Meredith Clement

Subject: FW: Questions for SMP Phase 2D

See below in red for the items Calleguas is responsible for…

Thanks.

Fernando

From: Meredith Clement [mailto:MeredithClement@KennedyJenks.com]
Sent: Wednesday, June 11, 2014 3:28 PM
To: Jim Henderson; Kristine McCaffrey
Cc: Michael Duckworth; Fernando Baez
Subject: RE: Questions for SMP Phase 2D

3. What is the estimate of irrigated acreage shares for Zone Mutual Water Company and Berylwood Heights Mutual Water Company.

    Berylwood Heights MWC:
    Total acreage with shares = ~1,300;
    2013 deliveries to ~614 acres

    Zone MWC:
    Total acreage with shares = ~5,700;
    2013 deliveries were to ~3,000 acres

12. Meredith to see if there is any documentation showing how more water needed by ag when water quality is poor, how less water needed when water quality good (argument is that less water needed to flush salts when less salts to start with).

--Meredith

From: Jim Henderson [mailto:JHenderson@stratusconsulting.com]
Sent: Wednesday, June 11, 2014 4:19 AM
To: Meredith Clement; Kristine McCaffrey
Cc: Michael Duckworth
Subject: Questions for SMP Phase 2D

Hi Meredith and Kristine,

Attached are our questions for SMP Phase 2D. We look forward to talking with you later today.

Thanks,
Jim

Jim Henderson
Managing Economist
____

STRATUS CONSULTING
1881 Ninth Street, Suite 201
Boulder, Colorado 80302

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main 303.381.8000
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RESOLUTION NO. 1816

A RESOLUTION OF THE BOARD OF DIRECTORS
OF CALLEGUAS MUNICIPAL WATER DISTRICT
CALLING FOR ENHANCED WATER USE EFFICIENCY
EFFORTS TO CONSERVE AND EXTEND
REGIONAL WATER RESERVES

WHEREAS, Calleguas Municipal Water District (Calleguas) is responsible for providing a reliable supply of high quality, supplemental water to the communities of southern Ventura County, for which this supply comprises 70% of Calleguas purveyors' combined water demand; and

WHEREAS, Calleguas is entirely reliant upon deliveries of water imported by the Metropolitan Water District of Southern California from the California State Water Project (SWP); and

WHEREAS, the State of California experienced its driest year on record in 2013, is now in its third consecutive year of drought, and in each year of the current drought, annual precipitation levels were inadequate to fill the state's key reservoirs, and

WHEREAS, on November 20, 2013, the California Department of Water Resources (DWR) announced an initial allocation of 5 percent of requested deliveries to SWP contractors in calendar year 2014 -- a historic low; and

WHEREAS, the National Weather Service's most recent *Three-Month Outlook* for California forecasts above normal temperatures and below normal precipitation throughout the entire state; and

WHEREAS, on January 17, 2014, California Governor Edmund G. Brown, Jr. officially proclaimed a State of Emergency to exist due to drought conditions and has called on Californians to reduce their water usage and directed state officials to take all necessary actions to alleviate drought impacts throughout the state; and

WHEREAS, on January 31, 2014, upon determining that the northern Sierra snowpack was 6 percent of average, the lowest level since record-keeping began in 1960, DWR announced a reduction in the SWP annual allocation from five percent to zero, an unprecedented action; and

WHEREAS, following the severe 1987-92 drought, southern California water agencies aggressively developed and implemented a variety of programs designed to buffer against the social and economic impacts of water shortages due to drought; and

WHEREAS, Over the past 20 years, southern California rate payers have invested more than $5 billion in regional storage, infrastructure improvements, and water conservation programs that are now serving to sustain supplies during this historic dry period; and

WHEREAS, Metropolitan has indicated that its water storage reserves dedicated to meeting regional drought demands remain relatively high at nearly 2.4 million acre feet and, as such, it does not intend to institute mandatory water delivery reductions within its service area in 2014, and

WHEREAS, nonetheless, the current extreme statewide drought condition serves to underscore the long-standing inadequacy of the existing Sacramento-San Joaquin Delta water conveyance system, which resulted in the loss of an estimated 900,000 acre feet to state and federal water contractors in 2013, as well as the need for additional storage facilities and enhanced conservation measures to maintain reliable supplies during prolonged water shortages.

NOW, THEREFORE, IT IS HEREBY RESOLVED that the Board of Directors of Calleguas Municipal Water District encourages water users within its service area to remain mindful of their water use and implement feasible water use efficiency measures in an effort to extend stored water supplies and minimize effects associated with a prolonged drought condition.

BE IT FURTHER RESOLVED that we urge Governor Brown, the Obama administration, members of congress, state legislators, and local elected officials and policymakers to support the Bay Delta Conservation Plan process and other state and regional initiatives necessary to improve water reliability for current and future Californians.

ADOPTED, SIGNED AND APPROVED this fifth day of February, 2014.

Scott H. Quady, President
Board of Directors

I HEREBY CERTIFY that the foregoing Resolution was adopted at a regular meeting of the Board of Directors of Calleguas Municipal Water District held on February 5, 2014.

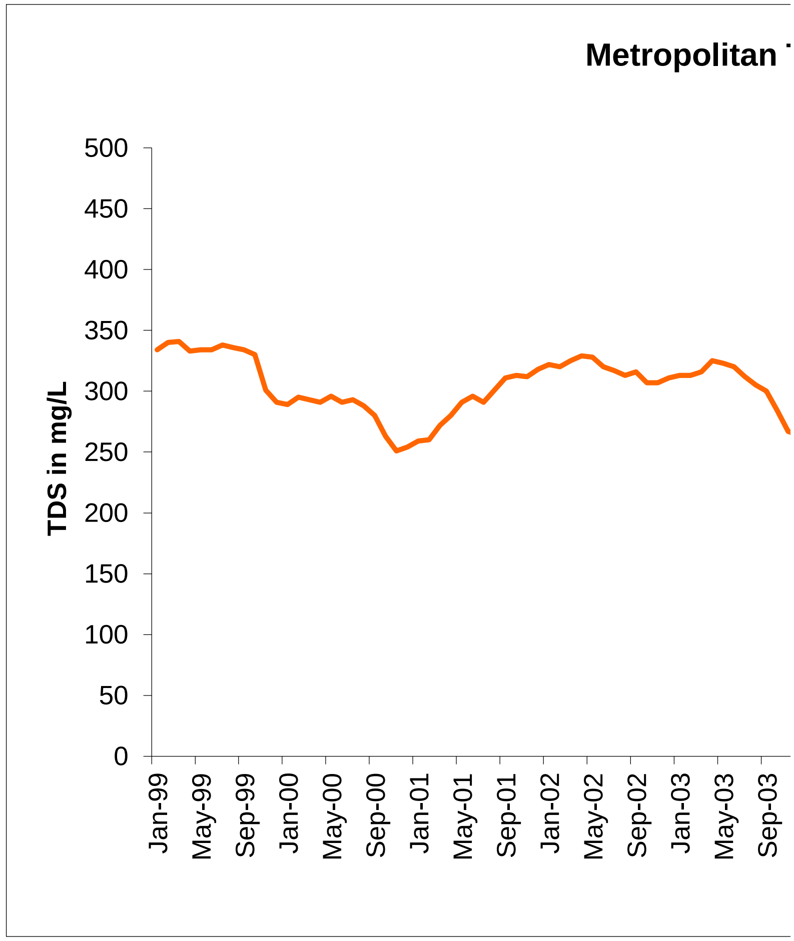
ATTEST:

Andy Waters, Secretary
Board of Directors

(SEAL)

Table D Results for TDS at Jensen Plant

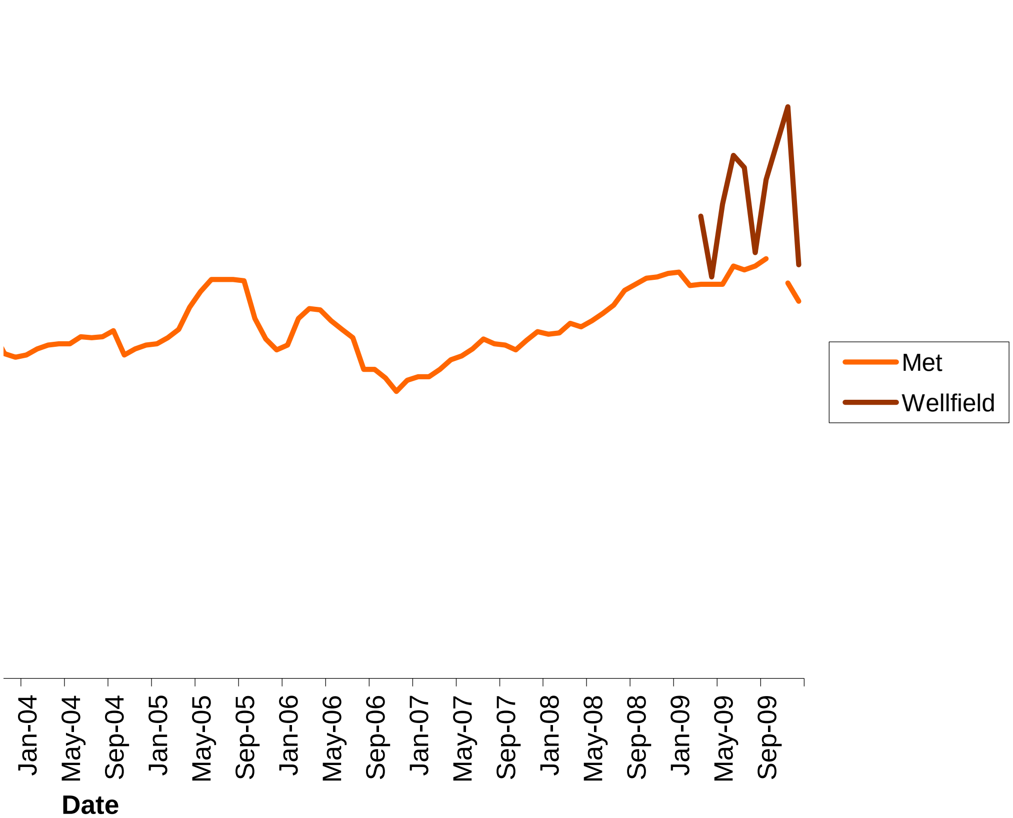
Date	Met	Wellfield
Jan-99	334	
Feb-99	340	
Mar-99	341	
Apr-99	333	
May-99	334	
Jun-99	334	
Jul-99	338	
Aug-99	336	
Sep-99	334	
Oct-99	330	
Nov-99	301	
Dec-99	291	
Jan-00	289	
Feb-00	295	
Mar-00	293	
Apr-00	291	
May-00	296	
Jun-00	291	
Jul-00	293	
Aug-00	288	
Sep-00	280	
Oct-00	263	
Nov-00	251	
Dec-00	254	
Jan-01	259	
Feb-01	260	
Mar-01	272	
Apr-01	280	
May-01	291	
Jun-01	296	
Jul-01	291	
Aug-01	301	
Sep-01	311	
Oct-01	313	
Nov-01	312	
Dec-01	318	
Jan-02	322	
Feb-02	320	
Mar-02	325	
Apr-02	329	
May-02	328	
Jun-02	320	
Jul-02	317	
Aug-02	313	
Sep-02	316	
Oct-02	307	
Nov-02	307	
Dec-02	311	
Jan-03	313	



Feb-03	313
Mar-03	316
Apr-03	325
May-03	323
Jun-03	320
Jul-03	312
Aug-03	305
Sep-03	300
Oct-03	284
Nov-03	267
Dec-03	264
Jan-04	266
Feb-04	271
Mar-04	274
Apr-04	275
May-04	275
Jun-04	281
Jul-04	280
Aug-04	281
Sep-04	286
Oct-04	266
Nov-04	271
Dec-04	274
Jan-05	275
Feb-05	280
Mar-05	287
Apr-05	305
May-05	318
Jun-05	328
Jul-05	328
Aug-05	328
Sep-05	327
Oct-05	296
Nov-05	279
Dec-05	270
Jan-06	274
Feb-06	296
Mar-06	304
Apr-06	303
May-06	294
Jun-06	287
Jul-06	280
Aug-06	254
Sep-06	254
Oct-06	247
Nov-06	236
Dec-06	245
Jan-07	248
Feb-07	248
Mar-07	254
Apr-07	262
May-07	265

Jun-07	271	
Jul-07	279	
Aug-07	275	
Sep-07	274	
Oct-07	270	
Nov-07	278	
Dec-07	285	
Jan-08	283	
Feb-08	284	
Mar-08	292	
Apr-08	289	
May-08	294	
Jun-08	300	
Jul-08	307	
Aug-08	319	
Sep-08	324	
Oct-08	329	
Nov-08	330	
Dec-08	333	
Jan-09	334	
Feb-09	323	
Mar-09	324	380
Apr-09	324	330
May-09	324	390
Jun-09	339	430
Jul-09	336	420
Aug-09	339	350
Sep-09	345	410
Oct-09		440
Nov-09	325	470
Dec-09	310	340

TDS Values Listed in Table D



RESOLUTION NO. 1845

A RESOLUTION OF THE BOARD OF DIRECTORS
OF CALLEGUAS MUNICIPAL WATER DISTRICT
APPEALING FOR IMPLEMENTATION OF EXTRAORDINARY
CONSERVATION EFFORTS AND A MINIMUM 20 PERCENT
REDUCTION IN WATER USE WITHIN ITS SERVICE AREA IN
CONSIDERATION OF HISTORIC DROUGHT CONDITIONS

WHEREAS, Calleguas Municipal Water District (Calleguas) is responsible for providing a reliable supply of high quality, supplemental water to the communities of southern Ventura County, for which this supply comprises three-quarters of Calleguas purveyors' combined water demand; and

WHEREAS, Calleguas is entirely reliant upon deliveries of water imported by the Metropolitan Water District of Southern California (Metropolitan) primarily from the California State Water Project (SWP); and

WHEREAS, the State of California is in its third consecutive year of unprecedented drought with state temperatures five degrees above average from January through May of 2014, as documented by the National Climatic Data Center; and

WHEREAS, on January 17, 2014, California Governor Edmund G. Brown, Jr. officially proclaimed a State of Emergency to exist due to drought conditions and called on Californians to reduce their water usage and directed state officials to take all necessary actions to alleviate drought impacts throughout the state; and

WHEREAS, the State Water Project allocation remains at 5 percent of requested deliveries for calendar year 2014 -- a historic low; and

WHEREAS, the National Weather Service's most recent *Three-Month Outlook* for California for the remainder of the 2014 water year forecasts above normal temperatures throughout the entire state; and

WHEREAS, on February 11, 2014, the Metropolitan Water District of Southern California declared a Water Supply Alert calling for cities, counties, member agencies and retail water agencies to implement extraordinary conservation through drought ordinances and other measures to mitigate use of storage reserves; and

WHEREAS, following an exceptionally dry and warm winter season, on April 25, 2014, Governor Brown issued a second Executive Order asking Californians to redouble their efforts to conserve water, calling on "every city, every community, every Californian to conserve water in every way possible", and directing the State Water Resources Control Board to adopt and implement emergency regulations, as necessary, to prevent the waste and unreasonable use of water and to promote water recycling or water conservation; and

WHEREAS, although prior regional investments in water storage, infrastructure improvements, and efficiency programs will serve to sustain adequate supplies for the Calleguas service area during the remainder of 2014, in the event dry conditions persist in the coming year and conservation measures are not taken immediately by southland water users that result in substantial water savings, dwindling water reserves will not likely meet regional demands, thereby triggering potentially severe, mandatory delivery cutbacks in 2015; and

WHEREAS, the current extreme statewide drought condition serves to underscore the long-standing inadequacy of the existing Sacramento-San Joaquin Delta water conveyance system, which resulted in the loss of an estimated 900,000 acre feet to state and federal water contractors in 2013, as well as the need for additional storage facilities and enhanced conservation measures to maintain reliable supplies during prolonged water shortages.

NOW, THEREFORE, IT IS HEREBY RESOLVED that the Board of Directors of Calleguas Municipal Water District, under its adopted water shortage contingency plan, declares that a Stage 3 Shortage exists and urges area water users to 1) implement extraordinary water conservation measures in an effort to reduce water consumption by a minimum of 20 percent and extend available water reserves and 2) vigorously explore and participate in the numerous water saving tips and rebate programs offered through www.bewatewise.com; and

BE IT FURTHER RESOLVED that Calleguas encourages its area retail water purveyors to fully implement their respective drought response plans and conservation ordinances in light of Governor Brown's April 25, 2014 Executive Order and the rapidly dwindling SWP storage supplies; and

BE IT FURTHER RESOLVED that Calleguas remains steadfast in its support of the Bay Delta Conservation Plan (BDCP) and regional initiatives necessary to improve water reliability for current and future Californians and, as such, implores Governor Brown, the Obama administration, members of congress, state legislators, and local elected officials and policymakers to actively support these efforts.

ADOPTED, SIGNED AND APPROVED this second day of July, 2014.

Scott H. Quady, President
Board of Directors

I HEREBY CERTIFY that the foregoing Resolution was adopted at a meeting of the Board of Directors of Calleguas Municipal Water District held on July 2, 2014.

ATTEST:

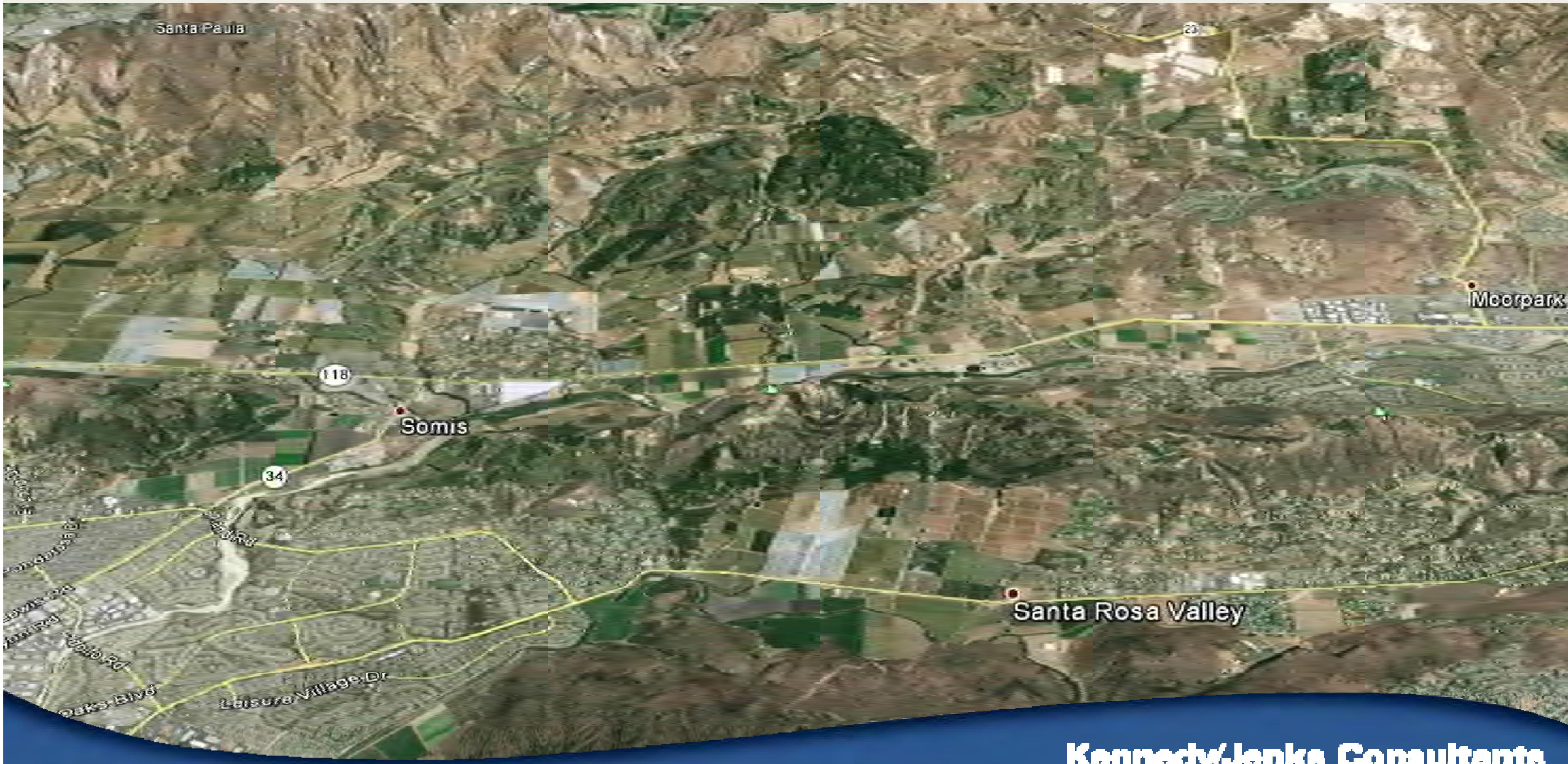
Andres Santamaria

Andres Santamaria, Secretary
Board of Directors

(SEAL)

Las Posas Basin Conjunctive Use Study
Phase 2

Las Posas Users Group – Workshop No. 3



Kennedy/Jenks Consultants

June 26, 2014

Agenda

- **Introductions**
- **Study Update**
- **Objectives for Workshop 3**
- **Alternatives Review**
  - Concept Diagrams & Layout Maps
  - Cost Criteria
  - Other Criteria
  - Summary Comparison
  - Preferred Alternative
- **Next Steps**
  - Workshop Minutes
  - Prepare Report

Study Scope

- ✓ Define Irrigation Demands (Workshop No. 1)
- ✓ Develop Potential Alternatives (Workshop No. 2)
- Evaluate Alternatives (Workshop No. 3)
- Prepare Report

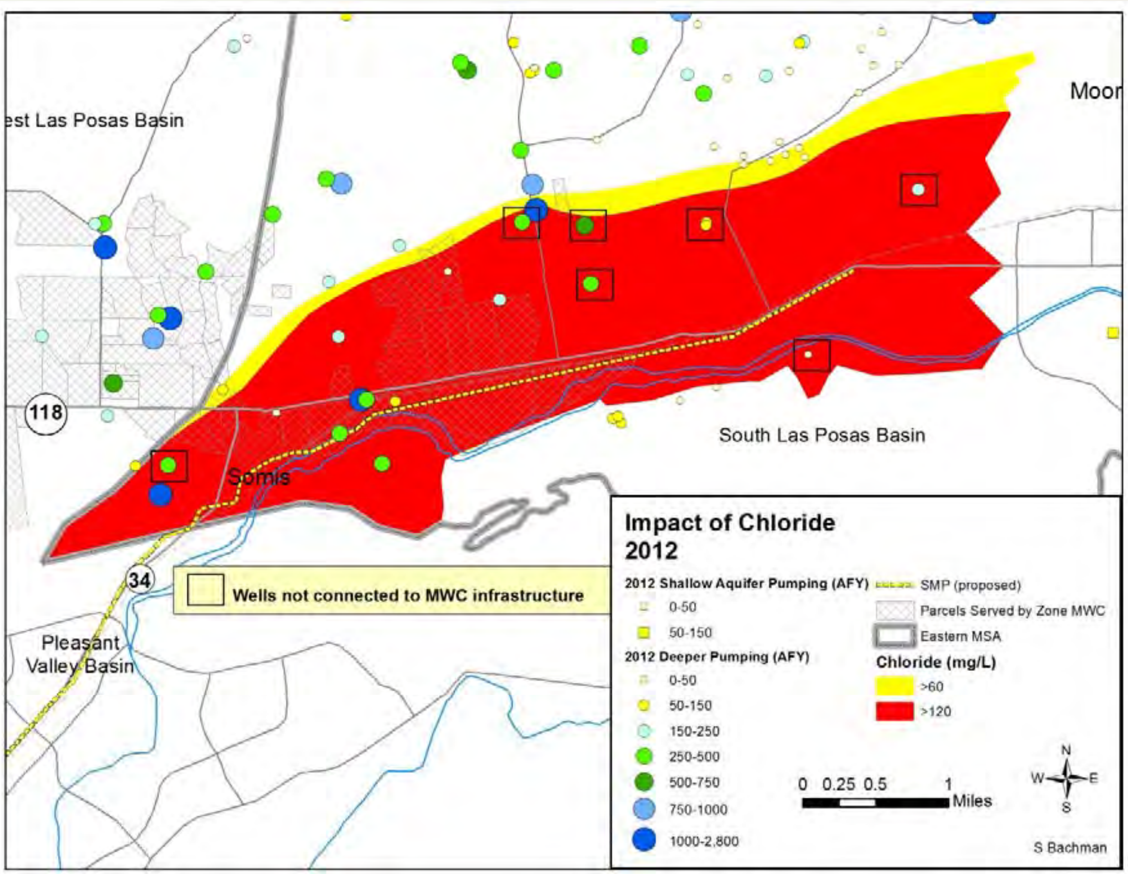
Objectives for Workshop No. 3

- **Review Concepts, Sizes & Layouts for Alternatives at 120 mg/l Chlorides**
  - Concepts are similar for 120 mg/l and 60 mg/l chlorides
  - Layouts are similar for 120 mg/l and 60 mg/l chlorides
  - Sizes are different for 120 mg/l and 60 mg/l chlorides
- **Review Costs and Other Criteria**
  - Compare Costs for 120 mg/l chlorides for 3 Alternatives
  - Compare Total Costs for 60 mg/l versus 120 mg/l chlorides
- **Identify Preferred Alternative(s)**

Recap Key Points from Workshop 2

- **Use Near-Term Impacted Wells as basis for Planning-Level Desalter Sizing (2012 – 2024)**
  - Review Berylwood MWC Wells for impacts in near-term (3 Wells > 120 mg/l)
  - Review Las Posas Orchards MWC wells for near-term impacts (None Impacted)
  - Review Private Wells – MWC Shareholders
    - ✓ Zone MWC – 3 Private Wells
    - ✓ Berylwood MWC – 1 Private Well
- **Use VCWWD #19 Impacted Deliveries (vs Well #4)**
- **Average Run Times for impacted wells**
  - Assume 31% based on AFY Production and Well Capacities
- **Opportunities to Refine Desalter Facility Size and Operations**
  - Modify pumping patterns to increase run time for impacted wells
  - Consider reducing capacity needed for peaking

Current Conditions – Areas Impacted by High Chlorides (2012 & Near-Term)



Impacted Wells > 120 mg/l

- Zone MWC – 4 Wells
- Berylwood MWC – 3 wells
- Arroyo Las Posas – 1 Well
- VCWWD #19 – 1 Well
- Private Well Owners (MWC Shareholders) – 4 Wells
- Other Private Wells – 6 Wells

Impacted Wells 60 mg/l ≤ 120 mg/l

- Zone MWC – 1 Well

Kennedy/Jenks Consultants

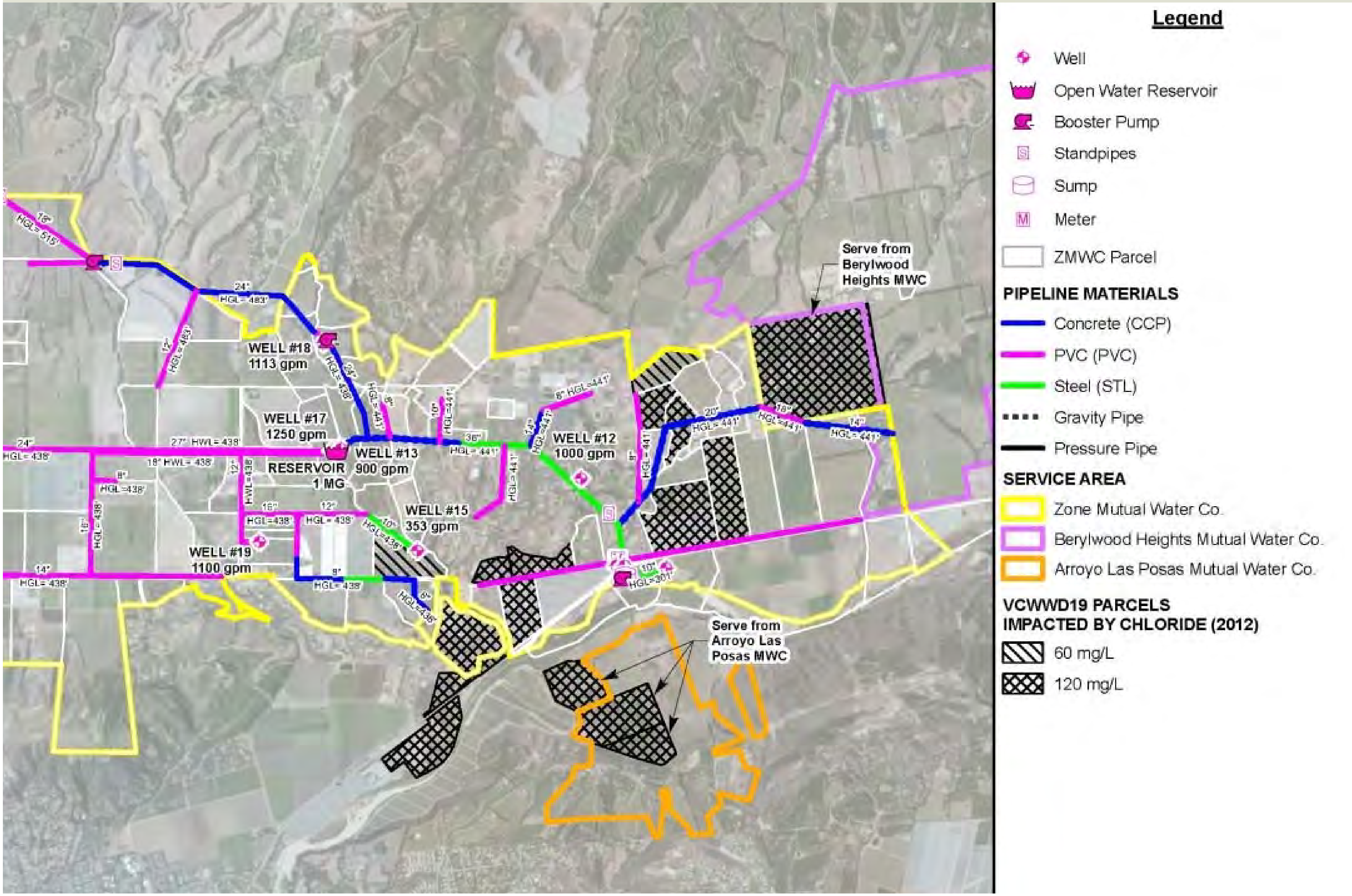
Chloride Impacted Wells & VCWWD #19 Deliveries > 120 mg/l (2012 & Near-Term)

	No. of Wells	Well No.	Capacity (gpm)	Annual Production AFY (2012)	Chloride Conc mg/l (2012)	Avg Run Time %
Mutual Water Company Wells and VCWWD #19 Impacted Deliveries ≥ 120 mg/l						
System						
Zone MWC		#10	856	56	179	4%
		#12	1000	216	160	13%
		#14	500	311	181	39%
		#20	1850	1167	220	39%
Berylwood MWC		#2	700	6	183	1%
		#3	1000	393	183	24%
		#4	1000	802	183	50%
Arroyo Las Posas MWC		#1	800	280	183	22%
VCWWD #19 Deliveries			400	609	183	54%
Combined Total	8		8106	3840		27%
Private or Non-MWC Wells ≥ 120 mg/l						
Private Well/MWC Shareholders	4		~ 1800	870		
Other Private Wells	7		~ 9300	4500		
Mutual Water Company Wells ≤ 120 mg/l and ≥ 60 mg/l						
Zone MWC	1	#15	350	130	74	23%

Some Key Desalter Sizing Assumptions

- Treat/blend wells with near-term Impacts > 120 mg/l chloride
- Provide blended water for VCWWD #19 deliveries > 120 mg/l chloride
- Wheel blended water for VCWWD #19 deliveries through other MWC systems
- Zone MWC Well #15 and VCWWD 19 Well #4 are not included
- Provide wells may be added in future studies

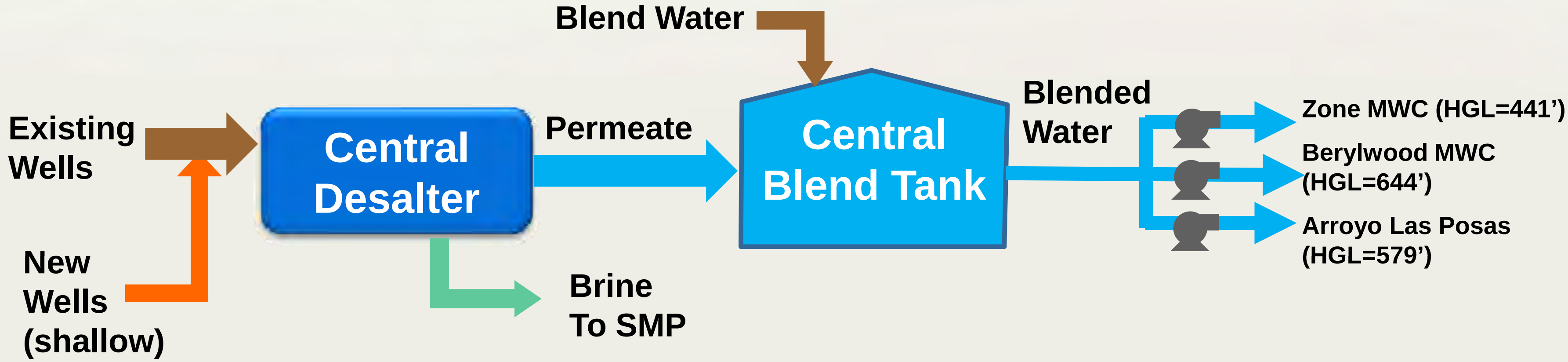
VCWWD #19 Impacted Deliveries (2012)



3 Treatment/Blending System Alternatives

- Alternative 1 – Centralized Treatment and Blending
- Alternative 2 – Centralized Treatment and Local Blending
- Alternative 3 – Multiple Treatment/Blending Facilities

Alternative 1 – Centralized Treatment and Blending (120 mg/l)



Locate at Zone MWC Existing Well #20 Site

1. Treat /Blend Existing wells:

- ✓ Zone MWC Wells #20, #14
- ✓ Berylwood Heights Wells #2, #3, #4
- ✓ Arroyo Las Posas Well

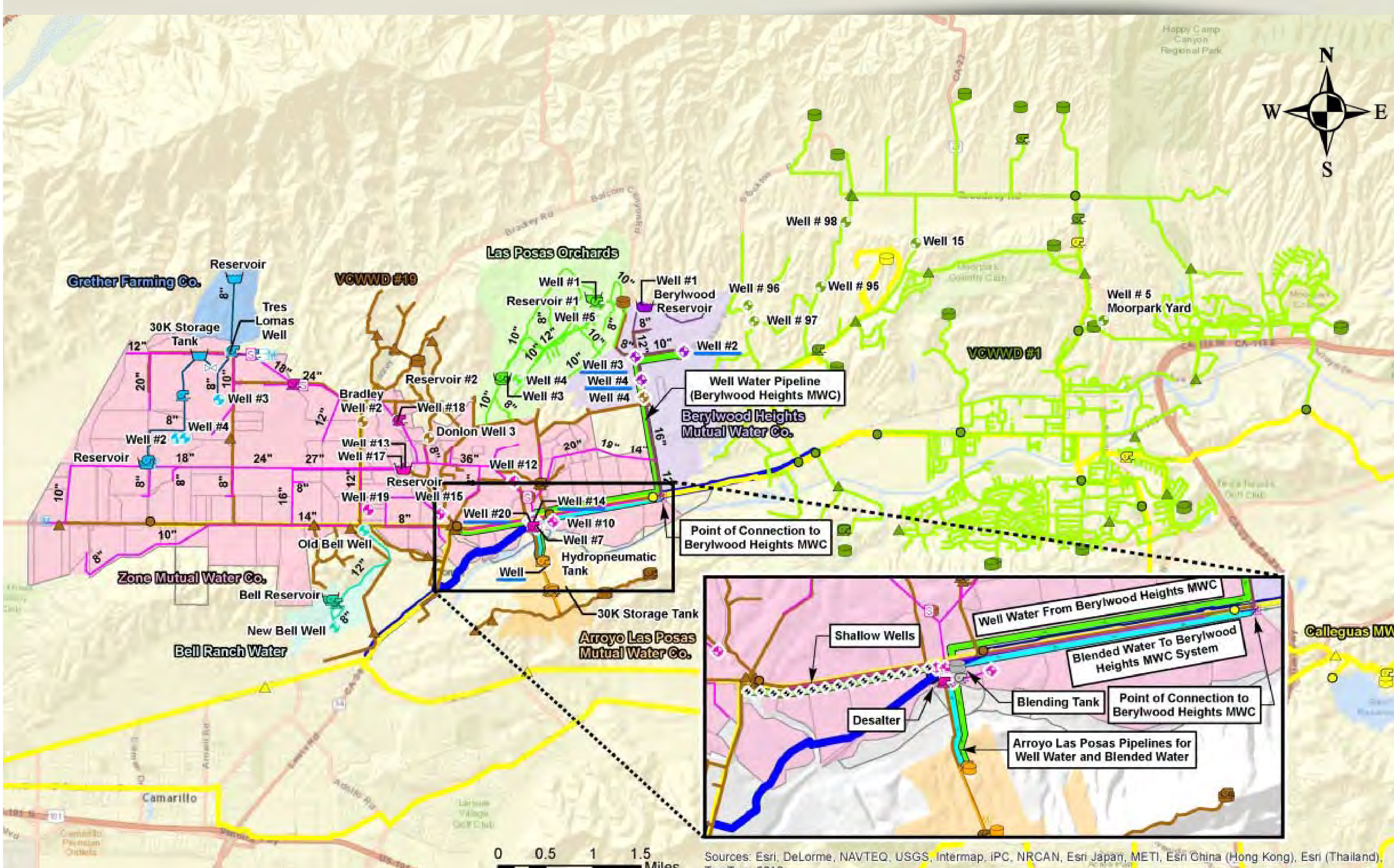
2. Add New Shallow Wells:

- ✓ Zone MWC Wells #10, #12 (9 wells)
- ✓ VCWWD 19 Impacted Demands (2 wells)
- ✓ Brine Make-up (4 wells)

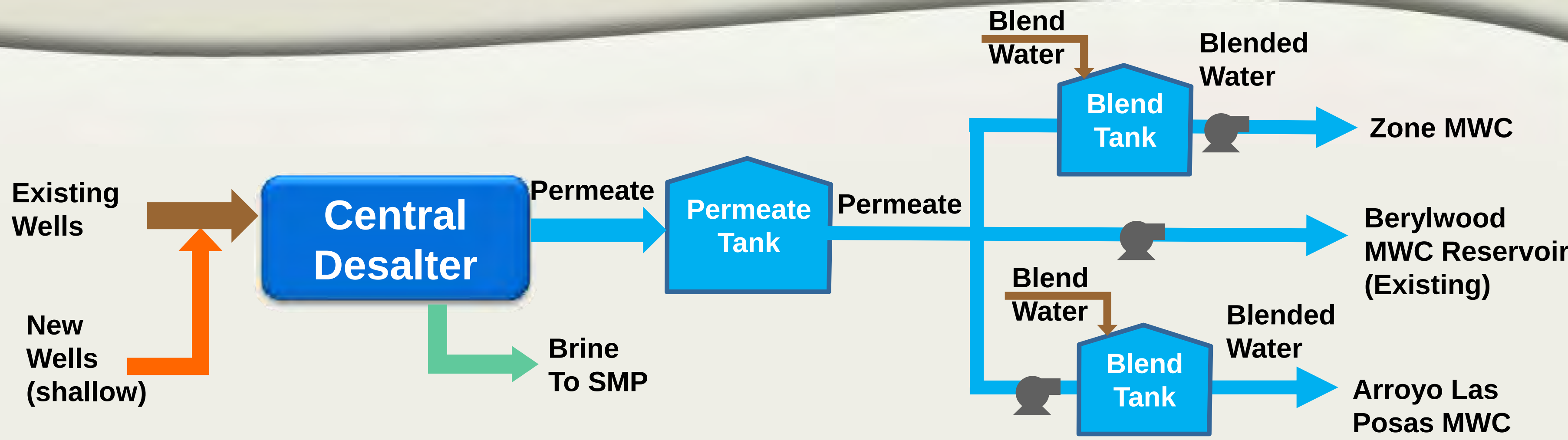
3. Construct Conveyance Systems

- ✓ Raw water pipelines
- ✓ Treated water pipelines
- ✓ Route Treated water for VCWWD 19 customers through Zone MWC, Berylwood Heights MWC and Arroyo Las Posas MWC Systems

Alternative 1 – System Concept Map



Alternative 2 – Centralized Treatment and Local Blending (120 mg/l)



Locate at Zone MWC Existing Well #20 Site

Local Blend Tanks at Each System

1. Treat existing wells:

- ✓ Zone MWC Well #20
- ✓ Berylwood Heights MWC Well #4

2. Add New Shallow Wells:

- ✓ VCWWD 19 Impacted Demands (2 wells)
- ✓ Arroyo Las Posas MWC Well (1 well)
- ✓ Brine Make-up (3 wells)

3. Construct Conveyance and Blending Tanks:

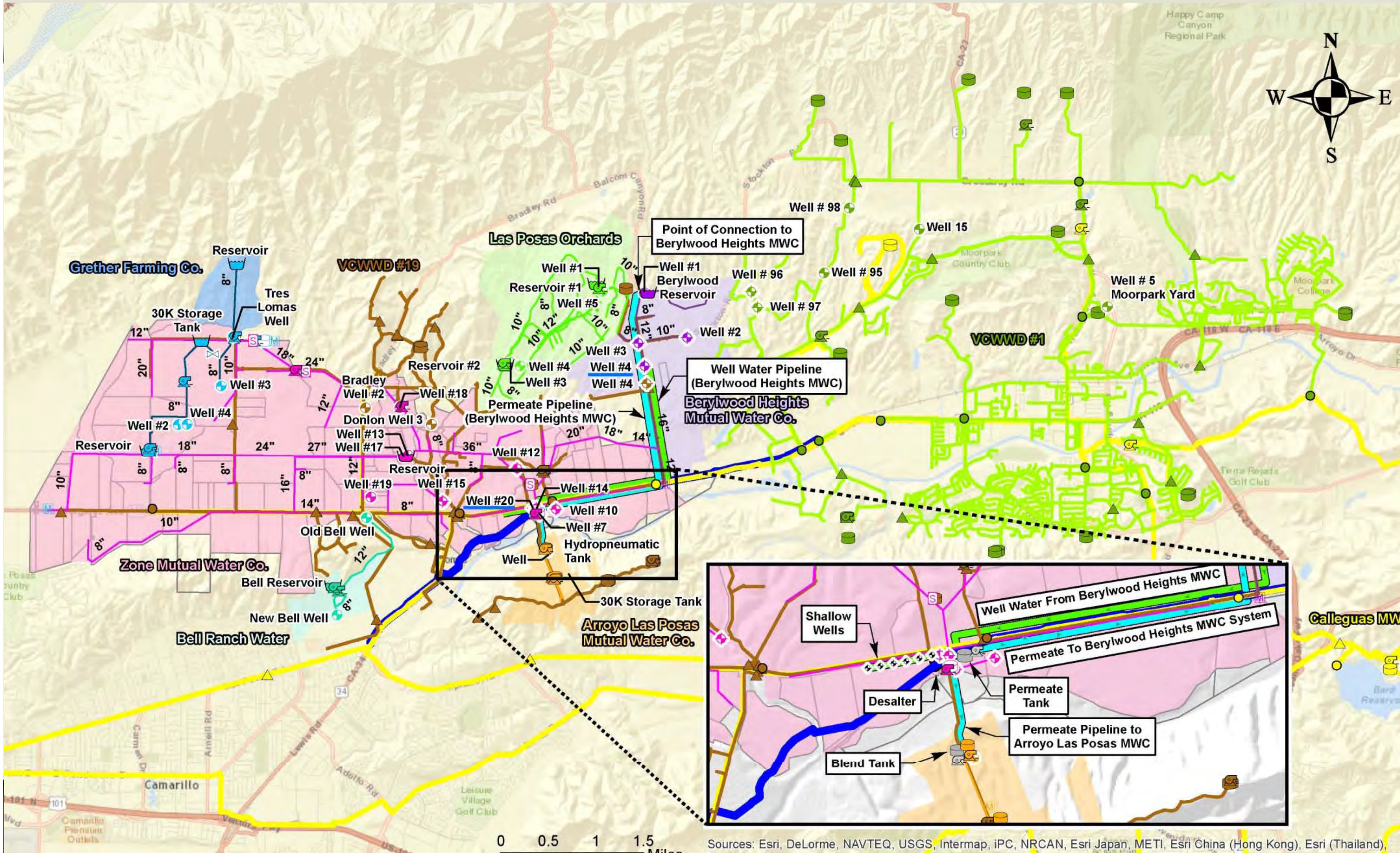
a) Raw water pipelines to central facility

b) Permeate water pipelines and blend tanks:

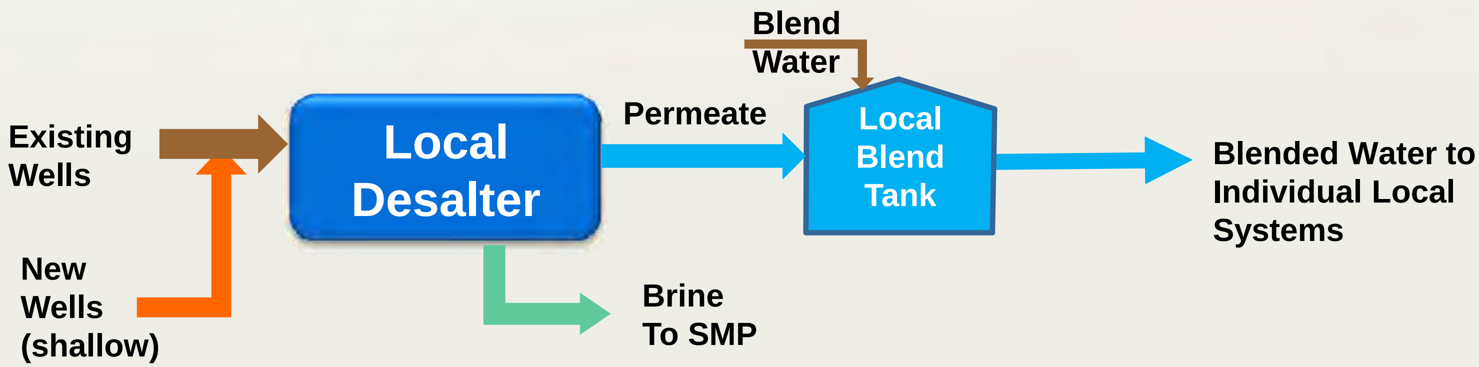
- New Blend Tank at Central Facility for Zone MWC
- New Blend Tank at Arroyo Las Posas MWC (near existing well)
- Use Existing Berylwood Heights MWC Reservoir for blending

c) Route Treated water for VCWWD 19 customers through Zone MWC, Berylwood Heights MWC and Arroyo Las Posas MWC Systems

Alternative 2 – System Concept Map



Alternative 3 – Multiple Treatment/Blending Facilities (120 mg/l)

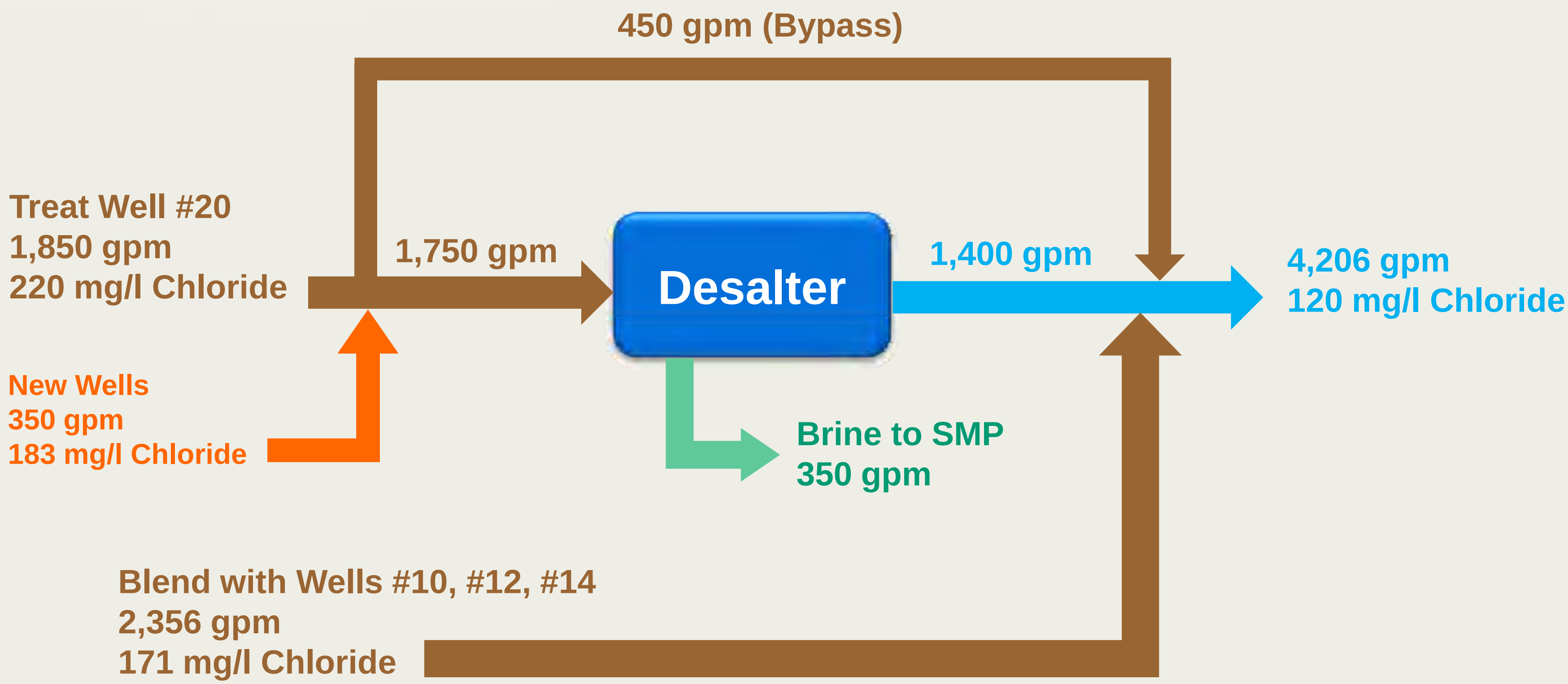


1. **Construct Local Desalters and Treat/Blend Existing Wells**:
    a) Zone MWC Well #20
    b) Berylwood MWC Well #4
    c) Arroyo Las Posas MWC Well
2. **Add New Shallow Wells to makeup for brine loss (4 wells)**
3. **Construct Brine Lines from each facility to SMP**
4. **Route Treated water for VCWWD 19 customers through Zone MWC, Berylwood Heights MWC and Arroyo Las Posas MWC Systems**

Alternative 3 - Desalter Concept for Zone MWC (120 mg/l)

Zone Mutual Water District (WQO ≤ 120 mg/l)

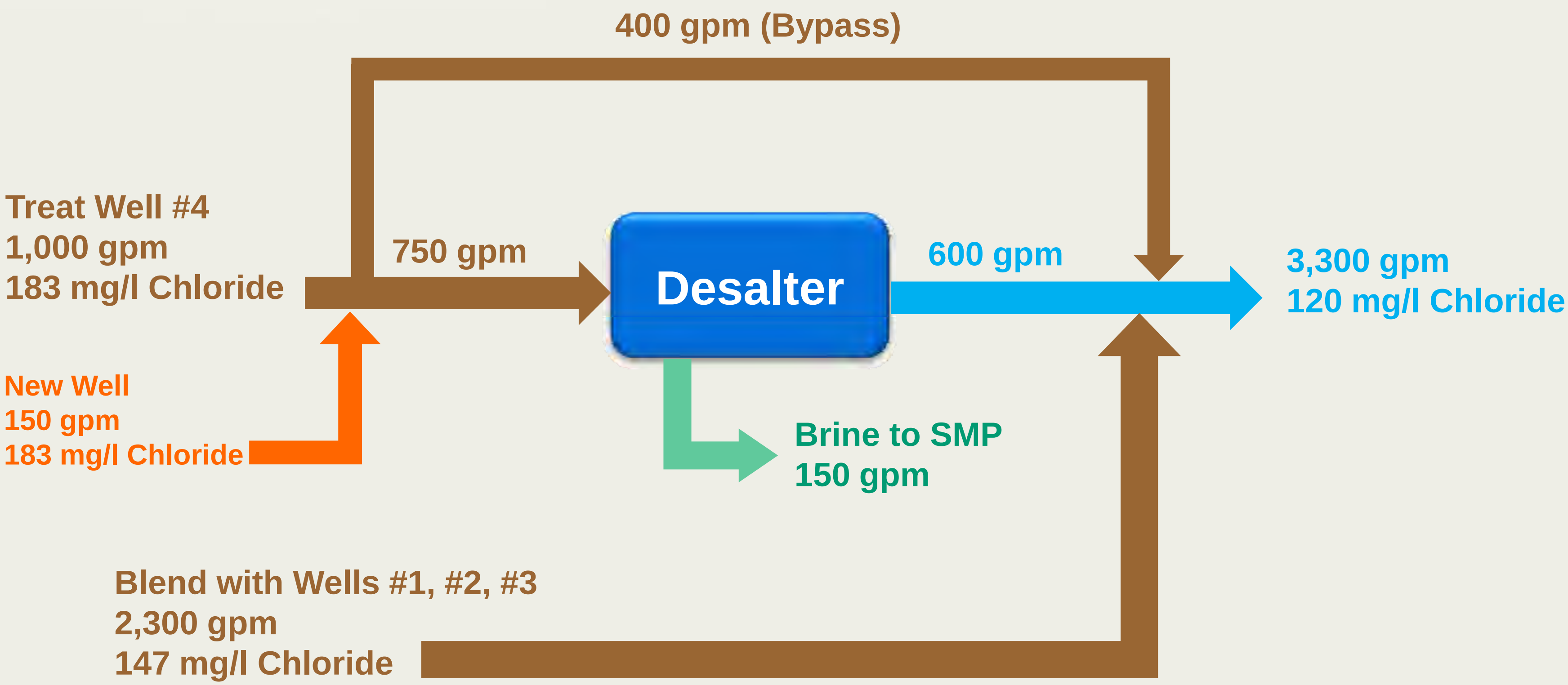
- Add New Wells to Maintain Pumping Capacity



Alternative 3 - Desalter Concept for Berylwood MWC (120 mg/l)

Berylwood Mutual Water District (WQO ≤ 120 mg/l)

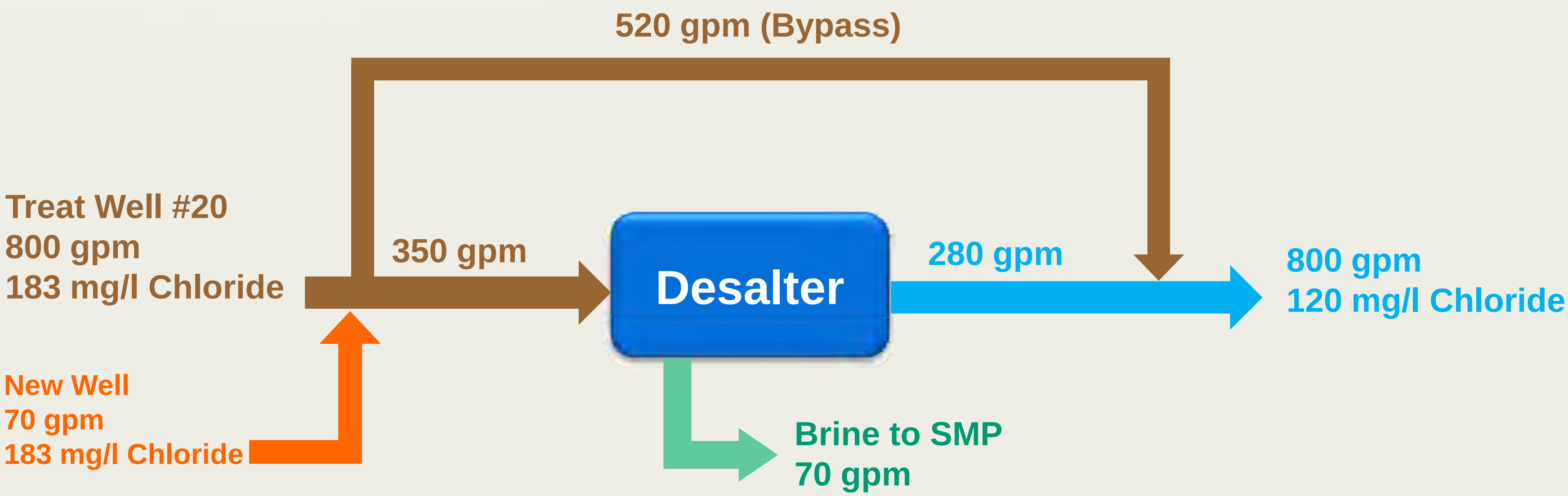
- Add New Wells to Maintain Pumping Capacity



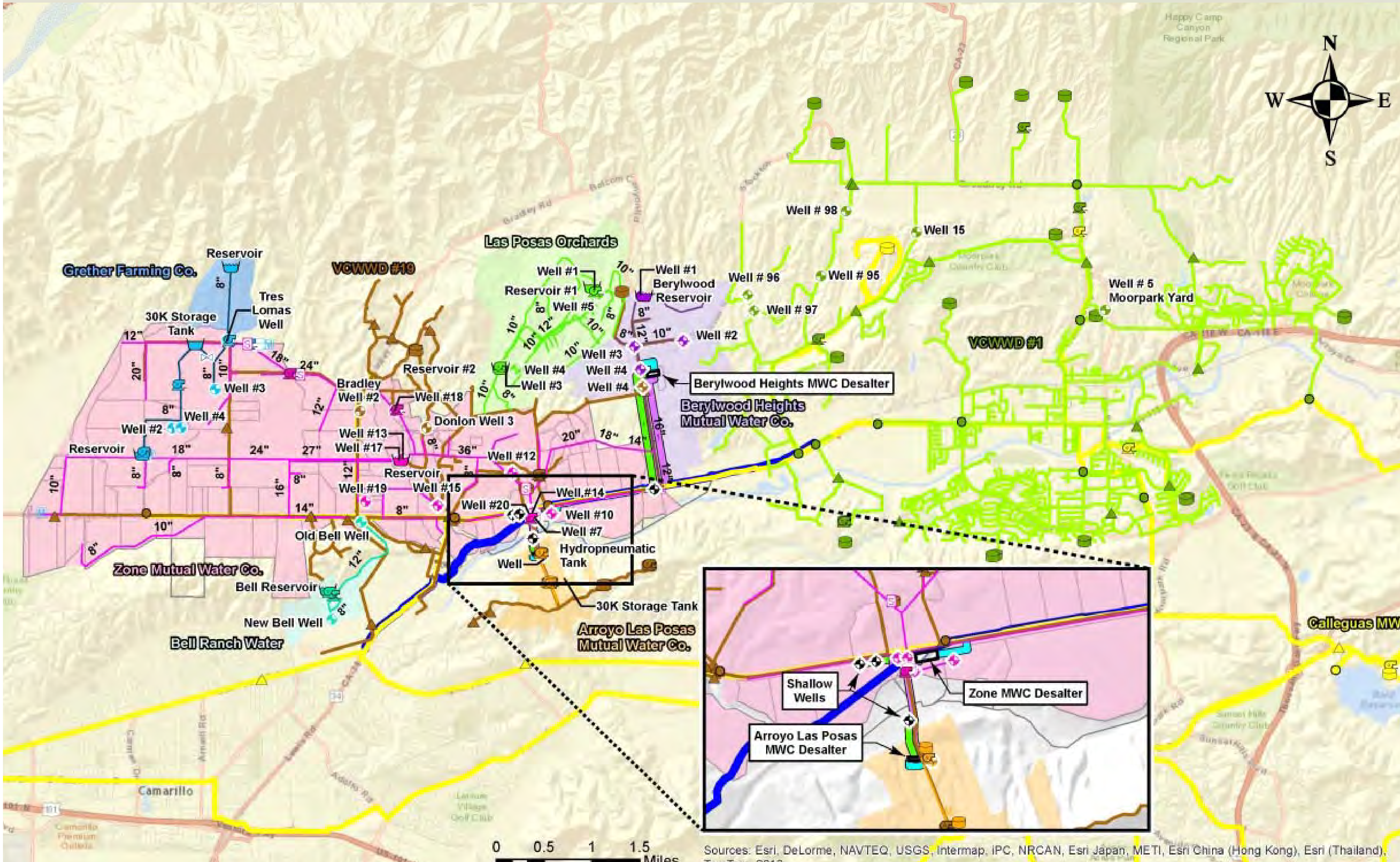
Alternative 3 - Desalter Concept for Arroyo Las Posas MWC (120 mg/l)

Arroyo Las Posas Mutual Water District (WQO ≤ 120 mg/l)

- Add New Wells to Maintain Pumping Capacity



Alternative 3- Location Map for Three Desalters



Desalter Sizes for 120 mg/l Chlorides

Water Quality Objective ≤ 120 mg/l Chloride

Alternative	No. of Supply Wells Impacted	Total Flow from Existing (or New) Wells at Capacity (gpm)	Wells Treated	Flow from Existing (or New) Wells Diverted to Desalter (gpm)	Flow from New Wells (for Brine Loss) (gpm)	Desalter Flows: Feed (gpm)	Desalter Flows: Permeate (gpm)
Alternative 1		8106		3000	750	3750	3000
Zone	4	4206	Wells 14, 20 & New Shallow Supply Wells***	1650	413	2063	1650
Berylwood	3	2700	Wells 2, 3, 4	930	233	1163	930
Arroyo Las Posas	1	800	Well 1	280	70	350	280
VCWWD 19*		400	New Shallow Supply Wells	140	35	175	140
Alternative 2		8106		2420	605	3025	2420
Zone	4	4206	Well 20	1400	350	1750	1400
Berylwood**	3	2700	Well 4	600	150	750	600
Arroyo Las Posas	1	800	New Shallow Wells for permeate	280	70	350	280
VCWWD 19*	2	400	New Shallow Supply Wells	140	35	175	140
Alternative 3		8106		2420	605	3025	2420
Zone	4	4206	Well 20	1400	350	1750	1400
Berylwood**	3	2700	Well 4	600	150	750	600
Arroyo Las Posas	1	800	Well 1	280	70	350	280
VCWWD 19*	2	400	New Shallow Supply Wells	140	35	175	140

* Capacity to be incorporated into each local desalter based on parcel demands

** Berylwood Well No. 1 is used for blending in Alternatives 2 and 3

*** New Shallow Wells to Replace Wells 10 and 12

Desalter Sizes for 60 mg/l Chlorides

Water Quality Objective = 60 mg/l

Alternative	No. of Supply Wells Impacted	Total Flow from Existing Wells at Capacity (gpm)	Wells Treated	Flow from Existing Wells Diverted to Desalter (gpm)	Flow from New Wells (for Brine Loss) (gpm)	Desalter Flows: Feed (gpm)	Desalter Flows: Permeate (gpm)
Alternative 1		8106		5515	1379	6894	5515
Zone	4	4206	Wells 14, 20 & New Shallow Supply Wells	2885	721	3606	2885
Berylwood	3	2700	Wells 2, 3, 4	1820	455	2275	1820
Arroyo Las Posas	1	800	Well 1	540	135	675	540
VCWWD 19*	2	400	New Shallow Supply Wells	270	68	338	270
Alternative 2		8106		5185	1296	6481	5185
Zone	4	4206	Wells 10, 14, 20	2700	675	3375	2700
Berylwood**	3	2700	Wells 3, 4	1675	419	2094	1675
Arroyo Las Posas	1	800	New Shallow Wells for Permeate	540	135	675	540
VCWWD 19*	2	400	New Shallow Supply Wells	270	68	338	270
Alternative 3		8106		5185	1296	6481	5185
Zone	4	4206	Wells 10, 14, 20	2700	675	3375	2700
Berylwood**	3	2700	Wells 3, 4	1675	419	2094	1675
Arroyo Las Posas	1	800	Well 1	540	135	675	540
VCWWD 19*	2	400	New Shallow Supply Wells	270	68	338	270

* Capacity to be incorporated into each local desalter based on parcel demands

** Berylwood Well No. 1 is used for blending in Alternatives 2 and 3

*** New Shallow Wells to Replace Wells 10 and 12

Basis for Costs & Life Cycle Cost Assumptions

- **Basis for Costs**
  - Desalter Feasibility Studies for Treatment
    - ✓ Moorpark (Kennedy/Jenks for VCWWD#1, 2010)
    - ✓ Somis (Kennedy Jenks for Calleguas, 2010)
    - ✓ Zone MWC (SPI for Zone MWC, 2013)
  - Well and Conveyance Costs – Various Projects and Suppliers
- **Life Cycle Cost Assumptions**
    - ✓ 30 Year Life Cycle
    - ✓ 3.3% Inflation Rate
    - ✓ 3.9% Discount Rate

Major Cost Items and Assumptions

- Desalter Facility
  - ✓ Membrane Treatment and Infrastructure
  - ✓ Iron and Manganese Pretreatment
  - ✓ Chemicals and Clean in Place Systems
- New Shallow Wells
  - ✓ 200 gpm, 250-feet deep
  - ✓ Equipped with submersible pumps
- Pipelines
  - ✓ PVC
  - ✓ Jack & Bore major crossings
- Storage Tanks - Bolted Steel
- Booster Pumps
- Power Supply – SCE Service, $0.20/kwhr

Planning Level Capital Costs – Conveyance (120 mg/l)

System	Capital Costs (Million Dollars) - Conveyance		
	Alternative 1	Alternative 2	Alternative 3
Zone MWC	$4.2 M	$1.8 M	$ 1.2 M
Berylwood MWC	$7.1 M	$4.3 M	$1.5 M
Arroyo Las Posas MWC	$2.0 M	$1.0 M	$1.1 M
VCWWD 19	$0.6 M	$0.3 M	$0.2 M
Total	$13.9 M	$7.4 M	$4.0 M

Alt 1 Includes:

6.2 Miles of Pipe, 15 Shallow Wells

3 booster pump stations, 1 tank

Alt 2 Includes:

7.4 Miles of Pipe, 6 Shallow Wells

3 booster pump stations, 2 tanks

Alt 3 Includes:

3.1 Miles of Pipe, 4 Shallow Wells

3 booster pump stations, 3 tanks

Planning Level Capital Costs – Treatment (120 mg/l)

System	Capital Costs (Million Dollars) - Treatment		
	Alternative 1	Alternative 2	Alternative 3
Zone MWC	$14.6 M	$14.0 M	$16.0 M
Berylwood MWC	$ 9.3 M	$6.0 M	$8.8 M
Arroyo Las Posas MWC	$2.8 M	$2.8 M	$5.0 M
VCWWD 19	$1.4 M	$1.4 M	$1.8 M
Total	$28.1 M	$24.0 M	$31.6 M

Planning Level O&M Costs – Conveyance (120 mg/l)

System	O&M Costs (Thousands Dollars) - Conveyance		
	Alternative 1	Alternative 2	Alternative 3
Zone MWC	$198 K	$ 81 K	$ 56 K
Berylwood MWC	$304 K	$ 130 K	$ 51 K
Arroyo Las Posas MWC	$ 80 K	$ 35 K	$ 44 K
VCWWD 19	$ 25 K	$ 12 K	$ 9 K
Total	$607 K	$ 258 K	$ 160 K

Alt 1 Includes:

15 Shallow Wells, 3 Booster Pump Stations

Alt 2 Includes:

6 Shallow Wells, 3 Booster Pump Stations

Alt 3 Includes:

4 Shallow Wells, 3 Booster Pump Stations

Planning Level O&M Costs – Treatment (120 mg/l)

System	O&M Costs (Thousands Dollars) - Treatment		
	Alternative 1	Alternative 2	Alternative 3
Zone MWC	$899 K	$ 809 K	$ 809 K
Berylwood MWC	$577 K	$ 346 K	$ 346 K
Arroyo Las Posas MWC	$ 171 K	$ 162 K	$ 162 K
VCWWD 19	$ 86 K	$ 81 K	$ 81 K
Total	$1, 733 K	$ 1,398 K	$1,398 K

Summary of Planning Level Costs (120 mg/l)

	Total Costs - Treatment & Conveyance		
Cost Criteria	Alternative 1	Alternative 2	Alternative 3
Capital Cost, $ Millions	$42 M	$31.4 M	$ 35.5 M
Annual Operating Costs $ Millions	$2.3 M	$1.7 M	$1.6 M
Cost Per Acre-Feet	$881	$595	$605

Summary of Planning Level Costs (60 mg/l)

Cost Criteria	Total Costs - Treatment & Conveyance		
	Alternative 1	Alternative 2	Alternative 3
Capital Cost, $ Millions	$59.2 M	$53 M	$60.4 M
Annual Operating Costs, $ Millions	$3.8 M	$3.5 M	$3.3 M
Cost Per Acre-Feet	$1370	$1151	$1164

Other Study Criteria

- Ability to Study Goals and Objectives (Water Quality)
- Agricultural Acreage Served with Blended Water
- Volume of Water Generated (Shallow Aquifer)
- Volume of Water Transferred (VCWWD Customers)
- Operational Flexibility (Blending)

Compare Alternatives using Study Criteria

	Alternative 1	Alternative 2	Alternative 3
Water Quality Objectives	Meets WQO's for 60 to 120 mg/l		
Acres Served	~ 2500 acres - Provides blended water to service areas for Zone MWC (East Side), Berylwood MWC and Arroyo Las Posas MWC and portions of VCWWD 19		
Shallow Aquifer	990 AFY (15 wells)	790 AFY (6 wells)	650 AFY (4 wells)
Water Transferred (VCWWD 19)	350 AFY (670 acres)		
Operational Flexibility	Single Blend for product water	Can adjust blend in local MWC systems	Can adjust blend in local MWC systems
Capital Costs (120 mg/l)	$42 M	$31.4 M	$35.5 M
Annual O&M Costs (120 mg/l)	$2.3 M	$1.7 M	$1.6 M
Cost per AF (120 mg/l)	$881	$595	$605

Cost and Other Considerations

- Increase Operating Run Time
- Reduce Peak Capacity
- Reduce No. or Eliminate New Shallow Wells
- Iron and Manganese Pre-treatment
- Phased Construction

Summary of Capital Costs by Major Items (120 mg/l)

	Capital Costs (Million Dollars)		
Major Items	Alternative 1	Alternative 2	Alternative 3
Pipelines	$6.4 M	$4.3 M	$ 1.5 M
Shallow Wells	$6.5 M	$2.6 M	$1.7 M
Tanks and Pumps	$1.1 M	$0.5 M	$0.8 M
Desalter Facility	$28.0 M	$24.0 M	$31.5 M
Total	$42.0 M	$31.4 M	$35.5 M

Alt 1 Includes:

6.2 Miles of Pipe, 15 Shallow Wells

3 booster pump stations, 1 tank

Alt 2 Includes:

7.4 Miles of Pipe, 6 Shallow Wells

3 booster pump stations, 2 tanks

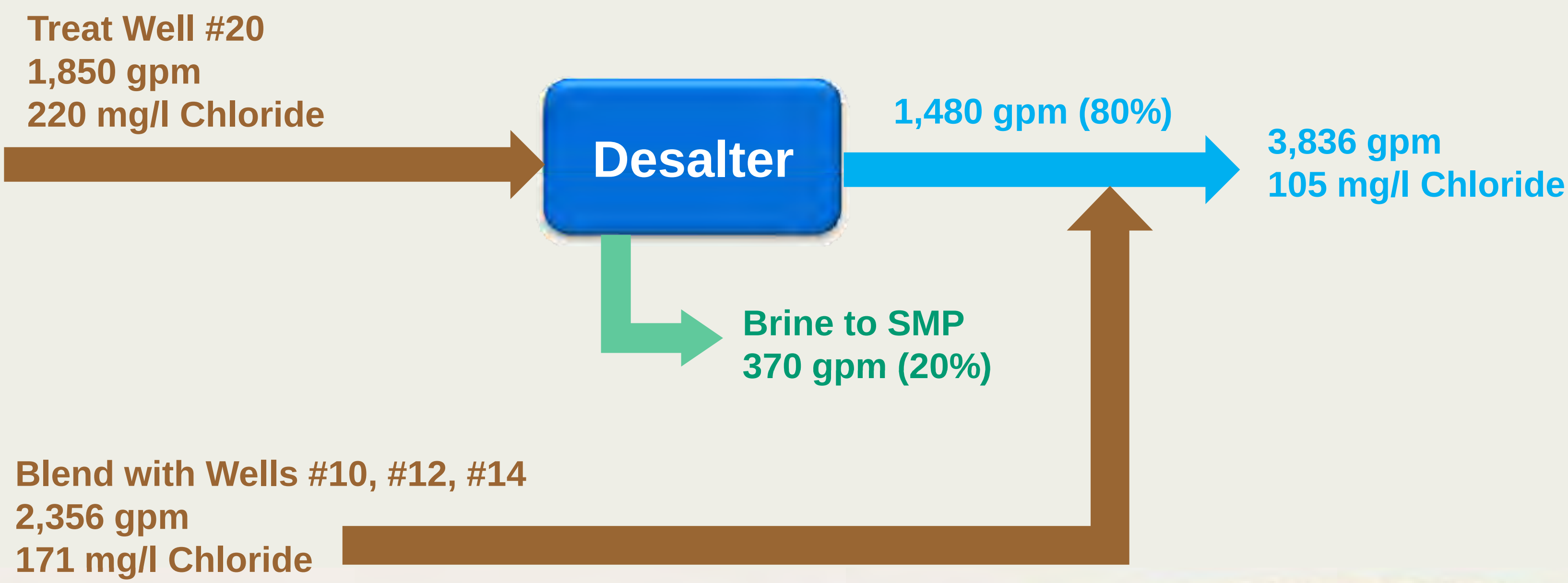
Alt 3 Includes:

3.1 Miles of Pipe, 4 Shallow Wells

3 booster pump stations, 3 tanks

Potential Desalter Concept for Zone MWC (Without New Shallow Wells) (WQO ≤ 120 mg/l)

- Combined Pumping Capacity (before treatment) = 4,206 gpm
- Combined Pumping Capacity (after treatment) = 3,836 gpm



Next Steps

- Workshop Meeting Minutes
- Prepare Report

Q&A

Kennedy/Jenks Consultants

Las Posas Basin Stakeholders Workshop No.2 Summary (Draft)

Meeting Time:	10 AM to 2 PM	**Page:**	
Meeting Location:	CMWD Board Room	**Date:**	May 15, 2014
Meeting Date:	April 17, 2014	**K/J Job No.:**	1344206*00
Project:	Las Posas Conjunctive Use Study, Phase 2		

Persons Attending:

Kennedy/Jenks	***LP Basin Stakeholders/Others***	
Brent Payne	Susan Mulligan, CMWD	Reddy Pakala, VCWWD Nos.1 & 19
Sunny Huang	Kristine McCaffrey, CMWD	Susan Pan, VCWWD Nos. 1 & 19
Steve Bachman (Consultant)	Bryan Bondy, CMWD	Ted Grether, Grether Farming Co.
	Carol Schoen, Zone MWC & Berylwood Heights MWC	Dale Zurawksi, Farm Bureau VC
	Sam McIntyre, Las Posas Orchards MWC & Arroyo Las Posas MWC	

Subject: Workshop No. 2 with Las Posas Basin Stakeholders

Purpose of Workshop No. 2

- Identify potential system alternatives for regional desalter(s), including size, location(s), blending and conveyance.
- Solicit input on system sizing and alternatives from Stakeholders to develop and refine alternatives.
- Select three or four potential system alternatives for further evaluation and discussion in Workshop No. 3.

Recap of Study Scope

- Define Chloride Impacted Irrigation Demands (Workshop No. 1) – to provide a basis for sizing desalter(s) systems.
- Develop Potential Alternatives (Workshop No. 2) – to screen potential alternatives and identify three or four alternatives for further evaluation.
- Evaluate Alternatives (Workshop No. 3) – to evaluate three or four system alternatives based on costs and other study criteria.
- Prepare Draft and Final Report.

Introduction and Study Update

- Comments on Workshop No. 1 summary were received from Reddy Pakala, VCWWD. The revised summary is attached.
- The study criteria for evaluation of system options were reviewed as follow-up to questions from Workshop No. 1. The criteria (as defined in the Proposition 84 Grant work scope) include capital cost, operations and maintenance cost, ability to meet water quality objectives, irrigation acreage served, volume of water generated or transferred, and operational flexibility.

- A key objective for the study is to consider developing the shallow groundwater zone as a resource, which is consistent with the criterion “volume of water generated.” To meet this objective, the system alternatives will consider opportunities to add new shallow wells to provide supplemental water for treatment in a regional desalter(s).

Recap Irrigation Demands from Workshop No. 1

- Existing wells and production impacted by high chlorides in 2012 or predicted to be impacted in 2042 were reviewed to confirm the basis for potential sizing options for a regional agricultural desalter(s). Based on stakeholder input, the following conclusions were made as the basis for sizing:
  - Existing wells and production impacted by high chlorides in 2012 will be used as a basis for sizing the agricultural desalter, with one modification: the Berylwood Heights MWC wells will be reviewed to identify wells that may be impacted in the next 5 to 10 years to be included in the basis for sizing. See Table 1 for a summary of impacted wells and production for 2012 at chloride concentrations at or above 120 mg/l and 60 mg/l (additional Berylwood Heights MWC Wells to be added once confirmed).
  - Potential impacts for 2042 were presented, but will not be used as a basis for sizing due to uncertainties in predicting plume migration and chloride concentrations that far into the future.
- The number of wells in the “other wells” category will be reviewed to identify other private shareholders that may be connected to the Berylwood Heights MWC system and/or to identify any Las Posas Orchards MWC wells that may be impacted (these were listed under other names in the GIS database such as Paramount Citrus or Sunshine Ranch).
- The chloride impacted wells were grouped into categories by Mutual Water Company (MWC), VCWWD, private wells whose owner is also a shareholder connected to a MWC system, and other wells. The “other wells” category includes privately owned wells within a MWC service area but whose owner is not a MWC shareholder, and wells outside a MWC service area whose owner is not a MWC shareholder. For purposes of this study, private wells that are not currently connected to a MWC system are not included in sizing a regional desalter, but can be added in future studies. The chloride impacted wells provide a basis for identifying each stakeholder’s part in a regional desalter. In the case of VCWWD, deliveries to its agricultural customers will be used to also consider development of the shallow aquifer to provide an alternate source of supply for those customers impacted by high chlorides that are connected to MWC systems, subject to the MWC(s) having sufficient wheeling capacity in their systems.
- Well capacity and 2012 annual production data were used to estimate run times for the chloride impacted wells. Well capacities were taken from the infrastructure system information provided from Phase 1 of the Conjunctive Use Study for MWC wells. Annual production for 2012 was taken from production data reported in the Fox Canyon Groundwater Management Agency (GMA) database. Based on these estimates, the run time for the chloride impacted wells (at or above 120 mg/l chloride concentration) in 2012 ranged from 4 to 54% with an average of about 31%. Annual production and estimated run times were used to estimate the combined capacity of private wells (well capacity data was not available from the Conjunctive Use Study Phase 1 or from the GIS database).
- According to stakeholder input (Carol Schoen, Zone MWC), the run times may be higher for certain MWC wells during certain periods of the year. Certain impacted wells may also be pumped more throughout the year (i.e., with higher annual run times) if treated in a regional desalter in

order to offset current pumping from the West Las Posas subbasin wells. The cost evaluation (Workshop No. 3) will consider the impacts of higher run times on both capital (amortization) and annual operating costs for a regional desalter.

Regional Agricultural Desalter – Preliminary Sizing Scenarios

- The regional desalter can be sized to include all or a portion of the stakeholder impacted demands. The following represent three potential sizing options:
  - Desalter Option 1 – Treat existing impacted wells from the MWCs, and add new shallow aquifer wells to provide an alternate water supply for VCWWD agricultural customers that are connected to MWC systems,
  - Desalter Option 2 – Includes Option 1 plus private shareholders' wells that are within MWC service areas and connected to the MWC systems, and
  - Desalter Option 3 – Includes Option 2 plus other private wells that are not connected to MWCs and/or outside MWC services.

  For purposes of the study, Option 1 will be considered for sizing the regional desalter. Option 2 will be presented as a possible expansion option. Option 3 may be considered in future studies on a case by case basis with individual private well owners.
- The calculation method for preliminary sizing of the desalter was done in two steps.

  Step 1 - The first step was to estimate the amount of permeate needed to blend with the production from chloride impacted wells to meet each water quality objective (i.e., 120 mg/l or 60 mg/l chloride concentration). Blending was assumed to be provided by a portion of the pumping capacity of the well, so as to provide blended water that meets the water quality objective at the pumping capacity of each well.

  Step 2 - The second step was to perform a water balance for the desalter to determine the feed flow needed to deliver the required permeate flow based on an assumed desalter recovery (i.e., to account for brine loss).
- The estimated recovery for the desalter is assumed to be 80% with a 20% loss to brine.
- Desalter facility and infrastructure sizing will be based on the 2012 chloride impacted wells (including any Berylwood wells that are anticipated to be impacted in the next 5 to 10 years) and new shallow wells needed to replace VCWWD chloride impacted deliveries and makeup for desalter brine loss. Future expansion options, if required, will be deferred to future studies.
- Conceptual design for the agricultural desalters will assume duty equipment only, and will not require standby or redundant equipment.
- Preliminary sizes for a regional desalter for Option 2 are presented in Table 2 for each water quality objective, for the base year 2012, with a breakdown by MWC, VCWWD agricultural customers and Zone MWC private shareholders. The estimated capacity of the desalter required to meet the water quality objective of 120 mg/l is about 3,375 gallons per minute (gpm). This would provide about 2,700 gpm of high quality water (chloride concentrations < 1 mg/l) for blending with flows from existing impacted wells. Approximately 675 gpm of brine would be discharged to the Salinity Management Pipeline (SMP). The estimated capacity of the desalter required to meet the water quality objective of 60 mg/l is about 6,775 gpm. This would provide about 5,420 gpm of high quality permeate for blending and discharge about 1,355 gpm of brine to the SMP.
- It was assumed that new wells in the shallow aquifer would be installed to feed the desalter to make up for losses due to brine (i.e., to maintain well pumping capacity for peak deliveries to

growers).

- The estimated pumping capacity for new shallow wells may vary with location. For purposes of this study, the estimated pumping capacity of new shallow wells will be based on a review of a report prepared by Hopkins Groundwater Consultants, Inc. for VCWWD No. 1 titled "Summary of Operations and Preliminary Hydrogeologic Study", dated February 2013, and other recent new shallow monitoring wells constructed in the southwest portion of the Las Posas Basin Eastern Management Sub-Area. Preliminary estimates of pumping capacity for a new shallow well are about 200 gpm.
- The estimated number of new shallow wells needed for brine make-up would range from 4 wells to 7 wells for the water quality objectives of 120 mg/l and 60 mg/l chlorides, respectively. This estimate is based on the estimated brine loss for each water quality objective, and an estimated pumping capacity of 200 gpm for a shallow well.
- The preliminary desalter sizes provide sufficient capacity to meet peak demands with all growers (and the VCWWD) pumping the impacted wells at capacity at the same time, in order to maintain the current level of service.
- Opportunities to reduce the size of the regional desalter may be considered if desalter capacity did not need to meet peak agricultural demands, i.e., if peak deliveries could have temporarily higher chloride levels than the water quality objectives. Preliminary discussions by stakeholders suggested that a 5 to 10% reduction may be acceptable.
- Sizing the desalter to meet peak demands provides extra capacity during periods when demands are low. For example, to meet the water quality objective of 120 mg/l chloride at peak demands, the desalter is sized to treat 3,375 gpm of water and can deliver 2,700 gpm of permeate, or up to 4,355 acre-feet per year (AFY) if the facility operates year round (see Table 3). However, the facility is only required to deliver 1,350 AFY to meet blending requirements for impacted wells that operate with an estimated run time of 31%.
- Opportunities to use the extra desalter capacity were discussed. One idea was to consider use of a desalter that can provide potable water to meet municipal and industrial customers during periods when it is not used to meet agricultural demands. In order to meet California Department of Health (CDPH) requirements, this would require new source wells that are located in areas and constructed to meet CPDH requirements (e.g., located further away from the Arroyo Las Posas Creek). The desalter facility would also need to meet CDPH requirements, such as disinfection, and operate under the supervision of CDPH certified operators. Potable water from a regional desalter could also be injected into the aquifer through existing and/or new Aquifer Storage and Recovery wells. Another idea was for Zone MWC to shut down wells in the West Las Posas and use more water from the desalter when there is excess supply.

System Alternatives

- A system required to produce, treat and distribute water to agricultural users will include a combination of desalters, existing and new wells, existing and/or new tanks for blending, and conveyance facilities. Three system alternatives were reviewed to represent a range of potential supply/distribution options, as follows:

System Option 1- Centralized Treatment and Blending – provides a single facility for treatment and blending at a regional location and delivers blended water to each MWC system. It is assumed that blended water to VCWWD agricultural customers would be wheeled through an existing MWC system such as Zone MWC and/or Berylwood Heights MWC for customers within these services areas. Further evaluation of Zone MWC and Berylwood Heights MWC distribution systems is needed to confirm the capacity of these systems to deliver the extra water to the various VCWWD agricultural customers within these areas.

System Option 2 - Centralized Treatment and Local Blending – provides a single facility for treatment, but delivers permeate to each system for localized blending in existing or new blend tanks.

System Option 3 - Multiple Treatment/Blending Facilities – provides smaller desalters at multiple locations to treat clusters of impacted wells, or individual wells, with local blending.

- Criteria for selecting a site for a regional desalter were reviewed and included the following:
  - Proximity to impacted wells
  - Proximity to points of connection to MWC distribution systems,
  - Proximity to the proposed alignment for the SMP, and
  - Proximity to favorable hydrogeological conditions for constructing new shallow wells

  Based on a review of this criteria, the Zone MWC Well #20 site (or in that vicinity) was identified as generally meeting all the criteria for a central location for System Options 1 and 2. For System Option 3, two additional sites were identified: a site near the Berylwood Heights MWC Well #4, and the Arroyo Las Posas MWC well site.

- A preliminary concept for each of the three system alternatives was developed during the Workshop, with input from the Stakeholders. Figures 1, 2 and 3 provide a description of the concept for each of the three system alternatives. These system alternatives will be used as a basis for the next step in the study, which includes an evaluation of each alternative based on cost and other study criteria.

Basis for Order of Magnitude Costs

- Costs for treatment will be developed based on four previous desalter feasibility studies, as follows:
  - Somis Desalter Feasibility Study for Calleguas MWD (Kennedy/Jenks, 2010)
  - Preliminary Feasibility For Groundwater Desalter for Zone MWC (Separation Processes, Inc., February 2013)
  - Brackish Water Desalination Pilot Study for City of Camarillo (CDM, January 2009)
  - Moorpark Desalter Preliminary Design Report for VCWWD No. 1 (Kennedy/Jenks, August 2010)
- Costs for other infrastructure will be developed consistent with the concept level of project definition, based on cost/capacity curves and factors.
- Based on a preliminary review of water quality for the chloride impacted wells, it appears that iron and manganese concentrations are at levels that will require pre-treatment as part of the desalter facility. Unit costs for pretreatment will be considered based on the treatment cost studies identified above.

Next Steps

- Develop concept figure and map for each of the three system alternatives that show the elements of the system for each water quality objective.
- Develop planning level (order of magnitude) capital costs for each system alternative and water quality objective.
- Develop planning level operating and maintenance costs for each system alternative and water quality objective.

Distribution:
Project File (Original)
KJ and CMWD Attendees Listed Above

T. Brent Payne

T. Brent Payne

Table 1 - Chloride Impacted Wells (2012)

	No. of Wells	Well No	Capacity (gpm)	Annual Production AFY (2012)	Chloride Conc (mg/l) (2012)	Run Time (percent)
Mutual MWCs and VCWWD Wells ≥ 120 mg/l						
System						
Zone Mutual Water Co. (MWC)		#10	856	56	179	4%
		#12	1000	216	160	13%
		#14	500	311	181	39%
		#20	1850	1167	220	39%
Arroyo Las Posas MWC		#1	800	280	183	22%
VCWWD #19		#4	1200	1044	148	54%
Combined - Subtotal	**6**		**6206**	**3074**	**183**	**31%**
Private or Non-MWC Wells ≥ 120 mg/l						
Zone MWC Private Shareholders	6		1800	870		30%
Other Wells > 120 mg/l	7		9300	4504		30%
MWC Wells ≤ 120 and ≥ 60 mg/l						
Zone MWC	1	15	350	130	74	23%

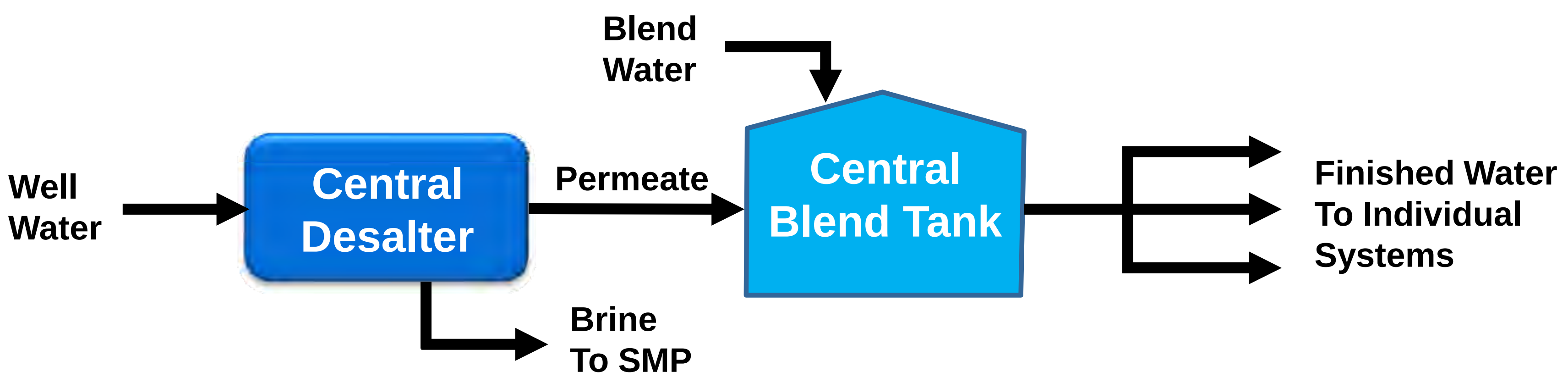
Table 2 - Regional Desalter to Treat Impacted Demands from Mutual MWCs & VCWWD (Includes Zone MWC Private Shareholder) Basis: Year 2012

Water Quality Objective	Desalter Flows		
	Feed (gpm)	Permeate (gpm)	Brine (gmp)
Chlorides ≤ 120 mg/l			
Zone MWC	1938	1550	388
Arroyo Las Posas MWC	350	280	70
VCWWD #19	300	240	60
Zone MWC Private Shareholders	788	630	158
Total	**3375**	**2700**	**675**
Chlorides ≤ 60 mg/l			
Zone MWC	3694	2955	739
Arroyo Las Posas MWC	669	535	134
VCWWD #19	900	720	180
Zone MWC Private Shareholders	1513	1210	303
Total	**6775**	**5420**	**1355**

Table 3 - Regional Desalter to Treat Impacted Demands from MWCs & VCWWD - Capacity and Production

			Desalter			
Year	Water Quality Objective (mg/l)	Impacted Demands (AFY)	Capacity (Permeate) (gpm)	Capacity (Permeate) (AFY)	Run Time %	Permeate Delivered (AFY)
2012	120	3944	2700	4355	31	1350
2012	60	4074	5420	8711	31	2700

Alternative 1 – Centralized Treatment and Blending



Description of Alternative:

Location: Zone MWC Existing Well #20 Site for Desalter and Blend Tank

1. Treat existing wells as follows:

- Zone MWC Wells #20, #14,
- Arroyo Las Posas Well, and
- Berylwood Heights Wells #2, #3, #4.

2. Add New Shallow Wells to replace production from existing wells, as follows:

- Zone MWC Wells #10, #12 and
- VCWWD 19 Well #4.

3. Construct Conveyance Systems

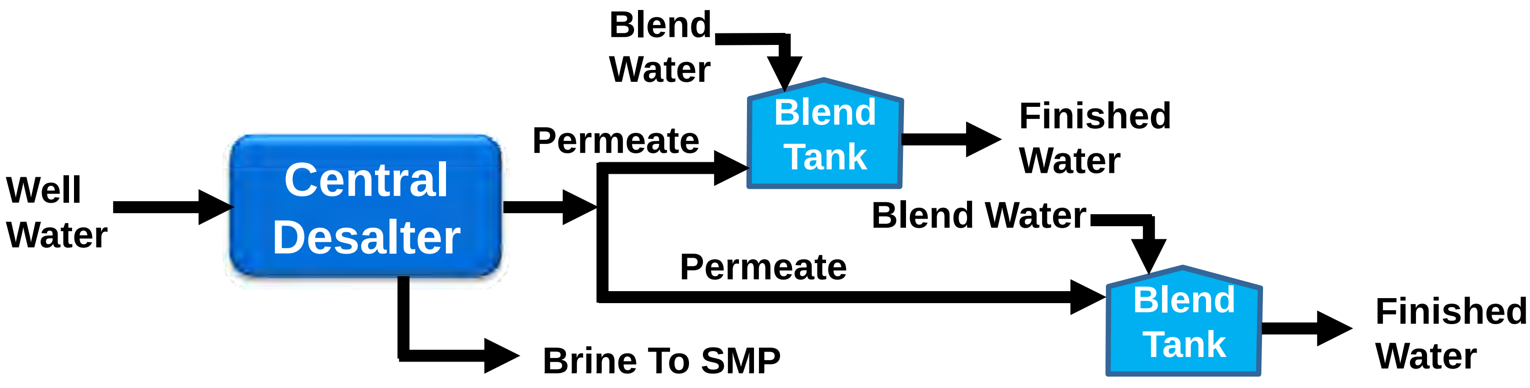
- Raw water pipelines from wells to central facility
- Treated water pipelines from central facility to individual system points of connection
- Treated water for VCWWD 19 customers routed through Zone MWC and/or Berylwood Heights MWC Systems

Kennedy/Jenks Consultants

Las Posas Basin Stakeholders Workshop No. 2
Alternative 1 – Centralized Treatment and Blending

K/J 1344206
May 2014
Figure 1

Alternative 2 – Centralized Treatment and Local Blending in Each System



Description of Alternative:

Location: Zone MWC Existing Well #20 Site, with Blend Tanks at Each System

1. Treat existing wells, as follows:

- Zone MWC Wells #20 and #14
- Berylwood Heights MWC Wells #2, #3, #4

2. Add New Shallow Wells to provide permeate for blending with production from existing wells, as follows:

- Zone MWC Wells #10, #12
- VCWWD 19 Well #4, and
- Arroyo Las Posas MWC Well

3. Construct Conveyance and Blending Tanks, as follows:

a) Raw water pipelines from wells to central facility

b) Permeate water pipelines from central facility to individual systems with new or existing blend tanks as follows:

- New Blend Tank at Central Facility for Zone MWC
- New Blend Tank at Arroyo Las Posas MWC (near existing well)
- Existing Berylwood Heights MWC Reservoir for blending

c) Route blended water from Zone MWC Blend Tank to existing VCWWD 19 agricultural customers through Zone MWC system and Berylwood Heights MWC

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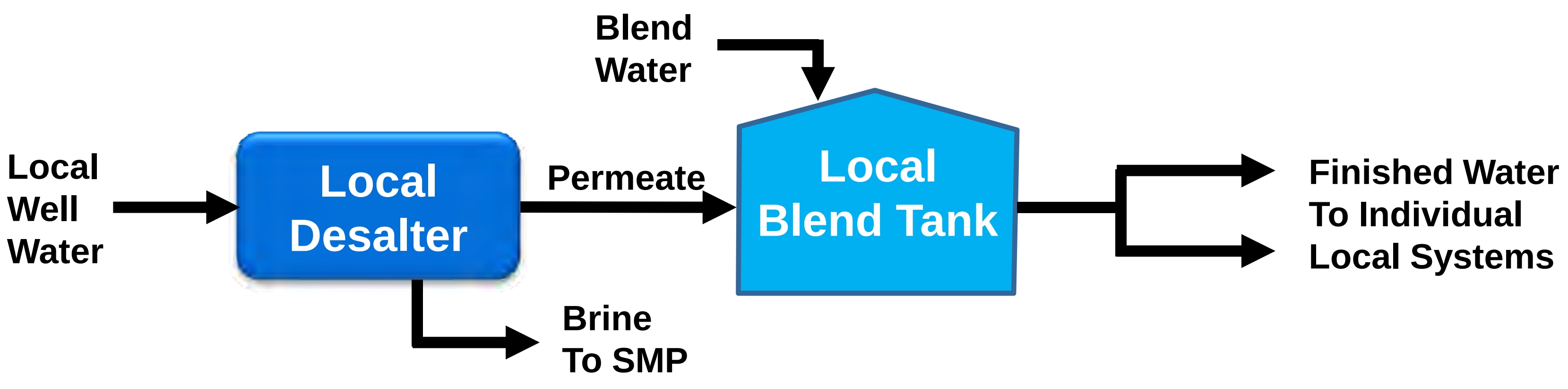
Las Posas Basin Stakeholders Workshop No. 2
Alternative 2 – Centralized Treatment and Local Blending in Each System

K/J 1344206
May 2014
Figure 2

Alternative 3 – Multiple Treatment/Blending Facilities



1. **Construct Local Desalters at the following locations:**
   - **a) Zone MWC**
     - Treat Zone MWC Wells #20 and #14
   - **b) Arroyo Las Posas MWC Well**
   - **c) Berylwood MWC**
     - Treat Berylwood MWC Wells #2, #3, #4
2. **Construct Brine Lines from each facility to SMP**
3. **Add New Shallow Wells to provide capacity needed to makeup for brine loss and to replace production from VCWWD 19 Well #4**
4. **Route blended water from Berylwood MWC Desalter to existing VCWWD 19 agricultural customers through Zone MWC system and Berylwood Heights MWC**

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Las Posas Basin Stakeholders Workshop No. 2
Alternative 3 – Multiple Treatment/Blending Facilities

K/J 1344206
May 2014
Figure 3

Kennedy/Jenks Consultants

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Brine Disposal Alternatives Evaluation, Moorpark Desalter

March 2014

Prepared for

Ventura County Waterworks District No. 1
800 South Victoria Avenue
Ventura, CA 93009

K/J Project No. 1344209*00

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Section 1: Introduction

Ventura County Waterworks District No. 1 (District) is in the process of implementing a long term strategy to supplement and improve its potable water sources for its customers and sustainably manage salinity levels within the local groundwater basin. To these ends, the District is in the process of the design and construction of a brackish water desalination facility. This facility, the Moorpark Desalter (Desalter), would consist of a reverse osmosis (RO) water treatment plant and a new groundwater wellfield to supply the Desalter. Efforts to date for this project include the following:

- Preliminary Design Report (PDR) for the Moorpark Desalter (Final Draft, Kennedy/Jenks Consultants, August 2011)
- Moorpark Desalter Pilot Well Test Project (Hopkins Groundwater Consultants, February 2013).

Included in the PDR was an assessment of options for disposal of the brine generated by the Desalter and a recommendation for disposal to the Calleguas Municipal Water District (CMWD) Salinity Management Pipeline (SMP). However, the District has since expressed concerns over the potential escalation of future costs for brine disposal via the SMP. As a result, the District has requested that Kennedy/Jenks Consultants (Kennedy/Jenks) develop a Brine Disposal Alternatives Evaluation which would assess additional alternatives capable of either reducing the brine volume discharged to the SMP or eliminating discharge to the SMP. The evaluation would consider both the use of additional unit operations to further reduce the brine volume generated from the Desalter as well as alternate disposal options. The findings of this evaluation are presented herein.

1.1 Brine Disposal Alternatives

While RO brine can sometimes be used for landfill dust control, and some manufacturing processes, the typical methods of handling and disposing of brine include:

- Discharge as a liquid to a WWTP outfall or regional brine pipeline
- Concentration and dewatering to a solid for landfill disposal or other beneficial use
- Deep well injection

Deep well injection is not an available alternative in the Oxnard Plain; therefore, this study evaluates alternatives for liquid discharge and for concentration and dewatering for disposal.

There are also a number of alternatives for concentration of brine to increase the overall recovery of the system. These alternatives often build one each other in a process that could lead to approximately 99% recovery and zero-liquid discharge. The various typical brine concentration and dewatering alternatives include:

- 3rd Stage RO System to reduce the volume and concentrate the liquid brine

- Electrodyalisis (ED or EDR) System to concentrate the liquid brine
- Ion Exchange and a 4th stage RO system to further concentrate the liquid brine
- Precipitative softening and a 4th stage RO system to further concentrate the liquid brine
- Precipitative softening and a HERO™ RO system to further concentrate the liquid brine
- Non-conventional "disc-tube" RO system to further concentrate the liquid brine
- Non-conventional Vibratory Shear Enhanced Processing (VSEP) RO system to further concentrate the liquid brine
- Mechanical Evaporation to concentrate the to further concentrate the liquid brine
- Crystallization to further concentrate the liquid brine
- Crystallization to convert the liquid brine to a solids slurry
- Solar drying beds to convert the liquid brine to a solids slurry

These different brine concentration and dewatering alternatives have primary application in the concentration of industrial waste streams; but they are more frequently being evaluated for inland municipal Desalter brine control and disposal options. The different alternatives also have varying capital costs, energy costs, chemical costs and operations and maintenance costs, such that it is important to evaluate them on a life-cycle basis.

Based on the results of Kennedy/Jenks prior evaluations of brine disposal and zero-liquid discharge alternatives for other projects, and the results of published studies on brine concentration and disposal alternatives, Kennedy/Jenks worked with the District to screen out the alternatives that were not likely to meet the Districts objectives. Based on the initial screening and at the direction of the District, the following alternatives were included in this report:

- Alternative 1 – Discharge brine generated from the Desalter to the SMP. This is the original disposal alterative recommended in the Final Draft PDR. The cost for disposal via this method as described in the PDR was updated to reflect current unit costs and served as the baseline for comparison with the other brine disposal alternatives.
- Alternative 2 – Concentrate the brine from the Desalter through a 3rd stage RO array (brine concentrator) and dispose of the reduced brine volume to the SMP.
- Alternative 3 – Concentrate the brine from the Desalter with the brine concentrator used for Alternative 2 followed by further reduction with a brine evaporator. The final minimized brine volume would be discharged to evaporation ponds located at the Moorpark Wastewater Treatment Plant (MWWTP) and ultimately blended with the waste solids at the MWWTP for disposal offsite at a landfill. Also included in the analysis of this alternative is an option to expand the solar voltaic array at the MWWTP. The expansion of the solar array would be used to reduce the quantity of electrical power

purchased from the local utility (Southern California Edison, SCE) needed to power the brine evaporator system.

The other potential alternatives noted above were excluded from this analysis for one or more of the following reasons:

- Higher anticipated capital and/or operational and maintenance costs than the RO brine concentrator or evaporator processes (zero-liquid discharge and solid slurry processes; ion exchange).

- Large foot print requirements (evaporation ponds).

- Substantial complexity and/or residual management issues (precipitative softening; ion exchange).

- Limited track record or limited large installations for this application in the municipal potable water market (VSEP, disc-tube RO, ED/EDR, HERO^{TM} RO process).

1.2 Objective and Evaluation Criteria

The objective of the evaluation is to determine the most appropriate and cost-effective means to dispose of brine generated from the future Desalter facility. To arrive at the recommended alternative, the evaluation assessed the impact of costs as well as non-cost related criteria for each option. Specifically, the following were evaluated:

- Cost Criteria.

    - Capital Costs – these consist of planning level opinions of probable construction cost for unit operations required to achieve brine reduction for each alternative.

    - Operations and Maintenance (O&M) Costs – these include only the O&M costs associated with brine disposal to the SMP and O&M costs associated with the brine reduction unit operations for each alternative.

    - Lifecycle Analysis – the lifecycle window used for this analysis is 25 years, which is consistent with the lifecycle cost analysis duration used in the Desalter PDR.

- Non-Cost Criteria. These include factors that could impact the long term operation of each alternative or salinity management within the local groundwater basin, and consist of:

    - Reliability

    - System and Operational Complexity

    - Ease of Expandability

    - Ability to Maximize Water Recovery for Watershed

- Ability to accommodate Future Regulatory Changes

- Alternatives Ranking and Sensitivity Analysis. The alternatives were given a score for each of the evaluation criteria. These scores were summed to yield a ranking of the alternatives assuming all criteria were equally weighted. A sensitivity analysis followed which assessed the impact of non-equal weighting of the criteria on the ranking for the alternatives. The criteria weighting were adjusted to consider a cost-focused ranking and an operational-focused ranking. The detailed methodology for the ranking and weighting processes are presented in Section 3.

1.3 Assumptions Used in This Report

The following are the assumptions used in the evaluations presented in this report.

- Opinions of probable construction cost were developed on a conceptual level (i.e., -30%/+50%) in accordance with the Association for the Advancement of Cost Engineering for Class 5 planning level projects.

- Opinions of probable construction cost do not include soft costs (i.e., engineering, permitting, and administration).

- A 30% contingency was applied to all opinions of probable construction cost.

- The equipment requirements and lifecycle cost for each alternative were based on the projected brine discharge rate for the initial treatment capacity of the Desalter (i.e., 625 gallons per minute (gpm)). The increased brine volume from future Desalter expansions was excluded from this analysis due to the uncertainty of when the expansions would occur.

- A number of unit costs were assumed to generate the O&M costs for this evaluation. These unit costs are summarized in Table 1-1.

Table 1-1: Unit Costs Used for Analysis

Parameter	Unit	Value	Notes
Labor	$/man-hr	36	Moorpark Desalter PDR
Electricity	$/kW-hr	0.082	Average based on SCE billings for Moorpark WWTP 8/2011 - 8/2013
Antiscalant	$/gal	23.79	$1,308.60 per 55 gal drum Pretreat Plus Silica, King Lee Technologies 12/2013
Sulfuric Acid	$/lb	0.234	50% solution strength. Hill Bros., 8/2011
Membrane Replacement	$/element	500	
Solids Haul and Landfill Disposal	$/ton	44	Moorpark WWTP solids disposal cost
Annual Escalation Rates			
Labor Inflation	-----	5.85%	CA Dept. of Industrial Relations - Average for minimum wage inflation 1/1981 - 1/2012.
Electical Inflation	-----	1.50%	Based on 2010 California Energy Commission Demand Forecast.
Inflation - Others (CCI increase)	-----	3.30%	Average ENR CCI increase for San Francisco 1/90 - 8/12.
20 Year Nominal Discount Rate	-----	3.50%	US Office of Management and Budget, Circular A-94 Appendix C, Revised 12/2011.
Chemical Inflation	-----	5.70%	Based on 2010 Freedonia group Inc. estimated increase in water treatment product demands.

- Additional assumptions specific to the individual alternatives are presented accordingly in the sections in which they are evaluated.

Section 2: Brine Disposal Alternatives Evaluation

This section presents a discussion on and evaluation of the three brine disposal alternatives.

2.1 Verification of Brine Water Quality

The initial step in the evaluation was to verify that the projected water quality profile for the brine indicated in the PDR is still appropriate for this analysis. This verification was performed by comparing the source water quality profile used in the 2010 PDR against the recent source water quality data generated for the 2013 Hopkins report. A comparison of the water quality data is presented in Table 2-1.

Table 2-1: Comparison of Water Quality

		Moorpark Desalter PDR		Average for Pilot Wells 2013 Hopkins Report	
Parameter	**Unit**	**RO Feed**	**Concentrate**	**All Pilot Wells**	**Excl. MPWWTP**
Alkalinity	mg/L as CaCO3	NA	NA	229	210
Boron	mg/L	0.85	4.3	0.9	0.8
Bicarbonate	mg/L as CaCO3	280.2	1380	276	253
Calcium	mg/L	146.6	731	204	148
Carbonate	mg/L	0.45	2.3	<10	<10
Chloride	mg/L	149.7	741	180	157
Specific Conductance	µmho/cm	1,750	8680	2191	1803
Fluoride	mg/L	0.40	2.0	0.2	0.2
Iron	mg/L	<0.3	<1.5	0.08	0.08
Potassium	mg/L	2.8	13.8	3.6	3.5
Magnesium	mg/L	42.7	213	59	48
Manganese	mg/L	<0.05	<0.25	<0.01	<0.01
Nitrate	mg/L	16.7	78.5	116.7	13.4
Sodium	mg/L	194.8	961	221	194
Sulfate	mg/L	431.2	2150	680	540
Total Dissolved Solids (TDS)	mg/L	1,287	6380	1620	1253
Total Hardness	mg/l as CaCO3	544.4	2720	753	566
pH	unit	7.0	7.6	7.4	7.4
Barium	mg/L	0.015	0.075	0.0207	0.0199
Strontium	mg/L	NA	NA	1.869	1.457
Turbidity	NTU	<0.1	<0.1	NA	NA
Silica	mg/l as SiO2	42	208	35	33

NA - Parameter not available
MPWWTP - Moorpark Wastew ater Treatment Plant

The findings for the average of all of the pilot wells in the 2013 Hopkins report show that many of the water quality parameters are moderately higher than the values used for the source water in the PDR (e.g., 1,620 mg/L vs. 1,287 mg/L TDS, 204 mg/L vs. 146.6 mg/L calcium, 116.7 mg/L vs. 16.7 mg/L nitrate). However, included in the pilot well average are the results from a monitoring well which monitors the impact of treated effluent discharged from the Moorpark Wastewater Treatment Plant (MWWTP) to the Arroyo Las Posas. These monitoring well results seemed to significantly skew the pilot well dataset. Discussions with District staff indicated that the monitoring well location is not within the new Desalter supply wellfield boundary and could therefore be excluded from the pilot well dataset. When excluded, the averages for the 2013 pilot well dataset are much more closely in line with the source water data used for the PDR. Therefore, the projected brine water quality profile from the PDR is appropriate for use as the starting point for this evaluation.

2.2 Alternative 1 – RO Brine Disposal to SMP

This alternative updates the estimated cost of the recommended alternative presented in the PDR.

2.2.1 Description of Alternative

The basis for the design of the RO system of the Moorpark Desalter, as described in the PDR, focused on the objective of maximizing the recovery of feed water in the form of permeate, while balancing the costs associated with membrane cleaning frequency and maximizing the life of the membrane elements. The resulting design was a 2-stage array operating at a recovery of 80%. A process schematic showing the general configuration and primary process flows for the Desalter is presented in Figure 2-1. Table 2-2 summarizes the Desalter flows for the initial facility capacity of the system.

Table 2-2: Summary of Process Flows, Moorpark Desalter (Initial Capacity)

	Flow Rate	
Parameter	**(gpm)**	**(AFY)**
Supply from Well Field	3,725	6,008
Reverse Osmosis System Feed	3,125	5,041
Permeate	2,500	4,033
Blend Water	600	968
Product Water (to distribution)	3,100	5,000
Brine	625	1,008

Based on this configuration, the system would discharge 625 gpm of brine to the SMP.

2.2.2 Cost Analysis

The updated amortized lifecycle cost for disposal of 625 gpm of brine to the SMP is estimated at $552,000 per year. A breakdown of the cost details is presented in Table 2-3.

Insert

Figure 2-1: Alternative 1 – Moorpark Desalter Treatment Scheme

Table 2-3: Cost Analysis for Disposal to SMP, Brine Disposal Alternative 1

Parameter	Unit	Value
Opinion of Probable Construction Cost[1]	-----	$ -
O&M Costs		
Brine from Moorpark Desalter	gpm	625
Brine from Moorpark Desalter	AFY	1,008
CMWD SMP Rate Schedule		
Brine Discharge Rate[2]	$/AF	500
O&M, Repair[3]	$/Mo.	3,750
Replacement Charge[2, 3, 4]	$/Mo.	1,320
Annual SMP Disposal Cost		
Brine Discharge Rate	$/yr	504,000
O&M, Repair	$/yr	45,000
Replacement Charge	$/yr	15,840
Annual Disposal Cost (2014)	-----	*564,840*
Lifecycle Cost (2014$)		
Capital Cost	-----	$ -
Net Present Value (NPV) 25 Year O&M Cost	-----	$ 13,800,000
NPV Lifecycle Cost	-----	$ 13,800,000
Amortized Annual Lifecycle Cost	-----	**$ 552,000**

Notes:
(1) SMP does not have one time connection fee.
(2) Rates effective January 1, 2012. Replacement Charge at 0.33% of Discharge Station construction cost per Rate Schedule.
(3) Salinity Management Pipeline - Information for Potential Dischargers, CMWD November 2011.
(4) Assume $400,000 Discharge Station constructed cost per direction from the District.

The annual cost for disposal to the SMP is based on the SMP Rate Schedule as established in CMWD Resolution No. 1728. The rates cited are those effective as of January 1, 2012 and are the current rates available as of this report. Components of the Rate Schedule include the following:

- Unit Rate for Brine Discharge for Dischargers Inside of Service Area = $500/AF. This rate and other operations costs were increased in the future at an inflation rate of 3.3-percent.

- O&M Repair Charge = Variable, based on actual repairs costs incurred on a monthly basis. CMWD estimates a typical annual cost for O&M repairs at $45,000 (CMWD, Salinity Management Pipeline – Information for Potential Dischargers, November 2011).

- Replacement Charge = Monthly charge at 0.33% of the discharge station construction cost. A cost of $400,000 was assumed for discharge station at direction from the District, which is based on the cost of the facility constructed for the Camrosa Water District.

A detailed breakdown of the lifecycle cost analysis is included in Appendix A.

2.3 Alternative 2 – RO Brine Concentration and Disposal to SMP

This alternative considers the addition of a 3rd stage RO system, or brine concentrator, whose intended function is to reduce the volume of brine generated from the RO system of the Desalter prior to disposal to the SMP. Details of this alternative and associated costs are presented below.

2.3.1 Description of Alternative

The brine concentrator would be located at the Desalter treatment plant location. It would consist of a single stage RO array, composed of nine parallel pressure vessels with each housing six 8-inch diameter spiral wound RO membrane elements in series. The concentrator system would be fed brine from the Desalter system, which would be dosed with an additional antiscalant to specifically target the high silica concentration anticipated to be present in the Desalter brine. This stream would then pass through a booster pump to increase the operating pressure as needed, followed by treatment with the brine concentrator RO membranes. Permeate from the concentrator would be combined with permeate from the Desalter system. The concentrator brine would be discharged to the SMP. Figure 2-2 presents a schematic showing the general configuration of the brine concentrator system.

The modeling software projects an allowable recovery of 35% for the brine concentrator, limited by the high silica present in the brine from the Desalter. This would result in a concentrator brine flow of 406 gpm.

The following assumptions were made to address the membrane cleaning and system footprint requirements of the bine concentrator.

- It is assumed that the brine concentrator would share the Clean-In-Place (CIP) system installed for the Desalter RO system for membrane cleanings.
- It is assumed that the initial size of the Desalter building would be increased prior to building construction to accommodate the additional footprint required by the brine concentrator system (approximately 20'W x 40'L).

Table 2-4 presents the conceptual design criteria for this system.

Insert

Figure 2-2: Alternative 2 – Brine Concentrator Treatment Scheme

Table 2-4: Conceptual Design Criteria for Brine Concentrator, Brine Disposal Alternative 2

Parameter	Unit	Value
Feed Flow Rate	gpm	625
Feed Flow Rate	AFY	1,008
Booster Pump		
Motor Size	HP	85
Pump Efficiency	percent	80
Total Dynamic Head Required	psi	183
Antiscalant		
Dosing Rate[1]	ppm	18
Consumption Rate	gpd	16.2
30 Day Storage	gal	486
Reverse Osmosis System		
Configuration		
Stages	No.	1
Pressure Vessels	No.	9
Membrane Elements per Vessel	No.	6
Total Membrane Elements	No.	54
Element Type		Brackish Water Spiral Wound Thin Film Composite
Element Diameter	inch	8
Element Length	inch'	40
Average Flux	GFD	14.6
Recovery	percent	35
Permeate	gpm	219
Permeate	AFY	353
Brine	**gpm**	**406**
Brine	**AFY**	**655**

Notes:
(1) Recommended dose of Pretreat Plus Silica product, King Lee Technologies

Table 2-5 presents the RO model output for projected feed, permeate and brine water quality from the proposed brine concentrator.

Table 2-5: Projected Water Quality for Brine Concentrator
Brine Disposal Alternative 2

		Brine Concentrator RO		
Parameter	**Unit**	**Feed**	**Permeate**	**Brine**
Boron	mg/L	4.3	2.6	5.2
Bicarbonate	mg/L as CaCO3	1380	26.7	2109
Calcium	mg/L	731	2.5	1123
Carbonate	mg/L	2.3	0.02	21.8
Chloride	mg/L	741	8.0	1136
Fluoride	mg/L	2.0	0.0	3.1
Potassium	mg/L	13.8	0.3	21.1
Magnesium	mg/L	213	0.7	327
Nitrate	mg/L	78.5	6.2	117.4
Sodium	mg/L	961	15.9	1470
Sulfate	mg/L	2150	5.8	3304.6
Total Dissolved Solids (TDS)	mg/L	6380	71.2	9971
Total Hardness	mg/l as CaCO3	2720	9.3	4172.0
pH	unit	7.6	6.3	8.1
Barium	mg/L	0.075	0.0000	0.1000
Strontium	mg/L	8.900	0.031	13.700
Silica	mg/l as SiO2	208	2.2	319

The data in Tables 2-4 and 2-5 were developed using the following basis:

- The brine concentrator array configuration, feed pressure requirements for the system, and projected water quality profiles were developed using IMS Design v. 2012 RO modeling software from Hydranautics, Inc. The detailed model output is attached in Appendix A.

- Recovery of the brine concentrator was limited to 35% due to the high silica concentration in the Desalter brine. Pretreat Plus Silica (King Lee Technologies) was used as the basis for addressing silica for this system, as it is a potable water antiscalant intended for use in high silica feed waters and can suppress silica scale formation at concentrations up to 320 mg/L.

2.3.2 Cost Analysis

The cost analysis for this alternative is presented in Table 2-6.

Table 2-6: Cost Analysis for Brine Concentrator
Brine Alternative 2

Parameter	Unit	Value	Frequency/Usage	Cost	Notes
Opinion of Probable Construction Cost	-----	-----	-----	**$ 1,300,000**	
O&M Costs					
Labor	$/man-hr	36	1,040 hrs/yr	$ 37,440	1 half time operator
Electricity	$/kW-hr	0.082	65 kW	$ 46,691	Assume year round operation
Antiscalant	$/gal	23.79	16.2 gpd	$ 140,670	Dosing rate of Pretreat Plus Silica, King Lee Technologies 12/2013
Membrane Replacement	$/element	500	54 elements/5 yrs	$ 5,400	Annualized cost assumes 5 year membrane life due to aggressive usage
Equipment Maintenance and Repair	$	26,000	Annual	$ 26,000	Assume 2% of constructed system cost
Brine Disposal to SMP					
Flow Rate	gpm	406	-----	-----	Based on modeling software
Flow Rate	AFY	655	-----	-----	
Brine Discharge Rate	$/AF	500	-----	$ 327,440	Assume year round operation
O&M, Repair	$/yr	45,000	-----	$ 45,000	See Table 2-3
Replacement Charge	$/yr	11,880	-----	$ 11,880	See Table 2-3
Brine Disposal Cost (2014)	-----	-----	-----	*$ 384,320*	
Subtotal O&M + Brine Disposal Cost	-----	-----	-----	$ 640,522	
Avoided Imported Water Purchases	$/AF	1,200	-----	$ (423,600)	Based on 1,008 - 665 = 353 AFY increased water recovery
Annualized O&M Cost (2014)				**$ 216,922**	
25 Year Lifecycle Cost (2014 $)					
Net Present Value (NPV) O&M Cost	-----	-----	-----	$ 6,500,000	
NPV Lifecycle Cost	-----	-----	-----	$ 7,800,000	
Amortized Annual Lifecycle Cost	-----	-----	-----	**$ 313,000**	

The opinion of probable construction cost for this alternative is $1,300,000. This cost assumes that it would be constructed in tandem with the Desalter system to take advantage of economies of scale as a single construction effort as opposed to a construction effort as a separate stand-alone system following the completion of the Desalter. In doing so, the requirements for a structure to house the system would be minimized, and the need for a separate CIP system was eliminated as noted in Section 2.3.1.

The annualized O&M cost is approximately $217,000. This cost consists of the labor costs plus brine disposal cost to the SMP less the avoided cost of imported water purchases from CMWD as a result of the approximate 353 AFY of potable water generated from this process. The amortized annual cost over a 25 year lifecycle is $313,000. Detailed breakdowns of the opinion of probable construction cost and the lifecycle cost analysis are included in Appendix A.

2.4 Alternative 3 – RO Brine Concentration + Brine Evaporation with Disposal to Landfill

This alternative considers the use of the brine concentrator evaluated in Section 2.3 followed by additional treatment with an evaporative process to minimize the brine volume. The intended purpose of alternative is to determine the requirements to eliminate or minimize the use of the SMP for brine disposal. Details of this alternative and its associated costs are presented below.

2.4.1 Description of Alternative

The brine concentrator system would be located at the Desalter facility location as described in Section 2.3. Brine from the concentrator system would be conveyed to the evaporator system located at the Moorpark WWTP through an 8-inch diameter pipeline. Residual pressure in the concentrator brine stream would be used to transfer the brine to the evaporator location, eliminating the need for pumping between the two sites. Once at the evaporator system, the brine would be pH adjusted with sulfuric acid and recirculated through the evaporator unit. Water vapor evaporated from the process would be captured and sent to potable water use. An 8-inch diameter condensate pipeline would be used, and would connect to the potable system.. The concentrated brine would be sent the sludge drying beds at the MWWTP, or blended directly with the solids generated from the WWTP. The solids would be trucked to a landfill for disposal.

2.4.1.1 Basis for Selection of Brine Evaporation System

Two commonly used evaporation technologies that would be most appropriate for this application include multiple effects distillation (MED) and mechanical vapor recompression (MVR). As noted in Section 1.1, other brine minimization technologies outside of these were discussed with District personnel for consideration in this evaluation, but were ultimately excluded due to cost, reliability, track record, and/or complexity issues. MED and MVR are briefly described and compared below:

- <u>MED</u> – Thermal process in which the liquid is evaporated in multiple sequential stages, or effects, with each effect operating under lower pressure to increase liquid evaporation. The process is thermal energy dependent and generally used where either waste heat is readily available or fuel to provide thermal energy is inexpensive and readily available.

- <u>MVR</u> – This process uses a single stage for distillation, but recirculates the liquid in the stage to promote increased evaporation. Thermal energy is imparted to the system through a mechanical vapor compressor. This process is generally preferred where waste heat is not available, electrical power is more readily available than fuel, and/or the cost of electrical power is less than the cost for thermal energy. This process is also more energy efficient than MED.

Discussions with District personnel have indicated that thermal energy is not as readily accessible as electrical power. Therefore, the use of an MVR system will be evaluated as part of this study.

2.4.1.2 Description of MVR System

Figure 2-3 presents a process schematic that shows the flow streams for the MVR process. As shown, brine from the concentrator is received in a feed tank where sulfuric acid would be injected to lower the brine pH to between 5 and 5.5. After this step, the brine is pumped through a brine heat exchanger to raise the temperature to boiling followed by passing through a de-aerator to remove non-condensable gasses, such as air and carbon dioxide. The de-aerated brine is fed to the evaporator chamber sump. A recirculation pump pumps the sump brine to the top of the evaporator chamber, where the liquid is allowed for coat the heat conductive surfaces on the liquid side of the evaporator as it falls back down into the sump. In the process, portion of the liquid is evaporated as water vapor. The water vapor is pumped through a mechanical vapor compressor, which slightly raises the temperature of the vapor stream, after which it is introduced to the vapor side of the evaporator chamber. The increased temperature of the water vapor following the mechanical compression step is what allows the transfer of heat from the water vapor to the brine through the heat conductive surfaces of the evaporator, thus

insert

Figure 2-3: Alternative 3 – Mechanical Vapor Recompression

causing more of the brine to evaporate. In transferring its heat to the brine, the water vapor condenses and is captured in a distillate holding tank. The condensate is pumped through the brine heat exchanger to heat the incoming brine from the feed tank. Afterwards, the condensate is sent to potable distribution. A small blowdown stream from the evaporator sump is continuously drawn off to prevent overloading the total solids inventory of the system. This stream is sent to the sludge drying beds or to blending with the solids generated at the MWWTP prior to hauling offsite for landfill disposal.

In addition to the equipment as described required for normal operation, a separate heating step is also required for startup of the evaporator. For startup, either closed loop thermal heating oil system to transfer heat from electrically powered heating coils to the brine or an electrically fired boiler system would be included as part of the evaporator system.

Based on planning level vendor performance estimates, an evaporator would be able to reduce the brine stream from 406 gpm to approximately 25 gpm. The brine TDS would be approximately 200,000 mg/L and would contain some suspended solids in the form of precipitated silica, calcium carbonate, and calcium sulfate. Concentration of the evaporator brine beyond this point would begin to precipitate excessive solids for the evaporator, and would require the addition of crystallization equipment normally used for zero liquid discharge (ZLD) applications.

The planning level system and performance criteria for the MVR evaporator are presented in Table 2-7.

Table 2-7: Planning Level Performance Criteria , Mechanical Vapor Recompression (MVR) Evaporator System, Brine Disposal Alternative 3

Parameter	Unit	Value
Feed Conditions (from Brine Concentrator)		
Flow Rate	gpm	406
Flow Rate	AFY	655
TDS	mg/L	9,970
Adjusted pH	unit	5.5
MVR System		
System Footprint[1,2]	SF	6,400 (80' x 80')
Electrical Energy Requirement[1]	kW	1,800
Acid Consumption (Sulfuric)[1]	lbs/hr	380
Acid Consumption (50% Sulfuric Acid Solution)	gal/day	1,188
Distillate (Condensate)	gpm	381
Distillate (Condensate)	AFY	615
MVR Brine		
TDS (Approximate)	**mg/L**	**200,000**
Brine[1]	**gpm**	**25**
Brine	**AFY**	**40**

Notes:
(1) HPD Evaporation and Crystallization (division of Veolia Water Solutions and Technologies).
(2) 3,600 SF required for primary MVR hardware. Assume additional space for ancillary equipment such as startup heating system and acid feed/storage.

2.4.1.3 Sludge Drying Bed Evaporation Capacity

The initial discharge option for the concentrated brine from the evaporator system is to the existing lined sludge drying beds at the MWWTP. The aggregate size of the sludge drying beds is 12,000 square feet (SF). To determine the drying capacity of the beds, evapotranspiration (ET) and rainfall data from April 2005 through January 2013 were obtained from the California Irrigation Management Information System (CIMIS) for the monitoring station in Santa Paula, California. Monthly averages for ET and rainfall were calculated, and an area factor of 0.7 was applied to the ET averages to estimate the ET for evaporation ponds. The data is summarized in Table 2-8.

Table 2-8: Evaporation Capacity Analysis, Sludge Drying Beds, MWWTP, Brine Disposal Alternative 3

Parameter	ETAF[1,2] (inch)	Rainfall[1] (inch)	Net Fill/ (Evaporation) (inch)	Allowable Monthly Inflow[3] (gal)
Month				
January	4.39	2.84	(1.56)	11,635
February	4.17	1.96	(2.21)	16,569
March	5.96	1.90	(4.06)	30,397
April	6.38	1.06	(5.32)	39,799
May	8.57	0.35	(8.21)	61,442
June	8.67	0.03	(8.64)	64,657
July	8.88	0.00	(8.87)	66,371
August	8.26	0.05	(8.22)	61,452
September	6.71	0.04	(6.66)	49,846
October	5.52	0.94	(4.58)	34,296
November	4.17	0.94	(3.23)	24,173
December	3.28	2.46	(0.83)	6,178
Annual Total	74.96	12.56	(62.40)	466,814

Notes:

(1) California Irrigation Management Information System (CIMIS) data from 4/2005 - 1/2013 from the Santa Paula monitoring station.

(2) ETAF = Evapotranspiration Area Factor; this is the monthly average evapotranspiration (ET) value adjusted with an evaporation pond adjustment factor of 0.7.

(3) Based on sludge drying bed area of 12,000 SF.

At the calculated inflow quantity to the sludge drying beds of 466,814 gallons, this equates to an annual continuous flow rate of approximately 0.9 gpm. Figure 2-4 shows the monthly variation in the sludge drying bed liquid depth with a 0.9 gpm continuous brine inflow. Assuming no other liquids are discharged to the sludge drying beds, the maximum liquid depth during the year for this scenario is approximately 14.7 inches.

Based on this analysis, the use of the sludge drying beds for evaporation of MVR brine will provide a minimal benefit, as is can only be used to evaporate approximately 4-percent of the MVR brine flow (i.e., 0.9 gpm of 25 gpm). The remaining brine solids and liquid would be mixed with the dewatered solids from the WWTP for landfill disposal. This report assumes that the overall combination of the dewatered wastewater solids and the brine liquid and solids meet the landfill requirements (paint filter test for % liquids) for disposal.

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Figure 2-4: Allowable Liquid Depth in Sludge Drying Beds, MWWTP, 0.9 gpm Continuous MVR Brine Flow

2.4.1.4 Optional Solar Photo Voltaic Array Expansion

The MWWTP currently utilizes a 1 megawatt (MW) solar photo voltaic (PV) array to meet a portion of the MWWTP power requirements. The electrical power needs during nighttime periods or beyond the PV system's generating capabilities during the day are met through purchased power from the local utility (Southern California Edison, SCE). As part of this evaluation, the potential expansion of the PV array will be assessed as a means to offset a portion of the power requirements for the evaporator system.

As a basis for sizing the system, estimating its power supply capability, and developing an opinion of probable construction cost for the expansion, the constructed cost and performance specifications for the existing PV array was used to generate unit values for power generating capability and installation cost. These unit values were applied to the area at the MWWTP designated for the PV array expansion. The summary of this information and resulting costs and power supply capability are presented in Table 2-9.

Table 2-9: Solar Photo Voltaic (PV) Array Expansion for Brine Evaporator, Brine Disposal Alternative 3

Parameter	Unit	Value
Existing Solar PV Array		
Contructed Cost	-----	$ 4,277,236
PV Array Footprint	acre	5.9
Power Supply Capability	MW	0.958
Estimated Unit Cost	$/acre	$ 724,955
Estimated Unit Power Supply Capability	kW/acre	162.4
Solar PV Array Expansion		
Total Area Available	acre	8.0
Estimated Power Supply Capability[1]	MW	1.3
Maximum Allowable Solar PV Array Size[2]	MW	1.0
Estimated Construction Cost	**-----**	**$ 4,464,756**
Estimated Power Supply Capability	**MW**	**1.0**

Notes:
(1) Power supply capability for new array only - does not include 0.958 MW from current system.
(2) SCE solar PV rebates currently available for installations up to 1.0 MW in size. Array expansion therefore capped to 1.0 MW in added capacity.

Based on space available at the MWWTP, the solar PV array at the MWWTP could be expanded by an additional 1.3 megawatts (MW) of electricity. However, rebates from SCE are currently available for construction of solar PV arrays up to 1.0 MW. Consequently, the District has indicated that the maximum size for any array expansion would be capped at 1.0 MW. Using this basis for sizing, the cost for a 1.0 MW solar PV array expansion is approximately $4,700,000. The expanded solar array could offset energy use by the proposed brine evaporator system.

2.4.2 Cost Analysis

Presented below are the capital, O&M, and 25 year lifecycle costs for this alternative. Included are two variants – one consisting of the brine concentrator plus the MVR system and landfill disposal of residuals, and a second which also includes the expansion of the solar PV array at the MWWTP to supplement electrical power.

2.4.2.1 Without Solar Photo Voltaic System

The cost analysis for this alternative without solar PV expansion is presented in Table 2-10.

Table 2-10: Cost Analysis, Brine Concentrator + MVR Evaporator (No Solar PV) + Landfill Disposal, Brine Disposal Alternative 3

Parameter	Unit	Value	Frequency/Usage	Cost	Notes
Opinion of Probable Construction Cost					
Brine Concentrator	-----	-----	-----	$ 1,300,000	
MVR System	-----	-----	-----	$ 22,000,000	
Total Capital Cost	-----	-----	-----	**$ 23,300,000**	
O&M Cost					
Brine Concentrator					
Labor	$/man-hr	36	1,040 hrs/yr	$ 37,440	1 half time operator
Electricity	$/kW-hr	0.082	65 kW	$ 46,691	Assume year round operation
Antiscalant	$/gal	23.79	16.2 gpd	$ 140,670	Dosing rate of Pretreat Plus Silica, King Lee Technologies 12/2013
Membrane Replacement	$/element	500	54 elements/5 yrs	$ 5,400	Annualized cost assumes 5 year membrane life due to aggressive usage
Equipment Maintenance and Repair	$	26,000	Annual	$ 26,000	Assume 2% of constructed system cost
Total for Brine Concentrator	-----	-----	-----	*$ 256,201*	
MVR Evaporator					
Labor	$/man-hr	36	2,080 hrs/yr	$ 74,880	1 full time operator
Electricity	$/kW-hr	0.082	1,800 kW[1]	$ 1,292,976	Assume year round operation
Sulfuric Acid	$/gal	0.234	380 lbs/hr[1]	$ 778,939	50% sulfuric acid solution, Hill Bros. 8/2011
Equipment Maintenance and Repair	$	233,000	Annual	$ 233,000	Assume 1% of constructed system cost
MVR Evaporator Total	-----	-----	-----	*$ 2,379,795*	
Landfill Disposal	$/ton	44	175 tons/day[2]	$ 2,810,500	
Subtotal Brine Concentrator, MVR, and Landfill O&M Costs	-----	-----	-----	$ 5,446,496	
Avoided Imported Water Purchases	$/AF	1,200	-----	$ (1,161,600)	Based on 1,008 - 40 = 968 AFY in increased water recovery
Annualized O&M Total (2014)				**$ 4,284,896**	
25 Year Lifecycle Cost (2014 $)	-----	-----	-----		
Net Present Value (NPV) O&M Cost	-----	-----	-----	$107,000,000	
NPV Lifecycle Cost	-----	-----	-----	$130,300,000	
Amortized Annual Lifecycle Cost	-----	-----	-----	**$ 5,200,000**	

Notes:
(1) HPD Evaporation and Crystallization (division of Veolia Water Solutions and Technologies).
(2) Estimated based on mass of 24.1 gpm of concentrated brine at 200,000 mg/L + dried solids from 0.9 gpm of concentrated brine at 200,000 mg/L.

The opinion of probable construction cost for this alternative without expansion of the solar PV array is $23,300,000. This assumes the same capital cost for brine concentrator developed in Alternative 2 plus the capital cost for the MVR system plus required ancillary equipment. The annualized O&M cost is approximately $4,300,000. This cost consists of the labor costs plus brine disposal cost to the SMP less the avoided cost of imported water purchases from CMWD as a result of the approximate 968 AFY of potable water generated from this process. The amortized annual cost over a 25 year lifecycle is approximately $5,200,000. Detailed breakdowns of the opinion of probable construction cost and the lifecycle cost analysis are included in Appendix A.

2.4.2.2 With Solar Photo Voltaic System

The cost analysis for this alternative with solar PV expansion is presented in Table 2-11.

Table 2-11: Cost Analysis, Brine Concentrator + MVR Evaporator + Solar PV + Landfill Disposal, Brine Disposal Alternative 3

Parameter	Unit	Value	Frequency/Usage	Cost	Notes
Opinion of Probable Construction Cost					
Brine Concentrator	-----	-----	-----	$ 1,300,000	
MVR System	-----	-----	-----	$ 22,000,000	
Solar PV Array Expansion				$ 4,700,000	
Total Capital Cost	-----	-----	-----	**$ 28,000,000**	
O&M Cost					
Brine Concentrator					
Labor	$/man-hr	36	1,040 hrs/yr	$ 37,440	1 half time operator
Electricity	$/kW-hr	0.082	65 kW	$ 46,691	Assume year round operation
Antiscalant	$/gal	23.79	16.2 gpd	$ 140,670	Dosing rate of Pretreat Plus Silica, King Lee Technologies 12/2013
Membrane Replacement	$/element	500	54 elements/5 yrs	$ 5,400	Annualized cost assumes 5 year membrane life due to aggressive usage
Equipment Maintenance and Repair	$	26,000	Annual	$ 26,000	Assume 2% of constructed system cost
Total for Brine Concentrator	-----	-----	-----	*$ 256,201*	
MVR Evaporator					
Labor	$/man-hr	36	2,080 hrs/yr	$ 74,880	1 full time operator
Electricity	$/kW-hr	0.082	1,800 kW[1]	$ 933,816	Assume 1.0 MW from solar PV for 12 hrs/day.
Sulfuric Acid	$/gal	0.234	380 lbs/hr[1]	$ 778,939	50% sulfuric acid solution, Hill Bros. 8/2011
Equipment Maintenance and Repair	$	233,000	Annual	$ 233,000	Assume 1% of constructed system cost
MVR Evaporator Total	-----	-----	-----	*$ 2,020,635*	
Landfill Disposal	$/ton	44	175 tons/day[2]	$ 2,810,500	
Subtotal Brine Concentrator, MVR, and Landfill O&M Costs	-----	-----	-----	$ 5,087,336	
Avoided Imported Water Purchases	$/AF	1,200	-----	$ (1,161,600)	Based on 1,008 - 40 = 968 AFY in increased water recovery
Annualized O&M Total (2014)				**$ 3,925,736**	
25 Year Lifecycle Cost (2014 $)					
Net Present Value (NPV) O&M Cost				$100,000,000	
NPV Lifecycle Cost				$128,000,000	
Amortized Annual Lifecycle Cost	-----	-----	-----	**$ 5,100,000**	

Notes:
(1) HPD Evaporation and Crystallization (division of Veolia Water Solutions and Technologies).
(2) Estimated based on mass of 24.1 gpm of concentrated brine at 200,000 mg/L + dried solids from 0.9 gpm of concentrated brine at 200,000 mg/L.

The opinion of probable construction cost for this alternative with the expansion of the solar PV array is $20,000,000. The annualized O&M cost is approximately $3,900,000, This cost consists of the labor costs plus brine disposal cost to the SMP less the avoided cost of imported water purchases from CMWD as a result of the approximate 968 AFY of potable water generated from this process. The energy savings from the expanded solar array helps to reduce the amortized annual lifecycle costs as compared to the alternative without solar power. The amortized annual cost over a 25 year lifecycle is approximately $5,100,000. A detailed breakdown of the lifecycle cost analysis is included in Appendix A.

2.4.3 Other Evaporator Considerations

Feedback from the equipment manufacturers generally suggest the addition of a precipitative softening process in conjunction with the RO brine concentrator to increase the TDS of the brine fed to the MVR to approximately 50,000 mg/L (vs. 10,000 mg/L as current from brine concentrator analysis). They note that doing so would significantly lower the capital cost and electrical power requirement for the system. Preliminary equipment requirements for comparable installations indicate a possible reduction in capital cost of approximately 50% and a potential reduction in electrical power consumption from 1,800 kW to approximately 600 kW (Proposal, GE Water and Process Technologies - RCC Thermal Products, June 2012, Ft. Irwin, CA). However, the use of precipitative softening would also necessarily entail the addition of a number of significant ancillary processes, including sludge handling, thickening, solids dewatering (e.g., belt filter press, plate and frame press, centrifuge, drying beds, etc.), and solids disposal beyond the quantities already noted for the MVR brine.

2.5 Evaluation of Non-Cost Criteria

This section describes non-cost criteria used to evaluate the alternatives. For each alternative, a raw score from 1 to 5 was assigned to the criteria, with 1 for the least favorable and 5 for most favorable. The basis the raw scores assigned to each alternative are described below.

2.5.1 Reliability

- <u>Alternative 1</u>: Score = 5. This option rates the most favorable given that the alternative consists of the brine pipeline and its connection to the SMP. Any issue of reliability would be attributed to unplanned SMP repair activities associated with an emergency shutdown.

- <u>Alternative 2</u>: Score = 5. This alternative is equally reliable for brine disposal as compared to Alternative 1 due to the ability to add more brine to the SMP for short-periods, if needed for RO concentrator repairs.

- <u>Alternative 3 without Solar</u>: Score = 3. Although MVR is an established technology, the addition of an MVR system adds significant mechanical complexity to the overall treatment scheme. Additional mechanical equipment is required to ensure redundancy and reliability.

- <u>Alternative 3 with Solar</u>: Score = 3. The inclusion of solar PV should not materially change the reliability of the treatment system.

2.5.2 System and Operational Complexity

- <u>Alternative 1</u>: Score = 5. This is the least complex of the alternatives.

- <u>Alternative 2</u>: Score = 5. The addition of an RO concentrator would only minimally add to the operational complexity of the overall system since it uses the same technology as the Desalter

- Alternative 3 without Solar: Score = 2. The MVR significantly increases the operational complexity of the system.

- Alternative 3 with Solar: Score = 2. The MVR significantly increases the operational complexity of the system. The inclusion of solar PV should not impact the operational complexity of the system.

2.5.3 Ease of Expandability

- Alternative 1: Score = 5. The brine line sizing is designed to accommodate future Desalter expansions. Therefore, no future modifications are needed for this alternative.

- Alternative 2: Score = 4. This alternative would require the addition of brine concentrator RO arrays to accommodate future increases in brine generation from the Desalter..

- Alternative 3 without Solar: Score = 2. Brine flow increases from future Desalter expansions would be addressed by constructing parallel MVR treatment systems. However, there could be issues with securing the additional electrical power needed to operate the expanded system.

- Alternative 3 with Solar: Score = 3. Brine flow increases from future Desalter expansions would be addressed by constructing parallel MVR treatment systems. However, the inclusion of a solar PV system lessens the impact of increased electrical demand with expansion.

2.5.4 Ability to Maximize Water Recovery to the Watershed

- Alternative 1: Score = 2. Of the three alternatives, this alternative recovers the least quantity of water.

- Alternative 2: Score = 3. This alternative increases the amount of recovered water by approximately 8%

- Alternative 3 without Solar: Score = 5. This alternative recovers the maximum recovery of water

- Alternative 3 with Solar: Score = 5. The use of solar PV would not impact the recovery of water for the treatment process.

2.5.5 Ability to Accommodate Future Regulatory Changes

- Alternative 1: Score = 3. Any changes in regulations affecting the constituents in the brine discharge would likely require the addition of alternate treatment technologies for the brine.

- Alternative 2: Score = 3. Since this alternative concentrates the existing constituents in the brine, it would likely be subject to the same requirements as Alternative 1 to address future regulatory changes.

- Alternative 3 without Solar: Score = 4. Since this alternative disposes of residuals to landfill, future regulations affecting SMP discharges would not apply to here. However, residuals from this process would be subject to future regulatory changes for landfill solids. It is assumed that any future regulatory changes to landfill solids would be less stringent that for brine discharges.

- Alternative 3 with Solar: Score = 4. The use of solar PV would not affect the impact of regulatory changes.

Section 3: Ranking of Alternatives and Sensitivity Analysis

Raw scores on a scale of 1 (least favorable) to 5 (most favorable) were assigned to each of the non-cost criteria, as described in Section 2.5. Similar raw scores were also assigned to the cost criteria. These raw scores were then weighted for a sensitivity analysis to address three weighting scenarios: equal criteria weighting, cost focused weighting, and operational focused weighting. Table 3-1 presents the findings from this analysis.

Table 3-1: Summary of Scores and Sensitivity Analysis for Brine Disposal Alternatives

Parameter	Weighting	Alt. 1 SMP Discharge	Alt. 2 Brine Concentrator + SMP Discharge	Alt. 3 Brine Evaporator + MVR + Landfill	Alt. 3 Brine Evaporator + MVR + Solar PV + Landfill
Amortized Annual Lifecycle Cost	-----	$ 552,000	$ 313,000	$ 5,200,000	$ 5,100,000
Evaluation Criteria - Raw Scoring[1]					
Cost	-----	4.0	5.0	1.0	1.0
Reliability	-----	5.0	5.0	3.0	3.0
System and Operational Complexity	-----	5.0	5.0	2.0	2.0
Ease of Expandability	-----	5.0	4.0	2.0	3.0
Ability to Maximize Water Recovery to Watershed	-----	2.0	3.0	5.0	5.0
Ability to Accommodate Future Regulatory Changes	-----	3.0	3.0	4.0	4.0
Equal Weighting					
Cost	16.7%	0.67	0.83	0.17	0.17
Reliability	16.7%	0.83	0.83	0.50	0.50
System and Operational Complexity	16.7%	0.83	0.83	0.33	0.33
Ease of Expandability	16.7%	0.83	0.67	0.33	0.50
Ability to Maximize Water Recovery to Watershed	16.7%	0.33	0.50	0.83	0.83
Ability to Accommodate Future Regulatory Changes	16.7%	0.50	0.50	0.67	0.67
Total Score - Equal Weighting	100.0%	**4.00**	**4.17**	**2.83**	**3.00**
Cost Focused Weighting					
Cost	25.0%	1.00	1.25	0.25	0.25
Reliability	15.0%	0.75	0.75	0.45	0.45
System and Operational Complexity	15.0%	0.75	0.75	0.30	0.30
Ease of Expandability	10.0%	0.50	0.40	0.20	0.30
Ability to Maximize Water Recovery to Watershed	20.0%	0.40	0.60	1.00	1.00
Ability to Accommodate Future Regulatory Changes	15.0%	0.45	0.45	0.60	0.60
Total Score - Cost Focused Weighting	100.0%	**3.85**	**4.20**	**2.80**	**2.90**
Operational Focused Weighting					
Cost	15.0%	0.60	0.75	0.15	0.15
Reliability	20.0%	1.00	1.00	0.60	0.60
System and Operational Complexity	20.0%	1.00	1.00	0.40	0.40
Ease of Expandability	10.0%	0.50	0.40	0.20	0.30
Ability to Maximize Water Recovery to Watershed	20.0%	0.40	0.60	1.00	1.00
Ability to Accommodate Future Regulatory Changes	15.0%	0.45	0.45	0.60	0.60
Total Score - Operational Focused Weighting	100.0%	**3.95**	**4.20**	**2.95**	**3.05**

Notes:
(1) Scoring range of 1 to 5 with 1 = least favorable and 5 = most favorable.

Based on this scoring methodology, Alternative 2 (i.e. addition of a brine concentrator prior to discharge to the SMP) is the most favorable alternative for all three weighting scenarios.

Section 4: Recommendations

Kennedy/Jenks recommends that the District include a 3rd Stage Brine Concentrator RO system to the Moorpark Desalter system design to reduce the net brine discharged to the SMP. The addition of a 3rd Stage Brine Concentrator RO system to reduce the brine volume provides the lowest amortized annual lifecycle cost based on the analysis in this evaluation while also increasing the amount of water that stays in the watershed and only minimally increasing the operational complexity of the overall Moorpark Desalter treatment system.

Appendix A

Detailed Analysis Tables

- 25 Year Lifecycle Cost Analysis – Alternative 1
- Reverse Osmosis Model Output for Brine Concentrator
- Opinion of Probable Construction Cost – Alternative 2
- 25 Year Lifecycle Cost Analysis – Alternative 2
- Opinion of Probable Construction Cost – Alternative 3 without Solar PV Expansion
- 25 Year Lifecycle Cost Analysis – Alternative 3 without Solar PV Expansion
- 25 Year Lifecycle Cost Analysis – Alternative 3 with Solar PV Expansion

Proposed Amendment to the Water Quality Control Plan – Los Angeles Region

to Incorporate the

Total Maximum Daily Load for Boron, Chloride, Sulfate, and TDS (Salts) in the Calleguas Creek Watershed

Adopted by the California Regional Water Quality Control Board, Los Angeles Region on October 4, 2007

Amendments

Table of Contents
Add:

Chapter 7. Total Maximum Daily Loads (TMDLs)

List of Figures, Tables, and Inserts
Add:

Chapter 7. Total Maximum Daily Loads (TMDLs)
Tables

Chapter 7. Total Maximum Daily Loads (TMDLs)
Calleguas Creek Watershed Salts TMDL

This TMDL was adopted by:

The Regional Water Quality Control Board on October 4, 2007.

This TMDL was approved by:

The State Water Resources Control Board on May 20, 2008.
The Office of Administrative Law on November 6, 2008.
The U.S. Environmental Protection Agency on December 2, 2008.

This TMDL is effective on December 2, 2008.

The elements of the TMDL are presented in Table 7-22.1 and the Implementation Plan in Table 7-22.2

Table 7-22.1. Calleguas Creek Watershed Salts TMDL: Elements

<table>
<tr><th>TMDL Element</th><th>Key Findings and Regulatory Provisions</th></tr>
<tr><td>Problem Statement</td><td>
Eleven of fourteen reaches in the Calleguas Creek Watershed (CCW) are identified on the 2002 Clean Water Act Section 303(d) list of water-quality limited segments as impaired due to elevated levels of boron, chloride, sulfate, or total dissolved solids (TDS) (these constitutions are commonly referred to as salts). Salts primarily impact two beneficial uses: agricultural supply and groundwater recharge. Below is 2002 303(d) list of water quality limited segments of the Calleguas Creek watershed:
<table>
<tr><th>Reach Name</th><th>Pollutant/Stressor</th></tr>
<tr><td>▪ Calleguas Creek Reach 3</td><td>Chloride, TDS</td></tr>
<tr><td>▪ Calleguas Creek Reach 6</td><td>Chloride, Sulfate, TDS</td></tr>
<tr><td>▪ Calleguas Creek Reach 7</td><td>Boron, Chloride, Sulfate, TDS</td></tr>
<tr><td>▪ Calleguas Creek Reach 8</td><td>Boron, Chloride, Sulfate, TDS</td></tr>
<tr><td>▪ Calleguas creek Reach 9A</td><td>Sulfate, TDS</td></tr>
<tr><td>▪ Calleguas Creek Reach 9B</td><td>Chloride, Sulfate, TDS</td></tr>
<tr><td>▪ Calleguas Creek Reach 10</td><td>Chloride, Sulfate, TDS</td></tr>
<tr><td>▪ Calleguas Creek Reach 11</td><td>Sulfate, TDS</td></tr>
<tr><td>▪ Calleguas Creek Reach 12</td><td>Sulfate, TDS</td></tr>
<tr><td>▪ Calleguas Creek Reach 13</td><td>Chloride, Sulfate, TDS</td></tr>
</table>
The list of impaired segments of the Calleguas Creek watershed in the 2002 303(d) list was maintained in the 2006 303(d) list.
The segment of Reach 4 below Laguna Road is tidally influenced and therefore not impaired for chloride, boron, sulfate, and TDS. Consequently, the waste load and load allocations developed for Reach 4 in this TMDL do not apply below Laguna Road.
The goal of this TMDL is to protect and restore the water quality in the Calleguas Creek watershed by controlling the loading and accumulation of salts.
</td></tr>
<tr><td>Numeric Targets</td><td>
Numeric targets are based on the site-specific numeric water quality objectives (WQOs) provided in the Basin Plan.
1. <u>Surface Water Quality Objectives</u>
Site-specific surface water quality objectives for the Calleguas Creek watershed are applicable upstream of Potrero Road. Site specific objectives have not been determined for Calleguas Creek below Potrero Road because the reach is tidally influenced. Below are WQOs for Calleguas Creek upstream of Potrero Road.
</td></tr>
</table>

TMDL Element	Key Findings and Regulatory Provisions
	(tables below)

Constituent	Water Quality Objective Upstream Potrero Road (mg/L)
Boron	1
Chloride	150
Sulfate	250
TDS	850

2. Groundwater Quality Objectives

Groundwater Basin[1]			Boron (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)
DWR Basin No.	**Groundwater Basin as Listed in the 1994 Basin Plan**	**Implementation Areas for Salts TMDL**				
4-6	Pleasant Valley	Conejo and Calleguas/Pleasant Valley	1.0	150	300	700
4-7	Arroyo Santa Rosa	Arroyo Santa Rosa and Conejo/Arroyo Santa Rosa	1.0	150	300	900
4-8	Las Posas Valley – East of Grimes Canyon and Hitch Blvd	Arroyo Simi/South Las Posas	3.0	400	1200	2500
4-8	Las Posas Valley – South of LA Ave between Somis Rd & Hitch Blvd	Arroyo Las Posas/South Las Posas	1.0	250	700	1500
4-8	Las Posas Valley – North Las Posas Area	Arroyo Las Posas/North Las Posas	1.0	150	250	500
4-9	Simi Valley	Arroyo Simi/Simi Valley	1.0	150	600	1200
4-10	Conejo Valley	Arroyo Conejo/Conejo Valley	1.0	150	250	800
4-15	Tierra Rejada	Arroyo Santa Rosa/Tierra Rejada	0.5	100	250	700
4-19	Thousand Oaks	Arroyo Conejo/Thousand Oaks	1.0	150	700	1400

[1] The groundwater quality objectives specified in this table are equivalent to the groundwater quality objectives in the 1994 Basin Plan. Groundwater basins are numbered in the first column according to Bulletin 118-80 (Department of Water Resources, 1980). Designated groundwater basins in the 1994 Basin Plan are specified in the second column and groundwater basin descriptions of Calleguas Creek used in this TMDL are listed in the third column of the table.

Source Analysis	Sources of salts in the watershed include water supply (water imported from the State Water Project or Freeman Diversion and deep aquifer groundwater pumping), water softeners that discharge to publicly owned treatment works (POTWs), POTW treatment chemicals, atmospheric deposition, pesticides and fertilizers, and indoor water use (chemicals, cleansers, food, etc.). These salts are then transported through POTW discharges and runoff to surface water, shallow groundwater, and/or stranded on the watershed in the soils. Salts transported in the surface water to the ocean are currently the only salts

TMDL Element	Key Findings and Regulatory Provisions
	that are exported from the watershed. While the concentration of salts in the introduced water is usually below the Basin Plan Objectives, the quantity of water brought into the watershed is sufficient to rank introduced water as the greatest source of salts to the watershed. Salts that are transported during dry weather to the surface water are quantified via the following mechanisms: groundwater pumping, groundwater exfiltration, POTWs, dry weather urban and agricultural runoff. Wet weather loadings from each of these sources have the potential to be significant, but tend to be lower in concentration and do not occur during the critical conditions for salts. Wet weather loads are significant from the perspective of transporting stranded salts off the watershed.
Linkage Analysis	The linkage analysis for salts focuses on the surface water concentrations of salts. However, surface water concentrations are only one component of the watershed salts issue. Because it is difficult to model other aspects of the salt problem (i.e. surface water and groundwater interactions, stranded salts), two simplified approaches have been used to demonstrate that salts will be removed from the watershed, which should have a correspondingly positive impact on surface water and groundwater salts concentrations. First, a surface water model was developed to provide a linkage between sources and surface water quality and to demonstrate the impact of projects on receiving water quality in the watershed. Second, a salt balance was developed to quantify the removal of salts from the watershed with the goal of achieving a mass balance in which the mass of boron, sulfate, TDS and chloride imported into Calleguas Creek subwatersheds is no more than the mass of boron, sulfate, TDS and chloride exported from the Calleguas Creek subwatershed. Achieving a salt balance in the watershed will prevent additional build-up of salts in any medium in the watershed and protect ground water supplies from increasing in salt concentrations. The Calleguas Creek Modeling System is a mass balance based model that was developed for the surface water to provide a linkage between sources and surface water quality. To estimate the salts balance in the watershed, a simple chloride mass balance was developed by the Camrosa Water District (Hajas, 2003a) and modified to address the other salts.

TMDL Element	Key Findings and Regulatory Provisions
Waste Load Allocations	**A. POTWs** The TMDL includes waste load allocations (WLAs) for five POTWs in the Calleguas Creek watershed: Simi Valley Water Quality Control Plant (WQCP), Hill Canyon Wastewater Treatment Plan (WWTP), Moorpark WWTP, Camarillo Water Reclamation Plant (WRP), and Camrosa Water Reclamation Facility (WRF). At the end of the implementation period, only Simi Valley WQCP and the Hill Canyon WWTP are expected to discharge to surface waters. Moorpark WWTP and Camrosa WRF currently discharge directly to ponds under dry weather conditions. As part of the TMDL implementation, the Renewable Water Resources Management Program (RWRMP) will introduce treated wastewater from the Camarillo WRP into the Camrosa recycled water storage and distribution system. Surplus treated wastewater from Camarillo WRP and Camrosa WRF will be discharged at a point downstream of Potrero Road Bridge to Calleguas Creek. Dry weather WLAs are included for the case when Camarillo WRP, Camrosa WRF, and Moorpark WWTP need to discharge to the stream (for example, if there is insufficient recycled water demand during the wet season). Including WLAs for these POTWs ensures that water quality objectives are not exceeded as a result of their discharge. POTW mass-based WLAs are calculated as the POTW effluent flow rate multiplied by the water quality objective and include a mass-based adjustment factor (AF) that is subtracted from the product of the flow-rate and the water quality objective. The adjustment factor is used to link POTW allocations to the required reductions in background loads. The adjustment factors are implemented through mechanisms that export salts out of the subwatershed, such as groundwater pumping, to meet the salt balance requirements. To ensure that the loading capacity is achieved in surface water and the reductions in background loads are achieved, minimum salt exports shown below are required for POTWs and are included in WLAs as a component of the adjustment factors. If the background load reductions are not achieved, POTWs shall be responsible for providing additional load reductions to achieve water quality standards. The AF is set equal to the difference between the minimum salts export requirement to attain a salt balance in the subject reaches and the actual salts export. If the calculated annual dry weather salt exports from the subwatershed to which the POTW discharges are less than the minimum required exports for the previous year and the annual average receiving water concentration at the base of the subwatershed to which the POTW discharges exceeds water quality objectives for the previous year, the POTW allocations will be reduced using the adjustment factor.

TMDL Element	Key Findings and Regulatory Provisions
	The adjustment factors are also used to address unusual conditions in which the inputs to the POTWs from the water supply may challenge the POTWs ability to meet the assigned WLAs. The adjustment factor allows for the additional POTW loading only when the water quality objectives are met in the receiving waters. POTW allocations can be adjusted upwards when imported water supply chloride concentrations exceed 80 mg/L and discharges from the POTW exceed the WLA. In order to apply the AF to the assigned WLAs, the POTW is required to submit documentation of the water supply chloride concentrations, receiving water chloride concentration, the effluent mass, and evidence of increased salt exports to offset the increased discharges from the POTW to the RWQCB for approval. WLAs shown in table below apply to POTWS during dry weather when the flows in the receiving water are below the 86th percentile flow. During wet weather, the loading capacity of the stream is significantly increased by stormwater flows with very low salt concentrations. Any discharges from the POTWs during wet weather would be assimilated by these large storm flows and would not cause exceedances of water quality objectives. Boron is only listed in the Simi and Pleasant Valley (Revolon) subwatersheds and exceedances of boron do not occur in other portions of the watershed. Therefore, boron allocations are only included for the Simi Valley WQCP. Interim limits are included to allow time for dischargers to put in place implementation measures necessary to achieve final waste load allocations. The monthly average interim limits are set equal to the 95th percentile of available discharge data.

1. Minimum Salt Export Requirements for Adjustment Factor [a]

POTW	Minimum Chloride Export (lb/day)	Minimum TDS Export (lb/day)	Minimum Sulfate Export (lb/day)	Minimum Boron Export (lb/day)
Simi Valley WQCP	460	3220	9120	3.3
Moorpark WWTP	460	3220	9120	3.3
Hill Canyon WWTP	1060	7920	4610	0
Camrosa WRF	1060	7920	4610	0
Camarillo WRP	1060	7920	4610	0

[a] Minimum export requirements include a 10% Margin of Safety.

TMDL Element	Key Findings and Regulatory Provisions
	(continued below)

2. Interim Monthly Average WLAs for POTWs

POTW	Chloride (mg/L)	TDS (mg/L)	Sulfate (mg/L)	Boron (mg/L)
Simi Valley WQCP	183	955	298	N/A
Hill Canyon WWTP	189	N/A	N/A	N/A
Moorpark WWTP	171	N/A	267	N/A
Camarillo WRP	216	1012	283	N/A
Camrosa WRF*	N/A	N/A	N/A	N/A

* Camrosa WRF has not discharged to surface water during the period under which interim limits were calculated. When effluent data are available, the Regional Board may adopt interim WLAs for Camrosa WRF.

N/A: The 95th percentile concentration is below the Basin Plan objective so interim limits are not necessary.

3. Final WLAs for POTWs[a,d]

POTW	Chloride (lb/day) [c]	TDS (lb/day) [c]	Sulfate (lb/day) [c]	Boron (lb/day) [c]
Simi Valley WQCP	150*Q-AF	850*Q-AF	250*Q-AF	1.0*Q-AF
Hill Canyon WWTP	150*Q-AF	850*Q-AF	250*Q-AF	N/A
Moorpark WWTP[b]	150*Q-AF	850*Q-AF	250*Q-AF	N/A
Camarillo WRP[b]	150*Q-AF	850*Q-AF	250*Q-AF	N/A
Camrosa WRF[b]	150*Q-AF	850*Q-AF	250*Q-AF	N/A

a. The allocations shown only apply during dry weather (as defined in this TMDL). During wet weather discharges from the POTWs do not cause exceedances of water quality objectives.

b. These POTWs are not expected to discharge after the end of the implementation period.

c. AF is the adjustment factor and equals the difference between the minimum salts export requirement and the actual salts export.

d. Q represents the POTW flow at the time the water quality measurement is collected and a conversion factor to lb/day based on the units of measurement for the flow.

N/A Boron is not listed in the reaches to which the POTW discharges. No WLA is required.

B. Urban Runoff

Permitted stormwater dischargers that are responsible parties to this TMDL include the Municipal Stormwater Dischargers (MS4s) of the Cities of Camarillo, Moorpark, Thousand Oaks, County of Ventura, Ventura County Watershed Protection District, and general industrial and construction permittees. Permitted stormwater dischargers are assigned a dry weather wasteload allocation equal to the average dry weather critical condition flow rate multiplied by the numeric target for each constituent. Waste load allocations apply in the receiving water at the base of each subwatershed. Because wet weather flows transport a large mass of salts at low concentrations, these dischargers meet water

TMDL Element	Key Findings and Regulatory Provisions
	quality objectives during wet weather. Dry weather allocations apply when instream flow rates are below the 86th percentile flow and there has been no measurable precipitation in the previous 24 hours.
	Interim limits are assigned for dry weather discharges from areas covered by NPDES stormwater permits to allow time to implement appropriate actions. The interim limits are assigned as concentration based receiving water limits set to the 95th percentile of the discharger data as a monthly average limit except for chloride. The 95th percentile for chloride was 267 mg/L which is higher than the recommended criteria set forth in the Basin Plan for protection of sensitive beneficial uses including aquatic life. Therefore, the interim limit for chloride for Permitted Stormwater Dischargers is set equal to 230 mg/L to ensure protection of sensitive beneficial uses in the Calleguas Creek watershed.

1. Interim Dry Weather WLAs for Permitted Stormwater Dischargers

Constituent	Interim Limit (mg/L)
Boron Total	1.3
Chloride Total	230
Sulfate Total	1289
TDS Total	1720

2. Final Dry Weather WLAs for Permitted Stormwater Dischargers

Subwatershed	Critical Condition Flow Rate (mgd)	Chloride Allocation (lb/day)	TDS Allocation (lb/day)	Sulfate Allocation (lb/day)	Boron Allocation (lb/day)
Simi	1.39	1,738	9,849	2,897	12
Las Posas	0.13	157	887	261	N/A
Conejo	1.26	1,576	8,931	2,627	N/A
Camarillo	0.06	72	406	119	N/A
Pleasant Valley (Calleguas)	0.12	150	850	250	N/A
Pleasant Valley (Revolon)	0.25	314	1,778	523	2

<table>
<tr><th>TMDL Element</th><th>Key Findings and Regulatory Provisions</th></tr>
<tr><td></td><td>

<u>**C. Final WLAs for Other NPDES Dischargers**</u>
Concentration-based WLAs are assigned at the Basin Plan objectives for other NPDES dischargers.

<table>
<tr><th>Constituent</th><th>Allocation (mg/L)</th></tr>
<tr><td>Chloride</td><td>150</td></tr>
<tr><td>TDS</td><td>850</td></tr>
<tr><td>Sulfate</td><td>250</td></tr>
<tr><td>Boron[a]</td><td>1.0</td></tr>
</table>

Other NPDES dischargers include, but are not limited to, permitted groundwater cleanup projects that could have significant salt concentrations as a result of the stranded salts in the shallow groundwater basins being treated. To facilitate the cleanup of the basins prior to alternative discharge methods (such as the brine line) being available, interim limits for other NPDES dischargers will be developed on a case-by-case basis and calculated as a monthly average using the 95th percentile of available discharge data.

</td></tr>
<tr><td>**Load Allocations**</td><td>

Dry weather load allocations are assigned as a group allocation to irrigated agricultural discharges. The load allocation (LA) is equal to the average dry weather critical condition flow rate multiplied by the numeric target for each constituent. Load allocations apply in the receiving water at the base of each subwatershed. Because wet weather flows transport a large mass of salts at a typically low concentration, these dischargers should meet water quality objectives during wet weather. Dry weather allocations apply when instream flow rates are below the 86th percentile flow and there has been no measurable precipitation in the previous 24 hours.

Interim limits are assigned for dry weather discharges from irrigated agricultural areas to allow time to implement appropriate actions. The interim limits are assigned as concentration based receiving water limits set to the 95th percentile of the discharger data as a monthly average limit except for chloride. The 95th percentile for chloride was 499 mg/L which is higher than the recommended criteria set forth in the Basin Plan for protection of sensitive beneficial uses including aquatic life. Therefore, the interim limit for chloride for Irrigated Agricultural Dischargers is set equal to 230 mg/L to ensure protection of sensitive beneficial uses in the Calleguas Creek watershed.

</td></tr>
</table>

TMDL Element	Key Findings and Regulatory Provisions
	I. Interims Load Allocations for Irrigated Agricultural Dischargers

Constituent	Interim Limit (mg/L)
Boron Total	1.8
Chloride Total	230
Sulfate Total	1962
TDS Total	3995

II. Final Load Allocations for Irrigated Agricultural Dischargers

Subwatershed	Chloride Allocation (lb/day)	TDS Allocation (lb/day)	Sulfate Allocation (lb/day)	Boron Allocation (lb/day)
Simi	641	3,631	1,068	4
Las Posas	2,109	11,952	3,515	N/A
Conejo	743	4,212	1,239	N/A
Camarillo	59	336	99	N/A
Pleasant Valley	305	1,730	509	N/A
Revolon	7,238	41,015	12,063	48

TMDL Element	Key Findings and Regulatory Provisions
Margin of Safety	A margin of safety (MOS) for the TMDL is designed to address uncertainties in the analysis that could result in targets not being achieved in the waterbodies. The primary uncertainties associated with this TMDL include the impact of implementing a salt balance on receiving water quality. The effect of the salt balance is estimated by the mass-balance and subject to the following uncertainties: 1) the flow rates used to determine the loading capacity may change due to TMDL implementation, 2) the use of a daily load for determining allocations and an annual mass balance to attain water quality objectives, and 3) the sources of salts may not be completely known. Both implicit and explicit MOS are included for this TMDL. The implicit MOS stems from the use of conservative assumptions made during development of the TMDL. The mass of salts transported out of the watershed during wet weather is on average over 15% of the annual mass of salts introduced to the watershed for all constituents. The salt export during wet weather ranges from 7% to 41% for TDS, 9% to 48% for chloride, and 13% to 89% for sulfate of the export required to meet a salt balance in the watershed. This mass is not used to determine compliance with the salt balance and represents a significant implicit margin of safety. The model also contains a component that serves to model the impact of "stranded" salts in the watershed. The component assumes low irrigation efficiencies and the ability of all salts applied as irrigation water anywhere in the watershed to be discharged to receiving water in

TMDL Element	Key Findings and Regulatory Provisions
	critical years. This likely overestimates the impact of "stranded" salts and results in a higher concentration of salts due to irrigation in the receiving water. An explicit MOS of 10% is applied to the adjustment factors for the POTWs to account for the uncertainties in the TMDL analysis. By applying the margin of safety to the adjustment factor, more salts are required to be exported than are necessary to offset the background loads in the watershed. This additional salt export provides a margin of safety on the salt balance to address uncertainties that the salt balance will result in compliance with water quality objectives. The 10% explicit MOS is determined sufficient to address the uncertainties associated with the estimated impact of the salt balance on receiving water loadings.
Future Growth	Ventura County accounts for slightly more than 2% of the state's residents with a population of 753,197 (US Census Bureau, 2000). GIS analysis of the 2000 census data yields a population estimate of 334,000 for the CCW, which equals about 44% of the county population. According to the Southern California Association of Governments (SCAG), growth in Ventura County averaged about 51% per decade from 1900-2000; with growth exceeding 70% in the 1920s, 1950s, and 1960s. Significant population growth is expected to occur within and near present city limits until at least 2020. Increased growth requires additional water. Therefore, future growth could result in increased loads of salts being imported into the watershed. However, the TMDL implementation plan is designed to maintain a salts balance in the watershed. If additional salts are imported into the watershed, a larger volume of salts will also be exported out of the watershed to maintain the balance. Consequently, increased imports from future growth are not expected to result in higher concentrations in receiving waters.
Seasonal Variations and Critical Conditions	The critical condition for salts is during dry weather periods. During wet weather, stormwater flows dilute the salt discharges and receiving water concentrations are significantly lower than water quality objectives. Dry weather, defined as days with flows lower than the 86th percentile flow and no measurable precipitation, is a critical condition regardless of the dry weather flows in the stream. The driving conditions for exceedances of water quality objectives are the concentrations in the water supply (which is driven by surface water concentrations in Northern California) and the previous year's annual precipitation and corresponding flows. Elevated salts concentrations during dry weather occur when stranded salts are discharged into the surface water after higher than average rainfall years. The elevated concentrations occur during years when the previous annual flow is

TMDL Element	Key Findings and Regulatory Provisions
	greater than the 75th percentile of the annual flows for the watershed (critical year). The higher concentrations occur during the dry periods of critical years regardless of whether the annual flow for the critical year is an average flow year, higher than average year, or lower than average year. The key parameter determining a critical year is the total annual flow volume for the previous year. Based on model results, four critical years were defined based on modeled results that resulted in receiving water concentrations greater than the 99th percentile concentration during at least 10% of the dry period. The critical years identified from the model occur with conditions similar to what occurred in 1978, 1979, 1983 and 1998.
Special Studies and Monitoring Plan	**Special Studies** Several special studies are planned to improve understanding of key aspects related to achievement of WLAs and LAs for the Salts TMDL. ***1. Special Study #1 (Optional) – Develop Averaging Periods and Compliance Points*** The TMDL technical report has provided information that shows instantaneous salts objectives may not be required to protect groundwater recharge and agricultural beneficial uses. It is possible that the beneficial uses will be protected and a salt balance achieved without achieving instantaneous water quality objectives in all reaches of the watershed. This optional special study is included to allow an investigation of averaging periods for the salts objectives in the CCW. Additionally, this study will investigate the locations of beneficial uses and the possibility of identifying compliance points for the salts objectives at the point of beneficial use impacts. The use of compliance points would alleviate the need to develop site-specific objectives for the reaches of the watershed upstream of the POTW discharges (described in Special Study #3) while still ensuring the protection of beneficial uses. Sensitive beneficial uses are not present in the upper reaches and POTW discharges dilute the salts from the upper reaches and may allow compliance with the objectives at the point of groundwater recharge downstream. This is an optional special study to be conducted if desired by the stakeholders or determined necessary or appropriate by the Executive Officer. ***2. Special Study #2 (Optional) – Develop Natural Background Exclusion*** Discharges of groundwater from upstream of the Simi Valley WQCP (Reaches 7 and 8) and Hill Canyon WWTP (Reaches 12 and 13) and

TMDL Element	Key Findings and Regulatory Provisions
	downstream of the Camrosa WRF (Reach 3) contain high salts concentrations. Natural marine sediments may contribute to the high concentrations in those discharges. This special study would evaluate whether or not the groundwater discharges in these areas would qualify for a natural sources exclusion. The special study could follow a 'reference system/anti-degradation approach' and/or a 'natural sources exclusion approach' for any allocations included in this TMDL that are proven unattainable due to the magnitude of natural sources. The purpose of a 'reference system/anti-degradation approach' is to ensure water quality is at least as good as an appropriate reference site and no degradation of existing water quality occurs where existing water quality is better than that of a reference site. The intention of a 'natural sources exclusion approach' is to ensure that all anthropogenic sources of salts are controlled such that they do not cause exceedances of water quality objectives. These approaches are consistent with state and federal anti-degradation policies (State Board Resolution No. 68-16 and 40 C.F.R. 131.12). This is an optional special study to be conducted if desired by the stakeholders or determined necessary for establishing a natural sources exclusion by the Executive Officer. ***3. Special Study #3 (Optional) – Develop Site-Specific Objectives*** The TMDL implementation plan provides for actions to protect the agricultural and groundwater recharge beneficial uses in the CCW. As shown in the linkage analysis, some downstream reaches may not achieve the water quality objectives through implementation of this TMDL because of the transport of salts out of the watershed through those reaches. Consequently, an optional special study is included to allow the CCW stakeholders to pursue development of site-specific objectives for salts for reaches upstream of the Hill Canyon WWTP and Simi Valley WQCP (Reaches 7, 8, 12, and 13), Calleguas Creek Reach 3, Revolon Slough (Reach 4) and Beardsley Wash (Reach 5). These alternative numeric water quality objectives would be developed based on the beneficial uses to be protected in a reach and the attainability of the current water quality objectives. This is an optional special study to be conducted if desired by the stakeholders or determined necessary or appropriate by the Executive Officer. ***4. Special Study #4 (Optional) – Develop Site-Specific Objectives for Drought Conditions*** During drought conditions, the load of salts into the watershed increases as a result of increasing concentrations in imported water. Stakeholders in the CCW cannot control the increased mass entering the watershed from the water supply. However, the stakeholders do have the ability to

TMDL Element	Key Findings and Regulatory Provisions
	manage the salts within the watershed to protect beneficial uses and export the additional mass of salts out of the watershed. If necessary, site-specific objectives may be developed to address situations that result in higher imported water salt concentrations to allow management of the salts and protection of beneficial uses. This special study may be combined with Special Study #3 if desired. This is an optional special study to be conducted if desired by the stakeholders or determined necessary or appropriate by the Executive Officer of the Regional Board. ***5. Special Study #5 (Optional) – Develop Site-Specific Objectives for Sulfate*** Sulfate is a necessary nutrient for plant growth and sulfate containing products are often applied to agriculture as fertilizers and pesticides. Therefore, site-specific objectives may be investigated and developed for sulfate that more accurately protects agricultural supply beneficial uses. Additionally, this study could evaluate whether or not a sulfate balance is necessary to maintain in the watershed. This special study may be combined with Special Study #3 and/or #4 if desired. This is an optional special study to be conducted if desired by the stakeholders or determined necessary or appropriate by the Executive Officer of the Regional Board. **<u>Monitoring Plan</u>** To ensure that the goal of a salts balance in the watershed is being achieved and water quality objectives are being met, a comprehensive method of tracking inputs and outputs to the watershed will be developed. A monitoring plan will be submitted to the RWQCB for Executive Officer approval within six months of the effective date of the CCW Salts TMDL. Monitoring will begin one year after Executive Officer approval of the monitoring plan to allow time for the installation of automated monitoring equipment. ***1. Input Tracking*** Inputs to the watershed are tracked through four mechanisms:1) Information on the import of State Water Project water is readily available and provides information on the mass of salts brought into the watershed; 2) Groundwater pumping records provide information on the mass of salts imported into the watershed from deep aquifer pumping; 3) Import records of water supply form the Santa Clara River can be obtained to determine the mass of salts imported through this source; 4) Monitoring data on imported water quality can be compared to

TMDL Element	Key Findings and Regulatory Provisions
	monitoring of effluent quality to estimate the amount of salts added through human use of the water. ***2. Output Tracking and Determining Compliance with Water Quality Objectives*** Outputs from the watershed will be tracked through surface water monitoring at key locations in the watershed and monitoring of discharges to the brine line. Monitoring will include both flow and quality. Compliance with water quality objectives will be determined at key locations where beneficial uses occur in the watershed. The stations used for output tracking will also be used to determine compliance with water quality objectives. The monitoring program will determine if the TMDL compliance points are protective of the beneficial uses for the subwatershed. If the monitoring determines that the compliance points are not protective of beneficial uses, an alternative compliance point will be selected. The Executive Officer may revise the TMDL compliance point based on the result of the monitoring. Additionally, if other places in the watershed are identified where sensitive beneficial uses occur, water quality monitoring stations can be added to determine compliance with water quality objectives. For the RWRMP, three new or upgraded automated flow measuring and sample collection stations will be installed at three points on the stream system to continuously record flow and various water quality parameters during dry weather. Preliminary monitoring locations include Arroyo Conejo in Hill Canyon, Conejo Creek at Baron Brothers Nursery and Calleguas Creek at University Drive. For the NRRWMP, one new or upgraded automated flow measuring and sample collection station will be added downstream of Simi Valley at the point at which groundwater recharge begins. A preliminary monitoring location is at Hitch Blvd. where an existing flow gauging station exists. However, the amount of groundwater recharge upstream of this site will need to be evaluated to determine the exact monitoring location. For Revolon Slough, the existing monitoring station at Wood Road. will be used to monitor quality and flow on Revolon Slough to determine the outputs from the Revolon portion of the Pleasant Valley subwatershed. Additional land use monitoring will be conducted concurrently at representative agricultural and urban runoff discharge sites as well as at POTWs in each of the subwatersheds and analyzed for chloride, TDS, sulfate, and boron. The location of the land use stations will be determined before initiation of the Calleguas Creek Watershed TMDL Monitoring Program (CCWTMP). All efforts will be made to include at least two wet weather sampling events during the wet season (October through April) during a targeted storm event.

TMDL Element	Key Findings and Regulatory Provisions
	3. Reporting and Modification of the Calleguas Creek Watershed TMDL Monitoring Program A monitoring report will be prepared annually within six months after completion of the final event of the sampling year. An adaptive management approach to the CCWTMP will be adopted as it may be necessary to modify aspects of the CCWTMP. Results of sampling carried out through the CCWTMP and other programs within the CCW may be used to modify this plan, as appropriate. These modifications will be summarized in the annual report. Possible modifications could include, but are not limited to the, following: ▪ The inclusion of additional land use stations to accurately characterize loadings; ▪ The removal of land use stations if it is determined they are duplicative (***i.e.,*** a land use site in one subwatershed accurately characterize the land use in other subwatersheds); ▪ The inclusion of additional in-stream sampling stations; and ▪ The elimination of analysis for constituents no longer identified in land use and/or instream samples. If a coordinated and comprehensive monitoring plan is developed and meets the goals of this monitoring plan that plan should be considered as a replacement for the CCWTMP. ***4. Other Monitoring*** Other surface water and groundwater monitoring will be implemented as necessary to assess the impacts of the implementation actions and adjust the activities as necessary to protect beneficial uses and achieve the salts balance. Examples of additional monitoring that may be conducted include: ▪ Monitoring under Phase 2 and 3 of the RWRMP to evaluate the effects of replenishment water releases and groundwater treatment and releases. ▪ Monitoring to assess the impacts of management of the Simi Basin groundwater dewatering wells under Phase 1 of the NRRWMP.
Implementation Plan	The identified implementation actions provided in this TMDL will result in a salt balance in the stream and are expected to result in compliance with the allocations. The implementation plan is comprised of actions that directly impact discharges to the receiving water and actions that will indirectly impact discharges to receiving water. Responsible agencies and jurisdictions shall consider minimum flow

TMDL Element	Key Findings and Regulatory Provisions
	requirements that may be imposed by federal or state regulatory agencies when implementing actions to comply with this TMDL. Should the proposed implementation actions not result in compliance with objectives and site-specific objective are not adopted, additional implementation actions may be required to achieve the water quality objectives. Any plans or programs for implementation of the TMDL for the Southern Reaches of the CCW upstream of the Conejo Creek Diversion and the Northern Reaches of the CCW, that would result in significant reduction in instream flow, including but not limited to, an application for Water Reclamation Requirements (WRRs) shall include an analysis of potential impacts to instream beneficial uses that could result from the reclamation of wastewater or extracted groundwater. For Phase 1 of the Southern Reaches of the CCW Renewable Water Resource Management Program (RWRMP), Water Rights Decision 1638 from SWRCB satisfies these requirements and establishes the minimum flow requirements for Conejo and Calleguas Creek downstream of the Conejo Creek Diversion Project. Any WRRs shall require that timely written notice be given to the Regional Board, and to any regulatory agency whose instream flow is at issue, if diversion or reclamation of waste water or extraction of groundwater results or threatens to result in (or contributes to) insufficient flows to maintain beneficial uses. The Executive Officer shall issue an order pursuant to Water Code section 13267, which requires responsible agencies and jurisdictions to file a technical report if reclamation of waste water or extraction of groundwater results or threatens to result in (or contributes to) insufficient flows to maintain beneficial uses. The order shall require that the technical report identify the causes of the impairments or threatened impairments, and identifies options to abate the conditions. The Regional Board shall reconsider this TMDL if adequate flows to protect instream beneficial uses are not maintained. The implementation actions described in the TMDL represent a range of activities that could be conducted to achieve a salts balance in the watershed. Future considerations may result in other actions being implemented rather than the options presented. However, any proposed actions will be reviewed using the salt balance model to ensure the action does not adversely impact other implementation actions in the watershed or the salt balance of a downstream subwatershed. Currently, the implementation plan is presented in phases with a tentative schedule for each phase. The implementation of projects may occur earlier than planned or begin during an earlier phase. Additionally, many of the implementation actions require the use of the Regional Salinity Management Conveyance (RSMC or brine line). As such, the implementation schedule for those actions will be linked the

TMDL Element	Key Findings and Regulatory Provisions
	construction schedule for the RSMC. The implementation plan for the Salts TMDL includes regional and subwatershed specific implementation actions. There are four key structural elements to the regional implementation: Regional Salinity Management Conveyance (RSMC), Water Conservation, Water Softeners, and Best Management Practices for Irrigated Agriculture. Subwatershed implementation includes Renewable Water Resource Management Program (RWRMP) for the Southern Reaches and Northern Reach Renewable Water Management Plan (NRRWMP). Detailed discussion for each implementation element including description of the action, status and schedule for implementing the action, and a summary of the expected contribution to achievement of the salts balance are provided in the Staff Report and Technical Report for this TMDL. Proposed implementation actions in the watershed, responsible agencies, and the estimated completion date based on the effective date of the TMDL are summarized below. **Summary of Proposed Implementation Actions**

Action	Responsible Agency/ies	Schedule for Completion
Water Conservation	POTWs, Permitted Stormwater Dischargers, and Other NPDES Permittees	3 years
Water Softeners	POTWs and Permitted Stormwater Dischargers	10 years
Best Management Practice for Agricultural Dischargers	Agricultural Dischargers	2 years
RMSC Phase 1	Calleguas Municipal Water District	2 year
RMSC Phase 2	Calleguas Municipal Water District	5 year
RMSC Phase 3	Calleguas Municipal Water District	10 years
RWRMP Phase 1	CamrosaWater District, Camarillo Sanitation District	3 years
RWRMP Phase 2	Camrosa Water District, City of Thousand Oaks	6 years
RWRMP Phase 3	Camrosa Water District, City of Thousand Oaks	10 years
RWRMP Phase 4	To Be Determined	15 years
NRRWMP Phase 1	Calleguas Municipal Water District, City of Simi Valley, Ventura County Water Work-District No.1	3 years
NRRWMP Phase 2	Calleguas Municipal Water District, Ventura County Water Work-District No.1, City of Camarillo	7 years
NRRWMP Phase 3	City of Camarillo, City of Simi Valley	10 years
NRRWMP Phase 4	To Be Determined	15 years
Final Completion Date		15 years

TMDL Element	Key Findings and Regulatory Provisions
	The sections below provide discussion of the application of the final WLAs for POTWs, specific permitted stormwater discharges, other NPDES dischargers, and agricultural dischargers. **I. POTWs, permitted stormwater discharges, and other NPDES discharges** The final WLAs will be included for permitted stormwater discharges, POTWs, and other NPDES discharges in accordance with the compliance schedules provided in Table 7-22.2. The Regional Board may revise these WLAs based on additional information developed through special studies and/or monitoring conducted as part of this TMDL. ▪ **POTWs** WLAs established for the POTWs in this TMDL will be implemented through NPDES permit limits. Compliance will be determined through monitoring of final effluent discharge as defined in the NPDES permit. The proposed permit limits will be applied as end-of-pipe mass-based monthly average effluent limits. Daily maximum effluent limit is not required because chloride is not expected to have an immediate or acute effect on the beneficial uses. Compliance with the minimum salt export requirements for POTWs will be based on the salt export from the subwatershed to which they discharge. The mechanisms for meeting the minimum salt export requirements and for monitoring progress towards meeting those requirements will be included in the monitoring program work plan and approved by the Executive Officer. At the end of each year, the amount of salt exported will be compared to the minimum required salt export. POTW allocations will be reduced using the adjustment factor if both of the following conditions occur: • The annual dry weather salt exports from the subwatershed to which the POTW discharges are below the minimum required exports for the previous year; and • The water quality objectives were exceeded in the receiving water at the base of the subwatershed The POTW allocations will be reduced for the following year by

TMDL Element	Key Findings and Regulatory Provisions
	the difference between the minimum required salt export and the actual amount exported. The discharger shall be notified by the Regional Board that the assigned WLAs are reduced and the reduced effluent limits shall be applied for the next year. If the POTW allocations are reduced, the POTW will need to increase the amount of salt export or reduce the mass of salts discharged from the POTW before the end of the following year when the adjustment will be evaluated again. POTWs can only request to adjust the assigned WLAs upwards using the adjustment factor under limited conditions provided below: • Water quality objectives are met in the receiving waters; • Imported water supply chloride concentrations exceed 80 mg/L; and • Discharges from the POTW exceed the allocation. When imported water supply chloride concentrations exceed 80 mg/L, the POTW will monitor the effluent to determine if the wasteload allocation is exceeded. If the wasteload allocation is exceeded and the POTW desires an adjustment to the allocation, the POTW will submit documentation of the water supply chloride concentrations, the receiving water chloride concentration, the effluent mass, and the evidence of increased salt exports to offset the increased discharges from the POTW to the Regional Board for approval. The adjustment factor will apply for three months and the POTW must submit the evidence outlined above every three months to keep the adjustment factor active. As long as the required information is submitted, the adjustment factor will be in effect upon notification in writing from the RWQCB. ▪ **Urban Stormwater Discharger** A group mass-based dry weather WLA has been developed for all permitted stormwater discharges, including municipal separate storm sewer systems (MS4s), and general industrial and construction stormwater permits. USEPA regulation allows allocations for NPDES-regulated stormwater discharges from multiple point sources to be expressed as a single categorical WLA when the data and information are insufficient to assign each source or outfall individual WLAs (40 CFR 130). The grouped allocation will apply to all NPDES-regulated municipal stormwater discharges in the CCW. MS4 WLAs will be incorporated into the NPDES

TMDL Element	Key Findings and Regulatory Provisions
	permit as receiving water limits measured in-stream at the base of each subwatershed. ▪ **Other NPDES Dischargers** WLAs established for other NPDES permitted dischargers in this TMDL, including minor non-stormwater permittees (other than Camrosa WRP) and general non-stormwater permittees, will be implemented through NPDES permit limits. The proposed permit limits will be applied as end-of-pipe concentration-based effluent limits, and compliance determined through monitoring of final effluent discharge as defined in the NPDES permit. **II. Agriculture** Load allocations for salts will be implemented through Conditional Waiver of Discharges from Irrigated Lands (Conditional Waiver Program) adopted by the LARWQCB on November 3, 2005. Compliance with LAs will be measured in-stream at the base of the subwatersheds and will be achieved through the implementation of Best Management Practices (BMPs) consistent with the Conditional Waiver Program. The Conditional Waiver Program requires the development of an agricultural water quality management plan (AWQMP) to address pollutants that are exceeding receiving water quality objectives as a result of agricultural discharges. Therefore, implementation of the load allocations will be through the development of an agricultural management plan for salts. Implementation of the load allocations will also include the coordination of BMPs being implemented under other required programs to ensure salts discharges are considered in the implementation. Additionally, agricultural dischargers will participate in educational seminars on the implementation of BMPs as required under the Conditional Program. Studies are currently being conducted to assess the extent of BMP implementation and provide information on the effectiveness of BMPs for agriculture. This information will be integrated into the AWQMP that will guide the implementation of agricultural BMPs in the Calleguas Creek watershed. After implementation of these actions, compliance with the allocations and TMDL will be evaluated and the allocations reconsidered if necessary based on the special studies and monitoring plan section of the implementation plan. As shown in Table 7-22.2, implementation of LAs will be conducted over a period of time to allow for implementation of the BMPs, as well as coordination with special studies and

TMDL Element	Key Findings and Regulatory Provisions
	implementation actions resulting from other TMDL Implementation Plans (Nutrient, Historic Pesticides and PCBs, Sediment, Metals, Bacteria, etc.).

Table 7-22.2 Calleguas Creek Watershed Salts TMDL: Implementation Schedule

Item	Implementation Action	Responsible Party	Completion Date
1	Effective date of interim Salts TMDL waste load allocations (WLAs)	POTWs, Permitted Stormwater Dischargers[1] (PSD), and Other NPDES Permittees	Effective date of the amendment
2	Effective date of interim Salts TMDL load allocations (LAs)	Agricultural Dischargers	Effective date of the amendment
3	Responsible jurisdictions and agencies shall submit compliance monitoring plan to the Los Angeles Regional Board for Executive Officer approval.	POTWs, PSD, Other NPDES Permittees, and Agricultural Dischargers	6 months after effective date of the TMDL
4	Responsible jurisdictions and agencies shall begin monitoring as outlined in the approved monitoring plan.	POTWs, PSD, Other NPDES Permittees, and Agricultural Dischargers	1 year after monitoring plan approval by Executive Officer
5	Responsible jurisdictions and agencies shall submit workplans for the optional special studies.	POTWs, PSD, Other NPDES Permittees, and Agricultural Dischargers	Within 10 years of effective date of the TMDL
6	Responsible jurisdictions and agencies shall submit results of the special studies.	POTWs, PSD, Other NPDES Permittees, and Agricultural Dischargers	2 years after workplan approval by Executive Officer
7	Re-evaluation of the interim WLAs and interim LAs for boron, chloride, sulfate, and TDS based on new data. Responsible jurisdictions and agencies shall demonstrate that implementation actions have reduced the boron, sulfate, TDS, and chloride imbalance by 20%.	POTWs, PSD, Other NPDES Permittees, and Agricultural Dischargers	3 years after effective date of the TMDL
8	Re-evaluation of the interim WLAs and interim LAs for boron, chloride, sulfate, and TDS based on new data. Responsible jurisdictions and agencies shall demonstrate that implementation actions have reduced the boron, sulfate, TDS and chloride imbalance by 40%.	POTWs, PSD, Other NPDES Permittees, and Agricultural Dischargers	7 years after effective date of the TMDL
9	Re-evaluation of the interim WLAs and interim LAs for boron, chloride, sulfate, and TDS based on new data. Responsible jurisdictions and agencies shall demonstrate that implementation actions have reduced the boron, sulfate, TDS, and chloride imbalance by 70%.	POTWs, Permitted Stormwater Dischargers (PSD), Other NPDES Permittees, and Agricultural Dischargers	10 years after effective date of the TMDL
10	The Los Angeles Regional Board shall reconsider this TMDL to re-evaluate numeric targets, WLAs, LAs and the implementation schedule based on the results of the special studies and/or compliance monitoring.	The Regional Board	12 years after effective date of the TMDL
11	Responsible jurisdictions and agencies shall demonstrate that the watershed has achieved an annual boron, sulfate, TDS, and chloride balance.	POTWs, PSD, Other NPDES Permittees, and Agricultural Dischargers	15 years after effective date of the TMDL
12	The POTWs and non-storm water NPDES permits shall achieve WLAs, which shall be expressed as NPDES mass-based effluent limitation specified in accordance with federal regulations and state policy on water quality control.	POTWs and Other NPDES Permittees	15 years after effective date of the TMDL

[1] Permitted stormwater dischargers that are responsible parties to this TMDL include the Municipal Stormwater Dischargers (MS4s) of the Cities of Camarillo, Moorpark, Thousand Oaks, County of Ventura, Ventura County Watershed Protection District, and general industrial and construction permittees.

Item	Implementation Action	Responsible Party	Completion Date
13	Irrigated agriculture shall achieve LAs, which will be implemented through the Conditional Waiver for Irrigated Lands as mass-based receiving water limits.	Agricultural Dischargers	15 years after effective date of the TMDL
14	The permitted stormwater dischargers shall achieve WLAs, which shall be expressed as NPDES mass-based limits specified in accordance with federal regulations and state policy on water quality control.	Permitted Stormwater Dischargers	15 years after effective date of the TMDL
15	Water quality objectives will be achieved at the base of the subwatersheds designated in the TMDL.	POTWs, PSD, Other NPDES Permittees, and Agricultural Dischargers	15 years after effective date of the TMDL

Central Arizona Salinity Study

Strategic Alternatives for Brine Management in the Valley of the Sun

January 2010

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Strategic Alternatives for Brine Management in the Valley of the Sun

Abstract:
In the Phoenix metropolitan area advanced water treatment, specifically reverse osmosis (RO), is being used now and increasingly more in the future to supplement potable water supplies. Large amounts of potable water will be produced but also large amounts of waste in the form of brine will be created. If there is not a sustainable method to manage the brine then possibly those future RO facilities will not be constructed.

In the Phoenix metropolitan area the two most common methods of brine management are evaporation ponds and sewer disposal. Neither method is sustainable as larger quantities of brine are generated. Large evaporation ponds are extremely expensive and brine disposal into sewers diminishes the usable hydraulic capacity at the receiving waste water treatment plant and is detrimental to the valuable effluent being produced there.

A logical next step in the planning process would be seek a regional solution and move the brine out of the urban environment to where land is cheaper, power is available and economies of scale can be implemented to seek a common solution. Regional solutions for brine management must be cost effective, energy efficient, environmentally friendly and implementable. This paper examines, at a planning level, six possible alternatives for a regional brine management solution.

A brine management solution for the Phoenix metropolitan area can not be devised using a little bit of economic mathematics, planning exercises and literature research. But it can show what won't work either because it's too expensive or too energy dependent or maybe not implementable. Alternatives such as brine concentrators use way too much energy; regional evaporation ponds are too expensive; and deep well injection needs special geology not found in central Arizona.

A system of brine management techniques linked together such as: chemical precipitation, secondary RO, Vibratory Shear Enhanced Processes (VSEP) and final disposal in a smaller evaporation pond could be an effective Zero Liquid Discharge (ZLD) solution. High technology solutions can recover a good portion of the water from the brine.

The opposite approach is using low technology, such as a wetland to remove contaminants and heavy metals from the brine, blend the brine with effluent and then surface discharging into the Gila River. The brine/effluent mixture would be lower in TDS and be of better quality water than the Gila River. This solution supplies a continuous source of water to the Gila River while other pressures on the River tend to dry it up. While high tech alternatives consume energy this alternative creates habitat to consume green house gasses.

Constructing a pipeline to Yuma to discharge the Valley's brine into the ocean requires cooperation at the local, State, Federal and international level, but it may be the most environmentally friendly solution.

Introduction

Reverse osmosis is a proven technology which can produce potable water from sea water, brackish sources or reclaimed water. Some Arizona communities use RO to produce potable water from brackish water now. In the future, more communities will be using RO to supplement their potable water supplies or to improve the quality of reclaimed water. Brine management is the foil which is keeping some communities from fully utilizing their brackish water sources or reclaimed water.

While the cost of RO produced water has continued to drop in the past decades, brine disposal can easily double the cost of constructing and operating an RO facility. The challenges associated with brine management are exacerbated for inland RO facilities where there is not an ocean for relatively economical brine disposal.

Central Arizona has many RO facilities in the conceptual, planning, design or construction stage. The current economic slow down has pushed some of these projects farther into the future but most of them will eventually be constructed. The Central Arizona Salinity Study (CASS) estimates that, in central Arizona, within the next 25 years nearly 300 million gallons a day (mgd) of potable water will be produced from brackish water sources. However, with that pure clean water comes a by product, a brine, which has very limited use and is difficult to manage.

By the year 2020, the cities of Phoenix, Scottsdale and Goodyear alone may be producing 52 mgd of potable water through RO processes and as a result produce 7.8 mgd of brine. And by the year 2035, these cities may produce over 200 mgd of potable water using RO and 30 mgd of brine. This is an enormous amount of brine to manage. Table 1 shows the RO facilities and size used for this paper. Only the Bullard Water Campus and the Scottsdale Water Campus are operating, the other facilities may or may not be constructed.

RO facilities considered in Strategic Alternatives paper (mgd)

Location	2010		2020		2035	
	Size Plant	Concentrate	Size Plant	Concentrate	Size Plant	Concentrate
Bullard Water Campus	3.50	0.53	4.00	0.60	4.00	0.60
Scottsdale Water Campus	24.00	3.60	24.00	3.60	24.00	3.60
Cave Creek RP	0.00	0.00	13.00	1.95	20.00	3.00
Rainbow Valley RO	0.00	0.00	5.00	0.75	60.00	9.00
Western Canal Well Field	0.00	0.00	6.00	0.90	6.00	0.90
Western Canal WTF	0.00	0.00	0.00	0.00	60.00	9.00
Water Market (91st WWTP)	0.00	0.00	0.00	0.00	30.00	4.50
		4.13		7.80		30.60

Table 1

Figure 1 shows the location of the RO Facilities operating and contemplated which would produce the quantity of brine used for this paper.

Reverse Osmosis Facilities used for Strategic Alternatives Analysis

Note: Facilities are in concept, planning, design, construction or operation

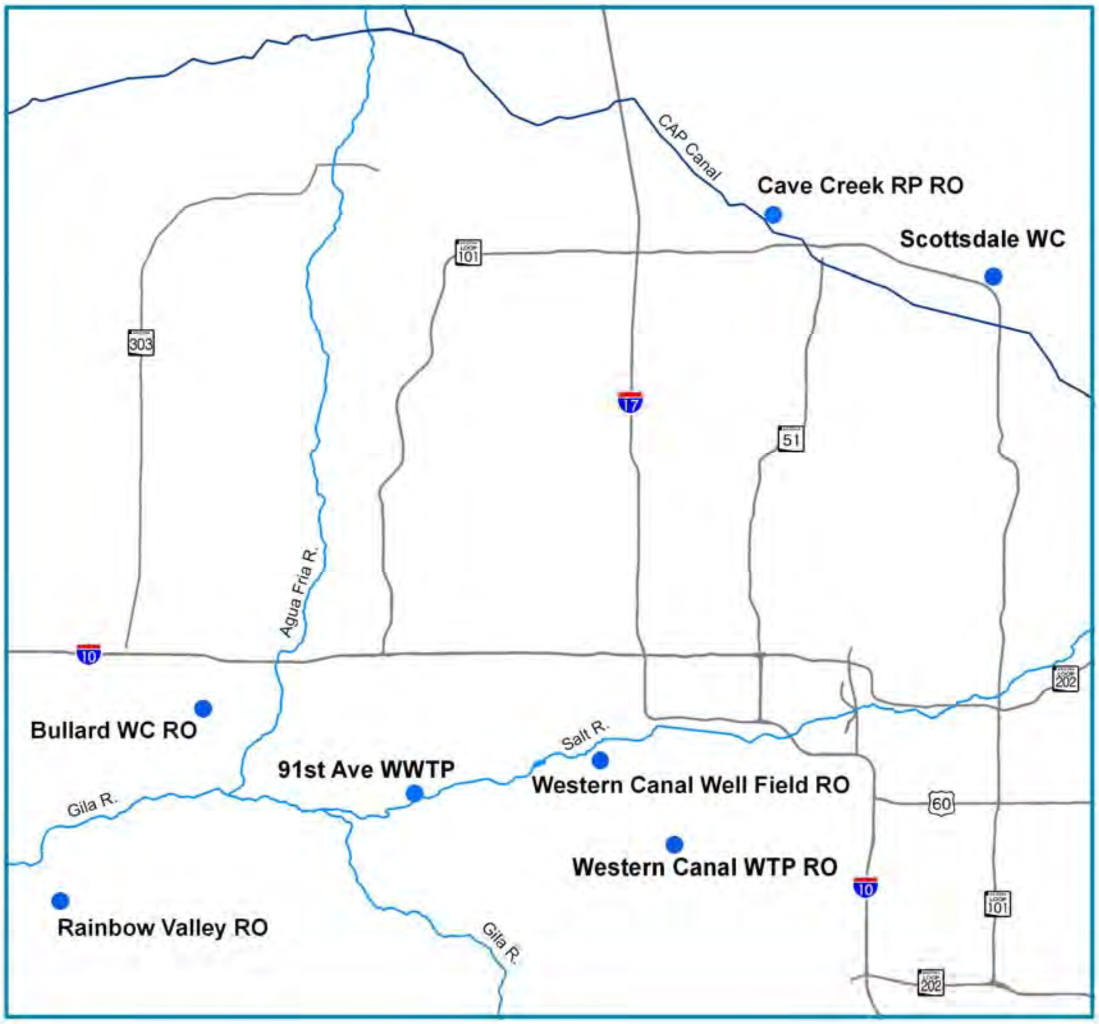

Figure 1

Sewer discharge is the number one method of brine disposal in the Phoenix metropolitan area currently and evaporation ponds are the next most popular method. The quantities of brine which will be produced in the future almost certainly preclude these methods of brine disposal. Ten square miles of valuable real estate would be needed to evaporate 30 mgd of brine and if those quantities of brine were discharged into the sewer the regional wastewater treatment plants would have unacceptable rises in the salinity concentration in the effluent. Clearly, if a portion of the potable water needs are to be met using RO, a sustainable solution to brine management needs to be discovered.

Methods

Six regional brine management alternatives were developed through brain storming sessions during CASS meetings. These alternatives were examined for cost, energy consumption, environmental acceptability and intangibles.

The main tool used to compare the alternatives was cost, both capital and operational. Some of the design/cost analysis tools (models) developed in the CASS Phase II report were used to calculate the costs. All the costs for each of the alternatives were developed using the same methods and tools so "apples can be compared to apples." The costs were calculated at a "planning level" and are accurate enough for comparison of the alternatives.

Energy consumption of the alternatives was also examined. Only the major energy consumption components of the alternatives were analyzed; such things as large pumps, brine concentrators, RO units, etc. were accounted for in the calculations. Energy consumption could be higher by possible 5-15% for incidental energy use such as lighting, air conditioning, small pumps, etc. which were not accounted for in the calculations. Although, for comparison purposes, it would seem they all would have about the same incidental energy use.

Another, criterion used was: How well does the alternative remove the salts from the local environment and/or return the salts to the ocean where they belong? This is a very narrow view of the environment but it does focus the discussion on the salts and removing the salts permanently from the local water cycle. Other issues of environmental concern are addressed in the discussion portion of this paper if they were relevant.

Each of the alternatives has unique factors which could make them very exciting or possibly make them very difficult to implement. These factors, by definition, are not easy to compare but by discussing some of the unique factors of each alternative they shed light on the overall benefit or problems of a given alternative.

This white paper uses the confluence of the Gila and Agua Fria Rivers as the beginning point for the cost calculations for all the Alternatives. The additional costs of getting the brine from where it is produced to that location have been calculated. Appendix B captures the costs of transporting the brine from the various advanced water treatment facilities to the collection point where the cost calculations for the alternatives begin.

<u>Alternative 1 - Pipe line to Yuma</u>

Most (70%) of the salt accumulating in the Phoenix metropolitan area comes from the Salt River and the Colorado River via the CAP. The salts were bound for the ocean before the water was diverted for agricultural and municipal uses. With the water, come the salts. The best solution, environmentally, would be to have the salts continue their journey to the ocean. The pipeline to Yuma alternative is a solution which transports the salts out of the local environment. A pipeline from the Phoenix metropolitan area to

Yuma would be approximately 174 miles in length and would be down gradient almost the entire length. This is a low technology simple solution.

Once the brine was delivered to Yuma, a couple of environmentally beneficial options are possible. One option would be to release it down the Santa Clara Slough to the Cienega de Santa Clara. The Ciénega de Santa Clara is an open water wetland that covers more than 40,000 acres. The Ciénega is by far the largest wetland in the Colorado River delta, and functions as an essential component of the ecosystem. This option would insure a constant source of water to the Cienega.

A second option would be to build a pipeline to the dying Salton Sea and use the relatively low TDS brine (4000-8000 mg/L) to "freshen up" the highly saline Salton Sea (40,000 mg/L). The Salton Sea is one of the few remaining stopovers for migrating birds in southern California. Millions of dollars have been spent trying to figure out how to save the Salton Sea, the pipeline to Yuma with this option could be the solution.

Alternative 2 - Pipe line to Evaporative Ponds in Desert

Evaporation ponds are a low tech, low energy, proven solution to brine management. The biggest drawback for the technology is the cost of land in an urban environment. Not only does one pay for high land prices but there are future tax revenues that are lost if this land could otherwise be developed into commercial, industrial or residential uses.

This strategy bypasses that problem by constructing a pipeline to transport brine out of the Phoenix metropolitan area south to a series of very large evaporation ponds east of Gila Bend. The evaporation ponds would be constructed in open desert areas where land prices are much lower and where development would not take place for many years.

Alternative 3 - Brine Concentrator/Evaporation Ponds

This strategy envisions building a pipeline, approximately 28 miles in length, from the Phoenix metropolitan area to near the Palo Verde Nuclear Power Plant. Enough land would be secured to construct a brine concentrator facility and evaporation pond.

While the previous two strategies discard the water with the salts, the brine concentrator/evaporation ponds alternative allows the recovery of additional water from the brine. The brine concentrator extracts water using thermal energy. The remaining brine would be evaporated in a pond. Approximately, 94% of the water would be recovered from the brine using brine concentrators leaving 6% of the brine to be evaporated. The size of an evaporation pond can be reduced by a factor of 16 by processing the brine through the brine concentrator.

But brine concentrators use enormous amounts of energy and are most commonly found at power plants processing blow down water and using "inside the wire" electrical costs. Being near the nuclear power plant, possibly an agreement could be arranged where lower electrical rates are secured in exchange for a steady supply of high quality water extracted from the brine. This is a symbiotic relationship where the nuclear power plant gets much needed good quality water for its cooling towers and the owners of the brine get subsidized power to operate the brine concentrators at a lower cost. This would be a win-win situation.

Alternative 4 - Softening/2nd RO/VSEP/Evaporation pond

This strategy would extract additional water from the brine and leave a small portion of the brine to be processed in an evaporation pond. A pipeline, approximately 28 miles in length, would be constructed from the Phoenix metropolitan area to near the Palo Verde Nuclear Power station to transport the brine to that location. At that location land would be purchased and a water softening facility, a RO facility, and a Vibratory Shear Enhanced Processing (VSEP) facility and evaporation ponds would be constructed. The softening facility would first soften the brine by removing calcium, magnesium and other select ions through chemical reactions. This softened brine would then be processed through a Reverse Osmosis facility to extract additional water from the brine. The brine from the RO would then be processed by the VSEP which would extract even more water and further concentrate the brine. The final fraction of extremely concentrated brine would then be evaporated in a pond.

Similar to the brine concentrator strategy, an agreement could be arranged with the Palo Verde Nuclear Power Plant where lower electrical rates are secured in exchange for a steady supply of high quality water extracted from the brine. This is also a symbiotic relationship where the nuclear power plant gets much needed good quality water for cooling and the owners of the brine gets subsidized power to operate the Softening/2nd RO/VSEP facility.

Alternative 5 - Wetlands with Surface Discharge to Gila River

This strategy is a very low tech approach to brine management. Brine would be treated through a series of wetlands specifically designed to remove heavy metals and other hazardous ions from the brine. The brine would then be blended with effluent or other waters in mixing ponds to reduce the TDS to the same level or lower then the Gila River (approximately 3200 mg/L TDS in the lower reaches). From the mixing ponds the brine/effluent blend would be surface discharged to the Gila River.

This strategy has many benefits to society and the environment. First none of the brine is wasted, it is used to support and/or create wetlands environment. Second, a minimal amount of energy is expended managing the brine. Third, this strategy supplies water to the Gila River when other factors are putting pressure to dry up the River. Finally, this strategy is relatively inexpensive compared to other strategies.

Alternative 6 - Pipeline to Deep Well Injection Site

Injection wells are a proven technology for brine management. They are being used mainly in Texas and Florida. With the right geology they are cost effective, environmentally sound and have a small footprint. This strategy envisions a pipeline to a location where a deep well would be constructed. The brine would then be pumped underground into a geological formation which is isolated from drinking water aquifers.

Figure 2 shows the Alternative's approximate locations and relative pipeline lengths.

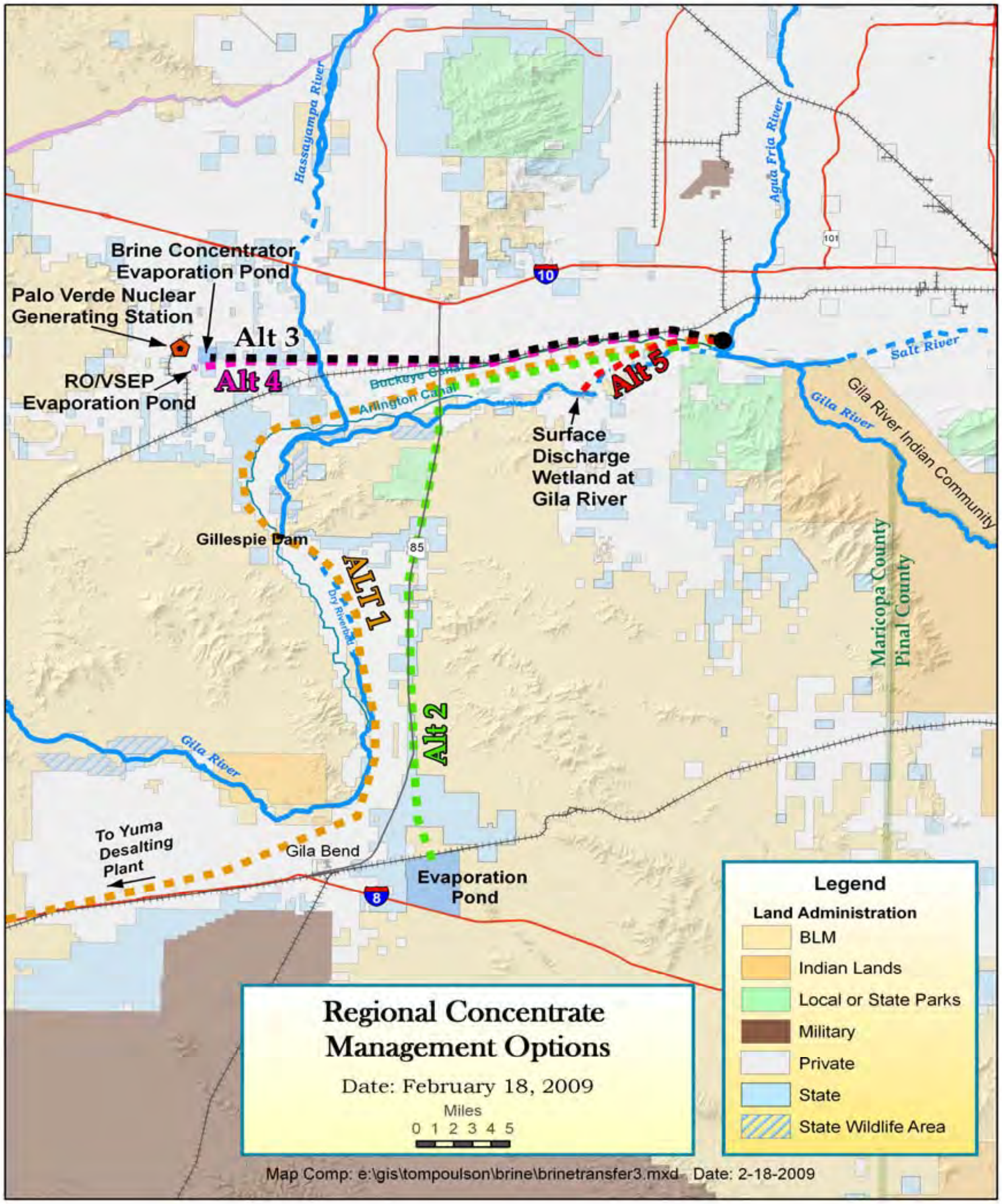

Figure 2

Alternative 1 - Pipeline to Yuma
Alternative 2 - Pipeline to Evaporative Ponds in Desert
Alternative 3 - Brine Concentrator/Evaporation pond
Alternative 4 - Softening/2nd RO/VSEP/Evaporation pond
Alternative 5 - Wetlands with Surface Discharge to Gila River
Alternative 6 - Pipeline to Deep Well Injection Site (not shown)

A deep injection well requires, among other things, that the receiving aquifer be above 10,000 mg/L TDS and that the receiving aquifer be isolated by geological formations from other drinking water aquifers. As of the writing of this report, no location in central Arizona has been identified where the geology meets the criteria for a deep injection well. An early investigation by a local consulting firm states that a location south of the Sierra Estrella Mountains may possibly have the geological characteristics needed for a deep injection well. An exploratory drill hole would be needed to confirm the site's suitability.

Since no suitable site has been located in central Arizona, an arbitrary pipeline of 50 miles was selected and the pumps and pressures were modeled after a deep well injection site in the Brazos River Basin, Texas to carry out the economics of the alternative.

Each alternative was evaluated at two sizes, 10 mgd representing the year 2020 brine production and 30 mgd representing the 2035 brine production. Costs and energy consumption were calculated for each alternative at both sizes. The project life for all alternatives was considered to be 50 years. The interest rate used was 4.875% which is Reclamation's construction interest rate for 2008. This information and the detailed cost estimates are in Appendix A.

Results

Table 2 shows the capital costs, O&M costs and annualized costs for the 10 mgd sized alternatives. Evaporation ponds have by far the most expensive upfront capital costs; while the brine concentrator alternative consumes tremendous energy and thus has high O&M costs. On an annualized basis, these two alternatives would be the most expensive to implement. The other four alternatives group together in a lower cost bracket.

Alternative Comparison 10 mgd (millions of dollars)

10 MGD	Pipeline to Yuma	Evaporation Pond	Brine Concentrator	Soften/ RO/ VSEP	Wetlands Surface Discharge	Injection Well
Capital	$266.11	$651.69	$272.71	$286.56	$150.22	$ 114.46
O&M	$ 0.62	$ 3.50	$ 29.75	$ 6.90	$ 1.75	$ 11.31
Annualized	$ 14.92	$ 40.26	$ 44.40	$ 22.30	$ 10.37	$ 17.46

Table 2

Table 3 shows the annual energy consumed, the cost of that energy and the amount of water recovered by the 10 mgd alternatives. Water recovered from the brine is an attractive feature of the Softening/RO/VSEP and the Brine Concentrator alternatives. But the brine concentrator energy costs are prohibitive.

Alternative Comparison - Annual Energy & Water Recovered

10 MGD	Pipeline to Yuma ****	Evaporation Pond	Brine Concentrator	Soften/RO VSEP	Wetlands Surface Discharge	Injection Well
Energy* (kilowatt-hours)	minimal	1,146,000	310,250,000	68,135,000	minimal	143,769,000
Energy Cost**	minimal	$88,000	$23,889,000	$662,000	minimal	$11,070,000
Water Recovered*** (af)	0	0	10,528	9,238	0	0

Table 3

Notes: * Kilowatt-hours of energy required (annual)
** $.077 per kilowatt-hour
*** Acre-feet of water recovered from the brine by this alternative (annual)
**** Does not include the pipeline to Salton Sea Option which would require energy for pumping

Table 4 shows the capital costs, O&M costs and annualized costs for the 30 mgd sized alternatives. The results are similar to the 10 mgd sized alternatives. If anything the brine concentrator alternative moved farther out of competition because of energy costs. The Wetlands Surface Discharge alternative remained the lowest cost alternative.

Alternative Comparison 30 mgd (millions of dollars)

30 MGD	Pipeline to Yuma	Evaporation Pond	Brine Concentrator	Soften/ 2nd RO/ VSEP	Wetlands Surface Discharge	Injection Well
Capital	$580.25	$1,837.74	$724.78	$718.94	$399.75	$204.98
O&M	$ 1.41	$ 10.22	$ 88.69	$ 20.01	$ 5.14	$ 33.60
Annualized	$ 32.58	$ 114.22	$125.63	$ 58.66	$ 26.62	$ 44.62

Table 4

Table 5 shows the annual energy consumed, the cost of that energy and the amount of water recovered by the 30 mgd alternatives.

Alternative Comparison - Annual Energy & Water Recovered

30 MGD	Pipeline to Yuma****	Evaporation Pond	Brine Concentrator	Soften/RO VSEP	Wetlands Surface Discharge	Injection Well
Energy* (kilowatt-hours)	minimal	3,438,000	930,750,000	204,405,000	minimal	431,307,000
Energy Cost**	minimal	$265,000	$71,668,000	$1,985,000	minimal	$33,210,000
Water Recovered*** (af)	0	0	31,583	27,719	0	0

Table 5

Notes: * Kilowatt-hours of energy required (annual)
** $.077 per kilowatt-hour
*** Acre-feet of water recovered from the brine by this alternative (annual)
**** Does not include the pipeline to Salton Sea Option which would require pumping

Table 6 compares the alternatives on two environmental issues: Does the alternative remove the salts from the local environment? Does the alternative use the brine in a beneficial manner?

Alternative Comparison of Environmental Aspects

	Pipeline to Yuma	Evaporation Pond	Brine Concentrator	Soften/ RO/ VSEP	Wetlands Surface Discharge	Injection Well
Remove Salts from Local Environment	Yes	Yes	Yes	Yes	No	Yes
Beneficial use of Brine	Yes	No	Yes	Yes	Yes	No

Table 6

Discussion

Alternative 1 - Pipeline to Yuma

The Pipeline to Yuma was first proposed in 1999 during the Tucson RO study. It even has a name, CASI or the Central Arizona Salinity Interceptor. A pipeline all the way to Yuma, sounds outrageous to new comers dealing with inland brine management, but it compares very well financially with the other alternatives. This alternative lands in the midrange of costs, and most of the costs are tied up in the 178 mile pipeline that would be built. Since it is down gradient to Yuma, the energy consumption would be minimal. Maintenance costs would be low because of the limited need for high technology apparatus to operate and maintain.

This alternative has some unique opportunities to improve the environment while solving Arizona's brine problem. First, it removes the salts from the local environment. There are two options beneficial to the environment once the brine reaches Yuma. The brine could be used to support habitat at either the Ciénega de Santa Clara or the Salton Sea.

From Yuma, if the brine was diverted to the Ciénega de Santa Clara, the additional costs would be minimal. Possibly, the slough would have to be rebuilt or expanded. Those costs were not examined.

From Yuma, if the brine was sent to the Salton Sea there, there would be significant additional costs. These costs would be for the pipeline and a pumping facility. The capital and O&M costs of a pipeline to the Salton Sea for the 10 mgd option are about \$9.5 million annualized and for the 30 mgd they are about \$15.7 million annualized. The aforementioned additional costs might be borne by California stakeholders interested in using the brine for restoration of the Salton Sea.

There are issues which would need to be addressed in getting this alternative in place. The first issue would be either to convince Mexico or California to accept the brine and believe it would be beneficial for them to do so. This could be problematic because by regulation RO brine is considered "industrial waste" which has negative environmental connotations. The brine may contain constituents (arsenic, selenium, etc.) above the legal limit for discharge which would make it unusable for the Salton Sea or the Ciénega de Santa Clara.

Dealing with Mexico would require the Federal Government to be involved. International negotiations with Mexico would take time and Mexico may want compensation for accepting “industrial waste” from the U.S.A. On the other hand, Mexico may see the value in a continuous supply of water for their Ciénega de Santa Clara.

Negotiating with Mexico may be easier then negotiating with California considering the acrimonious water conflicts between California and Arizona in the past. The Salton Sea would be receiving water which would be four times better quality but California Environmental Protection Agency (Cal/EPA) would have to approve discharging the brine into the Salton Sea. That may or may not prove difficult depending on how they view the discharge. Cal/EPA would have to decide if the brine is to be treated as a regulated industrial waste or a beneficial water which would improve the Salton Sea.

<u>Alternative 2 - Pipeline to Evaporation Pond in Desert</u>
This option tends to be on the high end of the costs. The capital costs for this alternative are the highest of the alternatives considered. The capital costs explode for this option as the size of the evaporation ponds increase. Dr. Mike Mickley’s research indicates that, “construction costs for evaporation ponds have little economy of scale and typically become excessive for all but the smallest plants.”[1] Capital costs for the 30 mgd option are $1,838 million, which is more than double the next highest alternative.

The high capital costs are somewhat off set by the low O&M costs. Maintaining evaporation ponds is relatively easy and it does not take specialized skills to operate this alternative. An evaporation pond is a simple reliable technology that works very well in central Arizona. On the down side, the brine is not used in a beneficial manner as no water is recovered from the brine but only evaporated away.

Environmentally, this project removes the salts from the local environment and places them in a pond approximately 45 miles to the south. At the end of the lifetime of the ponds the salts would be sequestered in place or moved to a land fill. But, there would be approximately 11 square miles of ponds for the 30 mgd alternative. If selenium or other toxic metals were concentrated in the evaporation ponds, there is some concern that these ponds would be hazardous to water fowl which would be attracted to them.

<u>Alternative 3 - Brine Concentrator/Evaporation Ponds</u>
Brine concentrators are a proven technology and are used at power plants which must employ ZLD techniques. They require specialized and highly trained personnel to operate and maintain them.

This is the most expensive alternative examined. Capital costs for the construction of the brine concentrators are high. Also, high energy usage and therefore costs add to the overall cost of this alternative. The annual cost for this alternative is nearly twice the cost of the next highest alternative examined.

Energy consumption is the major problem with this alternative. Brine concentrator energy consumption can range from 60 to100 kilowatts per hour per 1,000 gallons of brine. Using $.077 per kW/hr, the cost ranges from $4,600 to $7,700 per day to process 1 mgd of brine. Although, some of the cost could be defrayed by trading the high quality water recovered from the brine for a special deal on energy costs.

This alternative removes the salts from the local environment and will ultimately sequester them either in a land fill or in the closed and sealed evaporation pond. But, new electrical energy sources are already needed to meet the projected population growth in central Arizona without this project. Environmentalist groups may oppose the project because of the amount of energy required. This alternative is not attractive either financially or energy wise.

Alternative 4 - Softening/2nd RO/VSEP/Evaporation pond

This alternative is surprising because even with all the high technology processes in this alternative, it still falls right in the mid-range of the annualized costs. The big plus for this alternative is the recovery of the additional water from the brine. Approximately, 82% of the water would be recovered from the brine sent to the facility with this alternative. This recovery is achieved with a 65% recovery by the secondary RO and then another 50% recovery with the VSEP.

Environmentally, this alternative removes the salts from the local environment. The salts would be isolated either at a lined land fill or sealed in the lined evaporation ponds when the ponds useful life is at an end.

This alternative would require numerous highly skilled and trained operators to handle the equipment and operation at the different facilities.

The VSEP technology has only been used on small industrial water streams at the writing of this paper. It has never been used for a large scale municipal application. There is concern about the amount of maintenance (costs) required to keep a very large VSEP facility operating. The VSEP technology is proprietary and the company which owns the rights is not large. All replacement membranes must be purchased through that company. Currently, Reclamation and others are testing a small VSEP unit in Tucson, AZ.

The Palo Verde Nuclear Power Plant has the largest lime softening facility in the United States and seems to be able to handle all the complexities of the process. This alternative would have a softening facility similar in size and scope. The process produces a sludge which creates another management issue. The easiest method, but not the least expensive, would be to truck the sludge to a land fill. Another option would be to purchase additional land and create a local landfill for the sludge on site.

Alternative 5 - Wetlands with Surface Discharge to Gila River

The lowest annualized costs, and therefore, the least expensive alternative is the "Wetlands with Surface Discharge to the Gila River." Upfront capital costs were second lowest and O&M costs are reasonable. One of the reasons capital costs were low is because the site was the closest to the brine collection point, reducing pipeline costs significantly. The wetlands take up significantly less land than evaporation ponds reducing land acquisition costs. O&M costs are midrange, low energy consumption and the lack of high technology machinery drive O&M down but the replacement of the wetlands as they become saturated with heavy metals drives the O&M up. Financially, this alternative is quite attractive but it also has the most risk. A pilot project is under way to test if this alternative is feasible.

This alternative removes the heavy metals and other ions from the brine and from the environment. The contaminants which are monitored by Arizona Department of Environmental Quality (ADEQ) are contained in the wetlands and ultimately end up in a landfill, but the vast majority of the salts are not removed by the wetlands. The brine will be high in TDS when it leaves the wetlands. Blending with effluent or other water source will lower the TDS to match the Gila River's TDS. The salts will travel with the brine/effluent blend into the Gila River. From this point, the Gila River water is used two more times by the farms using the Arlington Canal and Paloma Irrigation and Drainage District. As these agricultural entities use the water, the salts would end up first in the root zone and then eventually be leached down into the aquifer. The receiving aquifers to the southwest of the Phoenix metropolitan area are already high in TDS.

This alternative has many benefits. The biggest benefit is to the environment along the Gila River southwest of Phoenix. Pressures on the Gila River in this area are making it likely that the River will "dry up" within the next 50 years. First, the farmers, whose irrigation practices contribute much of the water to the Gila River, are selling their land to developers. When all the farming is gone, the large amounts of water being delivered to this area of the Valley will be extremely slowed. Secondly, the City of Phoenix will continue to put effluent into the River but only enough to supply Tres Rios Wetlands (28,000 ac-ft/annually). According to the Agua Fria Linear Recharge Draft Environmental Impact Statement (DEIS), the rest of the 91st Ave. WWTP effluent will be diverted to the Agua Fria Recharge Project or other uses. Finally, the Luke cone of depression to the north will influence the direction of the groundwater flow. Traditionally, the groundwater flowed out of the Valley to the southwest. According to groundwater modeling, in the future, the natural flow of groundwater will change from flowing in the natural southwest direction and move in a northern direction towards the Luke cone of depression[8]. All these pressures will act on the Gila River in this area and will affect the amount of water in the River. This alternative would supply a continuous source of water for the Gila River and its habitat.

This alternative is very green, in that it does not use much energy, it contributes water to enhance the environment and it uses the concentrate in a beneficial manner. But there is a major concern, the brine/effluent blend may not be able to pass the whole effluent toxicity (WET) test because of high chlorides. If this is the case then rule R18-11-106

Net Ecological Benefit would have to be invoked. The implementation of this rule would take close cooperation with ADEQ. A wetlands pilot project is under way testing the concept, the capabilities of removing toxic ions and if the brine/effluent blend can pass the WET test.

Alternative 6 - Deep Well Injection Site

Deep well injection is a proven technology which has been put to good use in Florida and Texas disposing of RO brine. This alternative has the lowest upfront capital costs. The low capital outlay is offset by high energy costs. Pumping large amounts of brine into pressurized holes consumes large amounts of energy and therefore money. The pipeline to deep well injection alternative fell right into the mid-range of annualized costs.

O&M costs are highly dependent on the pressure needed to inject the brine into the receiving aquifer. The costs could be much higher or much lower then the costs portrayed in this document depending on the geological conditions if a suitable location is found.

Although, the brine is sequestered away from the environment, none of the water in the brine is reused in any manner.

The biggest intangible is that a site has not been identified in central Arizona after a fair amount of research has been done. If a suitable location is found close to the Phoenix metropolitan area this alternative would be a leading candidate for the best alternative.

Environment

Are the salts removed from the local environment? All of the alternatives do that except the Wetlands Surface Discharge alternative. Only the Pipeline to Yuma returns the salts to the sea where those salts were supposed to go before intercepted by man and diverted with the water via the CAP or SRP to the Phoenix metropolitan area. Three of the alternatives use evaporation ponds as the ending location of the salts. When the evaporation ponds useful life is over the salts will either be sequestered in place or moved to a lined land fill. The injection well puts the salts deep under the ground where they are isolated from drinking water aquifers. In the Wetlands Surface Discharge alternative, the salts would be moved out of the Phoenix metropolitan area to brackish groundwater located beneath the agricultural lands to the southwest of the Phoenix metropolitan area.

Is the brine put to beneficial use? There are two options for the final disposal of the brine in the Pipe line to Yuma alternative. The brine will be used to “sweeten up” the Salton Sea or send it down to the Ciénega de Santa Clara. Either way the brine is beneficially used. The Brine Concentrator and the Softening/RO/VSEP alternative recover water from the brine so that is considered a beneficial use. The Wetlands Surface Discharge alternative uses the brine to create or support existing wetland habitat. Only the Injection Well and Evaporation Pond do not use the brine in any beneficial manner.

Conclusion

In conclusion, numerous large and small RO facilities are in the design, planning or conception phase in the Valley. The large amount of brine produced from these facilities will be difficult to manage by the current methods employed in the local area, evaporation ponds and sewer disposal. A good solution to brine management could be the key to whether these RO facilities are constructed or not. A solution where the brine is moved out of the Valley to a regional processing center may be cost effective if several cities cooperated in the endeavor. A regional solution would also open up opportunities for other RO facilities to tag-along creating a synergy where more brackish water is treated through advanced water treatment techniques because there is a readily available solution to the vexing question; "What do we do with the brine?"

The size of the project, whether it was the 10 mgd or 30 mgd, did not change the relative ranking for the alternatives. Tripling the size of the projects did not make an alternative significantly better or worse relative to the other alternatives. Although, low energy alternatives are more attractive at the larger scale because the demand for energy in Arizona will continue to grow.

Several alternatives just don't seem worth pursuing. The brine concentrator concept just uses too much energy and money. Giant evaporation ponds are too capital intensive and all the water within the brine is wasted away. Giant evaporation ponds may create environmental hazards because of selenium, arsenic or other toxic ions concentrating in the ponds. While, deep well injection has some advantages as a disposal method, the right geology has not been located in central Arizona which would allow this alternative to be implemented.

The two alternatives which seem to have the most to offer are the "Softening/2nd RO/VSEP/Evaporation pond" and the "Wetland with Surface Discharge" on a local scale but possibly difficult to implement on the regional scale.

The "Softening/2nd RO/VSEP/Evaporation pond" alternative is relatively cost effective and also recovers much of the water from the brine which otherwise would be wasted. This alternative should be examined at many different magnitudes. It could be implemented as a zero liquid discharge (ZLD) brine management technique at a single RO facility which had sufficient space. It could be implemented by one or two cities working together which had two or three RO facilities located relatively close together. Or as this paper proposed, a regional solution could be implemented where several cities with several RO facilities worked together.

Further refinement to the concept should be examined. Because VSEP is a proprietary technology and maintenance costs of a large VSEP facility is suspect, other high technology systems could be examined. There are various different "chains of technologies" which could be linked together such as the HERO process, EDR, DewVaporation, etc. These "chains of technologies" would recover additional water from the brine and could be cost effective and environmentally friendly. Further research on high tech alternatives should be pursued through additional literature review and research in pilot or demonstration scale projects.

The "Wetlands with Surface Discharge" is attractive for different reasons. It has the lowest annualized costs of all the alternatives examined. Energy requirements are minimal. It supports habitat along the Gila River when other forces are acting on the River to dry it up. But there are a few environmental issues which need to be addressed. The first is that the Net Ecological Benefits rule would have to be successfully argued and accepted by ADEQ. The second is that while the regulated ions are sequestered from the environment, the majority of the salts are just moved further downstream.

While many engineers are looking for high tech, high energy solutions this alternative offers a low tech, low energy, green solution which would reduce the carbon foot print of brine management. If the regulatory hurdles can be over come this alternative offers a nifty method of brine management while keeping the Gila River habitat alive. At the small scale, this idea works well for West Valley communities.

The pipeline to Yuma is attractive. There are no engineering or economic reasons not to consider this alternative. This is a low tech engineering project and the costs are reasonable compared to the other alternatives and it does not consume lots of energy. It is the best solution environmentally, as it returns the salts to the ocean or supports the Salton Sea.

If California sees the possibility for a win-win situation, it may be possible to trade brine for a lesser amount of Colorado River water. California would get an abundance of water to improve the quality of the Salton Sea and Arizona would solve its brine disposal issues and get a lesser amount of potable water for its growing demands.

Or the brine could be discharged into the Sea of Cortez. In this option, the brine would support the Ciénega de Santa Clara wetlands before it eventually ends up in the ocean. Of all the ideas presented, this one is the only alternative where the salts end up where nature intended them to be.

All the alternatives can be implemented at a local level by individual cities or water providers on a smaller scale, except for the Pipeline to Yuma. The Pipeline to Yuma requires the Valley to work together for a regional solution.

High tech or low tech…regional solution or each city on their own…is there a solution for the Valley's looming brine management challenges?

The Membrane Technology Consultants

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February 25, 2013

Carol Schoen
Zone Mutual Water Company
P.O. Box 239
Somis, CA 93066

Subject: Preliminary Feasibility for Groundwater Desalter

Carol:

Please find attached SPI's Preliminary Feasibility conclusions. This work was completed with the budgeted contract value and believe you will find it thorough and at reasonable depth.

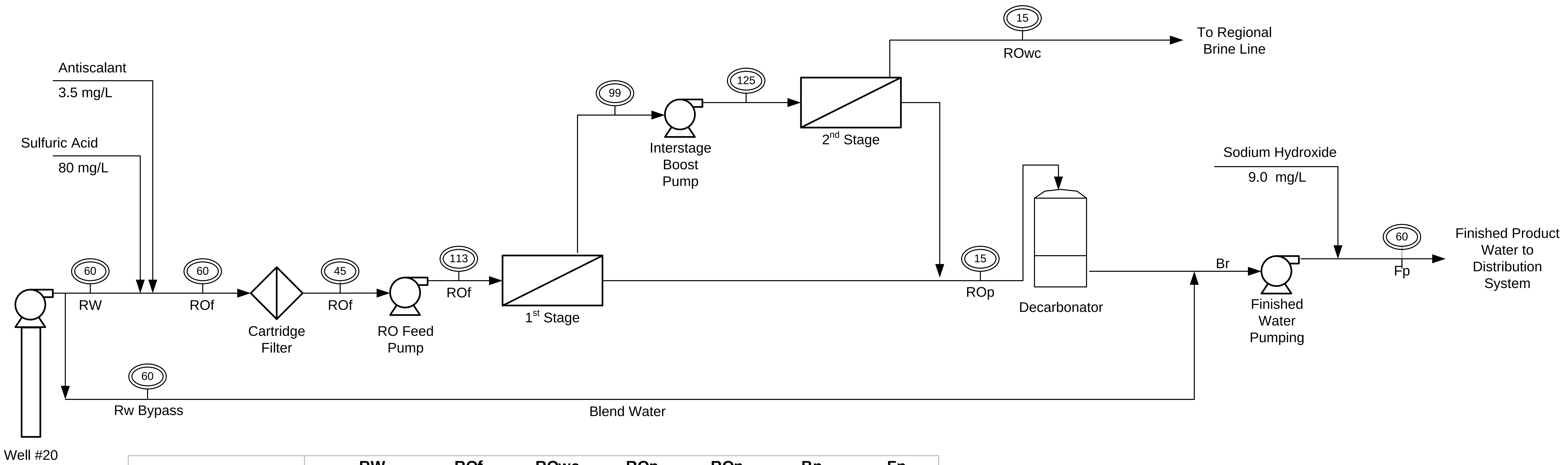
Note that the facility costs still carry a reasonable contingency factor, which would normally be reduced by successive phases of planning and establishment of any further needs by the Owners (such as architectural style, office space, paving, etc.). However, I believe the results accurately reflect our experience in the design of such treatment facilities and certainly would not be misleading for conversations within your organization about the possibilities of such a facility.

I'll look forward to discussing these results with you in the near future, perhaps after our meeting on March 7th. In the meantime, please let me know if I can clarify anything within the material attached.

If we can guide you as to how the project would move forward from this point, please let us know.

Regards,

Scott A. Lacy, P.E.
Project Manager



PARAMETER	**RW** Supply	**ROf** Feed to RO	**ROwc** RO Conc.	**ROp** RO Perm.	**ROp** RO Perm. Decarb	**Bp** Blended Water	**Fp** Finished Water
Flow (mgd)	2.44	1.86	0.28	1.58	1.58	2.16	2.16
(gpm)	1,694	1,294	194	1,100	1,100	1,500	1,500
Calcium (mg/L)	222.0	222.0	1,463.7	2.9	2.9	61.3	61.3
Magnesium (mg/L)	70.0	70.0	461.5	0.9	0.9	19.3	19.3
Sodium (mg/L)	213.0	213.0	1,333.3	15.3	15.3	68.0	73.2
Potassium (mg/L)	6.0	6.0	36.9	0.6	0.6	2.0	2.0
Ammonia (mg/L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bicarbonate (mg/L)	260.0	160.5	955.6	20.2	20.2	84.2	97.9
Sulfate (mg/L)	750.0	768.8	5,070.3	9.7	9.7	207.1	207.1
Chloride (mg/L)	200.0	200.0	1,259.1	13.1	13.1	62.9	62.9
Nitrate (mg/L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fluoride (mg/L)	0.3	0.3	1.9	0.0	0.0	0.1	0.1
Silica (mg/L)	32.0	32.0	201.4	2.1	2.1	10.1	10.1
Iron (mg/L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boron	0.8	0.8	3.1	0.4	0.4	0.5	0.5
TDS (reported)							
TDS (calculated)	1,650.1	1,608.4	10,401.6	56.6	56.6	481.4	494.8
pH	7.5	6.5	7.3	5.6	6.4	7.0	7.8
Temperature (F)	77.0	77.0	77.0	77.0	77.0	77.0	77.0
CO2 (mg/L)	13.5	85.2	85.2	85.2	12.0	12.4	2.5
LSI	0.8	-0.5	1.8	-4.0	-3.2	-0.7	0.1

Zone Mutual Water Co.

Preliminary Desalter Process Flow

SUMMARY OF O&M COSTS

The cost summary sheet provides additional information including billing rate for operations and maintenance manpower, operator and maintenance personnel man-hours and the equipment utilization factor which can be adjusted to reflect the period of equipment operation.

1. Cost Factors

On-Line Factor:	95.0%	24 hour per day for 12 months
Operating Days per Year:	346.8	
Maintenance Days per Year	365.0	
Product Water Flow Rate	1500.0	gpm
Water Production, AF/Year	2298.19	AF/yr
Water Production, Kgal/Year	748,867.39	Kgal/yr
Operators:	4	hours per day
Maintenance Personnel:	1	hours per day
Labor Rate:	30.00	$/per hour

2. Annual O&M Costs

	Total Daily Cost	Total Monthly Cost	Total Annual Cost	$/AF	$/Kgal
Equipment Power	$ 489	$ 14,883	178,600.39	77.71	0.24
Miscellaneous Energy	$ 15	$ 447	5,358.01	2.33	0.01
Chemical Costs	$ 183	$ 5,557	66,680.69	29.01	0.09
*Concentrate Disposal***	*$ 550*	*$ 16,729*	*200,750.63*	*87.35*	*0.27*
Operating Labor	$ 114	$ 3,468	41,610.00	18.11	0.06
Maintenance Labor	$ 30	$ 913	10,950.00	4.76	0.01
Maintenance Materials	$ 234	$ 7,113	85,352.00	37.14	0.11
Equipment Replacement	$ 51	$ 1,545	18,535.00	8.07	0.02
Miscellaneous	$ 83	$ 2,533	30,391.84	13.22	0.04
Total	**$ 1,748**	**$ 53,186**	**638,228.56**	**277.71**	**0.85**

Note: Maintenance Materials based on 1% of the capital cost of the facility
Miscellaneous Energy based on 5% of Energy
*** Concentrate costs based on Calleguas information stating $825/mo station cost, $45k/yr monitoring fee and $500/ac-ft*

3. Capital Amortization

Amortization Period	30	years
Interest	4.5%	
Capital Recovery Factor	0.061392	
Capital Cost of the Project	$ 5,563,077	

	Total Cost	$/AF	$/Kgal
Annual Capital Recovery(30 yrs)	$ 341,526	$ 148.61	$ 0.46

Total Production Cost (Amortized Capital and O&M Costs) $ 426.32 per Acre-ft

Pretreatment Parameters:

Acid and antiscalant are provided for scale control. Cartridge filtration is provided to reduce fouling.

RO Feed Flow	1294	gpm
2. Sulfuric Acid Addition		
Type of Chemical	Liquid Sulfuric Acid	
Bulk Chemical Concentration	93.00%	
Bulk Chemical Specific Gravity	1.83	
Bulk Chemical Costs	1.25	$/gallon
Chemical Dosing Rate	78.0	mg/L
Chemical Consumption	85.400	GPD
Number of Metering Pumps in Operation	1	
Metering Pump Horsepower	0.5	HP
Type of Flow Control	VFD	
Maximum Metering Pump Output	85.4	gpd
Turn Down Ratio	1.00	
Sulfuric Acid Power Requirements	0.50	HP
3. Antiscalant Addition (Threshold Inhibitor)		
Type of Chemical	Liquid Antiscalant	
Bulk Chemical Concentration	100.00%	
Bulk Chemical Specific Gravity	1.15	
Bulk Chemical Costs	9.5	$/gallon
Chemical Dosing Rate	3.5	mg/L
Chemical Consmption	5.7	GPD
Number of Metering Pumps in Operation	1	
Metering Pump Horsepower	0.5	HP
Type of Flow Control	VFD	
Maximum Metering Pump Output	5.7	gpd
Turn Down Ratio	1.0	
Antiscalent Power Requirements	0.50	HP
Pretreatment Chem Pump Replacement	$ 1,000.00	$/yr
4. Cartridge Filtration		
Number of Units in Operation	1.00	
Number of Cartridge Filters Per Unit	80	
Cartridge Filter Length	40	inch
Cost of Cartridge Filters	$ 4.95	
Percent of Cartridge Filters Replaced	100%	
Number of Cartridge Filters Replaced	80	
Cost per Replacement	$ 496.00	
Replacement Frequency	12	per year
Yearly Cartridge Filter Replacement Cost	$ 5,952.00	per year

Note: Manipulated Cells Highlighted

Membrane Parameters:

Following preliminary chemical injection and filtration, feed water is pumped to pressurize the feed so that the required transmembrane pressure is produced. Membrane pumps use VFD's to maintain a discharge pressure setpoint. The number of pumps in operation is equal to the number of RO skids in operation, which is determined by flow requiring treatment. The maximum flow to a single RO skid has been set at 0.8 MGD, based on experience with similar equipment. The pressure required by the membrane to achieve the required recovery has been estimated based on operating data by a membrane manufacturer. Another important consideration of the RO system is the cost of membrane replacement, which can be infrequent and large.

ROF Flow per Train	647	gpm
1st Stage Permeate	413	gpm
Interstage Flow	234	gpm
2nd Stage Permeate	138	gpm
Concentrate Flow	96	gpm

2. Reverse Osmosis

Total Number of RO Trains	2	
Number of RO Trains In Operation	2	
Pressure Vessels per RO Train	17	
Pressure Vessel Array per RO Train	12:5	
Membrane Elements per Pressure Vessel	7	
Total Number of Membrane Elements per RO Train	238	
Frequency of Replacement	5.00	years
Cost per Membrane Element	$ 500.00	each
Annual Membrane Replacement Cost	$ 47,600.00	

Membrane Feed Temperature	77	°F
RO System Recovery	85.0%	
Feed Flow to each RO Train	0.93	MGD
Permeate Flow per RO Train	0.79	MGD
Concentrate Flow for RO System	0.14	MGD

1st Stage Membrane Feed Pressure	125.00	psig
1st Stage dP	13	psig
Average Intermediate Pressure	112.00	psig

1. Membrane Feed Pump

Pumps in Operation	2	

Average Pretreatment Pressure	45	psig
Average Pump Discharge Pressure	125.00	psig
Feed Pump Motor Required Horsepower	47.07	HP
Feed Pump Horsepower	75	
Pump Efficiency	75%	
Motor Efficiency	90%	
VFD Efficiency	95%	

Total Operational Horsepower Requirements	94.13	HP

3. Membrane Feed Pump Replacement

Pump & Motor Costs	$60,000	
Replacement Frequency	10	years
Number of Pumps in Operation	2	
Annual Replacement Cost	12,000.00	$/year

1. Interstage Boost Pump

Pumps in Operation	2	

Average Interstage Pressure	99	psig
Average Pump Discharge Pressure	125.00	psig
Feed Pump Motor Required Horsepower	5.53	HP

Feed Pump Horsepower	7.5	
Pump Efficiency	75%	
Motor Efficiency	90%	
VFD Efficiency	95%	
Total Operational Horsepower Requirements	11.06	HP

3. Interstage Boost Pump Replacement

Pump & Motor Costs	$10,000	
Replacement Frequency	10	years
Number of Pumps in Operation	2	
Annual Replacement Cost	2,000.00	$/year

4. Membrane Valve Replacements

Valve Costs per RO Train	$12,000	
Replacement Frequency	5	years
Number of Trains in Operation	2	
Annual Replacement Cost	4,800.00	$/year

Note: Manipulated Cells Highlighted

Post Treatment

Sodium Hydroxide (Caustic) will be provided for stabilitization.

Blended Product Flow	1500	gpm

4. Sodium Hydroxide Addition

Type of Chemical	Liquid Sodium Hydroxide	
Bulk Chemical Concentration	25.00%	
Bulk Chemical Specific Gravity	1.252	
Bulk Chemical Costs	0.51	$/gallon
Chemical Dosing Rate	9.0	mg/L
Chemical Consumption	62.1	GPD
Number of Metering Pumps in Operation	1	
Metering Pump Horsepower	0.5	HP
Type of Flow Control	VFD	
Maximum Metering Pump Output	62.1	
Turn Down Ratio	1.0	
Sodium Hydroxide Power Requirements	0.50	HP
NaOH	$ 31.68	$/day

Note: Manipulated Cells Highlighted

Distribution and Disposal

This section estimates the cost of concentrate disposal and the amount of horsepower required for potable water transmission.

Concentrate Flow	194.0	gpm
Product Flow	1500	gpm

1. Concentrate Disposal

Cost of Regional Brine Line by Flow	1.53	$/1000 gallon
Cost of Regional Brine Line by Month	4575.00	$/month

Concentrate Production	0.28	MGD
Annual Disposal Cost	211,316	$/year

2. Finished Water Transmission

Distribution System Pressure	60	PSIG
Finished Water Flow to Distribution	2.16	MGD

Number of Distribution Pumps	2	
Large Pump Capacity	750	gpm
Number of Small Pumps in Operation	0	
Small Pump Capacity	0	gpm
Number of Small Pumps in Operation	0	
Pump Suction Pressure	0	psig

Method of Flow Control	VFD	
VFD Efficiency	95%	
Motor Efficiency	90%	
Pump Efficiency	75%	
Operational Horsepower	81.84	

2. Equipment Replacement

Pump & Motor Costs	$50,000	
Replacement Frequency	10	years
Number of Pumps in Operation	2	
Annual Replacement Cost	10,000.00	$/year

Note: Manipulated Cells Highlighted

Electrical Requirement and Cost Summary

Equipment Power Requirements Summarize the Costs of power associated with equipment operation. Miscellaneous requirements include site electricity, analyzer and instrument power and other power associated with daily water production.

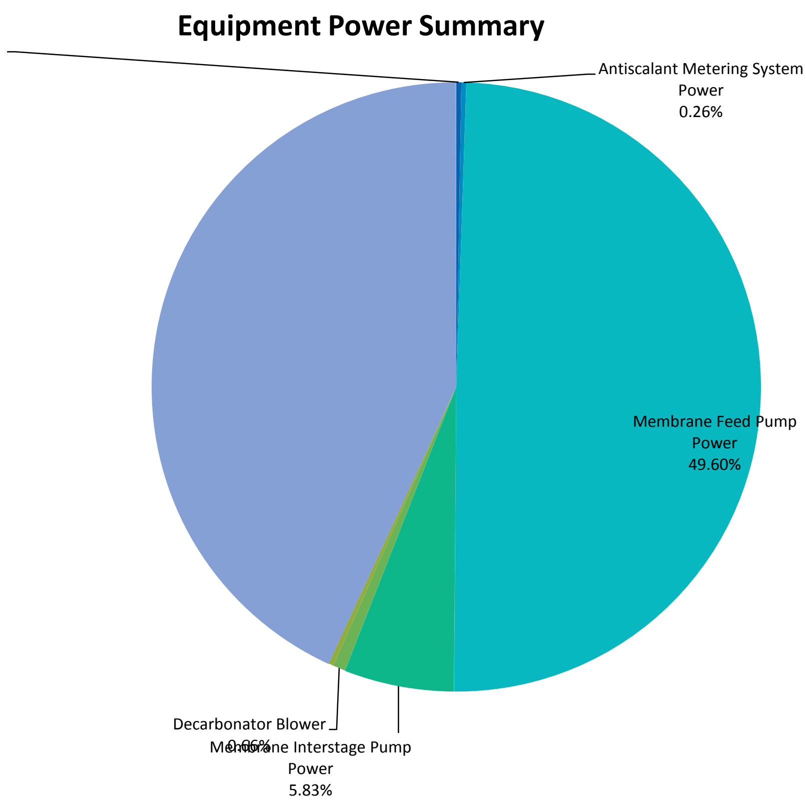
Energy Cost	**0.15**	$/kwh

1. Equipment Power Requirements

Description	Process Section	Horsepower	Hours/Day	HP-hr/day	Kw-hr/day	$/day	$/month	$/year
Sulfuric Acid Metering System Power	200	0.5	24	12.0	8.9	$ 1	$ 40	$ 490
Antiscalant Metering System Power	200	0.5	24	12.0	8.9	$ 1	$ 40	$ 490
Membrane Feed Pump Power	300	94.1	24	2259.1	1684.6	$ 253	$ 7,581	$ 92,234
Membrane Interstage Pump Power	300	11.1	24	265.5	198.0	$ 30	$ 891	$ 10,841
Decarbonator Blower	400	3.0	10	30.0	22.4	$ 3	$ 101	$ 1,225
Sodium Hydroxide Metering System Power	500	0.5	24	12.0	8.9	$ 1	$ 40	$ 490
Distribution Pump Power	600	81.8	24	1964.1	1464.6	$ 220	$ 6,591	$ 80,188
Total HP, HP/day, Kw-hr/day, $/day,		191.5		4555	3397	$ 509	$ 15,284	$ 185,959
Annual Equipment Power Consumption, KW*H		1,253,336						
Annual Equipment Energy Cost	***$ 188,000***							

2. Miscellanoues Electrical

Percentage of Equipment Power	3%
Annual Miscellaneous Energy Cost	***$ 5,640***



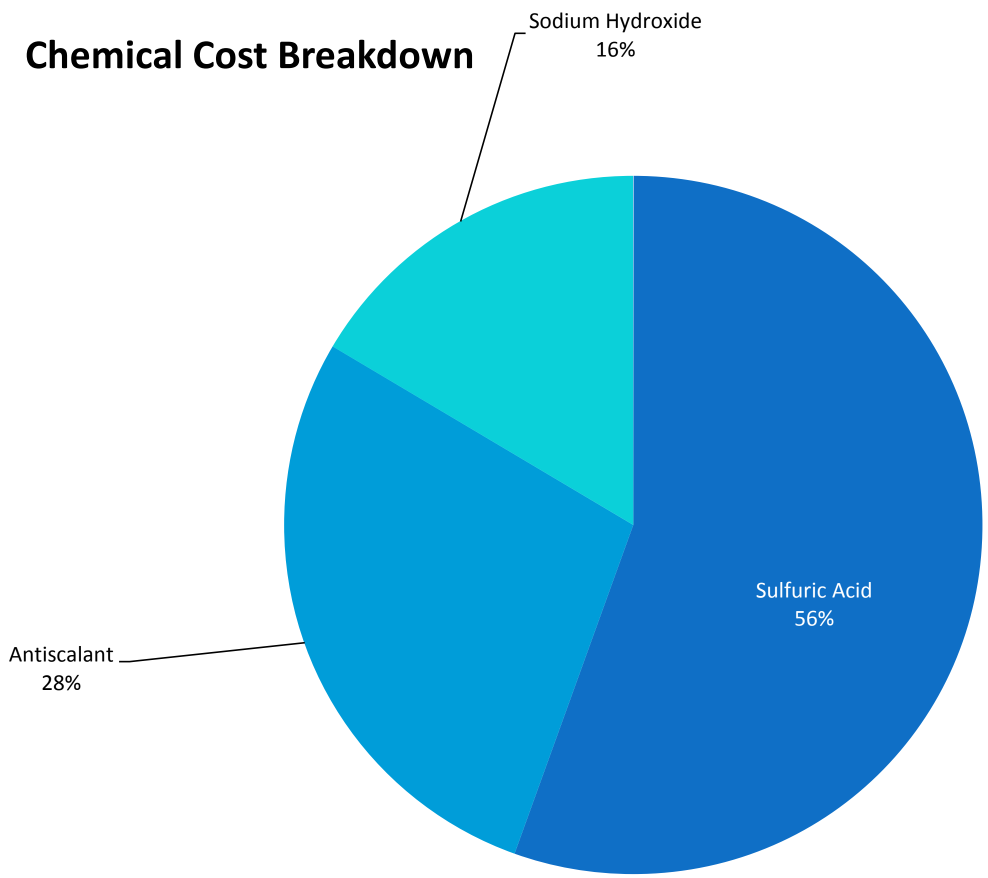
Chemical Requirement and Cost Summary

Chemical Costs summarize the annual consumption cost with no service factor inclued. This summary includes the cost of sulfuric acid, antiscalant , liquid CO2, sodium hypochlorite and lime.

1. Chemical Requirements

Chemical	Consumption, GPD	Chemical Cost/gal	Cost, $/day	Cost, $/month	Cost, $/year
Sulfuric Acid	85.40	$ 1.25	$ 106.75	$ 3,247	$ 38,964
Antiscalant	5.67	$ 9.50	$ 53.88	$ 1,639	$ 19,665
Sodium Hydroxide	62.11	$ 0.51	$ 31.68	$ 964	$ 11,562
Total Chemical Costs			$ 192	$ 5,850	$ 70,190

Annual Chemical Cost ***$ 70,190***



Material and Equipment Replacement Summary

Material and Equipment Cost Summary includes the costs associated with equipment replacement and the cst of materials associated with plant operation and maintenance. The cost of materials has been estimated to be 1% of the total capial cost of the facility.

Capital Cost of Facility	$ 3,707,000

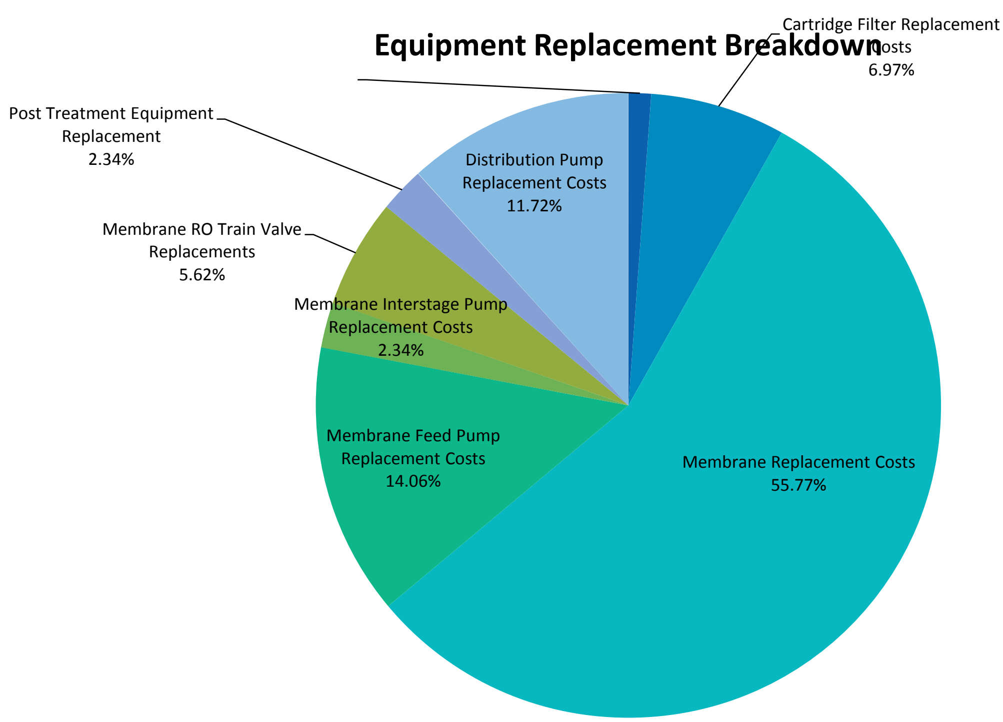
1. Equipment Replacement

Description	Process Section	Cost, $/day	Cost, $/month	Cost, $/year
Pretreat Chem Metering Pump Replacement Costs	400	$ 3	$ 33	1000.0
Cartridge Filter Replacement Costs	200	$ 16	$ 196	5952.0
Membrane Replacement Costs	300	$ 130	$ 1,565	47600.0
Membrane Feed Pump Replacement Costs	300	$ 33	$ 394	12000.0
Membrane Interstage Pump Replacement Costs	300	$ 5	$ 66	2000.0
Membrane RO Train Valve Replacements	300	$ 13	$ 158	4800.0
Post Treatment Equipment Replacement	500	$ 5	$ 66	2000.0
Distribution Pump Replacement Costs	300	$ 27	$ 329	10000.0
Annual Equipment Replacement Cost		***$ 234***	***$ 2,806***	***$ 85,352***

2. O&M Materials

Percentage of Total Capital (Lights, HVAC Filters, Misc.)	0.5%

	Cost, $/day	Cost, $/month	Cost, $/year
Annual O&M Materials Cost	**$ 51**	**$ 609**	***$ 18,535***



ZONE Mutual Water Company
Groundwater Treatment System

Rev 0 - February 25, 2013

Item		Cost
Sulfuric Acid System		$33,970
TI System		$23,627
RO Membrane Trains		$950,000
CIP System		$46,700
Decarbonator		$99,367
Blending System		$15,070
NaOH System		$18,954
Finished Water Pumping System		$234,340
Installation	35%	$497,710
Mechanical Total		$1,919,738
Building, 4000 SF	$150/SF	$600,000
Subtotal		***$2,519,738***
SiteWork	7%	$176,382
Building HVAC	3%	$75,592
Plumbing	3%	$75,592
Electrical I&C	20%	$503,948
Subtotal		***$3,351,251***
Contingency	35%	$1,172,938
Overhead and Profit	16%	$536,200
Engineering	15%	$502,688
		$5,563,077

SA System Cost Estimate

COMPONENT	1294 gpm ROF	QUANTITY	UNIT COST	TOTAL COST
SULFURIC ACID TANK ASS'Y				
Steel Tank, Dessicant Dryer, etc.	2500 gal	1	$17,000	$17,000
Subtotal				**$17,000**
PIPING				
Alloy 20	3/4-inch	1	$3,000	$3,000
PVDF	1-inch	1	$1,000	$1,000
Subtotal				**$4,000**
VALVES				
Diaphragm Valves	1-inch	10	$100	$1,000
Diaphragm Valves	3/4-inch	4	$100	$400
Diaphragm Valves	2-inch	6	$100	$600
Diaphragm Valves	1/2-inch	2	$100	$200
Pressure Relief Valves	1/2-inch	2	$100	$200
Diaphragm Check Valves	2-inch	2	$100	$200
Subtotal				**$2,600**
INSTRUMENTATION				
Pressure Gauge		2	$200	$400
Pressure Switch		2	$250	$500
Flow Indicator (Rotameter)		2	$285	$570
Level Indicator		1	$1,000	$1,000
Level Switch		2	$200	$400
Level Transmitter		1	$1,500	$1,500
Subtotal				**$4,370**
SA METERING PUMPS				
0.5 GPH piston diaphragm for ROF		2	$3,000	$6,000
Subtotal				**$6,000**
MISCELLANEOUS				
NA				
Subtotal				**$0**
SA SYSTEM				**$33,970**
MISCELLANEOUS				
Mechanical Installation	35%	0	$11,890	$0
Subtotal				**$0**
TOTAL ESTIMATED COST				**$33,970**

TI System Cost Estimate

COMPONENT	SIZE	QUANTITY	UNIT COST	TOTAL COST
TI TANK ASS'Y				
Tote Tank	450 gal	1	$2,027	$2,027
Subtotal				**$2,027**
PIPING				
SST	3/4-inch	1	$5,000	$5,000
PP	1-inch	1	$1,000	$1,000
Subtotal				**$6,000**
VALVES				
Diaphragm Valves	1-inch	4	$100	$400
Diaphragm Valves	1/2-inch	10	$100	$1,000
Pressure Relief Valves	1/2-inch	2	$100	$200
Ball Valves	2-inch	2	$100	$200
Subtotal				**$1,800**
INSTRUMENTATION				
Pressure Indicator		2	$1,500	$3,000
Pressure Switch		2	$200	$400
Flow Indicator		2	$1,500	$3,000
Level Switch		2	$200	$400
Level Transmitter		1	$1,000	$1,000
Subtotal				**$7,800**
TI METERING PUMPS				
Piston/Diaphragm metering pump	0.4 gph	2	$3,000	$6,000
Subtotal				**$6,000**
MISCELLANEOUS				
		1		$0
Subtotal				**$0**
TI SYSTEM				**$23,627**
MISCELLANEOUS				
Mechanical Installation		0	$0	$0
Subtotal				**$0**
TOTAL ESTIMATED COST				**$23,627**

RO System Cost Estimate

NUMBER OF TRAINS: 2
TRAIN PERMEATE CAPACITY: 0.80 MGD

COMPONENT	SIZE	NO./TRAIN	UNIT COST	TOTAL COST
MAJOR EQUIPMENT ITEMS				
RO Train Equipment (LOT)	150 HP	1	$475,000	$475,000
RO HP Pump and VFD				
RO interstage Pump and VFD	20 HP	1		
Steel Rack				
Pressure Vessels				
RO Membranes				
Manifolds				
Valves				
Piping				
Instruments				
Panels				
Programming				
Cartridge Filter Incl				
Subtotal				**$475,000**
RO EQUIPMENT				
PV Support Frames	7 VESSEL	1		$0
Pressure Vessels	7 ELEM - HP	17		$0
Membrane Elements		119		$0
Subtotal				**$0**
PIPING				
SS RO Feed	6-INCH	1		$0
PVC RO Permeate and RO Cleaning Line	6-INCH	1		$0
PVC RO Concentrate	3-INCH	1		$0
SST Skid Manifold Piping/Tree	17 VESS	1		$0
Piping Flanges and Fittings	N/A	1		$0
Subtotal				**$0**
VALVES				
Train Inlet (BFV w/EA)	6" BFV1-EA	1		$0
Pump Outlet (SCV2)	6" HP	1		$0
Pump Outlet (BFV2 w/MA)	6" HP-MA	1		$0
Bank 1 CF (BFV2 w/MA)	6" HP-MA	1		$0
Bank 2 CF/CR (BFV2 w/MA)	6" HP-MA	1		$0
Conc. Man. CR (BFV2 w/MA)	3" HP-MA	1		$0
CF/CR Isolation (BFV2 w/MA)	6" HP-MA	1		$0
Conc. Control Valve (FCV w/EA)	1.5" FCV-EA	1		$0
Conc. Check Valve (SCV3)	3" LP	1		$0
PCR Outlet (BFV1 w/MA)	3" BGS-MA	1		$0
Permeate Isolation (BFV1 w/EA)	6" BGS-EA	1		$0
Permeate Check (SCV3)	6" LP	1		$0
Permeate Dump Valve (BFV1 w/EA)	4" BGS-EA	1		$0
Conc. Vacuum Breaker	1" VB	1		$0
Perm. Vacuum Breaker	1" VB	1		$0
BV2	1/2-INCH	6		$0
Miscellaneous	--	1		$0
Subtotal				**$0**
INSTRUMENTATION				
Pressure Switches	--	3		$0
Pressure Gauges	--	3		$0
Diff. Pressure Indicating Trans.	--	2		$0
Pressure Indicating Trans.	--	2		$0
Magnetic Flowmeters	2-inch	2		$0
Conductivity Analyzer	--	2		$0
Subtotal				**$0**
RO TRAIN EQUIPMENT TOTAL				**$475,000**
MISCELLANEOUS				
Mechanical Installation		0	$0	$0
Subtotal				**$0**
TOTAL ESTIMATED COST				**$950,000**

CIP System Cost Estimate

COMPONENT	SIZE	NO./TRAIN	UNIT COST	TOTAL COST
CIP TANK ASS'Y				
Cleaning Pump - 316 SS 10 HP	320 gpm	1	$7,500	$7,500
FRP Tank	1500 gal	1	$6,500	$6,500
Bag Loader		1	$2,800	$2,800
Heaters & Panel	120 kW	1	$11,600	$11,600
Subtotal				**$28,400**
PIPING				
PVC	6-INCH	70	$35	$2,450
PVC	4-INCH	30	$25	$750
PVC	2-INCH	10	$10	$100
Subtotal				**$3,300**
VALVES				
BFV1	6-INCH	9	$700	$6,300
BFV1	4" BGS-MA	2	$250	$500
BFV1	2" BGS-MA	3	$100	$300
Subtotal				**$7,100**
CAUSTIC DOSING SYSTEM				
Drum		1	$500	$500
Dosing Pump		1	$1,000	$1,000
Valves		1	$200	$200
Containment Vessel		1	$100	$100
Subtotal				**$1,800**
INSTRUMENTATION				
Temperature Indication		1	$500	$500
pH Meter		1	$2,400	$2,400
Propeller Flow Meter		1	$2,500	$2,500
Level Indicator		1	$200	$200
Level Switch		2	$250	$500
Subtotal				**$6,100**
MISCELLANEOUS				
Immersion Heaters and Panel				$0
Subtotal				**$0**
CIP EQUIP TOTAL				**$46,700**
MISCELLANEOUS				
Mechanical Installation		0	$0	$0
Subtotal				**$0**
TOTAL ESTIMATED COST				**$46,700**

Decarbonator System Cost Estimate

NUMBER OF TRAINS: 1

TRAIN Product CAPACITY: 1.60 MGD

COMPONENT	SIZE	NO./TRAIN	UNIT COST	TOTAL COST
MAJOR EQUIPMENT ITEMS				
Blower	3 HP	1	$6,000	$6,000
Vessel - FRP	8' Dia	1	$90,000	$90,000
				$0
Subtotal				**$96,000**
PIPING				
Subtotal				**$0**
VALVES				
Subtotal				**$0**
INSTRUMENTATION				
Pressure Switches	--	2	$150	$300
Pressure Gauges	--	1	$150	$150
Diff. Pressure Indicating Trans.	--	1	$1,584	$1,584
Pressure Indicating Trans.	--	1	$1,333	$1,333
Magnetic Flowmeters	2-inch	0	$2,500	$0
Conductivity Analyzer	--	0	$1,905	$0
Subtotal				**$3,367**
RO TRAIN EQUIPMENT TOTAL				**$99,367**
MISCELLANEOUS				
Mechanical Installation		0	$0	$0
Subtotal				**$0**
TOTAL ESTIMATED COST				**$99,367**

Blending System Cost Estimate

COMPONENT	400 gpm	QUANTITY	UNIT COST	TOTAL COST
Equipment				
				$0
Subtotal				**$0**
PIPING				
DIP (Epoxy Lined)	6-Inch	100	$20	$2,000
Stainless Steel	6-Inch	20	$90	$1,800
Flanges and Fittings (15%)	6-Inch	1	$570	$570
Subtotal				**$4,370**
VALVES				
Butterfly Valves, BFV1	6-inch	2	$750	$1,500
Swing Check Valve	6-inch	2	$1,800	$3,600
V-Notch Ball Valve, FCV-1	4-inch	1	$1,800	$1,800
Subtotal				**$6,900**
INSTRUMENTATION				
Pressure Gauge		1	$200	$200
Magnetic Flow Meter	6-inch	2	$1,800	$3,600
Subtotal				**$3,800**
MISCELLANEOUS				
NA			$200	$0
				$0
Subtotal				**$0**
Blending SYSTEM				**$15,070**
MISCELLANEOUS				
Mechanical Installation		0	$0	$0
Subtotal				**$0**
TOTAL ESTIMATED COST				**$15,070**

NaOH System Cost Estimate

COMPONENT	SIZE	QUANTITY	UNIT COST	TOTAL COST
NaOH TANK ASS'Y				
Tote Tank	450 gal	2	$2,027	$4,054
Subtotal				**$4,054**
PIPING				
SST	3/4-inch	1	$5,000	$5,000
PP	1-inch	1	$1,000	$1,000
Subtotal				**$6,000**
VALVES				
Diaphragm Valves	1-inch	4	$100	$400
Diaphragm Valves	1/2-inch	10	$100	$1,000
Pressure Relief Valves	1/2-inch	2	$100	$200
Ball Valves	2-inch	2	$100	$200
Subtotal				**$1,800**
INSTRUMENTATION				
Pressure Indicator		1	$1,500	$1,500
Pressure Switch		1	$200	$200
Flow Indicator		1	$1,500	$1,500
Level Switch		1	$200	$200
Level Transmitter		1	$1,000	$1,000
Subtotal				**$4,400**
METERING PUMPS				
0.5 gph metering pump		2	$1,350	$2,700
Subtotal				**$2,700**
MISCELLANEOUS				
		1		$0
Subtotal				**$0**
NaOH SYSTEM				**$18,954**
MISCELLANEOUS				
Subtotal				**$0**
TOTAL ESTIMATED COST				**$18,954**

Product Pumping System Cost Estimate

COMPONENT	1694 GPM	QUANTITY	UNIT COST	TOTAL COST
Pumps				
100 HP Horizontal Split Case Pump with VFD, motor, and cable		2	$32,000	$64,000
Subtotal				**$64,000**
PIPING				
DIP (Epoxy Lined)	12-Inch	100	$40	$4,000
Flanges and Fittings (15%)	12-Inch	1	$600	$600
Subtotal				**$4,600**
VALVES				
Butterfly Valves, BFV1	12-Inch	2	$1,800	$3,600
Swing Check Valve	12-Inch	2	$3,200	$6,400
Air Relief Valve	2-inch	1	$490	$490
Subtotal				**$10,490**
INSTRUMENTATION				
Pressure Gauge		1	$200	$200
Pressure Switch		1	$250	$250
Magnetic Flow Meter	12-Inch	1	$4,800	$4,800
Subtotal				**$5,250**
MISCELLANEOUS				
Concrete Wetwell	30000 gallons	30000	$5	$150,000
		1		$0
Subtotal				**$150,000**
Well Pump SYSTEM				**$234,340**
MISCELLANEOUS				
Mechanical Installation		0	$0	$0
Subtotal				**$0**
TOTAL ESTIMATED COST				**$234,340**

Koch Membrane Systems, Inc.   ROPRO® Ver. 8.06-CP   Date: Dec-18-2012

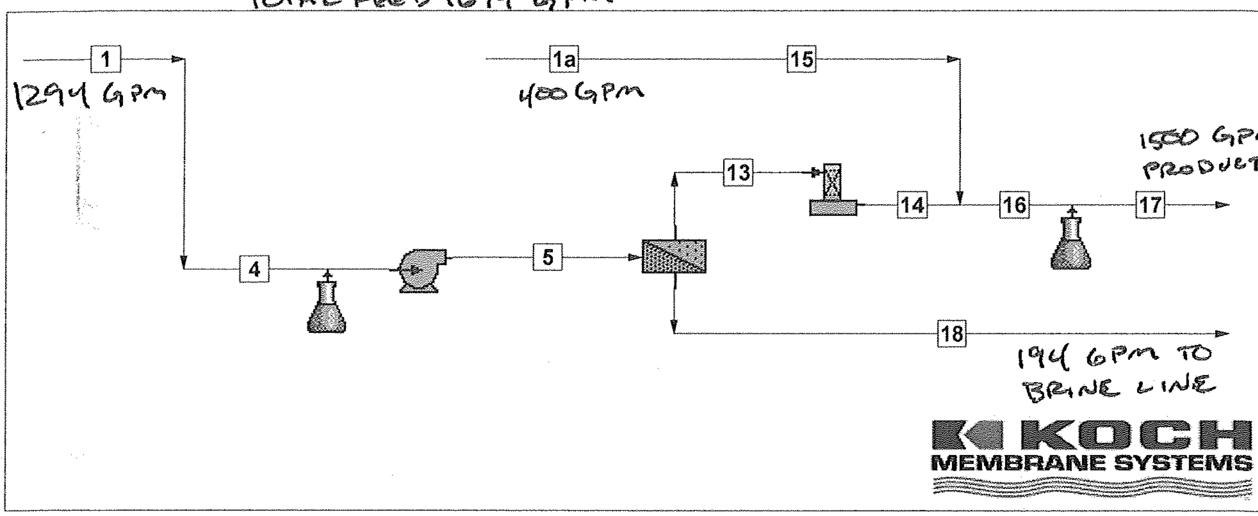
Project:
Prepared By:

Description:
Type: Single Pass Design

PROJECT SUMMARY

PROCESS FLOW DIAGRAM

TOTAL FEED 1694 GPM



RO Recovery [13/4] = 85.0%   Overall System Rec [17/(4+15)] = 88.5%
Design Temperature = 77.0 Deg F

PASS 1
Array Recovery [13/4] = = 85.0%
Element Age = 1.00 Years
Fouling Allowance (FA) = 0.0%

Bank	Element Type	Tubes /Bank	Elems /Tube	Avg Flux (GFD)
1	TFC 8040-ULP-400	24	7	17.7
2	TFC 8040-ULP-400	10	7	14.2
System/Pass Total				16.7

Stream	Pressure with FA (Psig)	Flow Rate (USGPM)	TDS 180C (mg/L)	Hardness (CaCO3)	Chloride (mg/L)
1	0.0	1294.1	1623.18	842.7	200.0
4	0.0	1294.1	1623.18	842.7	200.0
5	113.3	1294.1	1652.02	842.7	200.0
13	10.0	1100.0	54.51	10.9	13.1
14	10.0	1100.0	54.51	10.9	13.1
15	0.0	400.0	1623.18	842.7	200.0
16	0.0	1500.0	472.82	232.7	62.9
17	0.0	1500.0	486.13	232.7	62.9
18	108.2	194.1	10705.01	5555.9	1259.3

ALSO, BORON 0.8 $\xrightarrow{\sim}$ <0.4 mg/l OF BENEFIT FOR AG.

NITRATES NOT AN ISSUE FOR AG USE.

Koch Membrane Systems, Inc. ROPRO® Ver. 8.06-CP Date: Dec-18-2012

Project: Description:
Prepared By: Type: Single Pass Design

ARRAY SUMMARY - PASS 1

Permeate Flow	1100.0 USGPM	Temp (Design/Avg)	77.0/ 77.0 Deg F
Pass Recovery	85.0 %	Fouling Allowance (FA)	0.0 %
Inlet Pres w/o FA	113.3 Psig	Conc. Pres w/o FA	108.2 Psig
Inlet Pres w/FA	113.3 Psig		

Bank	Element Type	Tubes /Bank (#)	Elems /Tube (#)	Elems /Bank (#)	Elem Age (Yr)	Boost Pressure (Psig)	Manifold Loss (Psig)	Perm Back Pressure (Psig)
1	TFC 8040-ULP-400	24	7	168	1.00	0.0	5.0	10.0
2	TFC 8040-ULP-400	10	7	70	1.00	30.0	5.0	10.0

Bank	Total Feed (GPM)	Tube Feed (GPM)	Total Conc. (GPM)	Tube Conc. (GPM)	Avg Flux (GFD)	Inlet Pres (Psig)	Avg NDP (Psig)	Bank DP (Psig)	Final Element Beta
1	1294.1	53.9	468.4	19.5	17.7	113.3	77.2	13.8	1.128
2	468.4	46.8	191.7	19.2	14.2	124.5	61.3	11.3	1.084
System					16.7				

	Net Feed	RO Inlet	Conc.	Permeate
Stream Number	4	5	18	13
Concentration	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Ca++	222.00	222.00	1463.73	2.87
Mg++	70.00	70.00	461.54	0.91
Na+	213.00	213.00	1333.14	15.33
K+	6.00	6.00	36.88	0.55
NH4+	0.00	0.00	0.00	0.00
Sr++	1.92	1.92	12.66	0.02
Ba++	0.03	0.03	0.20	0.00
Fe++	0.00	0.00	0.00	0.00
Mn++	0.23	0.23	1.52	0.00
CO3--	0.00	0.05	0.31	0.00
HCO3-	260.00	162.73	971.12	20.22
SO4--	750.00	826.56	5455.68	9.66
Cl-	200.00	200.00	1259.26	13.07
NO3-	0.00	0.00	0.00	0.00
F-	0.30	0.30	1.94	0.01
SiO2	32.00	32.00	201.18	2.15
Specie1	0.00	0.00	0.00	0.00
Specie2	0.00	0.00	0.00	0.00
Specie3	0.00	0.00	0.00	0.00
Specie4	0.00	0.00	0.00	0.00
CO2	13.34	83.46	83.46	83.35
Sum of Ions	1755.48	1734.82	11199.14	64.80
TDS (180 C)	1623.18	1652.02	10705.01	54.51
pH	7.50	6.50	7.28	5.60
Hardness (as CaCO3)	842.66	842.66	5555.94	10.90
Osm Pressure (Psig)	10.38	10.02	63.91	0.51
Langlier Index	0.70	-0.51	1.89	-4.36
Stiff-Davis Index	---	---	1.14	---

<180 PREFERRED
LOWER RECOVERY
IF NEEDED DUE TO
PERSISTENT SCALING

Membrane data file version: May-07-2012
Please review the Design Notes & Warnings page attached.
Concentrate exceeds solubility limit - see warnings sheet.

Project:
Prepared By:

Description:
Type: Single Pass Design

CHEMICAL ADDITION

1302.1 lb/day of 93.2% Sulfuric Acid (H_2SO_4) is required to achieve the target pH in stream [5].

CONCENTRATE SATURATION DATA - STREAM 18

Langlier Index	=	1.889	<== Warning: Scaling Potential
Stiff-Davis Index	=	1.144	<== Warning: Scaling Potential
Ratio [Ca][SO4] to Ksp(CaSO4)	=	2.99	<== Warning!
Ratio [Ba][SO4] to Ksp(BaSO4)	=	28.32	<== Warning!
Ratio [Sr][SO4] to Ksp(SrSO4)	=	1.27	<== Warning!
Ratio SiO2 concentration to saturation concentration	=	1.65	<== Warning!

DESIGN WARNINGS - PASS 1: None

APPROXIMATE PUMPING POWER REQUIREMENTS (kW)

Feed pumping power (w/FA) @65.0% efficiency	98.18
Interbank pumping power @65.0% efficiency	9.41

NOTE

This projection is the anticipated performance and is based on nominal properties of the elements, with manifold losses as included.

The fouling allowance option (if included) increases the required 'clean water' net driving pressure by the stated percentage. Program default values are estimates only, and may not be representative of the actual fouling potential of the water source.

Koch Membrane Systems, Inc. ROPRO® Ver. 8.06-CP Date: Dec-18-2012

Project: Description:
Prepared By: Type: Single Pass Design

FEED STREAM SUMMARY

Stream	Name	Type	Percent of Total	Stream Flow Rate (USGPM)	Temperature Design (Deg F)	Temperature Average (Deg F)
1	Well 14	Well Water	100.0	1294	77.0	77.0
2	Feed 2	Other	0.0	0	77.0	77.0
3	Feed 3	Other	0.0	0	77.0	77.0
4	Net Feed	Other	100.0	1294	77.0	77.0
5	Treated Feed	Other	100.0	1294	77.0	77.0

CHEMICAL ADDITION

To achieve the target pH in stream [5], 1302.1 lb/day of 93.2% Sulfuric Acid (H2SO4) is required.

FEED STREAM COMPOSITIONS

Stream Number Concentration	1 (mg/L)	2 (mg/L)	3 (mg/L)	4 (mg/L)	5 (mg/L)
Ca++	222.00	0.00	0.00	222.00	222.00
Mg++	70.00	0.00	0.00	70.00	70.00
Na+	213.00	0.00	0.00	213.00	213.00
K+	6.00	0.00	0.00	6.00	6.00
NH4+	0.00	0.00	0.00	0.00	0.00
Sr++	1.92	0.00	0.00	1.92	1.92
Ba++	0.03	0.00	0.00	0.03	0.03
Fe++	0.00	0.00	0.00	0.00	0.00
Mn++	0.23	0.00	0.00	0.23	0.23
CO3--	0.00	0.00	0.00	0.00	0.05
HCO3-	260.00	0.00	0.00	260.00	162.73
SO4--	750.00	0.00	0.00	750.00	826.56
Cl-	200.00	0.00	0.00	200.00	200.00
NO3-	0.00	0.00	0.00	0.00	0.00
F-	0.30	0.00	0.00	0.30	0.30
SiO2	32.00	0.00	0.00	32.00	32.00
CO2	13.34	0.00	0.00	13.34	83.46
Sum of Ions	1755.48	0.00	0.00	1755.48	1734.82
TDS (180 C)	1623.18	0.00	0.00	1623.18	1652.02
pH	7.50	7.00	7.00	7.50	6.50
Hardness (as CaCO3)	842.66	0.00	0.00	842.66	842.66
Osm Pressure (Psig)	10.38	0.00	0.00	10.38	10.02
Langlier Index	0.70	-7.00	-7.00	0.70	-0.51
Stiff-Davis Index	---	---	---	---	---

Project: Description:
Prepared By: Type: Single Pass Design

BYPASS STREAM SUMMARY

Stream	Name	Type	Percent of Total	Stream Flow Rate (USGPM)	Temperature Design (Deg F)	Temperature Average (Deg F)
1A	Feed 1 Bypass	Well Water	100.0	400	77.0	77.0
2A	Feed 2 Bypass	Other	0.0	0	77.0	77.0
3A	Feed 3 Bypass	Other	0.0	0	77.0	77.0
15	Feed Bypass	Other	100.0	400	77.0	77.0

BYPASS STREAM COMPOSITIONS

Stream Number Concentration	1A (mg/L)	2A (mg/L)	3A (mg/L)	15 (mg/L)
Ca++	222.00	0.00	0.00	222.00
Mg++	70.00	0.00	0.00	70.00
Na+	213.00	0.00	0.00	213.00
K+	6.00	0.00	0.00	6.00
NH4+	0.00	0.00	0.00	0.00
Sr++	1.92	0.00	0.00	1.92
Ba++	0.03	0.00	0.00	0.03
Fe++	0.00	0.00	0.00	0.00
Mn++	0.23	0.00	0.00	0.23
CO3--	0.00	0.00	0.00	0.00
HCO3-	260.00	0.00	0.00	260.00
SO4--	750.00	0.00	0.00	750.00
Cl-	200.00	0.00	0.00	200.00
NO3-	0.00	0.00	0.00	0.00
F-	0.30	0.00	0.00	0.30
SiO2	32.00	0.00	0.00	32.00
CO2	13.34	0.00	0.00	13.34
Sum of Ions	1755.48	0.00	0.00	1755.48
TDS (180 C)	1623.18	0.00	0.00	1623.18
pH	7.50	7.00	7.00	7.50
Hardness (as CaCO3)	842.66	0.00	0.00	842.66
Osm Pressure (Psig)	10.38	0.00	0.00	10.38
Langlier Index	0.70	-7.00	-7.00	0.70
Stiff-Davis Index	---	---	---	---

Project:
Prepared By:

Description:
Type: Single Pass Design

PRODUCT STREAM SUMMARY

Stream	Name	Stream Flow Rate (USGPM)	Temperature Design (Deg F)	Temperature Average (Deg F)
13	Permeate	1100	77.0	77.0
14	Stripped Permeat	1100	77.0	77.0
15	Feed Bypass	400	77.0	77.0
16	Blended Product	1500	77.0	77.0
17	Treated Product	1500	77.0	77.0

CHEMICAL ADDITION

362.6 lb/day of 50% Sodium Hydroxide (NaOH) is required to achieve the target pH in stream [17].

PRODUCT STREAM COMPOSITIONS

Stream Number Concentration	13 (mg/L)	14 (mg/L)	15 (mg/L)	16 (mg/L)	17 (mg/L)
Ca++	2.87	2.87	222.00	61.31	61.31
Mg++	0.91	0.91	70.00	19.33	19.33
Na+	15.33	15.33	213.00	68.04	73.83
K+	0.55	0.55	6.00	2.00	2.00
NH4+	0.00	0.00	0.00	0.00	0.00
Sr++	0.02	0.02	1.92	0.53	0.53
Ba++	0.00	0.00	0.03	0.01	0.01
Fe++	0.00	0.00	0.00	0.00	0.00
Mn++	0.00	0.00	0.23	0.06	0.06
CO3--	0.00	0.00	0.00	0.00	0.76
HCO3-	20.22	20.22	260.00	84.16	97.93
SO4--	9.66	9.66	750.00	207.09	207.09
Cl-	13.07	13.07	200.00	62.92	62.92
NO3-	0.00	0.00	0.00	0.00	0.00
F-	0.01	0.01	0.30	0.09	0.09
SiO2	2.15	2.15	32.00	10.11	10.11
Specie1	0.00	0.00	0.00	0.00	0.00
Specie2	0.00	0.00	0.00	0.00	0.00
Specie3	0.00	0.00	0.00	0.00	0.00
Specie4	0.00	0.00	0.00	0.00	0.00
CO2	83.35	12.00	13.34	12.36	1.87
Sum of Ions	64.80	64.80	1755.48	515.65	535.96
TDS (180 C)	54.51	54.51	1623.18	472.82	486.13
pH	5.60	6.44	7.50	7.04	7.93
Hardness (as CaCO3)	10.90	10.90	842.66	232.70	232.70
Osm Pressure (Psig)	0.51	0.51	10.38	3.14	3.31
Langlier Index	-4.36	-3.52	0.70	-0.86	0.09
Stiff-Davis Index	---	---	---	---	---

Project:
Prepared By:

Description:
Type: Single Pass Design

ELEMENT BY ELEMENT DATA - PASS 1

Bank	Element	Inlet Pressure (Psig)	Diff Pressure (Psig)	NDP (Psig)	Element Flux GFD	Beta	Permeate TDS (mg/L)
1	1	113.3	3.3	90.6	20.8	1.076	17.8
1	2	110.0	2.8	86.2	19.7	1.082	22.5
1	3	107.3	2.3	82.0	18.8	1.088	28.7
1	4	105.0	1.9	77.8	17.8	1.096	37.4
1	5	103.1	1.5	73.5	16.8	1.106	50.0
1	6	101.6	1.2	68.8	15.7	1.117	63.0
1	7	100.4	0.9	63.4	14.4	1.128	82.0
	Avg			77.2	17.7	1.099	40.5
2	1	124.5	2.7	83.2	19.0	1.081	69.4
2	2	121.9	2.2	76.9	17.5	1.084	84.7
2	3	119.7	1.8	70.4	16.0	1.087	104.7
2	4	117.8	1.5	63.6	14.4	1.090	131.7
2	5	116.3	1.2	56.5	12.7	1.090	169.0
2	6	115.1	1.0	49.1	10.9	1.089	220.5
2	7	114.1	0.8	41.7	9.2	1.084	292.9
	Avg			61.3	14.2	1.086	136.6

ENVIRONMENTAL
Analytical Chemists
www.fglinc.com

August 29, 2011

Zone Mutual Water Co.
P.O. Box 239
Somis, CA 93066

Lab ID : SP 1107329-001
Customer ID : 2-3870

Sampled On : July 22, 2011-10:00
Sampled By : Not Available
Received On : July 22, 2011-14:37
Matrix : Ag Water

Description : Well #14 (SAME LOC AS #20)
Project : Well #14

Sample Result - Inorganic

Constituent	Result	PQL	Units	Note	Sample Preparation Method	Sample Preparation Date/ID	Sample Analysis Method	Sample Analysis Date/ID
Metals, Total[P:1]								
Aluminum	ND	10	ug/L		200.8	08/09/11:208680	200.8	08/09/11:211538
Barium	29.4	0.2	ug/L		200.8	08/09/11:208680	200.8	08/09/11:211538
Boron	0.8	0.1	mg/L		200.7	07/25/11:208058	200.7	07/25/11:210795
Calcium	222	1	mg/L		200.7	07/25/11:208058	200.7	07/25/11:210795
Iron	ND	50	ug/L		200.7	07/25/11:208058	200.7	07/25/11:210795
Magnesium	70	1	mg/L		200.7	07/25/11:208058	200.7	07/25/11:210795
Manganese	225	0.5	ug/L		200.8	08/15/11:208899	200.8	08/15/11:211860
Potassium	6	1	mg/L		200.7	07/25/11:208058	200.7	07/25/11:210795
Silica	32	2	mg/L		200.7	07/25/11:208058	200.7	07/25/11:210795
Sodium	213	2*	mg/L		200.7	07/25/11:208058	200.7	07/25/11:210795
Strontium	1920	50	ug/L		200.7	07/25/11:208058	200.7	07/25/11:210795
Wet Chemistry[P:1]								
Alkalinity (as CaCO3)	210	10	mg/L		2320B	07/25/11:208064	2320B	07/25/11:210770
Bicarbonate	260	10	mg/L		2320B	07/25/11:208064	2320B	07/25/11:210770
Carbonate	ND	10	mg/L		2320B	07/25/11:208064	2320B	07/25/11:210770
Hydroxide	ND	10	mg/L		2320B	07/25/11:208064	2320B	07/25/11:210770
Chloride	200	10*	mg/L		300.0	07/23/11:208099	300.0	07/23/11:210829
Fluoride	0.3	0.1	mg/L		300.0	07/23/11:208099	300.0	07/23/11:210829
Phosphate	1.3	0.3	mg/L		4500-P E	07/23/11:208394	4500PE	07/23/11:211145
Solids, Total Dissolved (TDS)	1570	20	mg/L		2540 G	07/27/11:208173	2540C	07/28/11:210889
Sulfate	750	20*	mg/L		300.0	07/23/11:208099	300.0	07/23/11:210829

ND=Non-Detected. PQL=Practical Quantitation Limit. Containers: (P) Plastic Preservatives: N/A ‡Surrogate. * PQL adjusted for dilution.

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24" 180/FT 12" 144K/mi