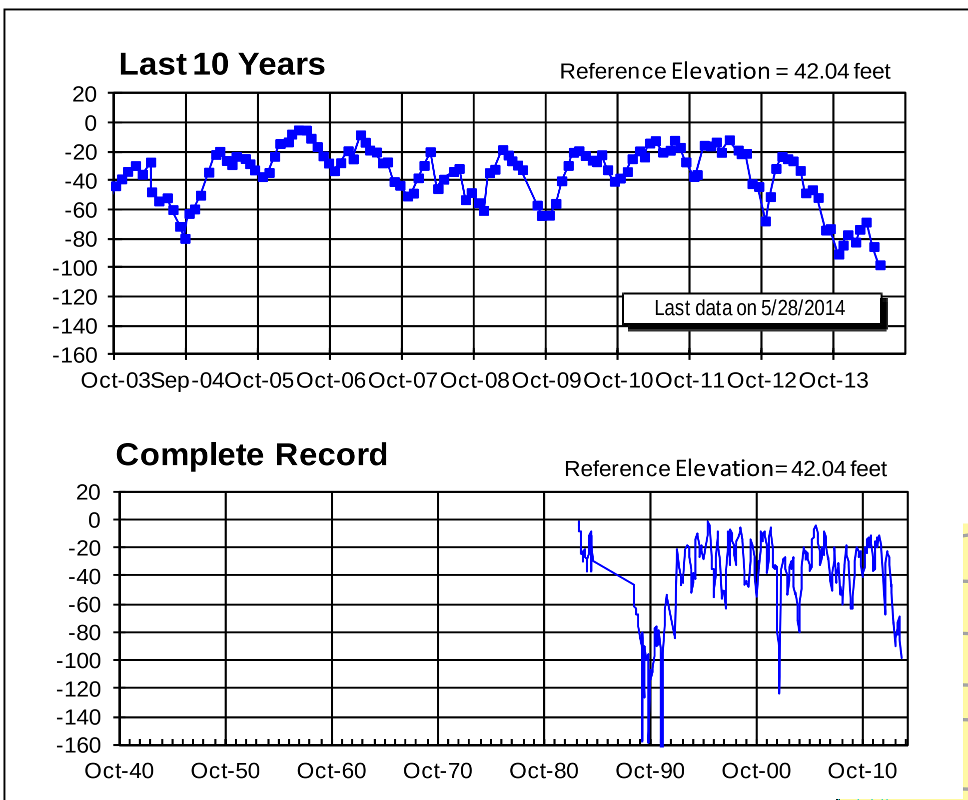


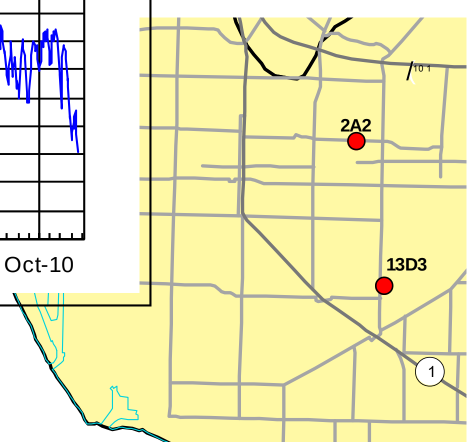


Historic groundwater elevation records, well 02N22W22R02S, Oxnard Forebay

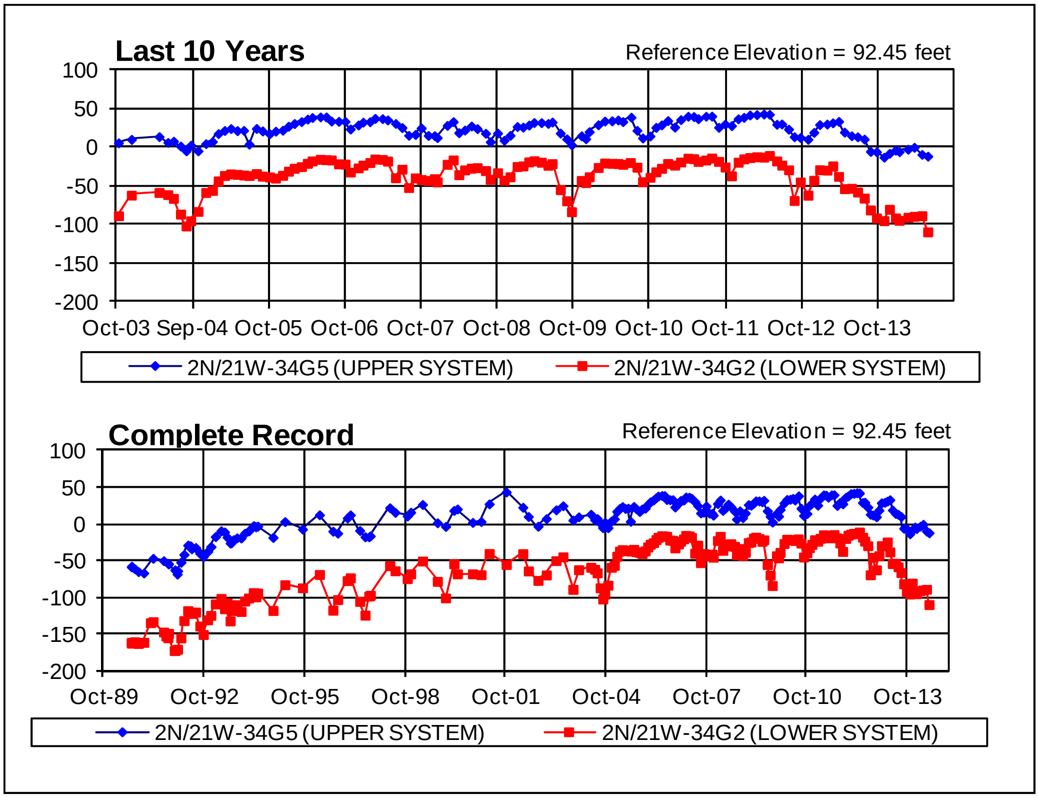


Historic groundwater elevation records, UAS well 01N22W02A02S, Oxnard Plain

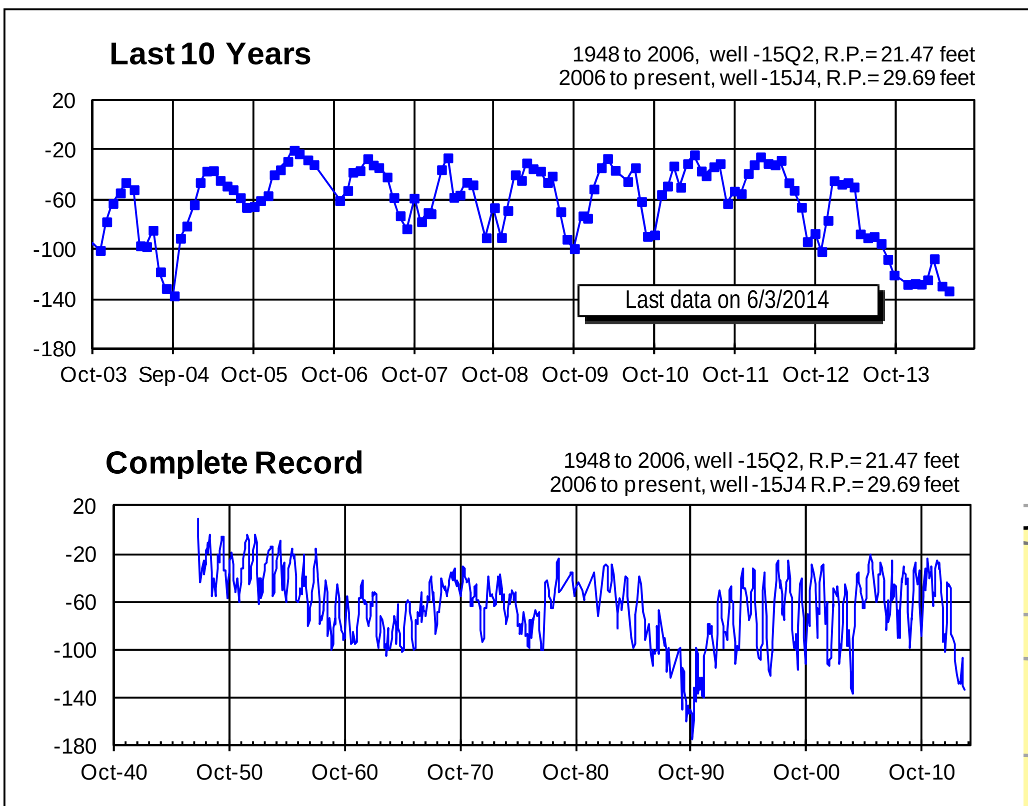


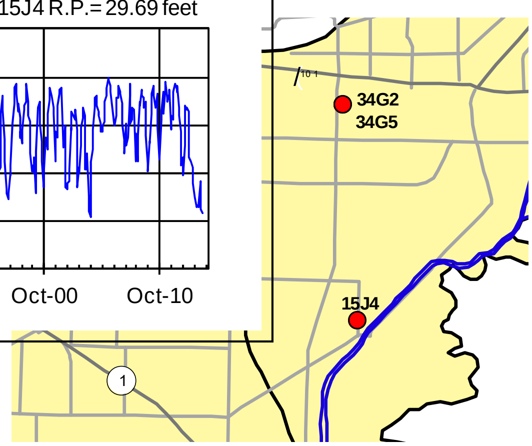


Historic groundwater elevation records, Lower Aquifer System well 01N22W13D03S(PTP #5), Oxnard Plain

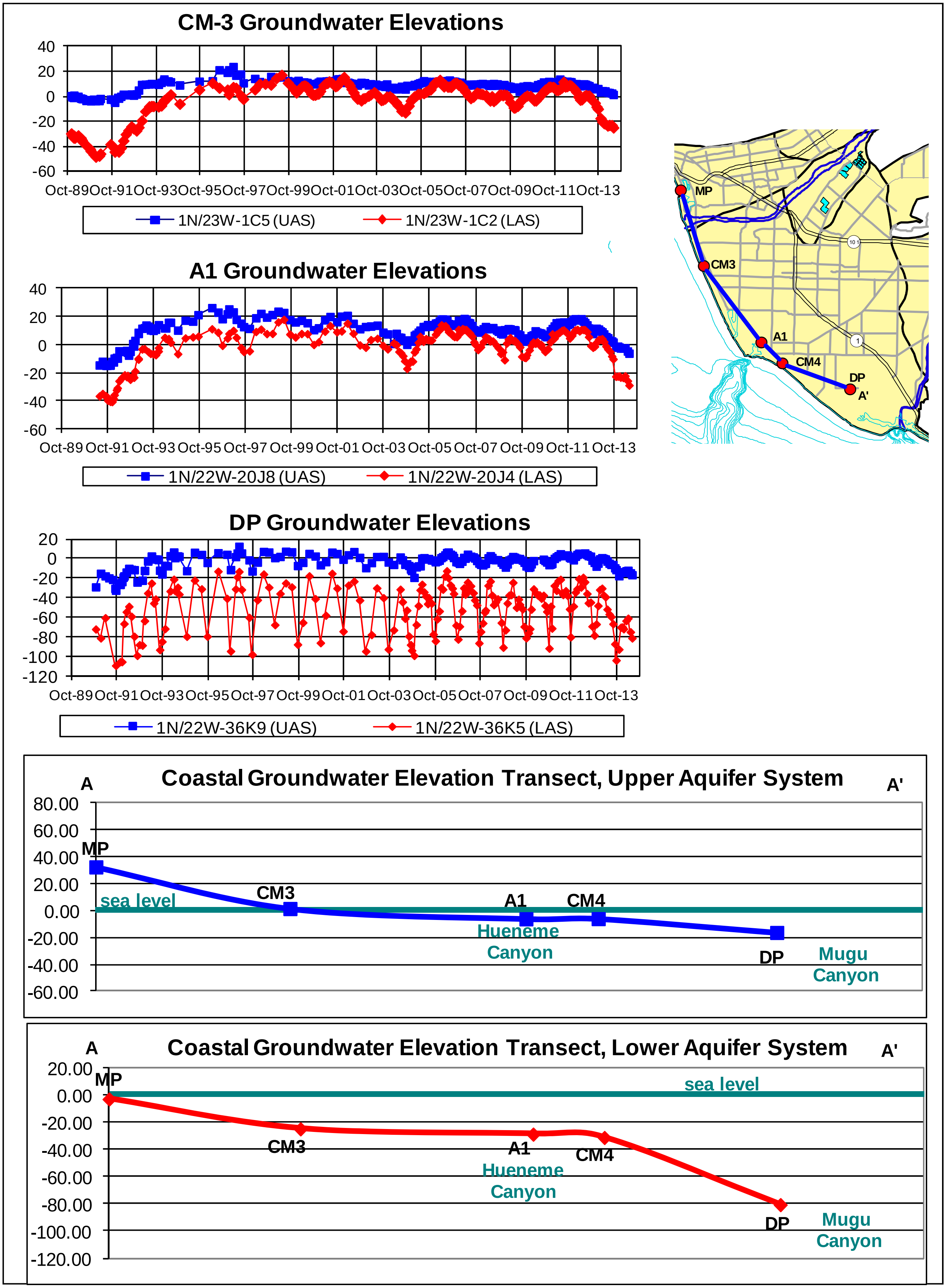


Historic groundwater elevation records, Upper and Lower Aquifer Systems, PV nested monitor well, Pleasant Valley basin





Historic groundwater elevation records,
LAS well 01N21W15J04S, Pleasant Valley basin



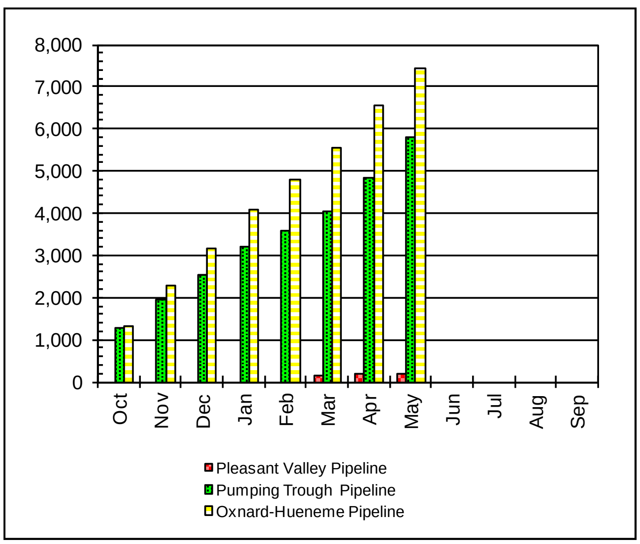
Coastal groundwater elevation transect, recent conditions

Monthly Water Deliveries - 2013-2014 Water Year (acre-feet)												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
PV Pipeline incl. c cust. (surface water)	0.0	0.0	0.0	0.0	0.0	161.2	38.0	1.9				
PV Pipeline inc. C cust.(saticoy well field and 12+13)	43.8	10.2	9.0	11.7	0.0	0.0	0.0	0.0				
Total to Pleasant Valley Pipeline	43.8	10.2	9.0	11.7	0.0	161.2	38.0	0.0				
Saticoy Well Field *(inc. OH-12, OH-13)	477.4	246.7	214.3	145.1	0.0	0.0	0.0	0.0				
PTP (surface water)	0.0	0.0	0.0	0.0	0.0	15.9	6.0	0.0				
PTP (groundwater)	844.1	408.3	404.5	514.2	378.9	465.9	789.8	947.9				
PTP (Saticoy well field & OH.)	433.6	256.5	204.5	133.4	0.0	0.0	0.0	0.0				
Total PTP	1,277.7	664.8	609.0	647.6	378.9	481.8	795.8	947.9				
O-H Pipeline (groundwater)	1,321.9	969.6	873.3	919.5	698.9	768.9	987.1	902.4				
Total Surface Water Delivery (PTP & PV)	0.0	0.0	0.0	0.0	0.0	177.1	44.0	1.9				
Total Groundwater Delivery (OH & PTP & SW & OH 12-13)	2,643.4	1,624.6	1,492.1	1,578.8	1,077.8	1,234.8	1,776.9	1,850.3				
Total Delivery, Surface Water & GW	2,643.4	1,624.6	1,492.1	1,578.8	1,077.8	1,411.9	1,820.9	1,852.2				

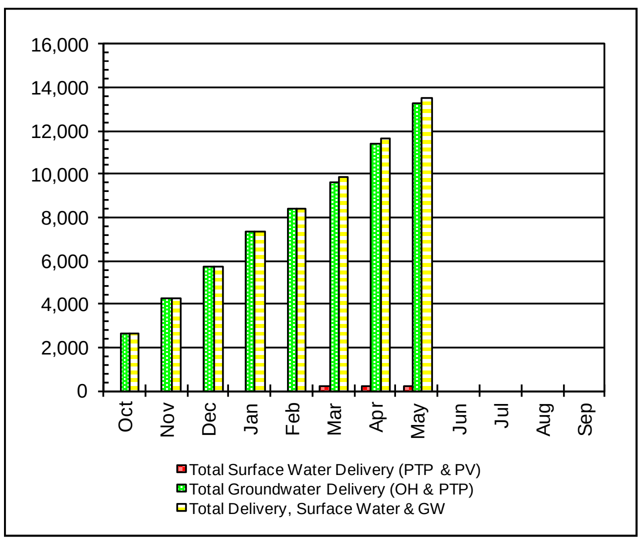
Monthly water deliveries, 2013-2014 water year, in acre-feet

Cumulative Water Deliveries - 2013-2014 Water Year (acre-feet)												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
PV Pipeline (surface water)	0.0	0.0	0.0	0.0	0.0	161.2	199.2	201.1				
PV Pipeline (saticoy well field)	43.8	54.0	63.0	74.7	74.7	74.7	74.7	74.7				
Total to Pleasant Valley Pipeline	43.8	54.0	63.0	74.7	74.7	235.9	273.9	273.9				
Saticoy Well Field *(inc. OH-12, OH-13)	477.4	724.1	938.4	1,083.5	1,083.5	1,083.5	1,083.5	1,083.5				
PTP (surface water)	0.0	0.0	0.0	0.0	0.0	15.9	21.9	21.9				
PTP (groundwater)	844.1	1,252.4	1,656.9	2,171.1	2,550.0	3,015.9	3,805.6	4,753.5				
PTP (Saticoy well field)	433.6	690.1	894.6	1,028.0	1,028.0	1,028.0	1,028.0	1,028.0				
Total PTP	1,277.7	1,942.5	2,551.5	3,199.1	3,578.0	4,059.8	4,855.5	5,803.4				
O-H Pipeline (groundwater)	1,321.9	2,291.5	3,164.8	4,084.3	4,783.2	5,552.1	6,539.2	7,441.6				
Total Surface Water Delivery (PTP & PV)	0.0	0.0	0.0	0.0	0.0	177.1	221.1	223.0				
Total Groundwater Delivery (OH & PTP)	2,643.4	4,268.0	5,760.1	7,338.8	8,416.6	9,651.4	11,428.3	13,278.6				
Total Delivery, Surface Water & GW	2,643.4	4,268.0	5,760.1	7,338.8	8,416.6	9,828.5	11,649.4	13,501.6				

Cumulative water deliveries, 2013-2014 water year, in acre-feet



Cumulative deliveries by system



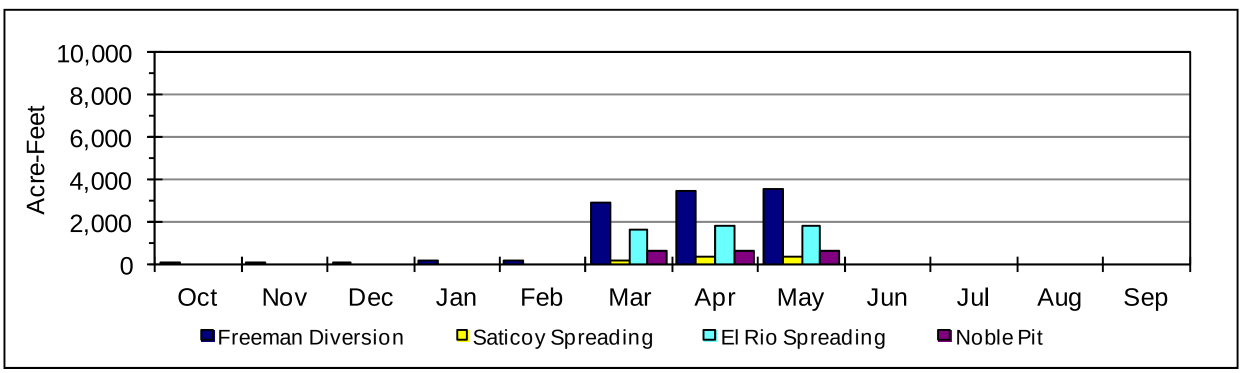
Cumulative deliveries by source/type

Month	Piru Spreading	Freeman Diversion	Saticoy Spreading	El Rio Spreading	Noble Pit
Oct	0	35	0	0	0
Nov	0	54	0	0	0
Dec	0	7	0	0	0
Jan	0	29	0	0	0
Feb	0	67	0	0	0
Mar	0	2,748	135	1,588	578
Apr	0	518	185	218	0
May	0	112	67	0	0
Jun					
Jul					
Aug					
Sep					

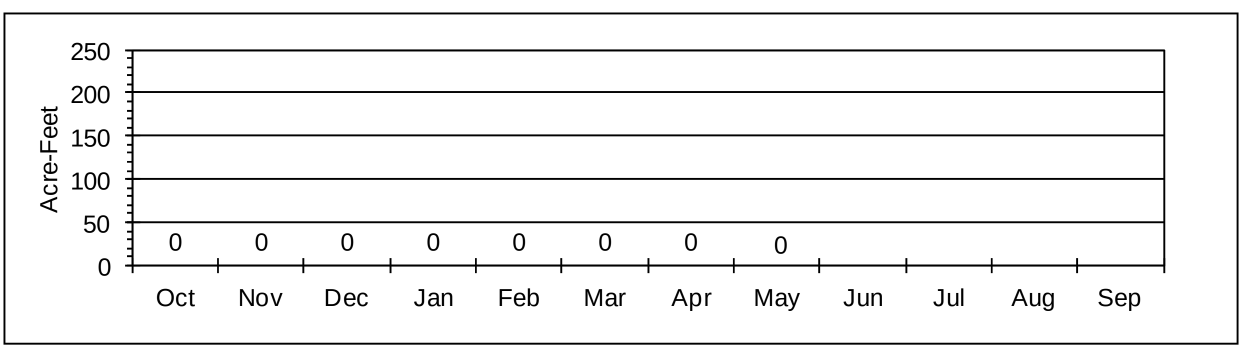
Monthly diversion and recharge totals by facility, 2013-2014, in acre-feet

Month	Piru Spreading	Freeman Diversion	Saticoy Spreading	El Rio Spreading	Noble Pit
Oct	0	35	0	0	0
Nov	0	88	0	0	0
Dec	0	95	0	0	0
Jan	0	125	0	0	0
Feb	0	191	0	0	0
Mar	0	2,939	135	1,588	578
Apr	0	3,457	320	1,806	578
May	0	3,569	387	1,806	578
Jun					
Jul					
Aug					
Sep					

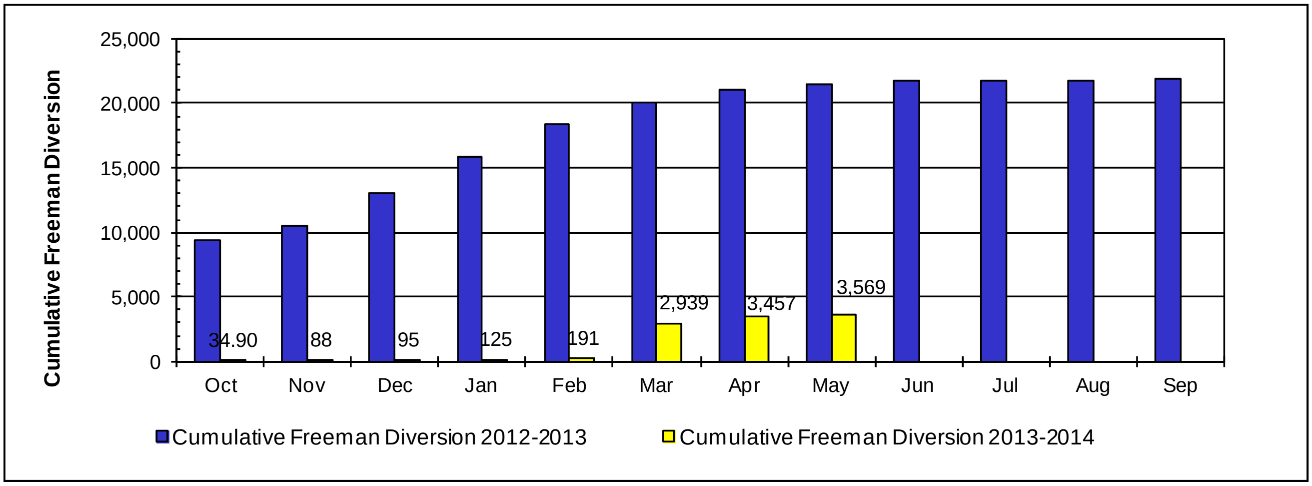
Cumulative diversion and recharge totals by facility, 2013-2014, in acre-feet



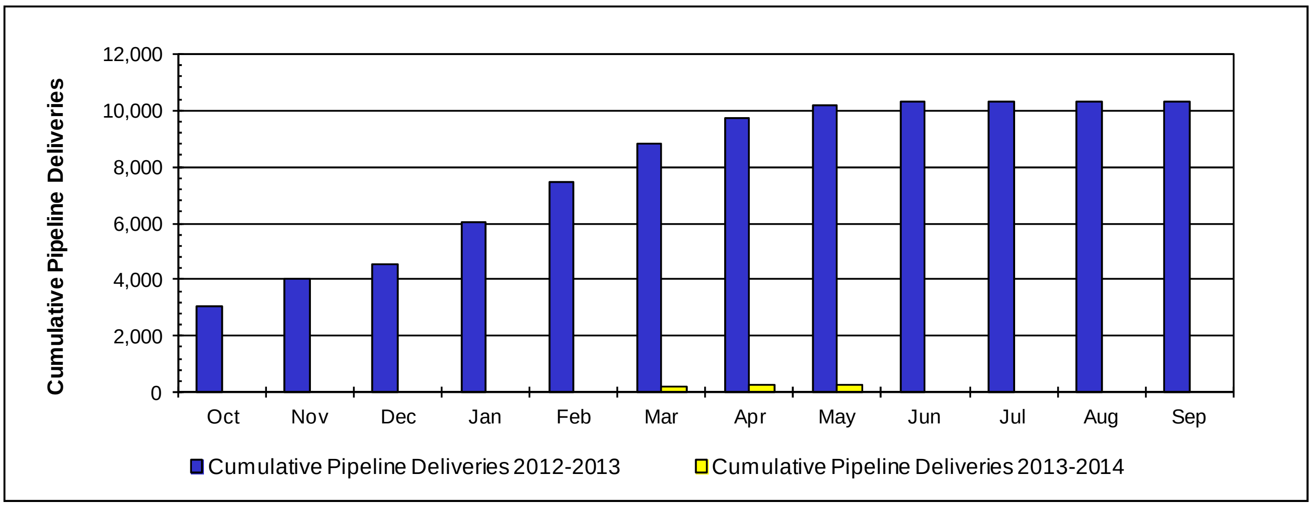
Cumulative diversion at Freeman, and distribution to recharge facilities, in acre-feet



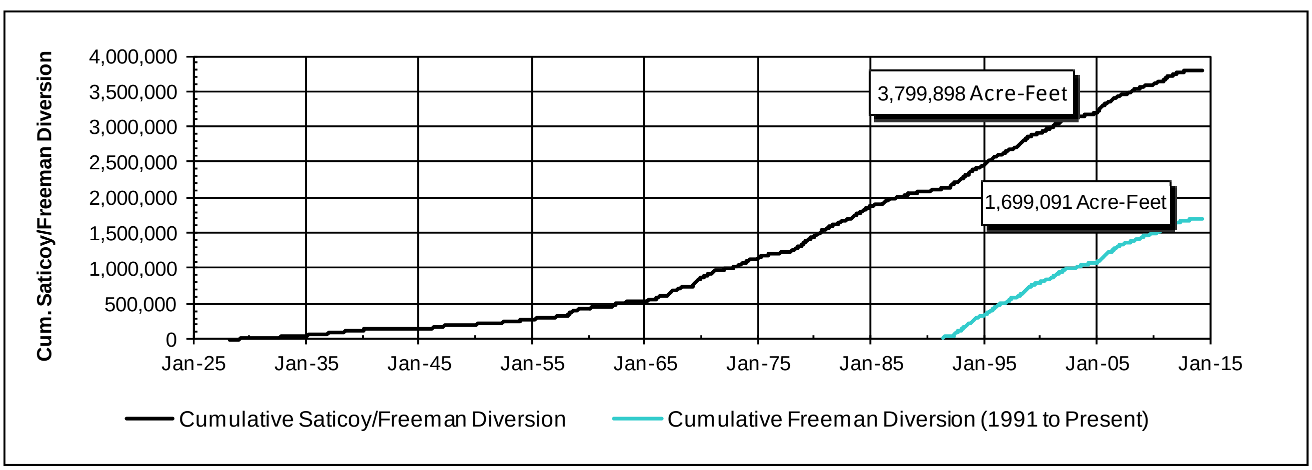
Cumulative diversions to Piru Spreading Grounds, 2013-2014, in acre-feet



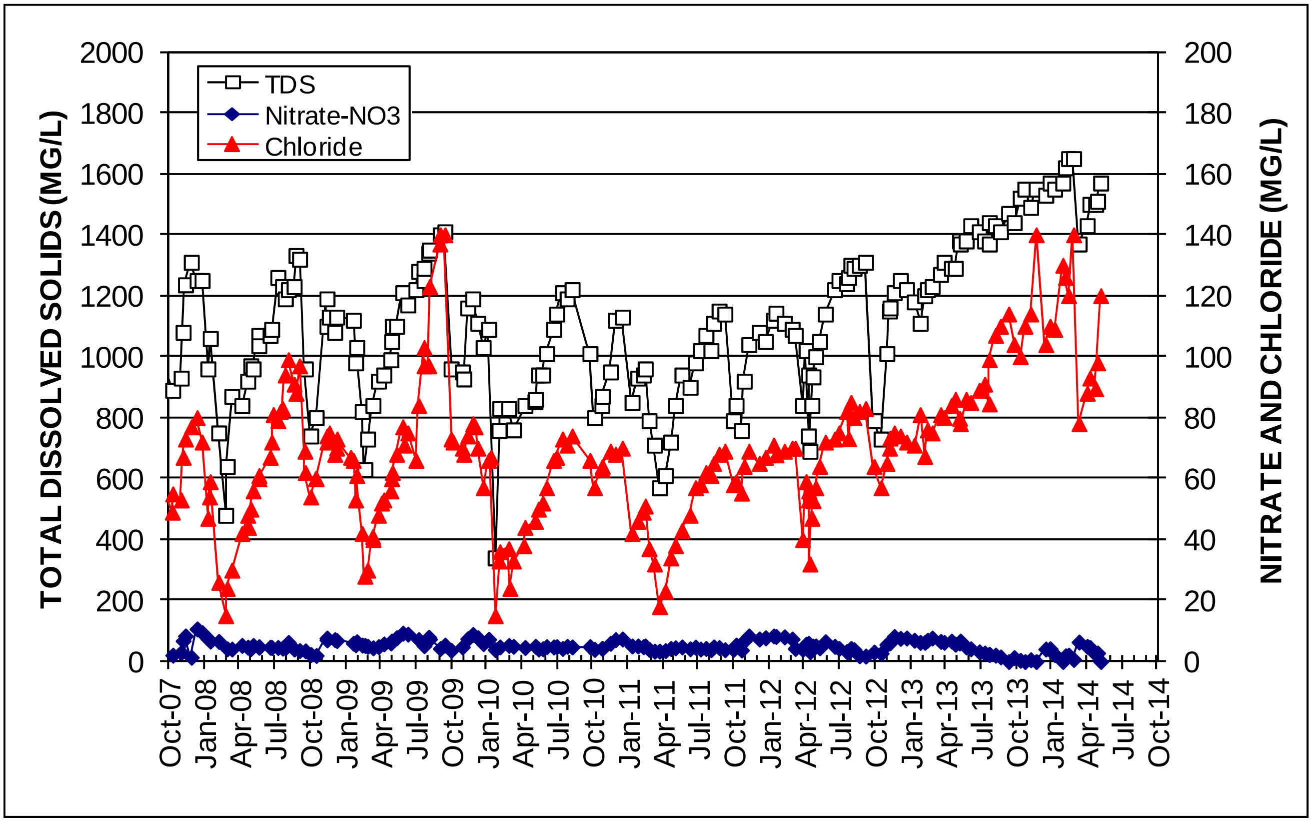
Cumulative 2013-2014 diversion at Freeman, compared to prior water year



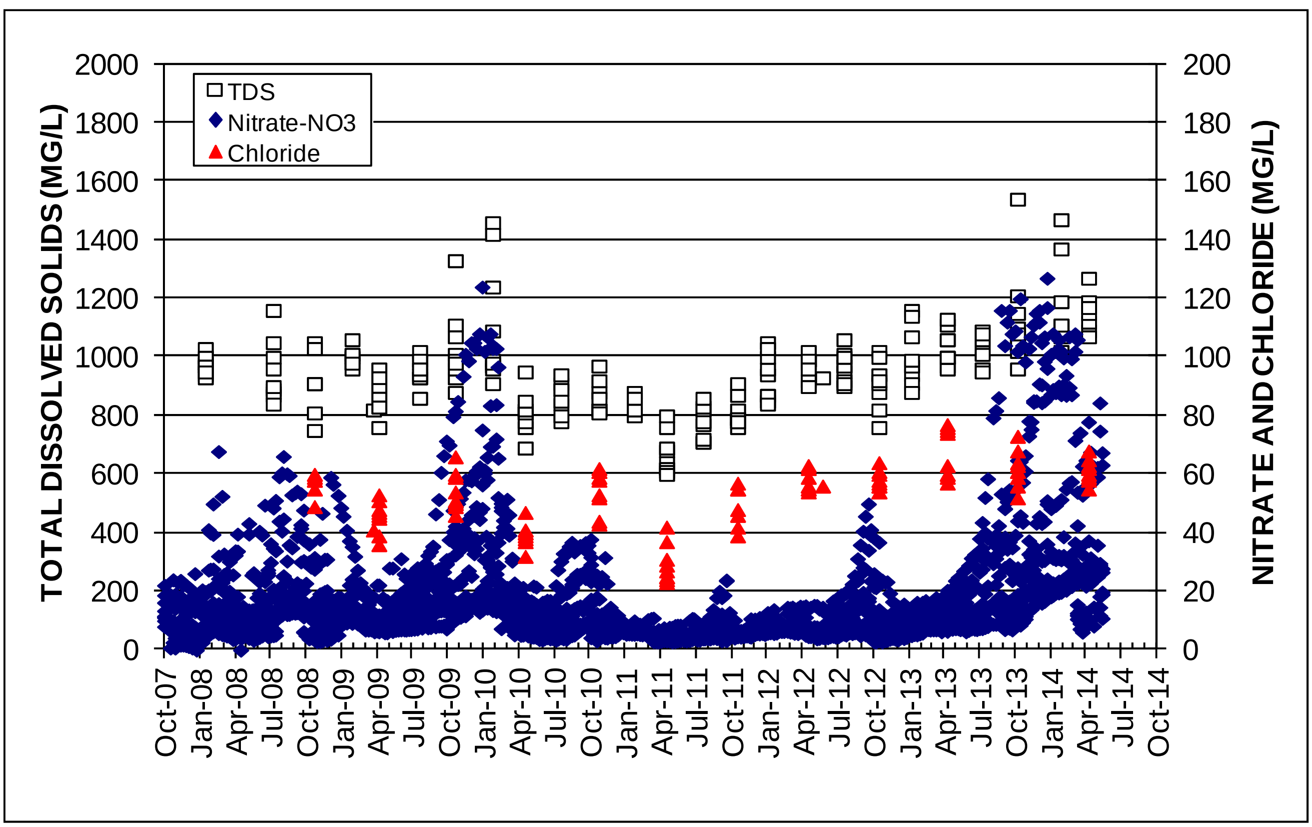
Cumulative 2013-2014 pipeline deliveries (surface water deliveries), compared to prior water year



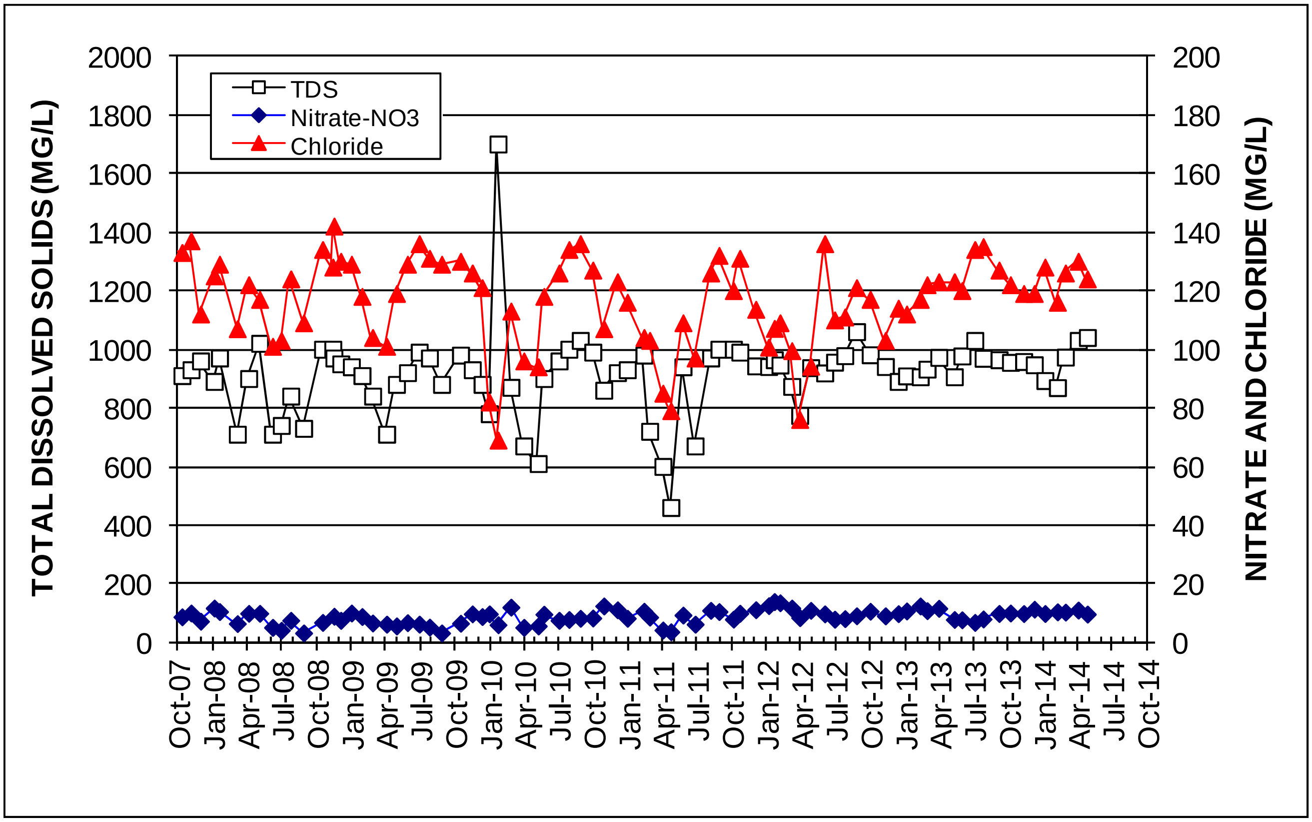
Cumulative diversion at Saticoy and Freeman diversion, in acre-feet



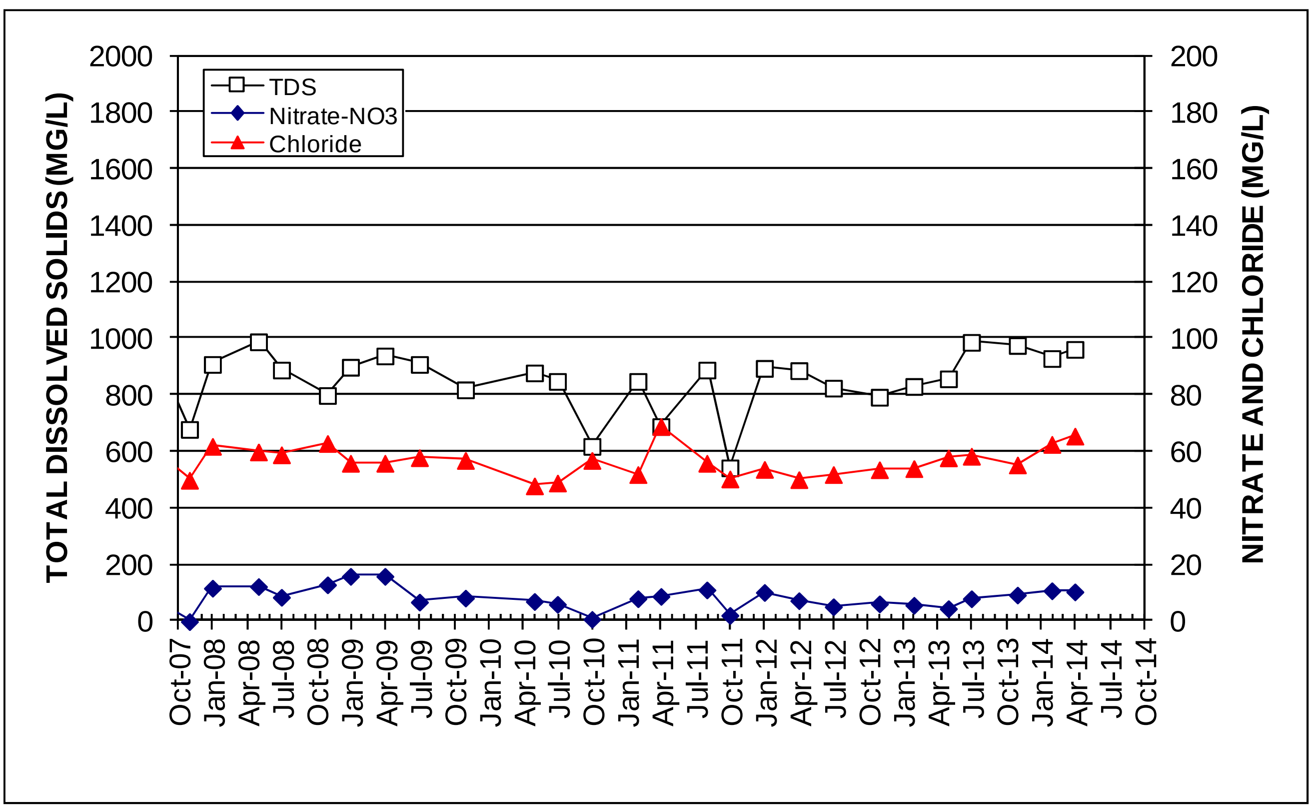
Santa Clara River water quality at Freeman Diversion



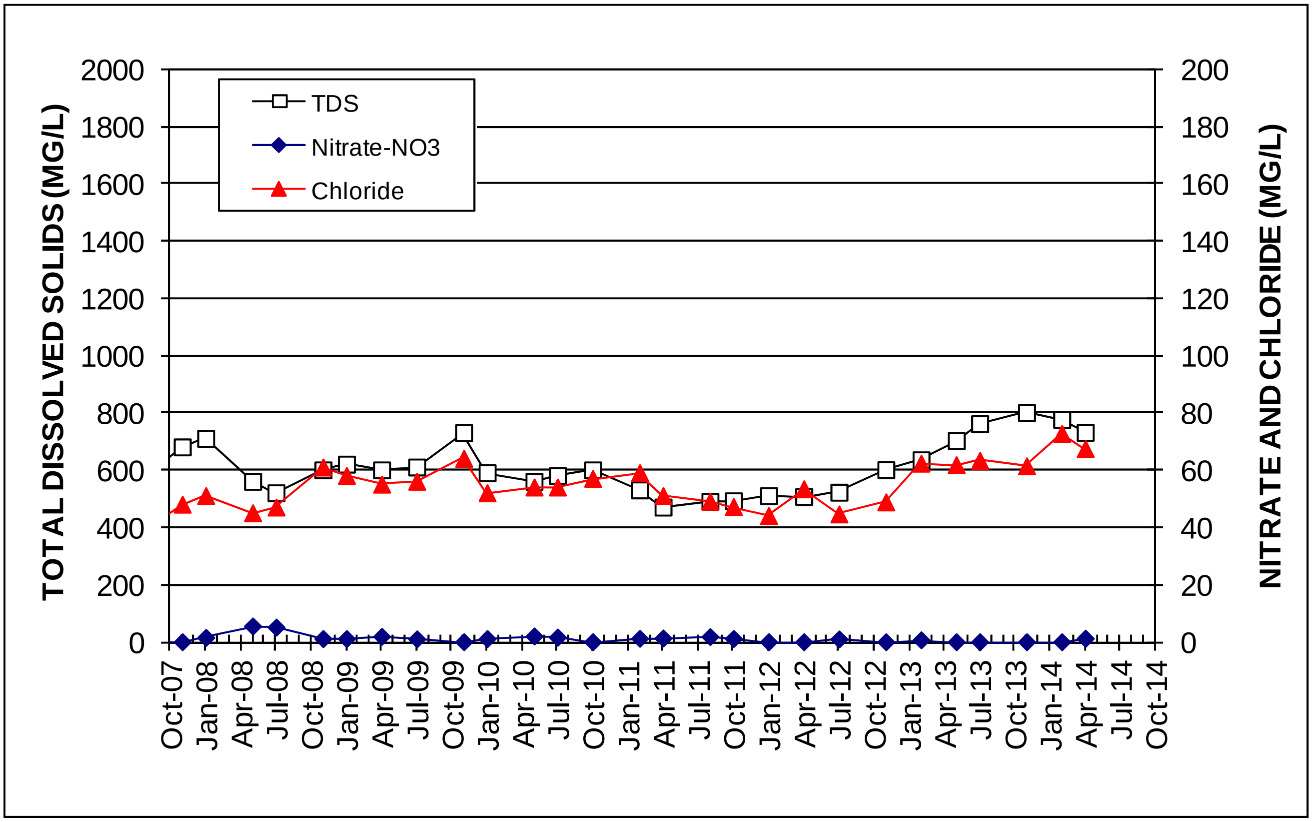
Water quality of Upper Aquifer System wells, El Rio well field



Santa Clara River water quality near Los Angeles/Ventura County line

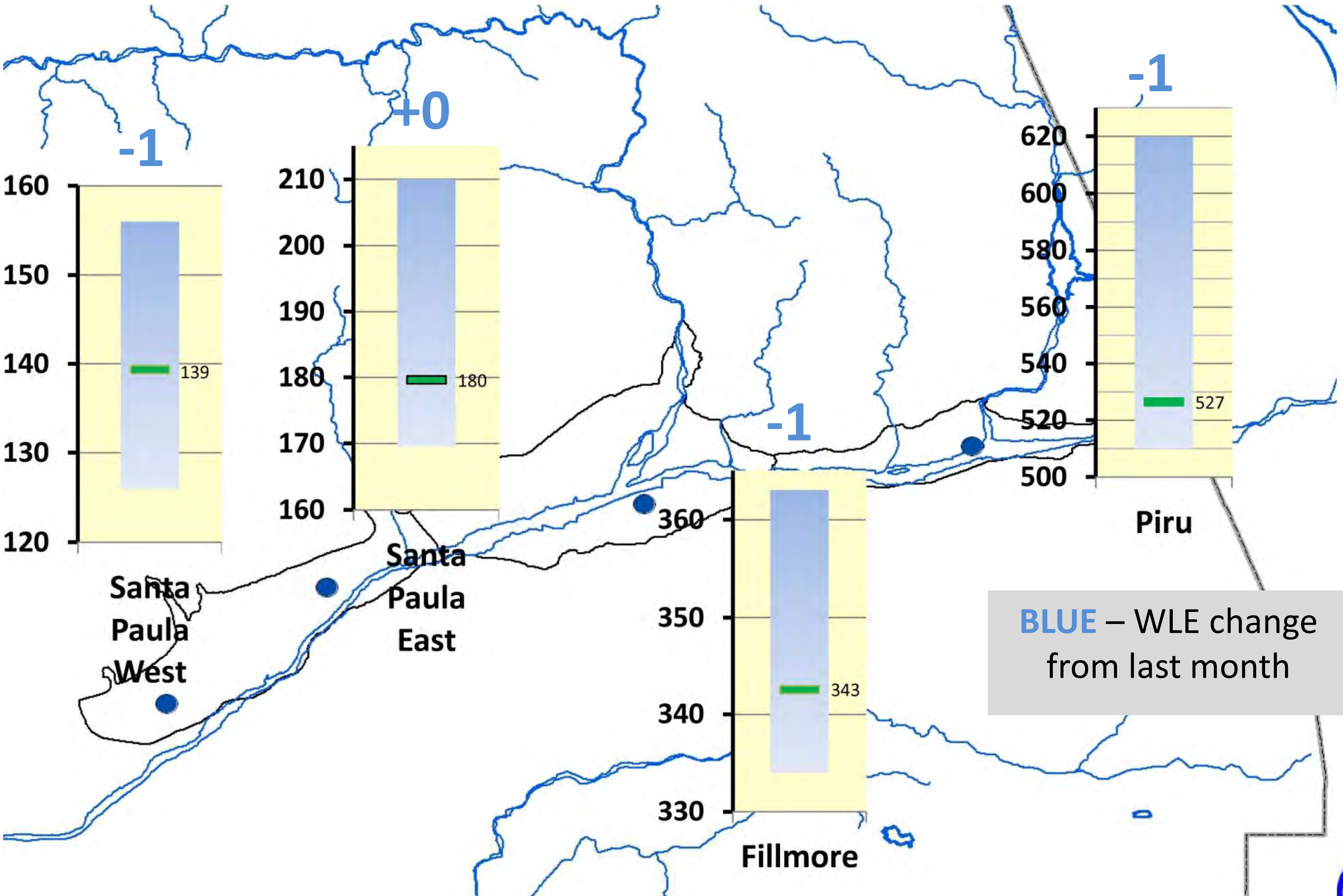


Santa Clara River water quality near Fillmore Fish Hatchery



Piru Creek water quality below Santa Felicia Dam

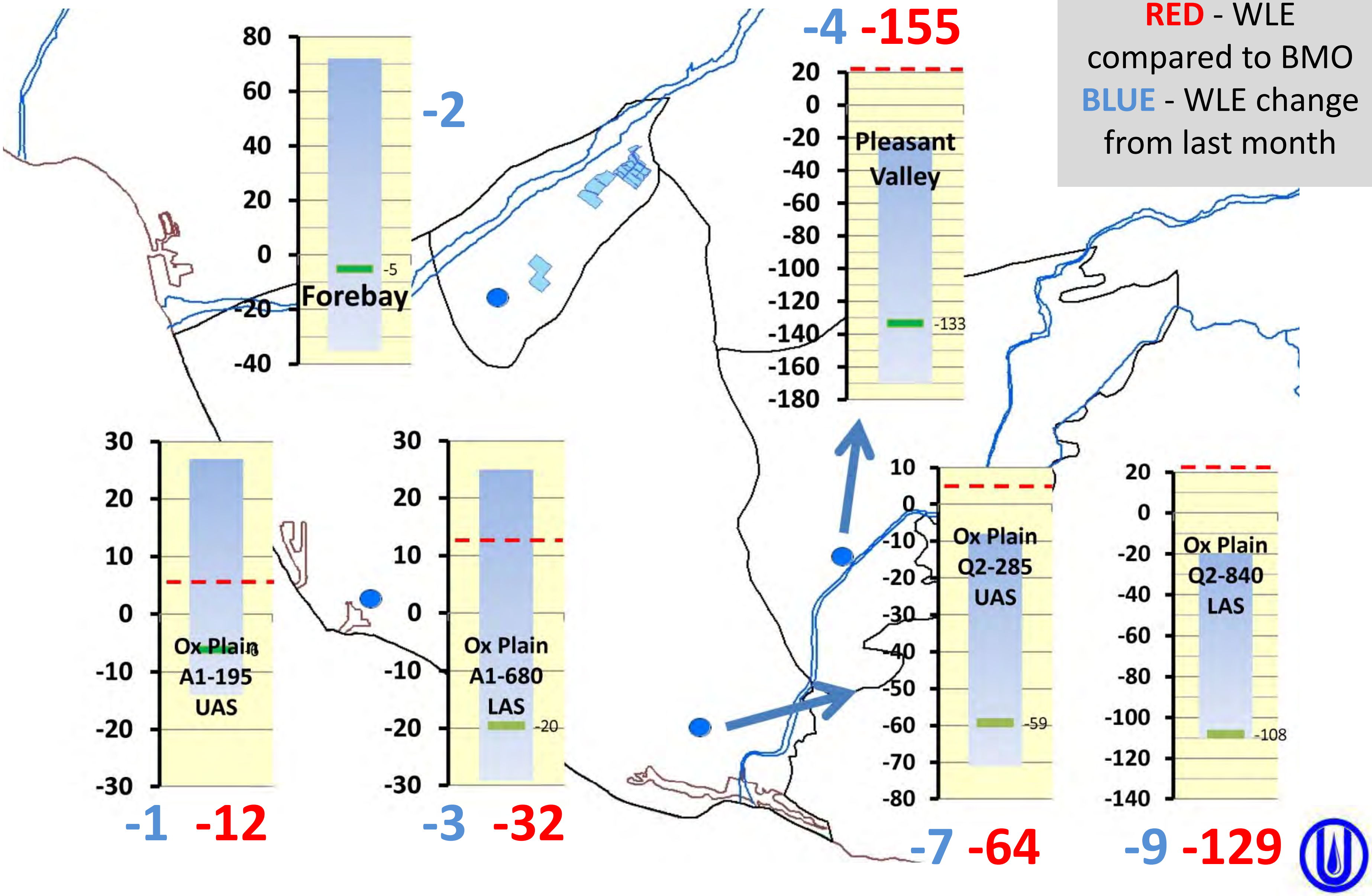
United Water Conservation District



BLUE – WLE change from last month

United Water Conservation District

RED - WLE compared to BMO
BLUE - WLE change from last month



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