Final Recycled Water Salt Management Plan

Irvine Ranch Water District
Irvine, California

Identifying Sources and Solutions to Managing Salt in Recycled Water

October 30, 2015

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Executive Summary

The salt content in the Irvine Ranch Water District's (IRWD or District) recycled water was exhibiting an increase over time. In fact, from March to September 2011, the Michelson Water Recycling Plant (MWRP) exceeded its Regional Water Quality Control Board (RWQCB) permit limit of 720 mg/L for total dissolved solids (TDS) in the recycled water produced. In this Recycled Water Salt Management Plan (RWSMP), IRWD seeks to understand the cause of this trend and identify opportunities to manage the salt loadings that may: 1) negatively impact recycled water customer satisfaction and 2) jeopardize the District's ability to consistently meet its permitted water quality requirements.

Domestic, commercial, and industrial uses of water contribute additional salinity or TDS that is subsequently discharged to the sewage collection and treatment system. The conventional sewage treatment system is not designed to remove dissolved salts, thus almost no reduction in TDS takes place. In fact, chemicals that are used to treat sewage and produce recycled water can also add to the salinity of the effluent. The TDS concentration in IRWD's potable water drinking sources typically ranges from 270 to 570 mg/L. Domestic use and treatment generally adds about 350 mg/L of TDS, thus the District is constantly challenged to consistently meet its recycled water quality requirement of 720 mg/L TDS as a running annual average (RAA). In addition, for IRWD to continue to serve non-potable water customers who have strict salinity requirements, managing salinity in the non-potable water system is essential.

IRWD's Salt Balance Model

To trace the source of salinity and identify mitigation measures to manage potentially increasing salinity concentrations, IRWD's Salt Balance Model was developed to perform a mass balance of flow and salinity loads (measured in pounds (lbs) of TDS) throughout the IRWD service area. IRWD's Salt Balance Model works in four stages to identify salt sources (Figure ES-1):

1. **Source Water**

   The Source Water Stage accounts for the salinity in imported water and local groundwater that enters IRWD's potable water system. Future water supply sources and a projected mix of supplies were incorporated into the analysis.

2. **Sewersheds**

   The Sewershed Stage accounts for the addition of salt loads from domestic residential use, water softeners, commercial/institutional use, and industrial use. Salinity that is lost to irrigation demands and do not return to the sewage collection system is also included.

3. **Treatment Plants**

   The Treatment Plant Stage accounts for influent and effluent flows, removed organic salts, chemical addition, and sludge production. This results in a salinity loading of the recycled water produced at the Michelson and Los Alisos Water Recycling Plants (MWRP and LAWRP). Salinity that is lost to sludge disposal is also included.

4. **Non-Potable Water System**

   The Non-Potable Water System Stage accounts for the blending of other non-potable water (including native runoff, untreated groundwater, and imported untreated water) to the recycled water effluent and any additional chemicals that are introduced to maintain water quality of the end product.

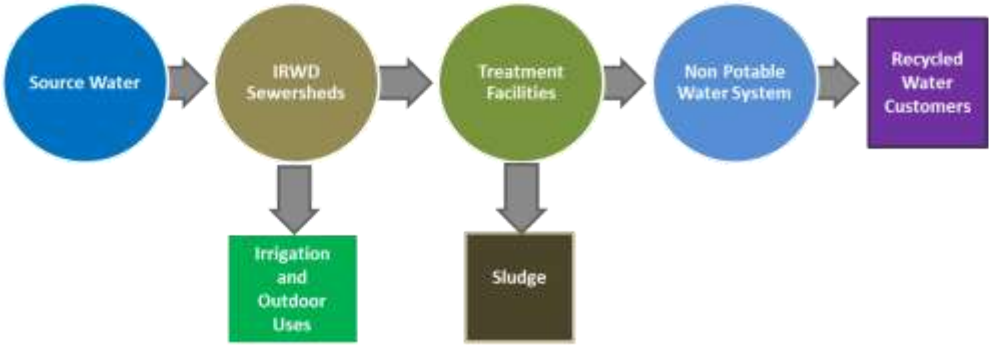

Figure ES-1. Contributing Sources and Losses of Salinity in Recycled Water

Model Operating Modes

The model was constructed to operate in three different modes: Historical Measured, Historical Predictive, and Future Predictive, each of which is described below.

Historical Measured: The Historical Measured mode was the first mode developed to balance the salts in the system using historical flow and water quality data. The data from this mode was also used to develop parameters such as seasonal variation of water use, consumptive losses, and salt exports via outdoor use and sludge production. This mode was used to correlate measured influent and effluent TDS values with model results.

Historical Predictive: The Historical Predictive mode tested IRWD’s Salt Balance Model using historical flow and projected water quality parameters rather than measured parameters. By comparing the results of the Historical Measured mode with the Historical Predictive mode, the accuracy of approach and methodology of the model could be assessed. This mode provided a quality assurance review of the model’s capability of predicting future salt loads.

Future Predictive: The Future Predictive mode calculated future salt loads based on the parameters determined from the Historical Measured Mode. The Future Predictive period assessed salt loads and TDS from 2013 through 2035.

Model Calibration

Calibration of IRWD’s Salt Balance Model was performed in two steps: Historical Measured and Historical Predictive. Both calibration steps compare monthly model estimates to observed data into and out of MWRP. The Historical Measured calibration used observed measurements and an iterative process to estimate key parameters for every month of the study period within a range of reasonable values and demonstrated the model’s ability to simulate historic flow and concentrations into and out of MWRP over the five-year study period when key unmeasured data is estimated from observations.

The Historical Predictive calibration used a single or monthly estimate of these same key parameters for every month of the study period. The Historical Predicted calibration demonstrated the uncertainty to expect when these key parameters are estimated. Because these same key parameters will be unknown in the future, the Historical Predicted results provided a qualitative assessment for how the model should be used for Future Predictive application. These results, in combination with the quality of the Historical Measured calibration indicate that **IRWD’s Salt Balance Model should not be used to forecast exact salt loadings in the future; however, it can be used to forecast future TDS trends.**

Historical Data

Based on an average of the 5 years (60 months) of historical data, IRWD’s Salt Balance Model identified the sources of salinity in the District’s sewage, as represented in Figure ES-2. The salt load in the IRWD sewer collection system during this time period is estimated to be 5,520,000 lbs per month. The largest contributor (41%) is source water, with imported water and local groundwater sources contributing equivalent salt loads, although imported water has a much greater TDS concentration. Residential use is generally considered an uncontrollable load and contributes approximately 33% of the salt that flows to the sewer system. Commercial and Industrial uses contribute 21% of the salt load and self regenerating water softeners contribute an estimated 5% of the salt load.

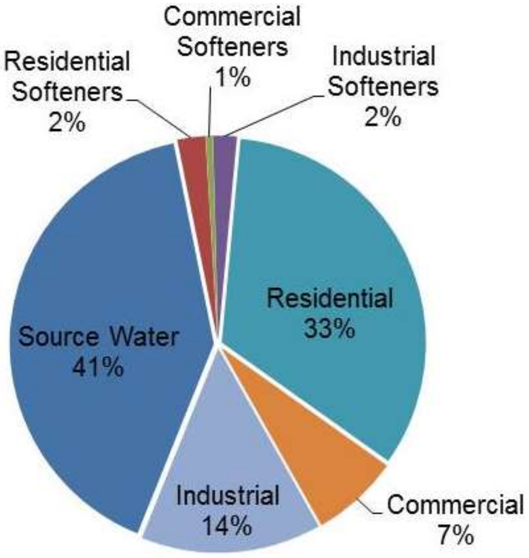

Figure ES-2. Salinity Load Contributions in IRWD Sewage (2008-2012 Average)

From 2008 to 2012, MWRP processed approximately 60% of the salt load in the District's sewer collection system, or 3,241,000 lbs per month. Figure ES-3 illustrates the contributing salinity sources specific to recycled water produced at MWRP. The largest salt loads to IRWD's recycled water system are from the source water and residential use. As shown, the chemical addition at the treatment plant contributes approximately 4% of the salt load in the effluent. The remaining 3% that is not called out on the graphic is attributed to water softeners. Note that most of IRWD's industrial customers are located in sewersheds that do not contribute flow to the MWRP, thus the industrial-based salinity load has less of an impact on the quality of the MWRP recycled water product.

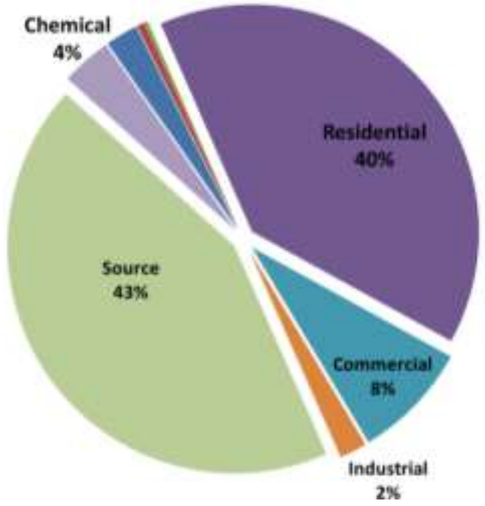

Figure ES-3. Salinity Load Contributions to MWRP Recycled Water (2008-2012 Average)

Model Results

The significant impact of source water on IRWD recycled water TDS is exemplified during the time period when MWRP effluent TDS was out of compliance with the RWQCB 720 mg/L limit. The three panels shown in Figure ES-4 are historical 2008 to 2012 data. The first panel shows the percent makeup of Colorado River water in imported water from Diemer Water Treatment Plant; the second panel shows the measured monthly MWRP effluent TDS and the running annual average; and the third panel shows the salt load in pounds from imported water and local groundwater sources.

As shown, the RAA was out of compliance from March 2011 to February 2012. This figure also shows that the monthly MWRP effluent TDS was increasing for one year prior to the out of compliance period. Leading up to and during this out of compliance period, several factors contributed to MWRP exceeding the TDS limit:

1. The source water blend at Diemer was over 50% Colorado River, which has more salt than State Water Project (SWP) water.
2. Salt load from imported water was abnormally high due to IRWD's participation in Orange County Water District's (OCWD) In-Lieu program.
3. MWRP received return flow from Sand Canyon reservoir in July and August 2011. Reservoir return contributes an additional salt load to MWRP that increases effluent TDS by about 15 mg/L.

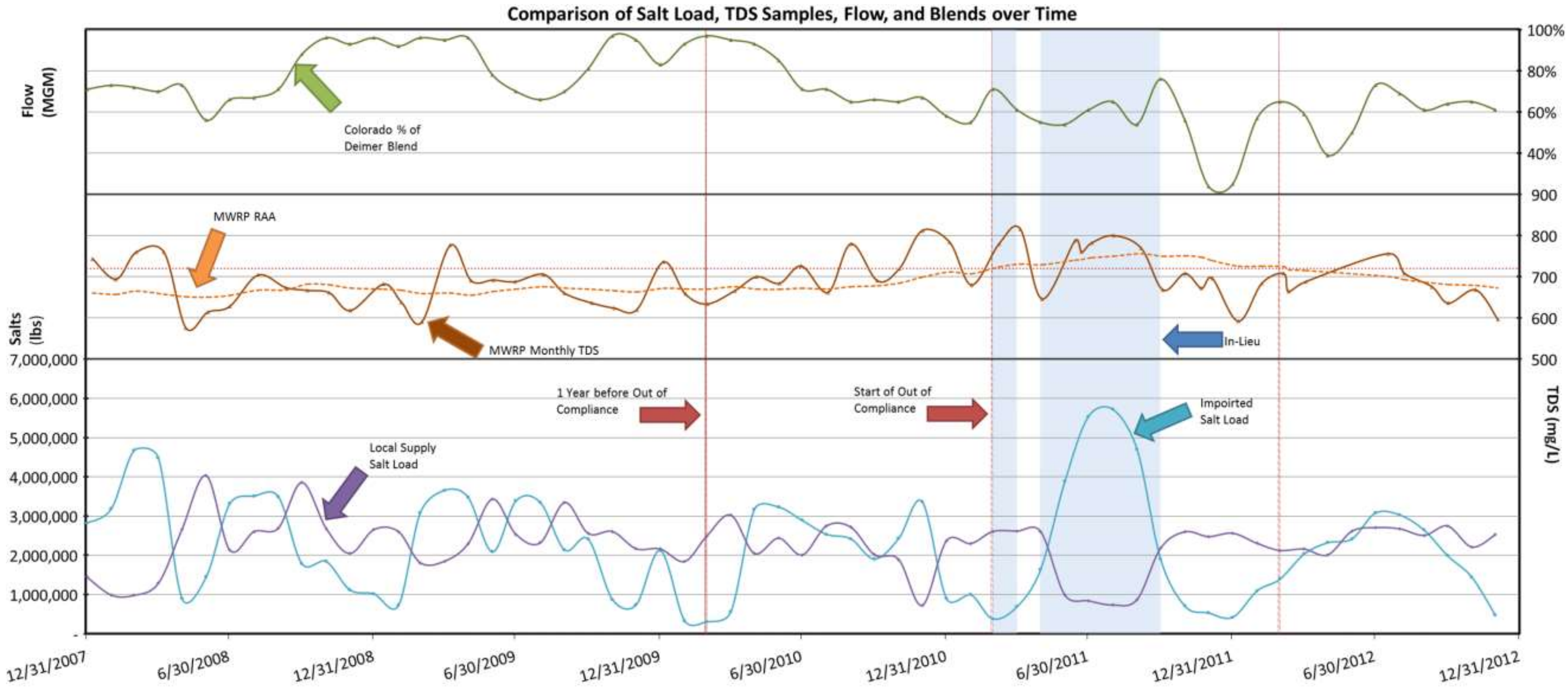

Figure ES-4. Historical Imported Salt Load Impact on MWRP Recycled Water (2008-2012)

Future Baselines

The Future Predictive mode calculated recycled water TDS with the same methodology as the Historical Predictive mode. The differences between the modes are the inputs for the calculations. The inputs are classified into three major categories; user defined parameters, model predictive data, and statistical trends. Each category has a wide array of probable and relevant settings which would change the results of the calculations. Two Baselines were developed to simulate possible futures. These baselines are labeled "Baseline A" and "Baseline B" and the parameters are listed in Table ES-1, below. In general, Baseline A represents a best case that will produce relatively low future TDS levels while Baseline B is a more conservative case that will produce relatively high TDS levels.

Table ES-1. Future Baseline Scenarios

No.	Parameter	Baseline A	Baseline B
1	Basin Pumping Percentage (BPP)	70% until 2024 75% after 2024	65%
2	In-Lieu Period	None	Every 7 years
3	Recycled Water (RW) Penalty	Expires in 2016	Never Expires
4	Diemer WTP Effluent TDS Concentration	Historical median by month	Conservative estimate: 85% Colorado River Water at 723 mg/L 15% State Water Project at 324 mg/L

MWRP

Figure ES-5 shows the estimated historic and future MWRP effluent TDS RAA projected into the future with Baseline A and Baseline B.

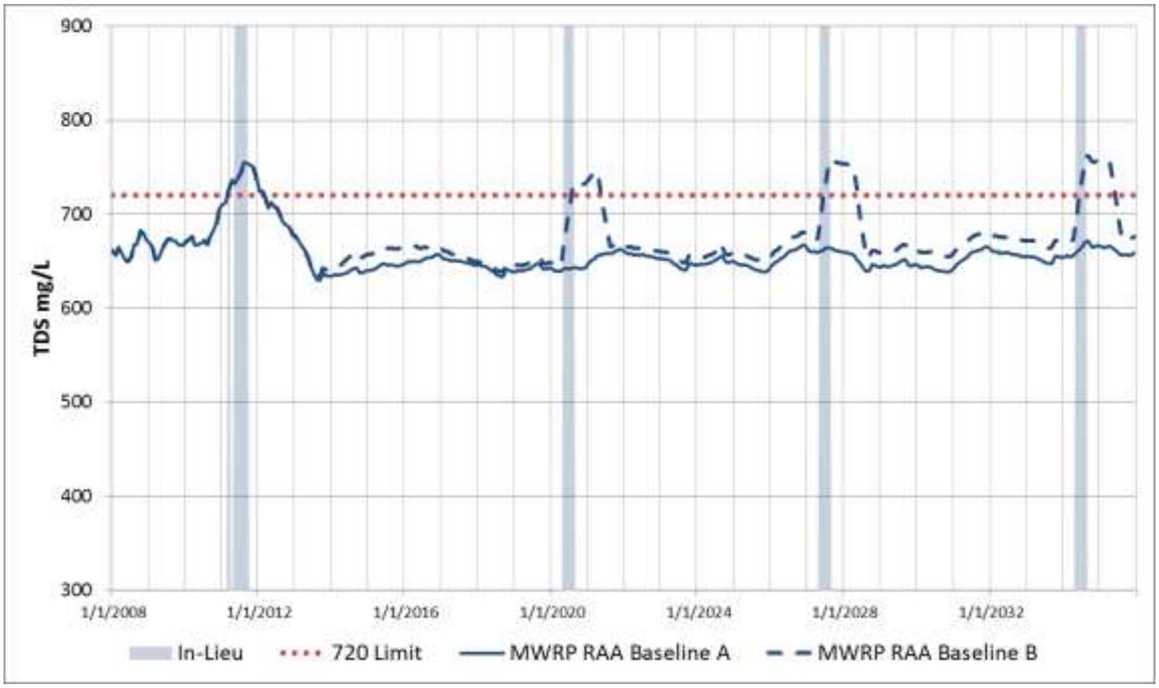

Figure ES-5. Future MWRP Effluent TDS RAA for Baseline A and Baseline B

California RWQCB, Santa Ana Region, Order No. R8-2008-0072 limits the MWRP recycled water TDS RAA to 720 mg/L. Based on the previously described parameters, the RAA for Baseline A does not exceed 720 mg/L TDS through 2035. On the other hand, the RAA for Baseline B exceeds 720 mg/L on several occasions through 2035 with the largest predicted TDS being approximately 40 mg/L over the limit in 2034 and 2035. In the future, Baseline B is generally below the TDS limit except during in-lieu periods, which the model estimates to occur every 7 years from May through September.

Both baselines show a gradual increase in TDS over time; however, the rate of TDS increase in Baseline B is about twice the rate of increase in Baseline A. This increase in Baseline A is the combined effect of the other parameters (BPP, RW Penalty, Colorado River, SWP, and Diemer blend) on the RAA, which are not as recognizable as in-lieu periods but have a steady impact on TDS.

Through 2035, both Baselines A and B would not exceed the TDS limit of 720 mg/L RAA if IRWD did not participate in the in-lieu program. However, the in-lieu program benefits IRWD by reducing groundwater pumping and allowing the groundwater basin to recharge faster. For Baseline A, the RAA is about 660 mg/L in 2035, which gives IRWD a TDS buffer of 60 mg/L before they exceed their permit limit of 720 mg/L. For Baseline B, the RAA is about 670 mg/L in 2035 during a non in-lieu period, which gives IRWD a TDS buffer of 50 mg/L before they would exceed their permit limit. Changes to or within IRWD's system that increase or decrease TDS would likewise affect the District's available buffer.

LAWRP

Based on these operational conditions and future demand-supply projections, the model predicts that LAWRP will typically produce recycled water for one or two summer months of the year. From 2013 to 2035, the Baseline A predicts that 11 of the 23 years will not require LAWRP to produce recycled water. When LAWRP does produce recycled water it results in relatively little difference in the recycled water concentration. Due to these reasons and the fact that MWRP has a greater impact on TDS in the non-potable system than LAWRP, the goal to mitigate TDS and develop scenarios focused on compliance with MWRP effluent discharge requirements.

Future Scenarios

IRWD identified five future scenarios that could impact the District's TDS concentrations in the non-potable water system and are not included in the baseline, as shown in Table ES-2. The future non-potable TDS concentrations were evaluated for these scenarios. Note that because these future scenarios reflect different conditions, they should not be compared against each other. Table ES-3 is a summary of the five scenarios including scenario criteria, TDS impact, and cost opinion. The following paragraphs briefly describe each of the five scenarios. A more detailed description of the development and evaluation of each scenario is provided in Chapter 4.

Table ES-2. Future Scenarios

Scenario No.	Name	Description
1	Salt Removal at MWRP	IRWD incorporates salt removal through reverse osmosis (RO) into the MWRP treatment process
2	Brine Disposal to MWRP	IRWD customers dispose of brine into IRWD sewers
3	Poseidon HBDP	Poseidon Huntington Beach Desalination Plant comes online
4	Poseidon HBDP Max	Poseidon HBDP comes online and IRWD receives maximum available capacity
5	MBI	Mid-Basin Injection online

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Table ES-3. Summary of Future Scenarios and Cost

Name [a]	**Scenario 1** [c]	**Scenario 2** [c]	**Scenario 3** [c]	**Scenario 4** [c]	**Scenario 5** [c]
	Salt Removal at MWRP	**Brine Disposal to MWRP**	**Poseidon HBDP**	**Poseidon HBDP Max**	**Mid-Basin Injection**
Basis of Scenario [b]					
Salt Removal System Design Criteria	50 mg/L TDS MWRP Effluent	450 mg/L TDS Target	500 mg/L High TDS Expected Poseidon	500 mg/L High TDS Expected Poseidon	43 mg/L TDS
		1 Sensitive User	1,500 AFY Poseidon enters IRWD (Average)	48,350 AFY Poseidon enters IRWD (Average)	1.5 MGD MBI-1 Well Injection
		640 AFY Each User	100 - 2,000 AFY Poseidon enters IRWD	100 - 48,500 AFY Poseidon enters IRWD	3 MGD/Future Well Injection
		0.57 MGD Demand for 1 User	0.09 - 1.8 MGD Poseidon enters IRWD	0.09 - 43.3 MGD Poseidon enters IRWD	8-10 Anticipated Future Wells
Total User Treatment System					
Influent		0.31 MGD 720 mg/L TDS			
Effluent		0.25 MGD 100 mg/L TDS			
Brine		0.06 MGD 3,200 mg/L TDS			
User Brine Discharge To		MWRP			
MWRP Treatment System					
Influent	2.6 MGD 735 mg/L TDS	0.37 MGD 772 mg/L TDS			
Effluent	2.0 MGD 100 mg/L TDS	0.30 MGD 100 mg/L TDS			
Brine	0.5 MGD 3,280 mg/L TDS	0.07 MGD 3,325 mg/L TDS			
MWRP Brine Discharge To	OCSD	OCSD			
Water Quality (in 2034-2035)					
MWRP Effluent					
Δ TDS	(50) mg/L TDS	(7) mg/L TDS	0 mg/L TDS	160 mg/L TDS	Expected reduction in TDS
Improved Water Quality for:	All Non-Potable Users	Sensitive User Only	No Effect	All Non-Potable Users	All Non-Potable Users
Sensitive User Water Quality					
Δ TDS		(270) mg/L TDS			
Life Cycle (2015-2035)[c]					
Net Present Value (2015 dollars)	$ 27,700,000 [d]	$ 4,600,000	$ -	$ -	$ -
Capital Cost (2015 dollars)	$ 3,400,000	$ 1,000,000	$ -	$ -	$ -
Total Salt (20 years)	102,100,000 lbs Removed	15,100,000 lbs Added for 1 User	0 lbs	- lbs	- lbs
Total Salt per Year [e]	5,105,000 lbs Removed	800,000 lbs Added for 1 User	0 lbs	- lbs	- lbs
Unit Cost	$ 0.27 per lb Salt	$ 0.30 per lb Salt	$ -	$ -	$ -
Annual Cost	$ 1,385,000 per year	$ 244,000 per year for 1 User	$ -	$ -	$ -

NOTES:

a Scenarios should not be compared to each other. Each scenario represents a different situation.

b All scenarios are based on projected future Baseline B during worst out of compliance period (2034-2035), where MWRP Effluent TDS RAA is 780 mg/L at 28 MGD.

c Scenario 1 estimates unit cost for IRWD to construct and operate salt removal (RO) system at MWRP.
Scenario 2 estimates unit cost to generate revenue for IRWD to construct and operate a future salt treatment system (RO) at MWRP to remove the additional brine discharged from 1 User Treatment System(s).
Scenario 3 estimates unit cost to IRWD to receive 100 - 2,000 AFY Poseidon HBDP water to supply Newport Coast. Newport Coast sewershed discharges to OCSD. IRWD does not plan to purchase Poseidon water.
Scenario 4 estimates TDS changes to IRWD if they receive the max 48,500 AFY of Poseidon HBDP water as part of the purchase and exchange program with other agencies. Unit costs could not be determined.
Scenario 5 was evaluated qualitatively and a reduction in total Salts is anticipated at no direct cost to IRWD. This scenario was not modeled.

d Assumes unit cost to discharge brine to OCSD is $1,290 per MG.

e Assumes even distribution of salt load per year.

f Average local and imported chloride concentration are 25 and 90 mg/L, respectively. Per Poseidon HBDP WQ specifications the mean and maximum chloride concentration are 75 and 100 mg/L, respectively.

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Scenario 1 - Salt Removal at MWRP

Scenario 1 – Salt Removal at MWRP evaluates the facilities required to reduce TDS concentrations of recycled water by installing a reverse osmosis (RO) process to treat a portion of the membrane bioreactor (MBR) permeate to be mixed with the conventional treatment plant stream and discharged as the plant's recycled water effluent.

As shown in Figure ES-5, Baseline B is projected to exceed the 720 mg/L limit by approximately 50 mg/L TDS in 2034 and 2035 during an in-lieu period. The RO process was sized to treat and reduce the Baseline B projection to consistently meet the RAA TDS limit of 720 mg/L with an additional buffer, which increases the total TDS buffer to 90 mg/L. Table Es-3 includes a summary of the design criteria, net TDS effect, and cost for Scenario 1 – Salt Removal at MWRP.

Scenario 2 – Brine Disposal to MWRP

Scenario 2 – Brine Disposal to MWRP takes into account the possibility of a customer installing an RO system onsite to reduce the TDS in their non-potable water to 450 mg/L and disposing of brine to the sewer system upstream of MWRP. This disposal of brine would have a direct impact on the salinity of water entering the MWRP, and thus the salinity of the recycled water produced at MWRP.

The TDS concentration of the MWRP recycled water product would increase by 7 mg/L for a single customer discharging brine with the understanding that non-potable water TDS would not exceed the permitted 720 mg/L. The TDS buffer would likewise be reduced by 7 mg/L, which does not prevent Baseline A or B from meeting the permit limit. However, several brine discharges of similar volume and quality would proportionally multiply the impact and create a situation where the TDS permit limit was exceeded. Table ES-3 includes a summary of the design criteria, net TDS effect, and cost for Scenario 2 – Brine Disposal to MWRP.

This scenario determined the TDS impact on MWRP effluent if the non-potable water quality to the customer did not exceed 720 mg/L TDS, which would otherwise instigate action to lower TDS back to 720 mg/L. Additional analysis is required to determine the potential for a cumulative impact on recycled water salinity as the non-potable water user begins to receive a product with escalating salinity over time. This potential for a cumulative impact may be dampened if the use and subsequent brine disposal is seasonal with peak flows and corresponds with periods when the District's potable water quality has a lower salinity content.

Scenarios 3 – Poseidon Huntington Beach Desalination Plant

This scenario evaluates Poseidon Huntington Beach Desalination Plant (HBDP) providing potable water to IRWD as part of a purchase and exchange program. IRWD may purchase up to 100 AFY of the project's yield and may be required to accept HBDP supplies instead of MWD imports. Under Scenario 3 – Poseidon HBDP, potable water produced from HBDP would be conveyed to the IRWD service area via the OC-44 and East Orange County Feeder #2 (EOCF #2) to serve the Newport Coast sewershed will inherently receive HBDP water because its potable supply is from an EOCF #2 turnout. The quality of potable water supplied by the HBDP must be the same or better than imported water supplied by Metropolitan Water District of Southern California (MWD). According to the water quality specifications provided by Poseidon, HBDP water will have less TDS than MWD water.

Scenario 3 – Poseidon HBDP analyzes the offset of MWD water with HBDP water to meet the Newport Coast sewershed demand, where delivery is anticipated to occur. If Poseidon does meet IRWD's requirements to be of the same water quality as the current MWD imported water source, then there will be no net impact of HBDP water on recycled water TDS. HBDP water will only replace MWD water, which has the same water quality levels. In addition, the sewage from the Newport Coast sewershed is conveyed to OCSD, not to MWRP or LAWRP; therefore, this would not impact IRWD's recycled water quality or the TDS buffer regardless of the quality of the HBDP desalinated water. Table ES-3 includes a summary of the design criteria, net TDS effect, and cost for Scenario 3 – Poseidon HBDP.

Scenario 4 – Poseidon HBDP Maximum Available Capacity

Similar to the previous scenario, this scenario evaluates the TDS impact of Poseidon Huntington Beach Desalination Plant providing potable water to IRWD. The difference is that in Scenario 4 – Poseidon HBDP Maximum, IRWD accepts as much Poseidon HBDP water as possible (43.2 MGD or 48,390 AFY). This scenario evaluates the maximum potential impact on the District's recycled water salinity due to offsetting imported MWD and local potable supplies with HBDP water. HBDP water will be distributed in IRWD's potable water system in several sewersheds and on average meet at least half of IRWD's potable water demand. This changes the source water allocation within each sewershed and affects the TDS in MWRP recycled water effluent and IRWD's non-potable system.

The potable water quality supplied by the HBDP must be the same or better than imported water supplied by MWD. Poseidon's water quality specifications indicate a 12-month average of 350 mg/L TDS in HBDP, which is slightly higher than local groundwater that averages about 280 mg/L. For Baseline B, this results in an initial TDS increase by about 40 mg/L and a TDS increase of 10 mg/L in 2035. IRWD may exceed the 720 mg/L TDS limit during in-lieu periods. If HBDP water TDS approaches their maximum 500 mg/L, which is significantly greater than local groundwater and slightly lower than imported MWD water, then IRWD would consistently be out of compliance with recycled water TDS increases ranging from 100 to 150 mg/L for Baseline B. This is because HBDP water is supplying several IRWD sewersheds that were formerly using local groundwater supplies.

Note that during in-lieu periods, MWRP recycled water salinity will be reduced with Poseidon HBDP water regardless of HBDP meeting the 350 mg/L (average) or 500 mg/L (maximum) TDS concentration as specified. This is because both of these water qualities still have a lower salinity than imported MWD water.

Table ES-3 includes a summary of the design criteria and net TDS effect for Scenario 4 – Poseidon HBDP Maximum. A cost opinion could not be developed for this scenario due to unknown cost impacts; however, several factors should be considered when evaluating cost and are described further in Chapter 5.

Scenario 5 – Mid-Basin Injection

This scenario evaluates the impact of OCWD's Mid-Basin Injection (MBI) project on IRWD TDS. Mid-Basin Injection consists of one injection well able to sustainably inject 1.5 MGD (1,680 AFY) of Groundwater Recharge System (GWRS) product water into the groundwater basin in the Principal aquifer. Design injection capacity of the well is 3 MGD (3,360 AFY). Mid-Basin Injection is located about a mile away from two wells associated with the Dyer Road Well Field (DRWF), which is IRWD's major local groundwater supply. OCWD is seeking approval to expand the Mid-Basin Injection project to construct four more injection wells (3-MGD capacity each) in Centennial Regional Park, which is closer to DRWF. OCWD's 2014 Long-Term Facilities Plan describes a potential for developing 8 to 10 MBI injection wells, but the ultimate MBI injection capacity has not yet been determined.

Regardless of the number of injection wells or the ultimate capacity, the Mid-Basin Injection project is expected to improve the salt content in IRWD's system and increase IRWD's TDS compliance buffer because GWRS product water has a TDS concentration of 43 mg/L, which is much lower than the local groundwater and imported water. Injecting GWRS product water into the Principal aquifer will improve the local groundwater quality for TDS, which will eventually reach the DRWF wells and be withdrawn and used as potable water in the IRWD service area.

This scenario was not modeled because the Mid-Basin Injection project will improve IRWD recycled water TDS and has no direct cost to IRWD.

Operational Strategies and Policy Considerations

IRWD's Salt Balance Model allows the District to evaluate operational strategies and consider policy recommendations associated with salinity management by projecting potential trends of TDS under different operating scenarios. Future TDS concentrations from MWRP were estimated to range from 50 to 60 mg/L less than the permitted RAA value of 720 mg/L. However, future TDS concentrations can have significant variability over time and this buffer can quickly erode if not managed with care and foresight. Several critical issues were identified during this study that are listed below and discussed in more detail in Section 6.3:

1. Monitor imported water TDS
2. Management of In-lieu periods
3. Management of return flows from Sand Canyon Reservoir to MWRP
4. Understand the TDS impact and associated cost to mitigate the introduction of new salt loads, including:
    a. Accepting brine disposal to IRWD's sewer and water recycling facilities
    b. Accepting desalinated water from HBDP and monitoring water quality requirements

IRWD’s Salt Balance Model may also be used to determine the TDS impact from additional changes to IRWD’s system. Some previously identified scenarios that may be considered for future analysis and evaluation include:

- Brine disposal to MWRP cumulative TDS impact
- Discharge of Irvine Desalter Project – Shallow Groundwater Unit to MWRP
- Discharge of Irvine Desalter Project – Potable Treatment Plant brine to MWRP
- Diversion of Irvine Business Complex sewershed to MWRP

1 Introduction

To conserve our water resources, the State of California encourages the use of recycled water in place of potable water for applications such as landscape irrigation and industrial processes. However, the salinity of recycled water is limited by a permit from the Regional Water Quality Control Board (RWQCB) and some recycled water customers are concerned that salinity levels in recycled water can have adverse affects on their end use.

Since the early 1960's, Irvine Ranch Water District (IRWD or District) has been on the forefront of technology in the production and use of recycled water. Recycled water is used throughout the District for agricultural and landscape irrigation and industrial processes, as well as toilet flushing and cooling towers in dual plumbed buildings. The concentration of salts in recycled water, measured as total dissolved solids (TDS) in milligrams per liter (mg/L), is an important water quality issue for the District's industrial customers and irrigation customers with salt sensitive plantings.

Recycled water from the District's Water Recycling Plants may be discharged to Rattlesnake Reservoir, Sand Canyon Reservoir, Syphon Reservoir, and San Joaquin Reservoir for storage. Three of the reservoirs (Rattlesnake, Sand Canyon, and Syphon) are Waters of the United States. The area of recycled water use overlies the Irvine Groundwater Management Zone. As such, the District's waste discharge permit limits TDS concentrations in recycled water to maximize opportunities for beneficial reuse and also to protect water quality in Waters of the United States and underlying groundwater supply sources. The beneficial uses and water quality objectives for these resources are defined in the Santa Ana Regional Water Quality Control Board Basin Plan.

The salt content of the District's recycled water was exhibiting an increase over time with a running annual average (RAA) of 661 mg/L in January, 2008 to 682 mg/L in January, 2013. In fact, from March to September 2011, the Michelson Water Recycling Plant (MWRP) exceeded its permitted TDS limit of 720 mg/L for recycled water. In this Recycled Water Salt Management Plan (RWSMP), IRWD seeks to understand the cause of this trend and identify opportunities to manage the salt loadings that may 1) negatively impact recycled water customer satisfaction and 2) jeopardize the District's ability to consistently meet its permitted water quality requirements.

1.1 Salinity in Recycled Water

Salinity is the concentration of dissolved mineral salts in water. Salts are compounds such as sodium chloride, magnesium sulfate, potassium nitrate, and sodium bicarbonate, which dissolve during natural weathering processes into ions and enter groundwater and surface waters. All natural waters contain dissolved salts.

Domestic, commercial, and industrial uses of water contribute additional salinity that is subsequently discharged to the sewage collection and treatment system. The conventional sewage treatment system is not designed to remove dissolved salts, thus almost no reduction in salinity takes place. In fact, chemicals that are used to treat sewage and produce recycled water can also add to the salinity of the effluent.

IRWD operates two recycled water facilities. The Michelson and Los Alisos Water Recycling Plants (MWRP and LAWRP) produce recycled water that is used for agriculture and landscape irrigation and industrial use, as well as toilet flushing and cooling towers in dual plumbed buildings. The District's current discharge permit (Order No. R8-2015-0024 *Irvine Ranch Water District Water Recycling Plants Waste Discharge Requirements and Master Reclamation Permit*) covers both of the District's recycled water plants and limits the 12-month running average TDS concentration of IRWD's recycled water to 720 mg/L. The TDS water quality objective for the Irvine Groundwater Management Zone is 910 mg/L. The 720 mg/L permit limit, however, is based on the Basin Plan water quality objective of the surface water reservoirs, which are designated as "waters of the United States" and used for non-potable water storage.

The TDS concentration in the District's potable water drinking sources typically ranges from 400 to 600 mg/L. Domestic use can add 200 to 300 mg/L[1], thus the District has little margin to consistently meet its discharge requirement of 720 mg/L.

1.2 Project Goals

The purpose of the RWSMP is to gain a comprehensive understanding of the factors that are contributing to the increasing trend of TDS concentration in the recycled water product. Once these factors are understood, cost effective projects and policies to manage the salt content of the recycled water can be identified and implemented.

The goals of the project were defined at the outset of the project and are listed below.

- **Reduce Recycled Water TDS.** Reducing or controlling the TDS concentration in recycled water is the ultimate goal of the project. As mentioned above, IRWD has two primary reasons to minimize recycled water TDS (permit requirements and customer satisfaction). All other goals for the project are means to achieve this goal.
- **Understand Salt Sources.** To the extent feasible, all of the sources contributing to the recycled water TDS must be understood and quantified. This is an important initial step that facilitates the rest of the project.
- **Quantify TDS of Entire Service Area.** The modeling of IRWD's service area must be comprehensive. Covering the entire service area will be important to make sure that important salt loads are not overlooked.

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[1] Santa Ana Basin Plan, July 2014, Chapter 5 Implementation, TDS/Nitrogen Management Plan, Mineral Increments

  - **Identify Contributions at Potable Water Sources, Recycled Water Treatment Plants, and Reservoirs.** When combined, potable water, recycled water, and reservoir operations constitute the locations over which IRWD has the greatest control. As a result, these are the locations where IRWD can most easily implement changes.
  - **Consider Potable Water Sources.** IRWD has groundwater resources and receives imported potable water from Metropolitan Water District (MWD). IRWD, to some extent, does control how much of its water comes from each of these sources. However, finite groundwater resources and the Basin Pumping Percentage (BPP) limit IRWD's control. Multiple potable water sources must be considered.
  - **Quantify Impact of New Processes at MWRP.** With the Phase 2 Expansion complete at MWRP, IRWD will have more process control. A second treatment train consisting of membrane bioreactor (MBR) treatment followed by ultraviolet (UV) disinfection will be available to treat a portion of the recycled water flow. A biosolids treatment process is also planned to be added at MWRP. Quantifying the varying effects on TDS by the old and new treatment trains is an important aspect of the project.
  - **Address LAWRP Operations.** LAWRP is one of IRWD's two recycled water treatment plants. IRWD has a degree of flexibility regarding which treatment plant it operates and how much recycled water it produces from each. The RWSMP must consider an appropriate range of operations scenarios at LAWRP.
  - **Evaluate Reservoir Operation.** Recycled water produced at MWRP is chlorinated at the treatment plant, dechlorinated prior to entering Rattlesnake and Sand Canyon Reservoirs to protect fish species, and then chlorinated again when reintroduced in the non-potable (NP) system. Future operation of Syphon Reservoir may have the same treatment requirements. The sequence of chemical addition may have an impact on the TDS in the recycled water system and must be considered.
  - **Evaluate TDS Contribution from Chemicals.** To the extent possible, the RWSMP will evaluate the TDS contribution from chemical addition in treatment processes.
- **Model TDS and Cost.** Model outputs will have greater value to the extent that they include impacts on processes and cost. Scenarios that extensively reduce TDS loads but have prohibitive costs are not desired, and vice versa.
- **Select Implementable Strategies.** The strategies that IRWD evaluates and potentially implements must have a high likelihood of being acceptable to IRWD and its customers. The success of the strategies depends not only on the extent to which the strategy reduces salt, but also on the extent to which the strategy is accepted by IRWD and those who use its potable water and recycled water. The RWSMP must demonstrate that the policies and procedures that are recommended will result in the highest quality recycled water for IRWD's customers at the lowest cost and will result in meeting TDS permit limits.

- **Consider Combining Strategies.** The most effective management strategy may be a combination of individual policies, operations changes, and capital projects. The strategy may depend on specific benchmarks and thresholds at which IRWD will implement particular operating policies and/or projects.
- **View Options Holistically.** All operations and activities by IRWD and its customers are interconnected. The project must appropriately consider these projects from a holistic point of view.
- **Clearly Define Sources of Salt and Means of Reduction.** A clear understanding of all of the sources that contribute to the salt load in IRWD's system and ways that IRWD can control them is the essence of the plan. This clear understanding will give IRWD a method for planning for the future as it relates to TDS in its recycled water. Defining the sources and means for reduction so that they are clearly understood will allow IRWD staff to use the model and plan to evaluate options in the future.

1.3 Project Methodology

To identify the sources of TDS in the District's recycled water product, a system-wide mass balance model was developed to identify the gains and losses in salt loads. These sources and losses were categorized by type, as illustrated in a simplified graphic in Figure 1-1, below.

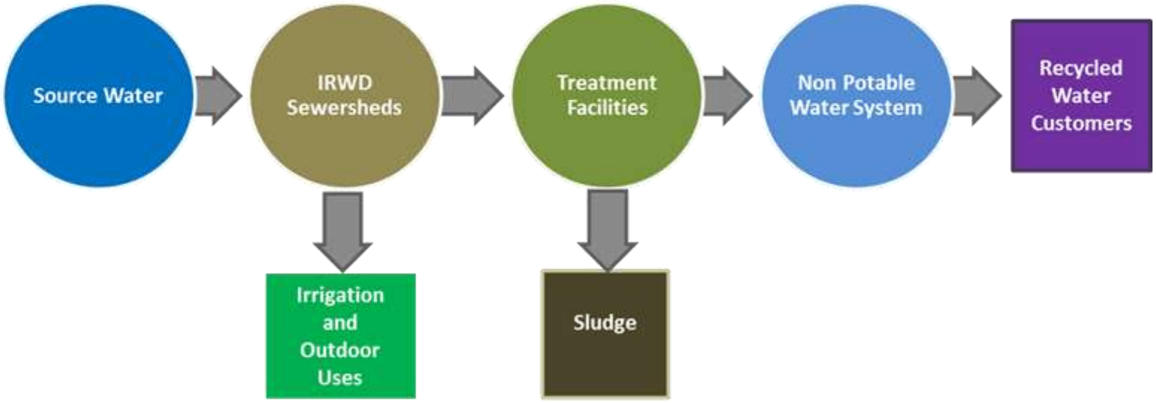

Figure 1-1. Contributing Sources and Losses of Salinity in Recycled Water

IRWD has substantial local groundwater resources that supply the majority of the potable water used by the District's customers. The District supplements that resource with imported potable water from MWD, which is a combination of Colorado River water and State Water Project (SWP) water. Potable water is provided to residential, commercial, industrial, and agricultural customers in IRWD's sewersheds. From 2008 to 2012, 40 to 60 percent of the potable water supply was used for irrigation and other outdoor uses and does not return to the sewer collection system.

The sewage from residential, commercial, and industrial users within the IRWD service area was evaluated to assess its impact on recycled water TDS. The treatment processes at MWRP and LAWRP were reviewed to determine the impact on recycled water TDS. Finally, the non-potable groundwater wells and storage reservoirs were incorporated into the model to more accurately represent IRWD's non-potable system and product water quality as delivered to the recycled water customer.

After the historical and current mass balances were developed, the baseline was extended into the future. The baseline includes the most likely scenario of potable water sources, potable water use, and recycled water treatment and use. Additional scenarios were evaluated that include variations of the baseline. The additional scenarios were based on other likely conditions for water sources, water use, and treatment processes, and also include projects and policies that IRWD may implement that would affect recycled water TDS. The future scenarios were compared against the baseline based on economic and non-economic impacts.

Key findings of the salt evaluation include the historical and current salt model balances, the future baseline, the scenario analysis, and a recommended salt management strategy. The recommended salt management strategy is a combination operating policies and salt reduction measures for IRWD to consider that provide IRWD with the flexibility to reduce salt concentrations in its recycled water.

1.4 Stakeholder Issues

Salt management options result in benefits and costs that may accrue to both the District and people and entities other than IRWD. Key internal and external stakeholders that have a vested interest in salt management planning were identified. For IRWD to gain support and approval for projects and policies, it will be important to objectively address stakeholder needs and concerns. Our understanding of those issues, listed below, was taken into account in the development of this RWSMP.

- **IRWD Board of Directors.** The Directors want a cost-effective plan that will be acceptable to IRWD customers and meets regulatory requirements. The Directors are motivated to do what is in the best interest of the District and its customers.
- **IRWD Customers.** IRWD's customers will benefit from improved recycled water quality and will also bear part of the cost for improvement projects. It will be important for IRWD's customers to understand the RWSMP's recommendations and how they impact them.
- **Regulators.** One of the two primary goals of the project is to satisfy regulatory requirements. As such, regulators like the Regional Water Quality Control Board (RWQCB or Regional Board) should be made aware of IRWD's efforts and how the plan may impact the District's current or future regulatory obligations.
- **City of Irvine (and Other Cities).** The RWSMP may result in recommendations that affect residents of the City of Irvine and businesses within the city. Other cities that are served by IRWD may be similarly affected if the recommendations extend to the entire IRWD service area.
- **Orange County Sanitation District (OCSD).** As the agency that currently receives a portion of IRWD sewer flows and monitors the majority of the

industrial users within the IRWD service area, OCSD's role may be modified by the RWSMP recommendations. OCSD could also benefit directly or indirectly from the implementation of IRWD's plan.

- **The Irvine Company.** The Irvine Company (TIC) is a major commercial and residential real-estate owner and developer in the IRWD service area. Policies that affect potable and recycled water users can have an impact on TIC. The use of self-regenerating water softeners is of particular importance. TIC also owns and operates golf courses and agricultural land within the IRWD service area; these users may desire even higher quality recycled water than other users.
- **Golf Course Management Companies.** Golf courses may have slightly different goals than other recycled water users. Those companies that manage golf courses, in addition to TIC, within the IRWD service area may be important stakeholders.
- **Water Quality Association.** The Water Quality Association (WQA) is a non-profit trade association representing water-softening companies, among others. Engaging WQA may facilitate implementation of IRWD's plans if they are involved properly. If not brought in as a stakeholder early in the plan development, the WQA can become an obstacle to successful implementation of policies and projects.
- **Metropolitan Water District of Southern California (MWD) and Metropolitan Water District of Orange County (MWDOC).** MWDOC purchases imported water from MWD and serves as a wholesale water supplier to IRWD. Changes in IRWD operations and/or policy can affect the volume of imported water entering IRWD's system.
- **Poseidon Water.** Poseidon is a private company specializing in the construction and operation of desalination facilities to produce potable water. Poseidon may construct a desalination plant in the City of Huntington Beach that could provide water to IRWD as a direct supply, by exchange, or by groundwater recharge. Poseidon will likely be interested in any water quality requirements that IRWD may establish to receive Poseidon water.

1.5 Acronyms and Abbreviations

For ease of reference, this section provides a summary of frequently-used acronyms and abbreviations in this report.

ACOO	Aliso Creek Ocean Outfall
AF	Acre-feet
AFY	Acre-feet per year
Ag	Agricultural
AMP	Allen-McColloch Pipeline
BPP	Basin Pumping Percentage
$C_6H_8O_7$	Citric acid
CCF	Hundred cubic feet
CEPT	Chemically Enhanced Primary Treatment

Cl	Chloride
DATS	Deep Aquifer Treatment System
District	Irvine Ranch Water District
DRWF	Dyer Road Well Field
EDR	Electrodialysis Reversal
EOCF #2	East Orange County Feeder #2
HATS	Harvard Avenue Trunk Sewer
HBDP	Huntington Beach Desalination Plant
HRC	High Rate Clarifier
I&I	Inflow and infiltration
IBC	Irvine Business Complex
IDP-PTP	Irvine Desalter Project – Potable Treatment Plant
ILP	Irvine Lake Pipeline
IRWD	Irvine Ranch Water District
kW-hr	Kilowatt-hour
LAWRP	Los Alisos Water Recycling Plant
lbs	Pounds
LRP	Local Resources Program
MBR	Membrane Bioreactor
mg/L	Milligrams per liter
MGD	Million gallons per day
MGM	Million gallons per month
MPS-3	Michelson Pump Station 3
MWD	Metropolitan Water District of Southern California
MWDOC	Metropolitan Water District of Orange County
MWRP	Michelson Water Recycling Plant
NaOCl	Sodium hypochlorite
NaOH	Sodium hydroxide
NII	North Irvine Interceptor
NP	Non-potable
OCF	Orange County Feeder
OCWD	Orange County Water District
OPA	Orange Park Acres
OCSD	Orange County Sanitation District
R&R	Repair and Rehabilitation
RAA	Running Annual Average
Regional Board	Regional Water Quality Control Board
RO	Reverse Osmosis
RW	Recycled Water
RWQCB	Regional Water Quality Control Board
RWSMP	Recycled Water Salt Management Plan
SCSMP	Sewer Collection System Master Plan
SII	South Irvine Interceptor

SMWD	Santa Margarita Water District
SOCWA	South Orange County Wastewater Authority
SRWS	Self-Regenerating Water Softeners
SWP	State Water Project
TDS	Total Dissolved Solids
TFS	Total Fixed Solids
TIC	The Irvine Company
USBR	United States Bureau of Reclamation
UV	Ultraviolet
W115	Well 115
W2122	Well 21 & 22
WAS	Waste Activated Sludge
WDR	Waste Discharge Requirements
WQA	Water Quality Association
WTP	Water Treatment Plant

2 Salinity Data

To develop IRWD's Salt Balance Model, opportunities to gain and lose salt loads were evaluated. The complexity of IRWD's water and recycled water systems, and the integration and sharing of regional facilities, makes tracing salt from the source water to the recycled water customer a challenging endeavor. The sources, uses, and general movement of salt in IRWD's system in 2014 are illustrated in Figure 2-1. An intense effort was performed to collect data and other relevant information and identify significant salt loads and losses affecting IRWD's recycled water system.

The methodology for obtaining and evaluating the salinity data for each of these categories is summarized in the following sections. Appendix A provides a more detailed review of the Data Collection effort and identifies the data sources.

Based on the availability of consistent data for all salinity sources and to represent a range of operating conditions, monthly data was obtained for the 5-year period from 2008 through 2012, for use in developing IRWD's Salt Balance Model. Annual data for 2011 through 2014 is referenced below to illustrate the District's most current conditions.

2.1 Source Water

IRWD distributes water to over 103,000 service connections through a combination of local and imported water sources, as shown in Figure 2-2. In 2012, the average annual water supply was approximately 58,000 AF. This includes approximately 40,400 AF from local water, 17,600 AF from imported water, and 26,200 AF of recycled water.

In 2012, local groundwater resources made up approximately 48% of the District's water supply resources. The District's main groundwater facility is the Dyer Road Well Field (DRWF), which pumps high quality groundwater from the Orange County Groundwater Basin, managed by the Orange County Water District (OCWD). The District also operates and treats groundwater produced from the Deep Aquifer Treatment System (DATS), the Irvine Desalter Project Potable Treatment Plant (IDP-PTP), and Wells 21 and 22 Desalter Facilities. To control withdrawals, OCWD limits the amount of water that IRWD can pump from the Orange County Groundwater Basin by assigning a Basin Pumping Percentage (BPP). The BPP is expressed as a percentage of the agency's total water usage that they can pump from the groundwater basin. The BPP can be adjusted annually. Outside of the OCWD boundaries, the District also operates wells in the Lake Forest area.

In 2012, the District purchased approximately 21% of its water supply from MWD, the region's wholesale water provider. Raw water is imported from the Colorado River via the Colorado Aqueduct and from the Sacramento Delta via the SWP Aqueduct. The raw water is treated at the MWD Diemer Water Treatment Plant (WTP). Historically the salinity of the Colorado River water has been much higher than the salinity of the SWP water, thus the mix of raw water used by MWD heavily influences the TDS quality of the potable water produced at Diemer. The Colorado River Basin Salinity Control Forum strives to maintain a maximum TDS level of 723 mg/L on this source of imported water upstream of the Parker Dam, where the Colorado Aqueduct branches off to supply

Diemer WTP. The TDS of the SWP water has historically been under 400 mg/L. In 2014, TDS in potable water produced at the Diemer WTP ranged from 600 to 650 mg/L, due to allocations on the SWP associated with California drought conditions. MWD's stated goal is to deliver potable water with a TDS at or below 500 mg/L.

At times, OCWD may request that water districts who withdraw groundwater from the Orange County water basin, including IRWD, to participate in OCWD's In-Lieu Program. This is to reduce or stop groundwater pumping operations to allow the basin to recharge. During this time, IRWD may purchase imported water at the same cost as local water. In-lieu periods occur irregularly and are determined by OCWD.

The potable water from Diemer WTP is conveyed to IRWD and other member agencies via several pipeline feeders, including the Allen-McColloch Pipeline (AMP) and the East Orange County Feeder #2 (EOCF #2) that serve IRWD. Potable water from the Weymouth Filtration Plant via the Orange County Feeder (OCF) is also available for District use, if desired.

With the completion of the 28.1 million gallons per day (MGD) Baker Water Treatment Plant regional project in 2016, the capability of treating imported untreated water from MWD in south Orange County will increase. The Baker Plant will receive untreated water from the Santiago Lateral and Irvine Lake, through the Baker Pipeline for treatment. The District will receive approximately 24%, or 6.8 MGD, of the potable water produced at the Baker Plant.

Recycled water makes up the final 31% of the District's water supply. Recycled water is used for non-potable irrigation, toilets, and cooling towers to offset potable water use in the service area. Although currently producing only 17 to 20 MGD (22,000 AFY), the District has capacity to produce up to 31.4 MGD (35,200 AFY) of recycled water at its Michelson (26.9 MGD) and Los Alisos (5.5 MGD) Water Recycling Plants.

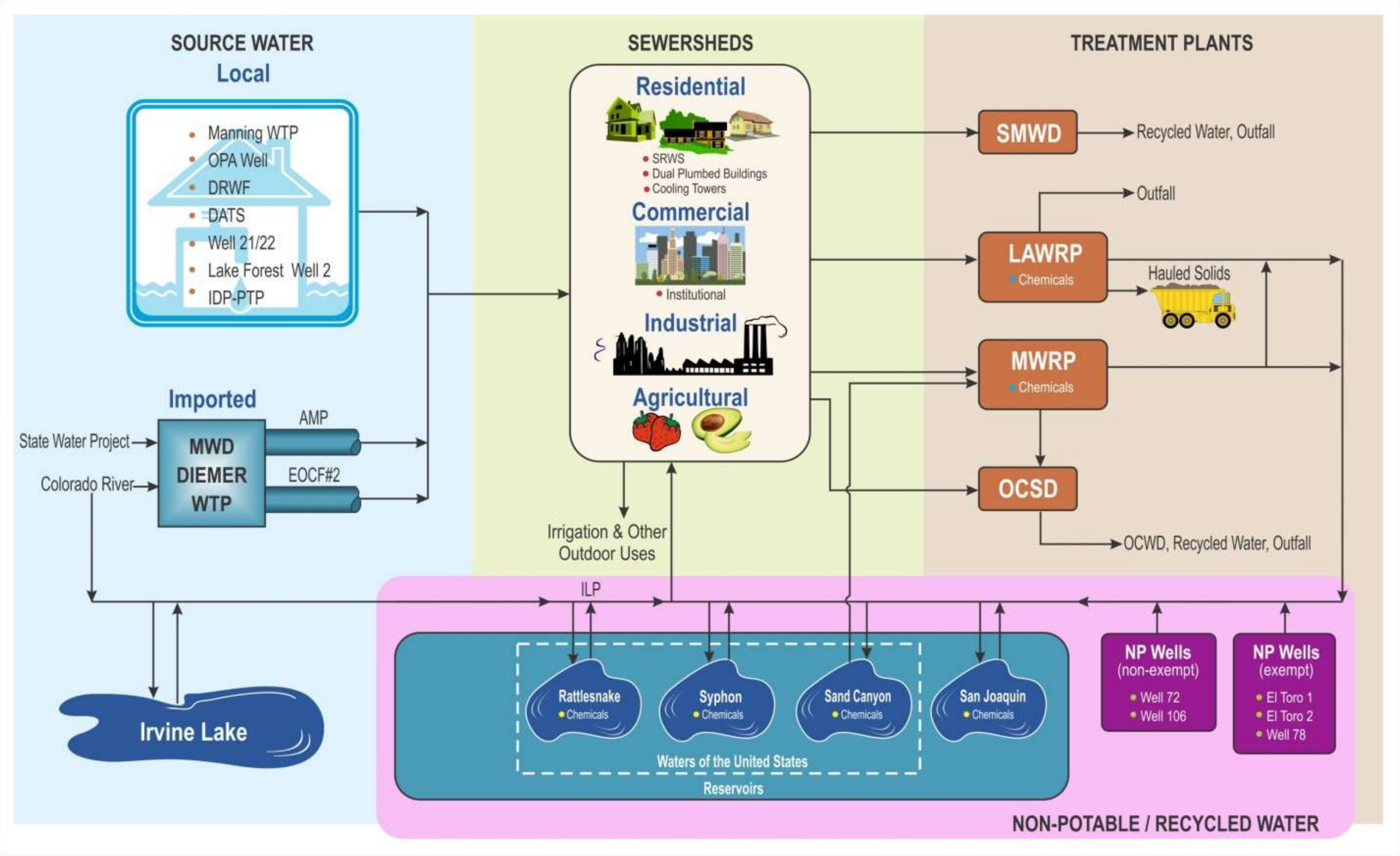

Figure 2-1. Salt Loads affecting IRWD's Recycled Water System in 2014

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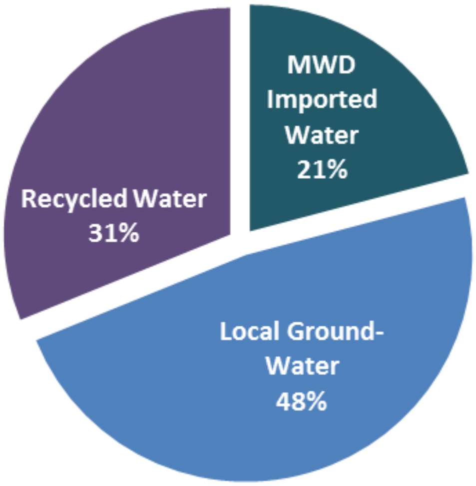
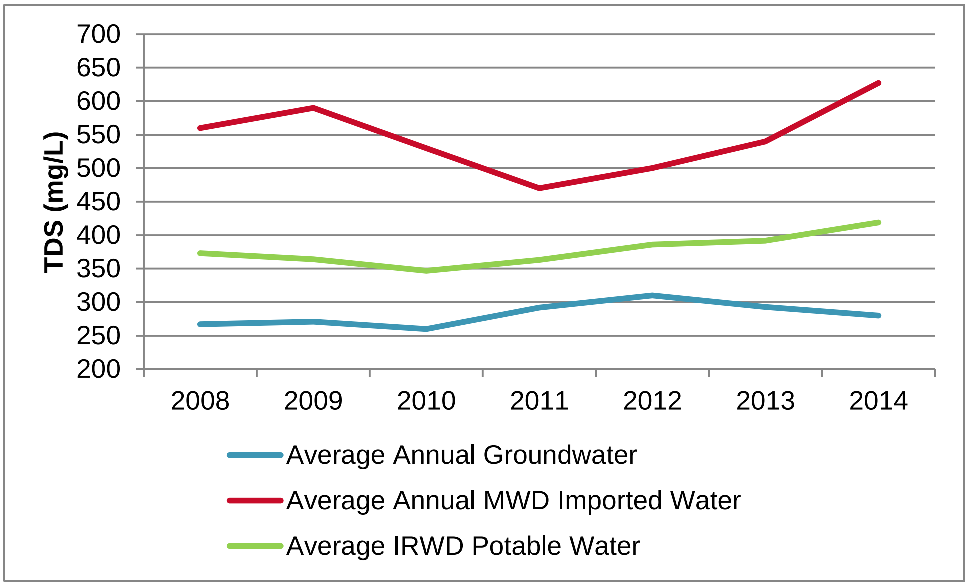


Figure 2-2. Flow Distribution of IRWD Water Supply Sources in 2012

2.1.1 Source Water Salinity

According to the District's 2015 Water Quality Report, the annual average TDS for locally treated groundwater in 2014 was 280 mg/L and the annual average for MWD imported treated water was 627 mg/L.

Figure 2-3 illustrates how the increasing TDS trend of imported water is affecting the overall salinity in the District's potable water supply. This trend indicates that, in the past 4 years, there has been a net 10% increase in TDS within the District's potable supply, as illustrated by the green line in the center of Figure 2-3. However, the TDS of IRWD recycled water supply is significantly more complex than the TDS of its source water. Because the TDS concentrations of source supplies can vary significantly by year and season, different sources are used in different parts of the District and water use itself adds TDS.



Source: IRWD Annual Water Quality Reports, 2012-2015

Figure 2-3. Salinity Trends in IRWD's Potable Water Sources

To develop IRWD's Salt Balance Model and identify the sources of TDS throughout the District, it was necessary to:

1. Evaluate the TDS concentrations and flow on a monthly basis for each individual potable water source, and
2. Determine which sources of water were used in which sewersheds.

The potable water that feeds the IRWD service area comes from a variety of existing sources, as shown in Figure 2-2. These sources were categorized as either Imported or Local. Monthly potable water quality data from 2008 through 2012 was obtained for each of the District's potable water sources. Flow and TDS data during this time period were considered to be the most complete within IRWD's potable, sewer, and non-potable system. Figure 2-4 summarizes how the source salinity varied monthly from 2008 to 2012.

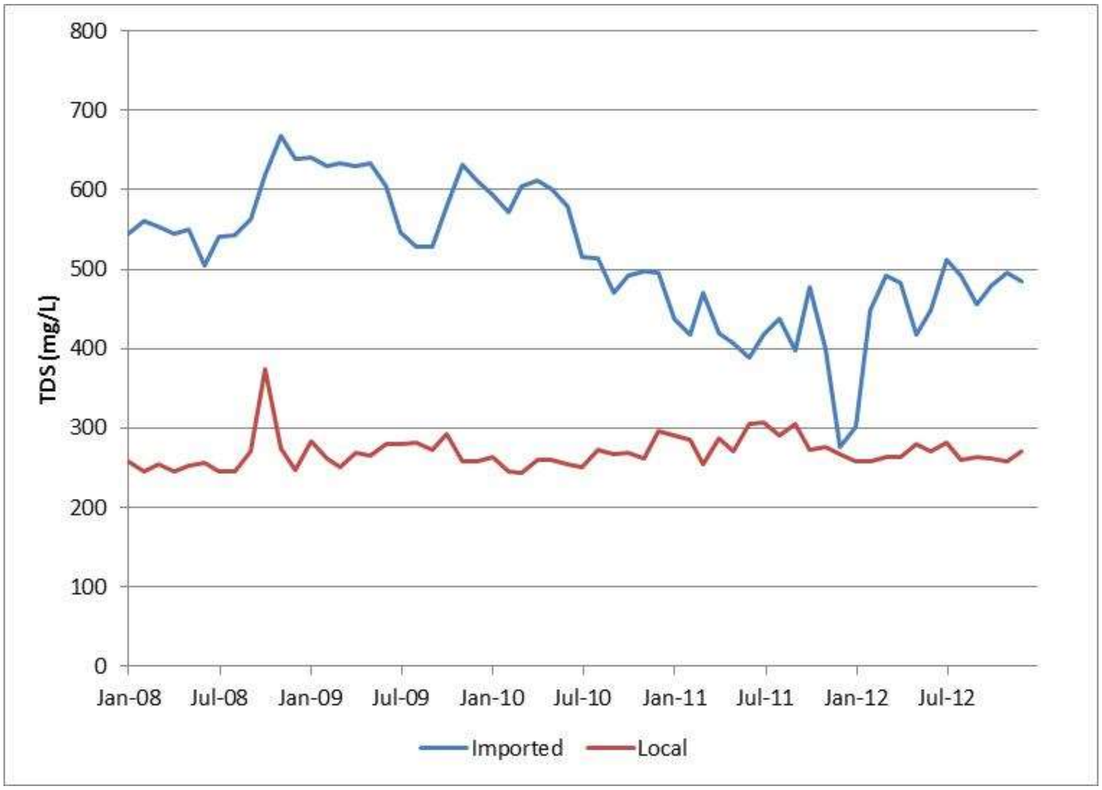


Figure 2-4. Monthly Salinity Data for IRWD Potable Water Sources, 2008-2012

IRWD identified a potential for six new sources of water to come on line before 2035, including Baker Water Treatment Plant, Poseidon Huntington Beach Desalination Plant, Well 106, Well 53, Future OPA Well, and Well 51/52. Projected future TDS values of the groundwater potable water sources were modeled to have the same monthly cycle as the historical period shown in Figure 2-4. This 5-year cycle is repeated throughout the study period.

Projected future TDS values for the imported potable water sources are based on the monthly median from 2008 through 2012.

2.1.2 Source Water Salinity Contribution to Sewersheds

To determine which potable sources were used in which sewersheds, interviews with District staff were held. Because of the complexity of the distribution system and the seasonal variations in how the District uses its supply sources to meet demand, multiple scenarios for potable water distribution were modeled.

Figure 2-5 provides an example of one scenario modeled for the distribution of potable water among the District's 15 sewersheds, which are shown in Figure 2-6. The sewersheds in turn feed sewage to different water recycling plants, also shown on Figure 2-6, to produce recycled water.

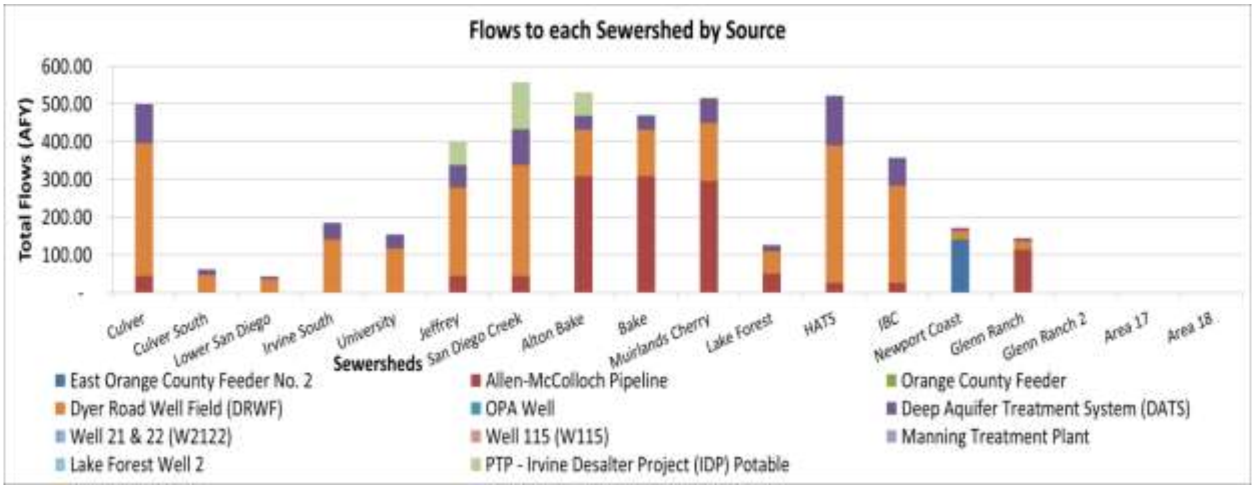


Figure 2-5. Estimated Potable Water Contribution by Source to IRWD Sewersheds (2008 to 2012)

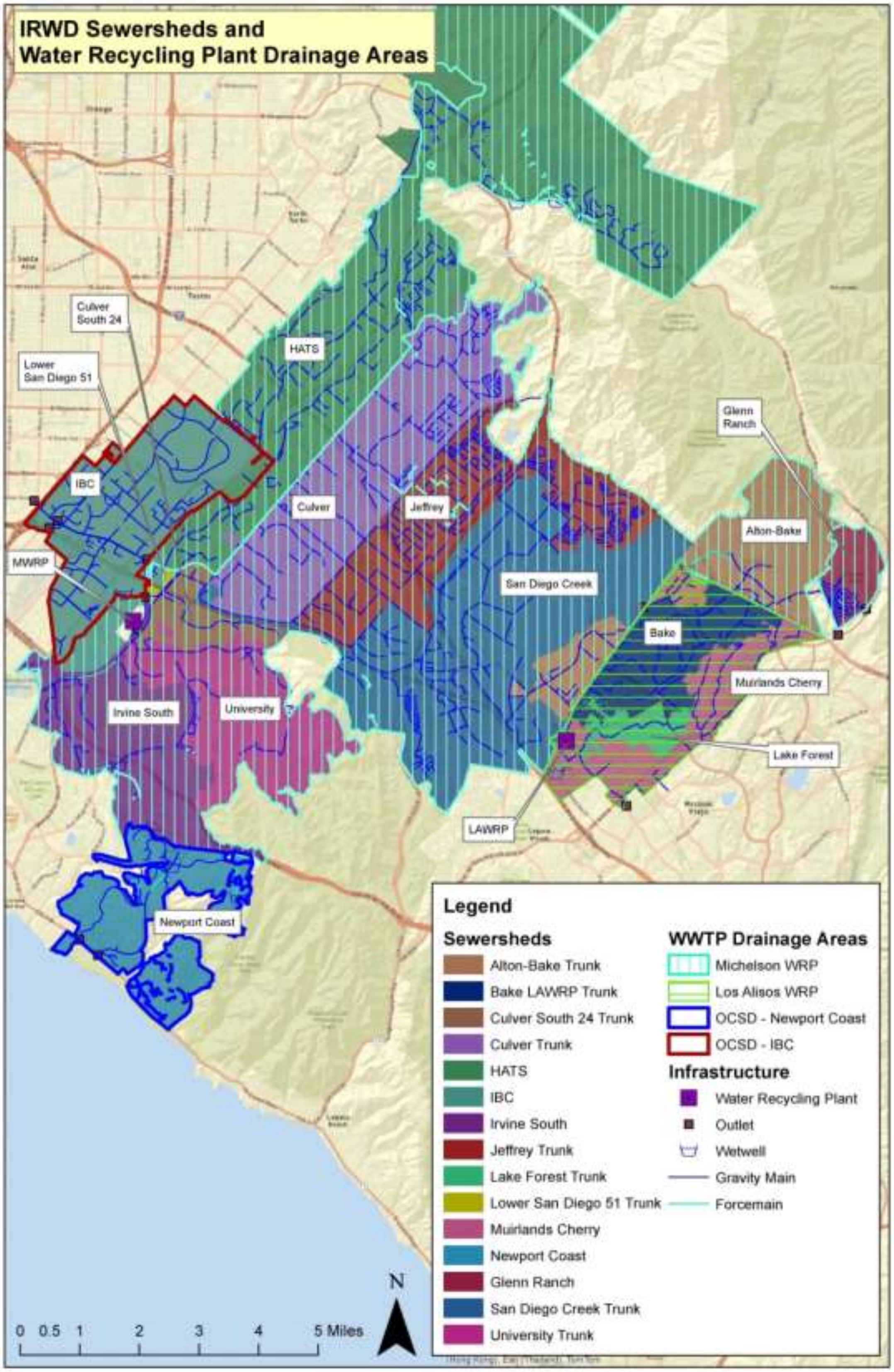


Figure 2-6. IRWD Sewershed Location Map

Table 2-1 provides an example of IRWD’s Salt Balance Model output that summarizes the estimated salt load contributing to each sewershed by the potable water sources. IRWD’s Salt Balance Model is set up to simulate different water supplies provided to different watersheds on a monthly basis.

Table 2-1. Example - Estimated Annual Salt Contribution by Potable Water Source (2008 to 2012)

Potable - Imported	Total Demand (AFY)	TDS (mg/L)	Total Salts (lbs/year)
East Orange County Feeder No. 2	1,958	506	2,692,870
Allen-McColloch Pipeline	17,625	506	24,235,833
Orange County Feeder	-	506	-
Dyer Road Well Field (DRWF)	24,875	258	17,411,294
Orange Park Acres (OPA) Well	361	583	572,532
Deep Aquifer Treatment System (DATS)	8,831	271	6,493,352
Well 21 & 22 (W2122)	-	-	-
Well 115 (W115)	-	-	-
Manning Water Treatment Plant	57	423	66,143
Lake Forest Well 2	43	682	79,598
Irvine Desalter Project Potable Treatment Plant (IDP-PTP)	3,178	299	2,585,877

Notes: Data shown represents the 2008-2012 mass and volume as totals and weighted averages for concentrations.
Manning Water Treatment Plant and OPA Well are used intermittently and only during a few months out of the year, based on District needs.

2.1.3 Water Supply Operations

Multiple discussions and meetings with IRWD planning, engineering, and operations staff revealed the complexity and flexibility of IRWD’s potable and non-potable systems. District boundaries encompass multiple cities and unincorporated areas of Orange County. Multiple flow control facilities allow IRWD to direct water supply towards or away from certain areas. When desired, the District can direct flow for use or treatment by other utility agencies.

The District continuously strives to diversify potential source waters, increase local water production, and ultimately reduce IRWD’s reliance on imported water. IRWD staff indicated that they withdraw and treat groundwater from the basin as allowed by their groundwater production limit, calculated with an established BPP set by OCWD. IRWD’s 2013 BPP was 70 percent. The calculation of the groundwater production limit, Equation 1 takes into consideration the amount of potable water IRWD uses annually within the OCWD boundary and includes an adjustment referred herein to as the Recycled Water Penalty. Within the OCWD boundary, the total amount of recycled water used is subtracted from the total water use and thus reduces the total groundwater that IRWD can pump from the Orange County Groundwater Basin.

$$Groundwater\ Production\ Limit = (Adjusted\ Use\ ) \times BPP$$

$$Adjusted\ Use\ = Total\ Water\ Use - Water\ used\ outside\ of\ OCWD - Recycled\ Water\ Use$$

Equation 1 – OCWD Groundwater Production Limit

Certain groundwater supplies may be exempt from the BPP because these facilities treat impaired groundwater to remove color, high nitrates, high hardness, and high TDS. The DATS was previously exempted from the BPP, but its exemption was terminated at the end of 2013. Wells 21/22 and IDP-PTP exemptions will continue through 2033. Well 115 is not exempt from the BPP even though it contributes to IDP-PTP.

IRWD typically maximizes the local supply produced from their potable water facilities, except in the following cases:

- DRWF is capable of supplying more groundwater, but IRWD has a contract with the City of Santa Ana to limit DRWF production to 28,000 acre-feet (AF) per fiscal year. This includes the 8,000 AFY withdrawn to match the additional 8,000 AFY produced by DATS.
- The District does not pump more groundwater from the OPA wells than the current demand for that area.
- Imported potable water is withdrawn from the AMP for higher elevation areas to supplement demand and minimize pumping costs.

These considerations regarding water supply operations were taken into account in the development of IRWD's Salt Balance Model.

2.2 IRWD Sewersheds

Potable water usage, non-potable water usage, and subsequent discharge into the sewers by IRWD residential, commercial, and industrial customers all contribute salinity to sewage flows. Information on IRWD's residential and commercial customers was obtained from multiple sources, including the 2013 IRWD *Water Efficiency Plan,* a 2006 multi-district study by AwwaRF entitled *Characterizing and Managing Salinity Loadings in Reclaimed Water Systems,* and discussions with District staff.

IRWD's hydraulic model developed for the 2006 Sewer Collection System Master Plan (SCSMP) was used to estimate expected flows from each sewershed for 2010, 2015, 2020, and 2025. This hydraulic model provided a basis for the Historical Model Results and provided additional sewershed characteristics, such as the amount of water used by residential, commercial, and industrial users.

2.2.1 Residential

IRWD monitors the efficacy of the water conservation effort by evaluating the per capita water usage of potable water within their service area. Although the total per capita water usage fluctuates seasonally due to irrigation, the indoor per capita water usage is relatively constant. The *Water Efficiency Plan* and AwwaRF study provided indoor per capita water usage for fixtures that discharge to the sewer, as shown in Table 2-2.

Table 2-2. Residential Use Salinity Contribution (2008-2012)

Fixture Type	Estimated Water Demand (gallons per capita per day)[1]	Percent Contribution to the Sewer System[2]	Salt Contribution (grams per capita per day)
Toilet	16.0	26.4%	Average Human Salt Contribution ranges from 63 to 83
Clothes Washer	15.1	24.9%	Average Gray Water Salt Contribution ranges from 10 to 14
Shower	9.5	15.8%	
Faucet	9.4	15.5%	
Leaks	8.2	13.5%	
Bath	0.8	1.3%	
Dishwasher	1.0	1.7%	
Other	0.7	1.1%	
TOTAL	60.6	**100%**	**73 to 97 (337 mg/L to 449 mg/L, based on 57.6 gpcd)**

[1] Calculated from percentages against total gpcd from 2013 IRWD Water Efficiency Plan.
[2] Values adjusted from 2006 AwwaRF study *Characterizing and Managing Salinity Load in Reclaimed Water*.

The 1999 AwwaRF *Residential End Uses of Water* study provided average per capita salt contributions from typical residential use (e.g. human waste and gray water). A 2006 AwwaRF *Characterizing and Managing Salinity Load in Reclaimed Water* study measured and evaluated residential salt contribution to the sewage flows in a case study for IRWD. Measuring a range of salt loadings among the sewersheds of 348 mg/L to 490 mg/L, the results of the case study were on par with Table 2-2, which calculated a range of 337 to 449 mg/L.

For IRWD's Salt Balance Model, a baseline discharge of 73 grams per capita per day, as shown in Table 2-2, was used and then multiplied by gallons per capita per day for each sewershed. Since per capita use of water varies among the sewersheds, the concentration of salinity contributed by domestic use varies by sewershed. These residential contributions are largely considered to be uncontrollable salt loads.

However, residential self-regenerating water softeners are a potentially controllable source of salinity. Water conservation can also influence the salt concentration of the sewer flows. IRWD's Salt Balance Model considers both the increased salt load due to both water softeners and decreases in per capita water use due to water conservation efforts.

Self-Regenerating Water Softeners

Information on self-regenerating water softeners (SRWS) was obtained from three references: 1) a similar study performed by HDR for the City of Phoenix focusing on salt contribution from SRWS (2010), 2) a United States Bureau of Reclamation (USBR) study that evaluated the prevalence of SRWS in the Phoenix residential areas (2004), and 3) the previously mentioned 2006 AwwaRF study. These studies collectively incorporated a survey of SRWS vendors, types, efficiencies, and residential and commercial usage.

The USBR study found a correlation between the year a Phoenix residence was constructed and the likelihood that the home would have a SRWS. In general, newer homes are more likely to have a SRWS installed. It is expected that this holds true for the

IRWD service area, but to a lesser degree because Phoenix's source water generally has higher hardness levels than IRWD source waters. Customers are more likely to install water softeners with harder water.

IRWD provided monthly hardness data for some imported and local source waters from 2008 to 2012, as well as geo-spatial data referencing the year a water meter was installed. The installation date was equated to the year a residence was constructed. Figure 2-7 is a map of IRWD sewersheds identifying the decade in which a general area was developed by year the water meter was installed.

Effective January 1, 2002 California Senate Bill SB 1006 and Assembly Bill AB 334 specified that newly installed residential water softeners were to be self regenerative, activated by demand control device, with a minimum efficiency rating of 4,000 grains of hardness removed per pound of salt used. The total salinity contribution from SWRS per sewershed is based on the estimated number of homes with SRWS devices in each age group, as shown in Table 2-3, distributed per sewershed, as shown in Figure 2-7.

Conservatively, it was estimated that the contribution of salinity from each SWRS is 0.9 lbs per day.

Table 2-3. Estimated Self Regenerative Water Softener Use

Meter Installation Date of IRWD Residence	Estimated SWRS Utilization
<1970	5%
1970-1980	10%
1980-1990	20%
1990-2000	40%
2000+	50%

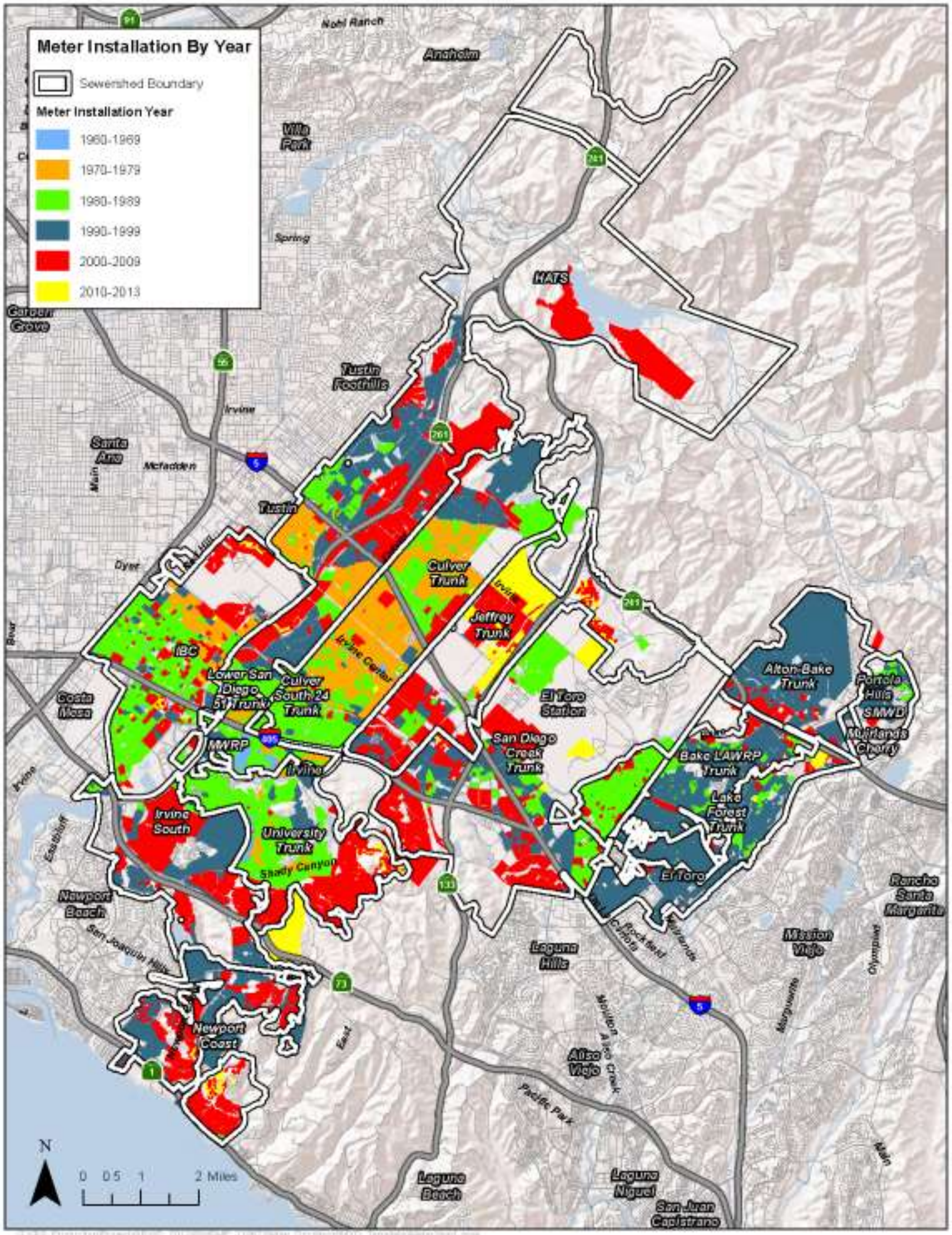


Figure 2-7. IRWD SWRS Meter Installation Time Periods

Water Conservation

IRWD proactively supports water conservation within their service area. Unfortunately, indoor water conservation, by its very nature, increases TDS by concentrating the same salt load in a reduced flow to the sewer collection system. The 2013 Water Efficiency Plan indicates that the District often surpasses their water conservation targets set by the State and other agencies through programs to improve water efficiency and increase awareness. Some of these programs provide financial incentives to reduce water usage, such as an allocation-based tiered rate structure and installation of high efficiency devices.

Discussions with IRWD staff indicate that the District intends to maintain or expand their current indoor conservation programs and expects per capita water usage to fluctuate plus or minus 5 percent moving forward. This is a rough estimate that can be expected to vary with the cost of water and the implementation of building and plumbing codes that require owner replacement of older equipment/appliances/toilets with high-efficiency models. These efforts apply to both residential and commercial customers.

Recycled Water Return Flows from Dual Plumbed Buildings

The majority of recycled water produced by IRWD is used for landscaping and irrigation, which does not return to the sewer. Recycled water, however, is used in residential and commercial dual-plumbed buildings and cooling towers, which returns to the sewer via toilet and urinal usage and cooling tower blow-downs. IRWD provided annual recycled water usage for dual-plumbed buildings and cooling towers from 2008 to 2013. The number of recycled water accounts increased from 43 accounts in 2008 to 59 accounts in 2013. The annual total recycled water used for these accounts increased from 55,200 hundred cubic feet (CCF) (41.3 MG) in 2008 to 128,700 CCF (96.3 MG) in 2013.

Recycled water has a higher TDS concentration than potable water. Since these customers use recycled water instead of potable water, the water discharged to the sewer will have an above average TDS concentration. As the number of dual-plumbed buildings and cooling towers using recycled water increases in the future, treatment plant influent TDS will also increase. A TDS concentration of 720 mg/L was used for recycled water delivered to dual plumbed buildings.

2.2.2 Commercial

IRWD’s commercial sector is comprised of a large number of office buildings, hotels, restaurants, laundromats, and more. The District provided the flow contribution attributed to commercial customers within each sewershed, based on the 2006 sewer hydraulic model.

TDS data for commercial customers within IRWD were not available. Commercial users are typically expected to contribute less TDS than residential because not all commercial customers, such as schools, hospitals, or office buildings, engage in food manufacturing/preparation or laundry/cleaning operations.

However, IRWD’s Salt Balance Model separates institutional users from commercial users. In doing so, the model removed low TDS institutional sources from higher TDS commercial sources. Since the residential TDS contribution benchmark is approximately 250 mg/l, this was used as a starting point to estimate commercial and institutional contributions. Through the calibration of the IRWD's Salt Balance Model a TDS increase of 220 mg/L due to institutional use and 270 mg/L due to commercial use was determined. As previously discussed in the Residential section, the model also considers the effect of self-regenerating water softeners, dual-plumbed buildings, and cooling towers.

2.2.3 Industrial

IRWD has a number of customers that contribute industrial waste to the District's sewage collection system. OCSD is responsible for issuing industrial discharge permits for those IRWD industrial customers whose discharges are conveyed for treatment at MWRP or OCSD. The South Orange County Wastewater Authority (SOCWA) issues permits for IRWD industrial customers whose discharges are conveyed to LAWRP or Santa Margarita Water District (SMWD).

The industrial sector is typically considered a controllable source of salinity because they require a discharge permit. In 2014, IRWD had 42 permitted industrial users. Of these industrial users 14 discharge to MWRP, 3 discharge to LAWRP, and the remaining 25 discharge to OCSD and therefore do not have an impact on the District's recycled water quality.

IRWD and neighboring agencies provided some flow and TDS information for industrial users. However, there are many flow and TDS data gaps regarding the industrial customers due to the following factors:

1. Only the maximum permitted flow was provided; average discharge flow is often significantly less than the maximum permitted flow.
2. When flow was not measured, the sewer discharge flow was calculated from potable water usage and the return to sewer flow was estimated.
3. Industrial users are not required to sample for TDS.

Where needed, flow and TDS were estimated for industrial dischargers by comparing the user to a similar industrial discharger and/or evaluating the type of industrial operation, manufacturing processes, and pretreatment processes. The District's sewer hydraulic model estimated the total industrial flow from each sewershed; however, this was used as a reference and was adjusted because the hydraulic model forecasted sewer flows indicated a larger industrial presence than currently exists. Table 2-4 provides a summary of estimated flow and salinity contributions from the District's industrial dischargers that are used in IRWD's Salt Balance Model.

Table 2-4. Estimated Flow and Salinity Contribution of Permitted Industrial Users

Organization Name	Discharge Plant	Sewershed Location	Estimated Average Flow (MGD)	Estimated Average TDS (mg/L)
Alliance Medical Products	MWRP	Alton Bake	0.0059	1,486[a]
ANCHEN Pharmaceuticals Inc. #2	MWRP	Alton Bake	0.0004	1,486[a]
ANCHEN Pharmaceuticals Inc. #2	MWRP	Alton Bake	0.0004	1,486[a]
C. C. Myers, Inc.	MWRP	Jeffrey		2,250
CALTRANS-District 12	MWRP	HATS	0.0000	1,820
Campus Cleaners	MWRP	University	0.0050	1,800
Coyote Canyon Energy	MWRP	Irvine South	0.0380	12,500[b]
Maruchan Inc. #2	MWRP	San Diego Creek	0.0543	2,000
Oakley Inc.	MWRP	Alton Bake	0.0021	1,486[a]
Parker Hannifin Corp.	MWRP	Alton Bake	0.0022	17,250[b]
TEVA Parenternal Medicines, Inc.	MWRP	Alton Bake	0.0549	2,250
The Irvine Company	MWRP	University	0.0050	1,800
Tropitone Furniture Co. Inc.	MWRP	Alton Bake	0.0068	1,486[a]
Lennar Homes of CA, Inc.	MWRP	HATS		1,486[a]
Beacon Bay	LAWRP	Muirlands Cherry	0.0025	1,486[a]
Dynacast	LAWRP	Bake	0.0070	1,486[a]
Global Power Device	LAWRP	Bake	0.0010	1,486[a]

[a] TDS data was unavailable for industrial user. Provided estimated TDS concentration based on flow-weighted average of industrial users.
[b] TDS data was provided as a potential range, and the most conservative values were used in the model.
[c] Values based on or estimated from available flow and TDS information collected in 2013.

2.2.4 Net Inflow, Infiltration and Exfiltration

IRWD has a relatively “tight” sewer collection system; therefore, the amount of inflow and infiltration (I&I) and exfiltration is expected to be minimal. The District’s sewer hydraulic model analyzed flows in certain sewers during three rain events that occurred from January to March 2006. During these rain events, there was an increased flow in the sewer system indicating the presence of I&I.

The effect of I&I and exfiltration specific to each sewershed could not be determined due to a lack of data regarding where I&I is occurring. Since rainfall within the District is minimal, it was estimated that more water was lost due to exfiltration than was gained through I&I. Therefore, IRWD’s Salt Balance Model incorporates the net effect of I&I to be a five percent loss from the sewer collection system before reaching IRWD’s water recycling plants. The TDS associated with this five percent loss was estimated to have the same level of concentration of TDS as the individual sewershed.

2.3 Treatment Plants

IRWD uses chemicals at multiple facilities within their service area, including groundwater wells, potable treatment plants, potable water reservoirs, source waters, sewer collection systems, MWRP, LAWRP, and non-potable water reservoirs.

Potable and non-potable storage reservoirs add chemicals to maintain the chlorine residual. Wells 21/22 and IDP-PTP use sodium hydroxide to control pH of water produced. IRWD staff provided chemical usage data or dosage estimates for the non-potable storage reservoirs.

The most significant chemical usage occurs at the water recycling plants. IRWD staff provided monthly chemical usage data for MWRP (January 2008 to December 2012) and LAWRP (January 2007 to December 2012).

The District's current discharge requirements for MWRP and LAWRP are governed by Order No. R8-2015-0024. This permit limits the flow-weighted, 12-month average TDS concentration of the recycled water effluent to 720 mg/L monitored at the plant discharge points. For recycled water use on sites overlying the Irvine Groundwater Management Zone, the flow-weighted, 12-month running average TDS concentration shall not exceed 910 mg/L. Since the recycled water produced at the plants could be stored at the surface water reservoirs at any time, the 720 mg/L limit is observed.

2.3.1 Michelson Water Recycling Plant

MWRP Phase 1 treatment capacity was 18 MGD, but operated at 20 MGD with enhanced primary sedimentation. Construction for the MWRP Phase 2 Expansion was completed in 2014, increasing treatment capacity to 28 MGD. Raw influent from the North Irvine Interceptor (NII) and South Irvine Interceptor (SII) is combined before entering the new MWRP headworks facilities. A Phase 3 Expansion would increase MWRP capacity to 33 MGD; however, this may not occur within the projected future.

Sewage subsequently undergoes primary sedimentation, secondary treatment (anoxic, oxic, and sedimentation), tertiary dual-media filtration, and sodium hypochlorite disinfection. The Phase 2 Expansion incorporates a high rate clarifier (HRC) for the conventional process treatment side when it is needed and splits primary effluent to the MBR and subsequent UV disinfection. Recycled water effluent is pumped into the non-potable distribution system. Primary sludge and waste activated sludge (WAS) have historically been discharged to OCSD for treatment. The MWRP Biosolids and Energy Recovery Facilities Project, currently under construction with an estimated December 2017 completion date, will enable IRWD to treat MWRP and LAWRP sludge and produce Class A biosolids.

For MWRP, IRWD provided monthly flow data for plant influent, recycled water effluent, and sludge discharged to OCSD. Monthly TDS data for both the influent and recycled water effluent were also provided. There were no TDS data available for the sludge discharged to OCSD from the Michelson Pump Station 3 (MPS-3). Therefore, the TDS concentration of sludge was estimated during calibration (see Section 3.1.4).

IRWD staff provided one day of matching data points to analyze TDS and total fixed solids (TFS) in MWRP influent and recycled water effluent. The difference between TDS and TFS is the organic dissolved solids. Theoretically, the organic dissolved solids should be reduced through the treatment plant, although TDS may increase due to chemical addition. The matching data points seem to support this trend, but with only one day of matching TDS and TFS data points, this statement not conclusive.

2.3.2 Los Alisos Water Recycling Plant

LAWRP has a secondary treatment capacity of 7.5 MGD and tertiary capacity of 5.5 MGD. The plant only produces recycled water to supplement supply during periods of peak demand. Sewage undergoes secondary treatment through a series of lagoons (two aeration ponds followed by three sedimentation ponds). A sludge blanket accumulates at the bottom of these ponds, which is maintained by a dredge that pumps pond sludge to LAWRP's onsite solids dewatering equipment. IRWD is considering alternatives to future dewatering operations including continuing to operate the plate-and-frame filter press, using an outside contractor to dredge the ponds and dewater the solids, and sending the dredged solids to MWRP. When the plant is not producing recycled water, the secondary-treated effluent is discharged to the SOCWA Aliso Creek Ocean Outfall (ACOO). When LAWRP is producing recycled water, the tertiary treatment system consists of coagulation/flocculation, dual-media filtration, and sodium hypochlorite disinfection.

For LAWRP, monthly flow data for plant influent, recycled water effluent, and discharge to SOCWA outfall were provided. LAWRP collected and analyzed samples for TDS only when recycled water effluent was actually being produced with a frequency of one sample every three months. There was no TDS data available for raw influent; therefore, LAWRP influent TDS was estimated based on the expected cumulative TDS from sewersheds discharging to LAWRP.

2.3.3 Salinity Contribution from Treatment Chemical Additions

IRWD uses chemicals at multiple facilities within their service area, including groundwater wells, potable treatment plants, potable water reservoirs, source waters, sewer collection system, MWRP, LAWRP, and non-potable water reservoirs.

IRWD provided monthly chemical usage data for MWRP (January 2008 to December 2012) and LAWRP (January 2007 to December 2012). For the 2008 to 2012 study period included in the historical salt mass balance model, there were several notable changes in chemicals used at both treatment facilities as follows:

For MWRP:

- December 2008 – Began using polymer and ferric chloride (40%) for chemically enhanced primary treatment (CEPT)
- October 2009 – Switched chemical disinfection from chlorine gas to sodium hypochlorite (12.5%)

For LAWRP:

- August 2008 – Switched chemical disinfection from chlorine gas to sodium hypochlorite (12.5%)

Not all chemicals add TDS to the water. Some added chemicals precipitate out of the water with other suspended solids, which theoretically has little to no effect on TDS. For some chemicals, only a portion of the chemical added contributes TDS. For these reasons, HDR evaluated the chemicals used at the treatment plants to develop a TDS factor for each chemical added that affects TDS. The following engineering judgments were made to estimate TDS contribution from chemical addition:

- All chemicals are solutions of the listed chemical and water only.
- All non-water portions of citric acid, sodium hydroxide, and sodium hypochlorite produce TDS in proportion to the weight added.
- All iron precipitates and does not contribute TDS.
- Muriatic acid (or hydrochloric acid) and methanol are volatile liquids and would not contribute to TDS because they would evaporate upon drying in the laboratory analytical test procedure for TDS.
- Magnesium precipitates as carbonates and does not contribute TDS.
- One pound of an anion or cation is equal to one pound of TDS.

Based on this preliminary evaluation, the chemicals shown in Table 2-5 were identified as a TDS source and used in IRWD's Salt Balance Model. A memorandum describing the development of the TDS factors used in the model is provided in Appendix F.

Table 2-5. IRWD Chemical Usage and TDS Factors

Chemical, Percent Strength	Location Added	TDS Factor [a]
Sodium Hypochlorite (NaOCl), 12.5%	DATS, Wells 21/22, PTP-IDP, MWRP, LAWRP, potable reservoirs, San Joaquin Reservoir effluent	2.20
Citric Acid ($C_6H_8O_7$), 50%	Cleaning of UV and MBR at MWRP	5.18
Sodium Hydroxide (NaOH), 20%	Wells 21/22, PTP-IDP	1.88

[a] TDS Factor = Pounds of TDS added per gallon of chemical solution added.

Potable and non-potable storage reservoirs add chemical to maintain the chlorine residual. Non-potable reservoirs that are designated as Waters of the United States (Rattlesnake, Syphon, and Sand Canyon Reservoirs) add sodium bisulfite to dechlorinate the water before storage. Wells 21/22 and IDP-PTP use sodium hydroxide to reduce the increase the pH of water produced. Chemical usage data at the potable and non-potable storage reservoirs was not available at the time of this data collection effort. IRWD staff manages chemical addition to maintain the required residuals and mitigate corrosion.

2.4 Supplemental Non-Potable Water

Following treatment, recycled water is directed to the District's non-potable system. While tertiary effluent from MWRP and LAWRP provide the largest source of recycled water, IRWD utilizes other sources of non-potable water to augment its supply for recycled water uses. In the upper reaches of the recycled water system, IRWD supplements the recycled water supply with untreated water from the Santiago Lateral via the Irvine Lake Pipeline (ILP). Irvine Lake receives untreated water from the Colorado River and natural inflow that is shared with the Santiago Water District. The ILP connects the untreated Irvine Lake to the non-potable Rattlesnake Reservoir.

The non-potable groundwater wells within the Irvine Groundwater Management Zone, listed below, are also used to supplement the recycled water system when the demand for recycled water exceeds available supply. IRWD is required to operate exempt, non-potable groundwater wells, El Toro 1 (ET-1), El Toro 2 (ET-2), and Well 78, at least 10 months out of the year. Because these wells are exempt, the water produced does not count towards the District's BPP. Well 72 and Well 106 are non-exempt, non-potable groundwater wells that IRWD operates as-needed. These wells represent additional supply and sources of salinity to the recycled water system.

Similar to the potable source water, discussed in Section 2.1, the TDS of non-potable source water from groundwater wells and untreated imported water is based on the monthly median of the 2002 to 2008 water quality data for these sources.

IRWD has four large non-potable storage reservoirs; three of which are designated as Waters of the United States. Non-potable reservoirs add sodium bisulfite to dechlorinate the water before storage for Waters of the United States (Rattlesnake, Syphon, and Sand Canyon Reservoirs). San Joaquin Reservoir does not have to dechlorinate prior to storage. As previously stated, chlorine is added at the discharge of non-potable reservoirs to maintain the chlorine residual, except for Sand Canyon Reservoir. The discharge of Sand Canyon returns dechlorinated water to MWRP upstream of the tertiary filters. The non-potable reservoirs are modeled as a single reservoir based on monthly inflow and outflow from the water supply sources that feed into the reservoirs. The volume and TDS concentrations of the inflows change the TDS of the water stored in the reservoir.

IRWD staff provided data regarding reservoir operation and the protocol associated with the inflows and outflows to the recycled water reservoirs as follows:

1. MWRP and the exempt non-potable wells operate at full capacity.
2. If there is an excess of recycled and non-potable water, IRWD does not purchase imported untreated water to supplement the non-potable system.
3. If recycled and non-potable water production exceeds demand, then the reservoirs are filled with that excess.
4. If the available recycled and non-potable water exceed the current available capacity of the reservoirs, LAWRP recycled water production is shut down.
5. The next facilities that may be shut off are non-exempt, non-potable wells.
6. Excess non-potable water, after the above actions have been taken is an export of salt from IRWD's Salt Balance Model. These exports include OCWD's Green Acres Project, OCSD's Plant No. 2 ocean outfall, and discharge to OCSD Plant No. 1.

2.5 Summary of Salinity Data

The information obtained from the data collection effort was used to construct IRWD's Salt Balance Model. It is a tool specific to IRWD's service area to analyze the data received and evaluate IRWD's contributing salt sources. Based on the availability and reliability of data, the historical mass balance model covers the years from 2008 through 2012. Some of the information provided was also used to develop the baseline and evaluate different salt management scenarios and management strategies.

3 IRWD’s Salt Balance Model

IRWD’s Salt Balance Model performs a mass balance of flow and salinity throughout the IRWD service area, using the data described in Section 2 and Appendix A. The system boundaries of the mass balance begin with the source water and end at the non-potable water distribution system. This section describes the methodology of the model and initial findings. A detailed methodology for the operation of IRWD’s Salt Balance Model is provided in Appendices B, C, and D.

3.1 Model Development

IRWD’s Salt Balance Model was built as a workbook in Excel 2010 with macros to automate calculations that are made repeatedly. Excel was selected as the programming tool because it has both a familiar software interface and a modular structure. IRWD’s Salt Balance Model requires additional functions and features that were either not available in Excel or less efficient using built-in excel functions. In Excel, a Macro is built using Visual Basic for Applications (VBA). Macros are executable software code saved inside a document to quickly automate repetitive calculations.

The entire workbook is comprised of over 50 interlinked worksheets that provide the salinity data, support data, and results. The workbook tracks both flow and salt mass from the potable water source to the non-potable water product delivered to the customer on a monthly time step.

3.1.1 Model Stages

IRWD’s Salt Balance Model works in four stages to incorporate the salinity data.

Stage 1 Source Water: The first stage is Source Water where water first enters the system from imported and local supplies which are blended before reaching the potable water customers. This is the first introduction of salinity into the District’s water system.

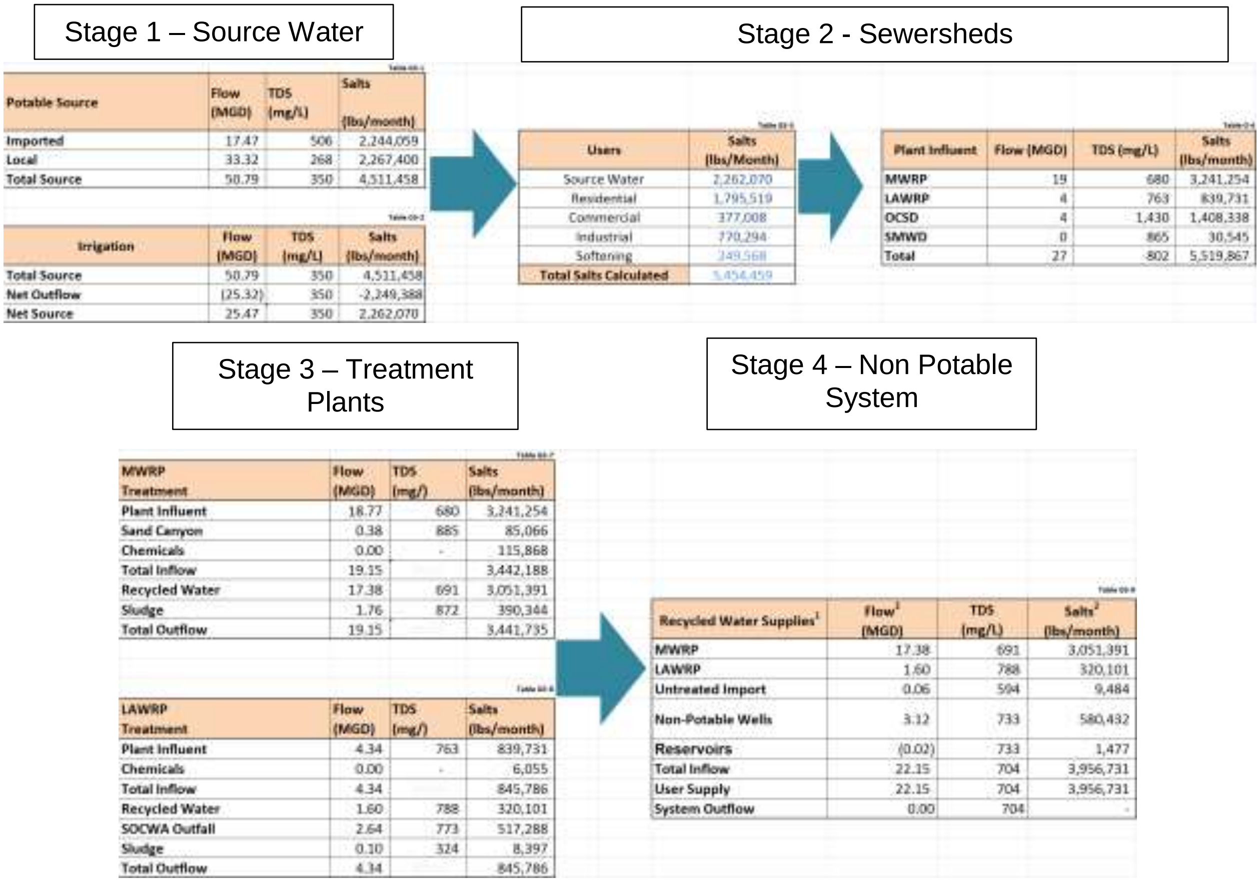
Stage 2 Sewersheds: The second stage is Sewersheds where the source water is consumed by the four user types: Residential, Commercial, Institutional, and Industrial. The sewage from these customers includes additional salt loads contributed through the use of the water. Not all of the source water is consumed, however. Some of the source water is used for outdoor irrigation or lost by exfiltration (water losses in the distribution system) and is not returned to the sewer system. This outdoor use constitutes an export of salt from the system. Sewage from some sewersheds is conveyed to neighboring agencies and result in an export of salt load.

Stage 3 Treatment Plants: The third stage is Treatment Plants where all the sewage from the Sewersheds is directed for secondary or tertiary treatment. The treatment train includes chemical, biological, and physical processes that can affect the salt load in the end product. Not all of the treated sewage becomes recycled water. An export of salts from the system occurs in the production of sludge and when secondary (or excess tertiary) treated water is sent to the ocean outfall. Salts that are conveyed to treatment plants outside of the IRWD service area and result in an export of salt load.

Stage 4 Non-Potable Water System: The fourth stage is the Non-Potable Water System. The District's Non-Potable Water Distribution System receives water from four non-potable sources: 1) tertiary treated recycled water from the Treatment Plants; 2) untreated (raw) imported water; 3) non-potable groundwater from local wells; and 4) a blend of these waters that are stored in the District's Non-Potable Reservoirs. The non-potable system is modeled as a completely blended mix of the four sources above. The TDS concentration is based on a flow-weighted average where multiple streams of non-potable water combine. The salt load is the sum of the salt loads from the four sources above.

3.1.2 Salt Balance Calculation Methodology

For each stage the salt mass that is passed through to the District's non-potable water customer is tracked so that the District can understand and potentially control or limit the amount of salt added to the system throughout the different stages of use. Figure 3-1 illustrates a simplified graphic produced by IRWD's Salt Balance Model for 2008 to 2012



Potable Source	Flow (MGD)	TDS (mg/L)	Salts (lbs/month)
Imported	17.47	506	2,244,059
Local	33.32	268	2,267,400
Total Source	50.79	350	4,511,458

Irrigation	Flow (MGD)	TDS (mg/L)	Salts (lbs/month)
Total Source	50.79	350	4,511,458
Net Outflow	(25.32)	350	-2,249,388
Net Source	25.47	350	2,262,070

Users	Salts (lbs/Month)
Source Water	2,262,070
Residential	1,795,519
Commercial	377,008
Industrial	770,294
Softening	249,568
Total Salts Calculated	5,454,459

Plant Influent	Flow (MGD)	TDS (mg/L)	Salts (lbs/month)
MWRP	19	680	3,241,254
LAWRP	4	763	839,731
OCSD	4	1,430	1,408,338
SMWD	0	865	30,545
Total	27	802	5,519,867

MWRP Treatment	Flow (MGD)	TDS (mg/)	Salts (lbs/month)
Plant Influent	18.77	680	3,241,254
Sand Canyon	0.38	885	85,066
Chemicals	0.00	-	115,868
Total Inflow	19.15		3,442,188
Recycled Water	17.38	691	3,051,391
Sludge	1.76	872	390,344
Total Outflow	19.15		3,441,735

LAWRP Treatment	Flow (MGD)	TDS (mg/)	Salts (lbs/month)
Plant Influent	4.34	763	839,731
Chemicals	0.00	-	6,055
Total Inflow	4.34		845,786
Recycled Water	1.60	788	320,101
SOCWA Outfall	2.64	773	517,288
Sludge	0.10	324	8,397
Total Outflow	4.34		845,786

Recycled Water Supplies[1]	Flow[1] (MGD)	TDS (mg/L)	Salts[2] (lbs/month)
MWRP	17.38	691	3,051,391
LAWRP	1.60	788	320,101
Untreated Import	0.06	594	9,484
Non-Potable Wells	3.12	733	580,432
Reservoirs	(0.02)	733	1,477
Total Inflow	22.15	704	3,956,731
User Supply	22.15	704	3,956,731
System Outflow	0.00	704	-

Figure 3-1. Example of Salt Load Calculations Approach (2008-2012 Average)

1. **Source Water:** Data associated with each of the Sources includes total flow and salt concentration. The Sources are allocated to individual sewersheds, allowing for a blend of imported and local water sources specific to each sewershed. From this data, the salt load is calculated by sewershed. The monthly calculated potable water quality for each sewershed moves on to the next stage. Average hardness of each

source water was also considered to estimate salt contributions due to water softeners within the sewersheds.

2. **Sewersheds:** For each sewershed, Residential, Commercial, Institutional, and Industrial salt contributions were estimated based on the parameters described in Section 2. Salt loads from domestic residential use, water softeners, commercial/institutional use, and industrial use are calculated and added to the Source water salt load. Sewage flows and their accompanying salt loads are conveyed to one of two Water Recycling Plants – Michelson WRP and Los Alisos WRP. Exports of salt occur within the sewersheds when source water is used for irrigation or other outdoor uses where the water does not returned to the sewer system. Additional salt exports include sewage flows that are diverted to two neighboring agencies, OCSD and SMWD. The model results show that the contributing salts from the users is essentially equal to the salt load of the influent to the treatment plants (5.5 million pounds (lbs) per month, in this example time step).
3. **Treatment Plants:** Having calculated the resulting salt load that enters each of the District's WRPs, the Treatment Stage accounts for influent and effluent flows, removed organic salts, chemical addition, and sludge production. With 3.2 million lbs per month of salt entering MWRP, in this example time step, there is a total of 3.4 million lbs of salt per month leaving MWRP. A relatively small percentage of this total, about 390,000 lbs per month is estimated to go to sludge production while the remainder is in the recycled water product. For MWRP, return flows and salinity from the Sand Canyon Reservoir are included, since the plant's effluent flow is measured after the introduction of non-potable water from this reservoir.
4. **Non-Potable Water System:** As noted in Section 3.1.1, the non-potable system is modeled as a completely blended mix of the four sources above. The salt load is based on a flow-weighted average where the multiple streams of non-potable water combine.

3.1.3 Model Modes

The model was constructed to operate in three different modes: Historical Measured, Historical Predictive, and Future Predictive, each of which is described below.

Historical Measured: The Historical Measured mode was the first mode developed to balance the salts in the system, using historical flow and water quality data. The data from this mode was also used to develop parameters such as seasonal variation of water use, consumptive losses, and salt exports via outdoor use and sludge production. This mode was also used to correlate measured influent and effluent TDS values with model results.

Historical Predictive: The Historical Predictive mode tests IRWD's Salt Balance Model using historical flow and projected water quality parameters rather than measured parameters. By comparing the results of the Historical Measured model mode with the Historical Predictive mode, the accuracy of approach and methodology of the model could be assessed. This mode provided a quality assurance review of the model's capability of predicting future salt loads.

Future Predictive: The Future Predictive mode calculates the future salt loads based on the parameters determined from the Historical Measured Mode. The Future Predictive period assessed is from 2013 through 2035.

3.1.4 Model Calibration

Calibration of IRWD's Salt Balance Model was performed in two steps; Historical Measured and Historical Predictive. Both calibration steps compare monthly model estimates to observed data into and out of MWRP. As presented in the following table, the Historical Measured calibration uses observed measurements and an iterative process to estimate key parameters for every month of the study period within a range of reasonable values. Also shown is the Historical Predictive calibration, which uses a single or monthly estimates of these same key parameters for every month of the study period. The Historical Measured calibration demonstrates the models ability to simulate historic flow and concentrations into and out of MWRP over the five-year study period when key unmeasured data is estimated from observations. The Historical Predicted calibration demonstrates the uncertainty to expect when these key parameters are estimated. Because these same key parameters will be unknown in the future, the Historical Predicted results provide a qualitative assessment for how the model should be used for Future Predictive application.

Historical Measured Calibration

IRWD provided monthly TDS samples at the influent and effluent of MWRP. Each month had a single value for both influent and effluent that represented an entire month. To calibrate IRWD's Salt Balance Model, the measured MWRP influent and effluent TDS values for the 60-month (2008 to 2012) historical period were compared with the calculated monthly values produced in the model. Table 3-1 presents the key data that was estimated from observed data that were adjusted iteratively within a range of reasonable values in the Historic Measured mode using a macro so the model results matched the measured historical data from 2008 through 2012.

Table 3-1. Key Parameters Adjusted During Model Calibration

No.	Parameter	Historical Measured	Historical Predictive
1	Percent of Water Supply used for Irrigation and Other Outdoor Uses [a]	25 to 88%	31 to 58%
2	Residential Salinity Loading – Black Water [b]	63 to 83 grams / capita-day	63 to 83 grams / capita-day
3	Residential Salinity Loading – Grey Water [c]	10 to 14 grams / capita-day	10 to 14 grams / capita-day
4	MWRP Influent to Sludge TDS Ratio	1.0 to 2.9	1.5
5	Sand Canyon Reservoir Return TDS Concentration	700 to 1000 mg/L	885 mg/L

[a] This flow does not return to the sewer and is a salt export.

[b] Black water includes flow from toilets. Unique value per sewershed.

[c] Grey water includes flow from washing machines, faucets, showers, and bathtubs. Unique value per sewershed.

The Historical Measured mode is the closest to a perfect correlation since calculated and actual measured values are based on the same data set and utilize the macros. The quantity R, called the linear correlation coefficient, measures the strength and the direction of a linear relationship between two variables.

The *coefficient of determination* (R^2) that can range from 0 to 1, and denotes the strength of the linear association between two variables. The stronger the relationship between the two variables, the closer R^2 is to 1.

The correlation charts shown in Figure 3-2 compare the calculated influent and effluent TDS values (Historical Measured mode) against the historical measured data. As shown, the Historical Measured mode shows a strong correlation with the measured influent and effluent data, with the R^2 values of 0.94 and 0.74, respectively. This indicates the model simulates flow and salt concentrations extremely well when key unknown data are allowed to fluctuate within a reasonable range to achieve a mass balance.

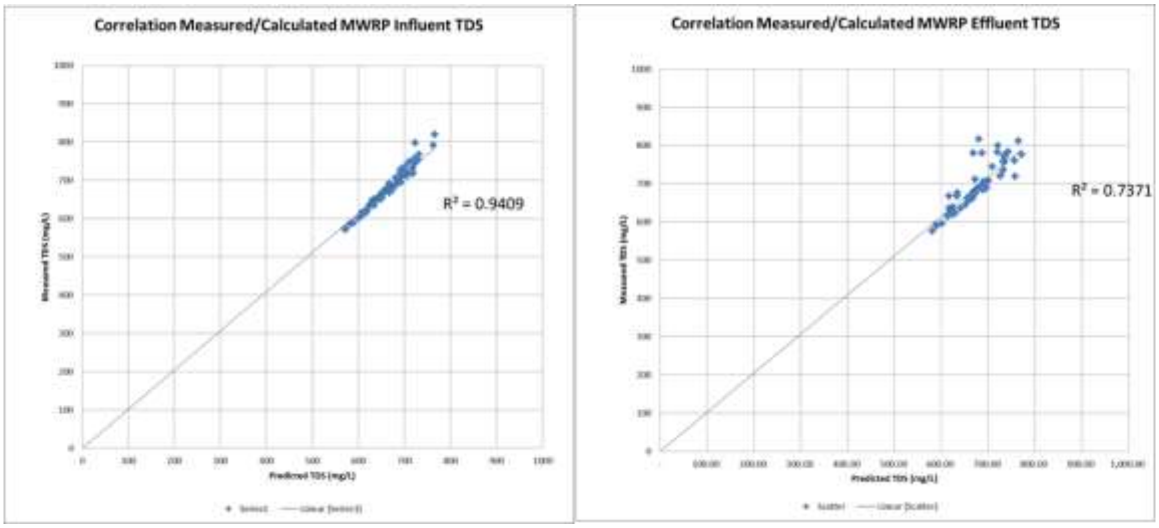


Figure 3-2. MWRP Historical Measured Mode Correlation Charts

Historical Predicted Calibration

The Historical Predictive calibration was created to assess how well the model calculations reflect measured values when the data used is based on statistically estimated values rather than actual data (Table 3-1**Error! Reference source not ound.**). In the Historic Predictive mode, the R^2 values for influent and effluent correlation were 0.03 and 0.05, respectively, as shown in Figure 3-3. These results in combination with the quality of the Historical Calculated calibration indicate that IRWD's Salt Balance Model should not be used to forecast future salt loads for a specific month or year; however, it can be used to forecast future TDS trends.

3.2 Model Results

IRWD's Salt Balance Model provides a greater understanding of the historical contributing salt loads and locations of input, and allows us to project future trends of TDS in the District's recycled water product.

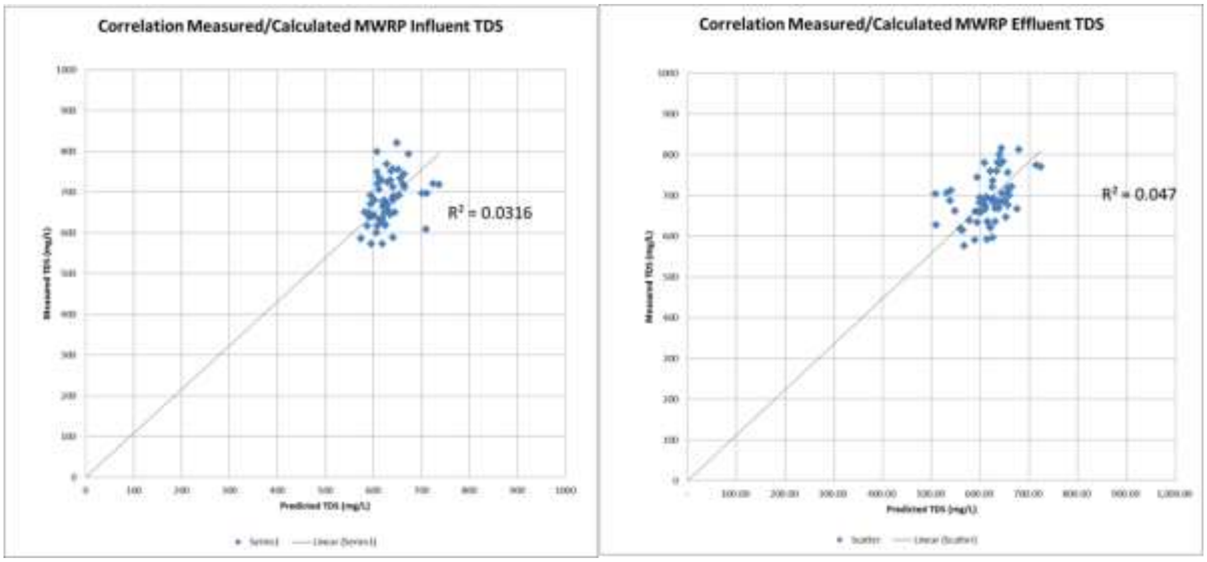


Figure 3-3. MWRP Historical Predictive Mode Correlation Charts

3.2.1 Historical Model Results

Based on an average of the 5 years (60 months) of historical data, the sources of salinity in the District's sewage are represented in Figure 3-4. The largest contributor is the source water. As previously shown in Figure 2-4, imported water typically has TDS concentrations that are 1.5 to 2 times higher than local groundwater sources. Residential use is generally considered an uncontrollable load and contributes approximately 33% of the salt that flows to the sewer system. Commercial and Industrial contribute 21% of the salt load and self regenerating water softeners contributed an estimated 5% of the salt load.

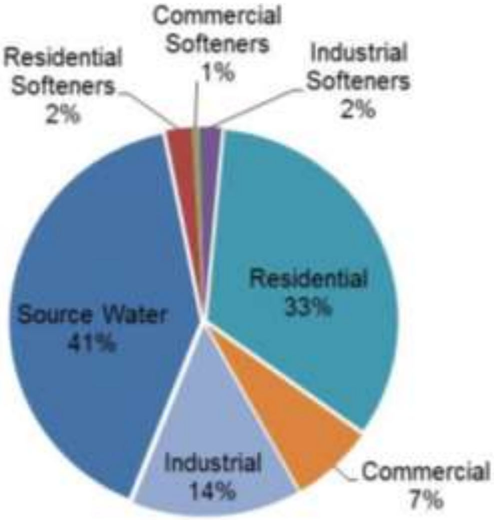


Figure 3-4. Salinity Load Contributions in IRWD Sewage (2008-2012 Average)

The model also simulates the origin by sewershed of various salt loads, as well as export of salt loads through irrigation and exfiltration. The average salt load per sewershed for the 5 years of historical data is shown in Figure 3-5. This type of information can help the

District target certain sewersheds and/or types of salt contributions for mitigation measures.

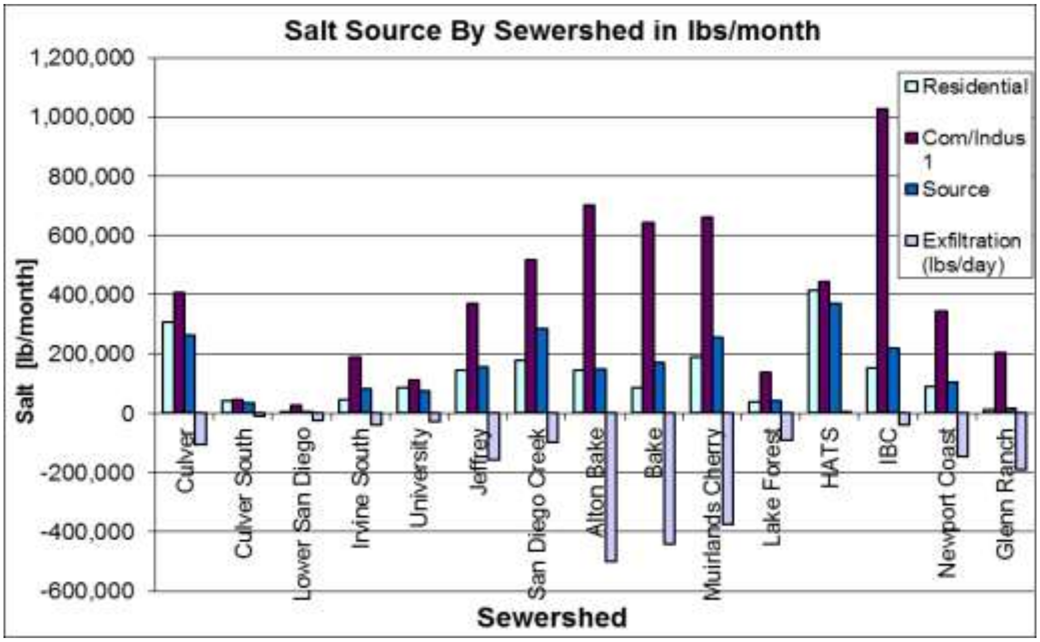


Figure 3-5. Salinity Load Contributions by Sewershed (2008-2012 Average)

Figure 3-6 illustrates the contributing salinity sources specific to recycled water produced at MWRP. The largest salt loads to IRWD's recycled water system are from the source water and residential use. As shown, the addition of chemicals to treat the sewage stream contributes approximately 4% of the salt load in the effluent. The remaining 3% that is not called out on the graphic is attributed to water softeners. This information can be used to identify where various salt mitigation measures should be focused to reduce TDS in IRWD's potable supply.

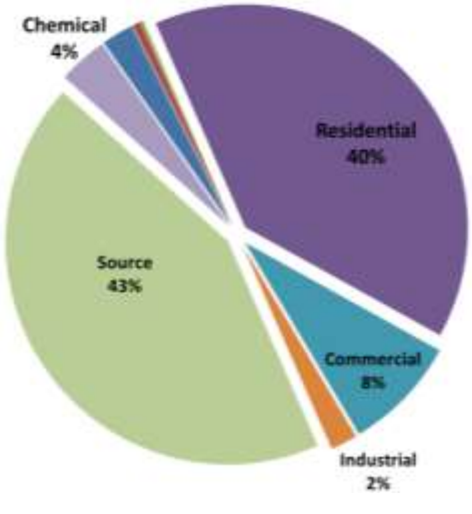


Figure 3-6. Salinity Load Contributions to MWRP Recycled Water (2008-2012 Average)

The significant impact of source water on IRWD recycled water TDS is exemplified during the time period when MWRP effluent TDS was out of compliance with the RWQCB 720 mg/L limit. Figure 3-7 shows the measured monthly MWRP effluent TDS and the running annual average (RAA) from 2008 to 2012. As shown, the RAA was out of compliance from March 2011 to February 2012. This figure also shows that the monthly MWRP effluent TDS was increasing for one year prior to the out of compliance period. Leading up to and during this out of compliance period, several factors contributed to MWRP exceeding the TDS limit:

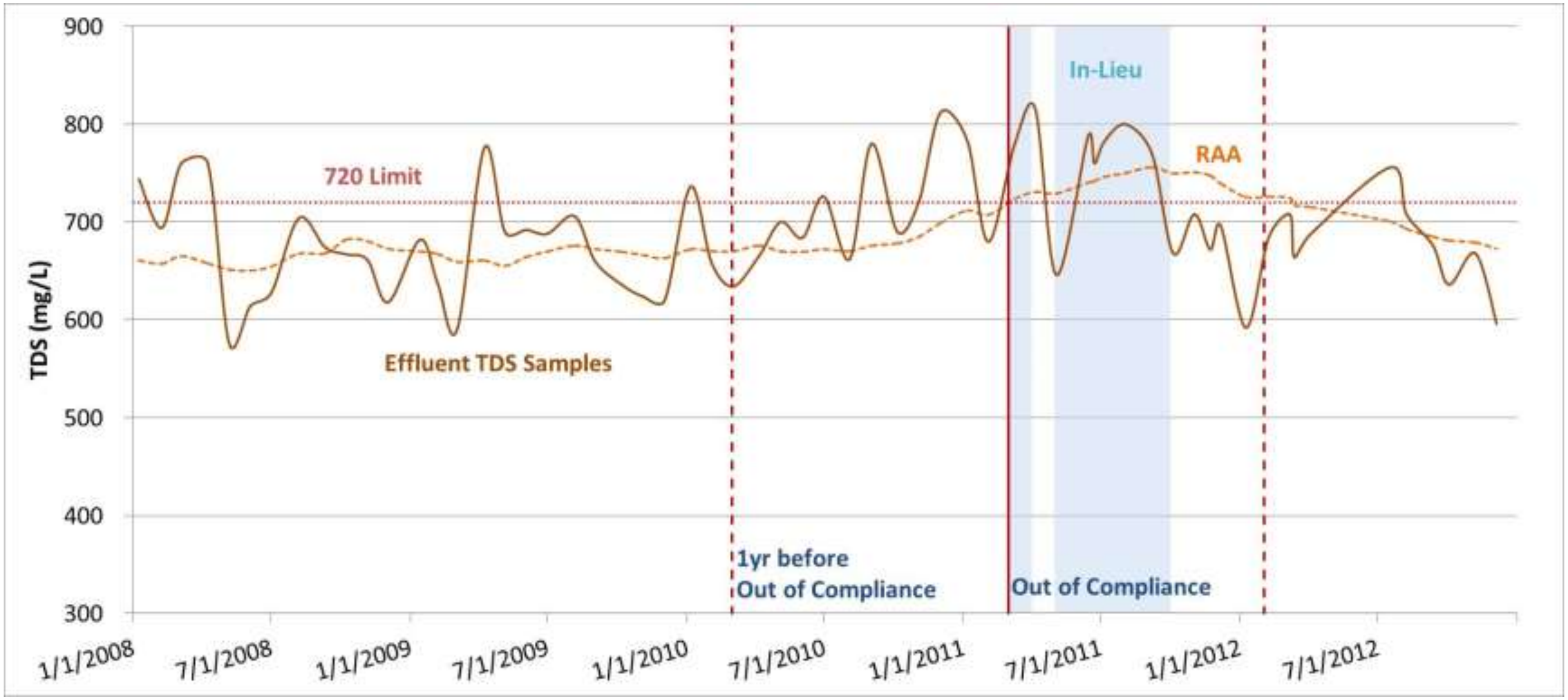
1. The source water blend at Diemer was over 50% Colorado River, which has more salt than SWP water.
2. Salt load from imported water was abnormally high due to IRWD’s participation in OCWD’s In-Lieu program.
3. MWRP received return flow from Sand Canyon reservoir in July and August 2011. Reservoir return contributes an additional salt load to MWRP that increases effluent TDS by about 15 mg/L.

Figure 3-8 illustrates the impact of the imported supply on the MWRP effluent. This figure is split into three panels with a common x-axis to represent the historical study period from 2008 to 2012:

1. The top panel shows the percent makeup of Colorado River water in imported water from Diemer Water Treatment Plant.
2. The middle panel shows the measured monthly MWRP effluent TDS and the running annual average. This is the same information shown in Figure 3-7.
3. The bottom panel shows the salt load in pounds from imported water and local groundwater sources.

3.2.2 Future Model Results

The Future Predictive mode calculates recycled water TDS with the same methodology as the Historical Predictive mode. The differences between the modes are the inputs for the calculations. The inputs are classified into 3 major categories; user defined parameters, model predictive data, and statistical trends. Each category has a wide array of probable and relevant settings which would change the results of the calculations. Two Baselines were developed to simulate possible futures. These baselines are simply labeled “Baseline A” and “Baseline B.” These future baselines are fully described in Section 4.



NOTE: MWRP effluent TDS data based on monthly samples.

Figure 3-7. Historical MWRP Effluent TDS

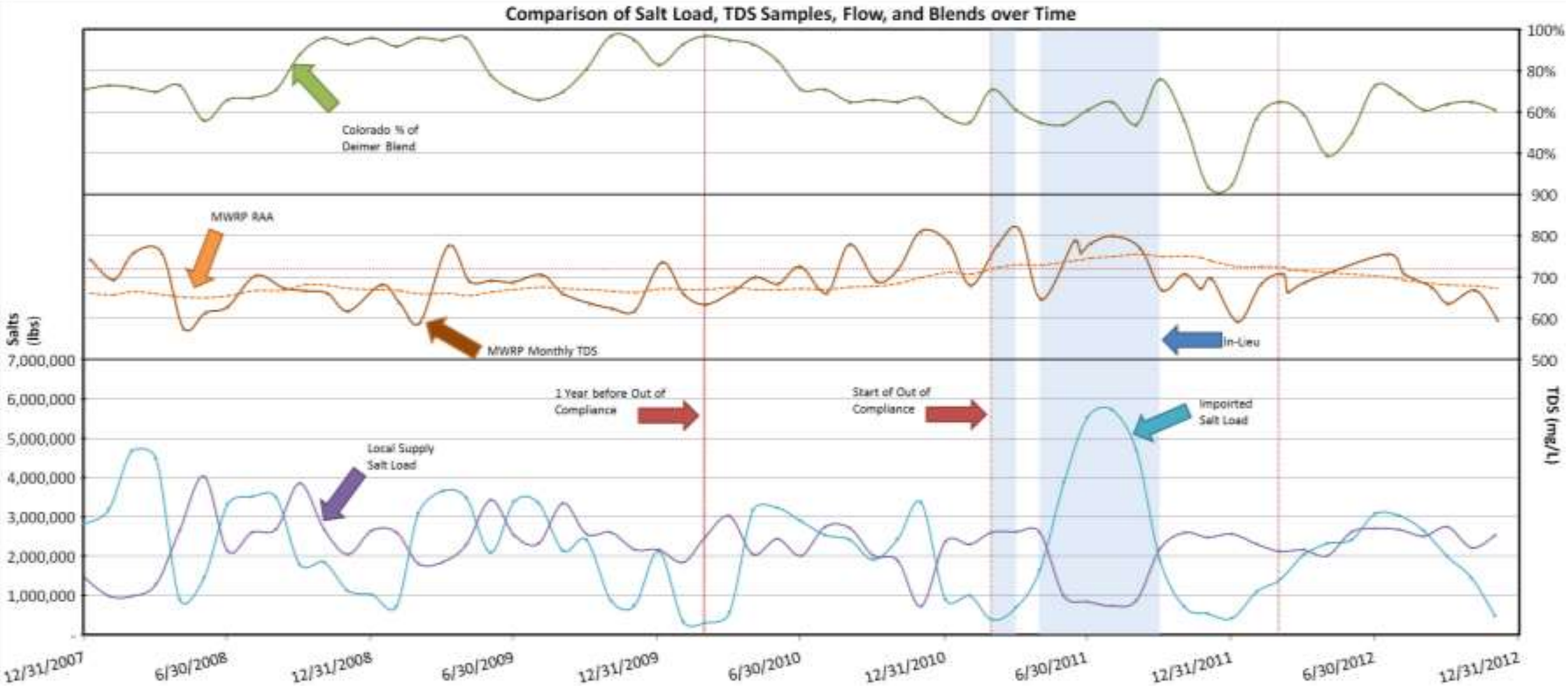


Figure 3-8. Historical Imported Salt Load

4 Future Baseline & Scenarios

4.1 Introduction

In order to estimate the TDS of recycled water produced by IRWD in the future, two future baselines were developed that extend from 2015 to year 2035. Each baseline assumes IRWD will construct and begin operation of the future facilities identified in Table 4-1. Two baselines were developed, Baseline A and Baseline B, to provide a range of realistic and plausible futures that IRWD may encounter. In general, Baseline A represents a best case that will produce relatively low future TDS levels while Baseline B is a more conservative case that will produce relatively high TDS levels.

Table 4-1. Future IRWD Projects

Item	Description	Estimated Year of Operation
1	Baker Water Treatment Plant (28.1 MGD capacity, 6.8 MGD to IRWD)	2016
2	Well 106 (874 AFY)	2016
3	Wells 51/52 Potable (2,322 AFY)	2016
4	Santiago Reservoir (2.4 MG)	2017
5	Well 53 (3,629 AFY)	2017
6	MWRP Biosolids and Energy Recovery Facilities	2016
7	Future OPA Potable Well (3,710 AFY)	2019
8	Syphon Reservoir Expansion to 5,000 AF	2025

Most of the future projects listed in Table 4-1 were included in the baselines such that the new supply replaced an equal amount of imported water as estimated by IRWD’s Groundwater Workplan 2013 model. Additional considerations were required to model the MWRP Biosolids and Energy Recovery Facilities. The Biosolids facility will receive MWRP sludge typically discharged to OCSD and process it into Class A biosolids using digesters, centrifuges, and a dryer. Thickening and dewatering centrate and facility sewers will return to MWRP for treatment. Preliminary analysis by the Biosolids project design firm indicates that the return flows will increase MWRP recycled water effluent TDS by 11.5 mg/L upon startup at 23.6 MGD. The TDS impact from the Biosolids return flow for future expansions of MWRP treatment capacity was not readily available; therefore, the resulting concentration of the return flow was estimated to be the same during startup and through the phased expansions of MWRP treatment capacity. However, the model considers the potential to change this future return flow TDS concentration and incorporates the net effect of estimated future biosolids return flows and salt loads. This was identified for further evaluation to refine the model in Section 6.4.2.

4.2 Baseline A and Baseline B Scenarios

Baseline A and Baseline B were developed to provide a range of realistic and plausible estimates of recycled water TDS concentrations that IRWD might encounter in the future. Both baselines include the same new facilities and construction dates listed in Table 4-1. The parameters that are different between Baselines A and B are summarized in Table 4-3 and include the Basin Pumping Percentage (BPP), In-Lieu Pumping, Recycled Water Penalty, and Diemer WTP effluent TDS concentration, which is mainly driven by the Colorado River TDS concentration, SWP TDS concentration, and the blend of Colorado and SWP water. Following is a description of each:

1. **BPP** – The BPP is the percent of IRWD's demand within the Orange County Groundwater Basin that IRWD is allowed to pump. Recent communication with OCWD indicated their goal is to maintain a 70% BPP for the next ten years and increase to a 75% BPP afterwards. Baseline A includes the OCWD values. Baseline B includes a lower BPP estimate of 65% that is representative of recent history.
2. **In-Lieu Pumping** – The In-Lieu pumping program allows IRWD to receive surface water from the Metropolitan Water District of Southern California (MWD) in-lieu of pumping local groundwater. Historically, the program was used when surface water supplies are significantly greater than average. It has the benefit of reducing local groundwater pumping and effectively increasing the volume of groundwater storage. In-lieu periods do not follow a pattern, but historically have occurred every 5 to 10 years. Baseline A does not include any in-lieu participation while Baseline B includes a 4-month (May through August) in-lieu period every 7 years based on recent history.
3. **Recycled Water (RW) Penalty** – The OCWD's BPP calculation currently adjusts for recycled water use and effectively reduces the amount of groundwater that IRWD can produce. Baseline A simulates a 2016 expiration date of the RW Penalty while Baseline B assumes the RW Penalty will continue into the future.
4. **TDS Concentration of Diemer WTP Effluent** – Diemer WTP final effluent TDS concentration is the resulting blend of two source waters (Colorado River and SWP) at the plant. Therefore, the TDS concentrations of both sources and blend ratio affects the final effluent TDS from Diemer. Baseline A uses the historical median TDS values of Diemer effluent for a given month. Baseline B uses the Colorado and SWP TDS concentrations and blend ratio as described below and summarized in Table 4-2.
    a. **TDS Concentration of Colorado River Water** –The Colorado River historical (1993 to 2013) median TDS values for a given month range from 606 to 623 mg/L. Baseline B includes a value of 723 mg/L, which is the maximum flow-weighted average required by the Colorado River Basin Salinity Control Forum.

b. **TDS Concentration of SWP** – The SWP historical (1993 to 2013) median TDS values for a given month range from 196 to 260 mg/L. Baseline B uses the historical maximum value of 324 mg/L TDS.

c. **Blend of Colorado River Water and SWP from the Diemer WTP** – MWD provides IRWD with imported potable water from the Diemer WTP that is a blend of the Colorado River and SWP supplies. The historical (1993 to 2013) median percent blend of Colorado River to SWP supplies for a given month ranges from 66% to 78% Colorado River water. Baseline B uses the historical median TDS value plus one standard deviation as the blend, which is 86% Colorado River water.

Table 4-2. Historical Monthly Medians for Diemer WTP Effluent TDS Concentration

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diemer Effluent TDS Concentration (mg/L) [a]	500	468	492	486	491	477	494	480	475	506	508	498

[a] Median value from monthly historical data from July 1993 to June 2013.

Table 4-3. Future Baselines

No.	Parameter	Baseline A	Baseline B
1	Basin Pumping Percentage	70% until 2024 75% after 2024	65%
2	In-Lieu Period	None	Every 7 years
3	Recycled Water Penalty	Expires in 2016	Never Expires
4	TDS Concentration of Diemer WTP Effluent	Historical median by month	N/A
4a	TDS Concentration of Colorado River	N/A	Maximum per Colorado River Basin Salinity Control Forum (723 mg/L)
4b	TDS Concentration of State Water Project	N/A	Maximum Historical (324 mg/L)
4c	Diemer WTP Blend of Colorado and SWP (Percent Colorado)	N/A	Historical Median Blend Percentage + 1 Standard Deviation (85.7% Colorado)

N/A = Not applicable

Figure 4-1 shows the estimated historic and future MWRP effluent TDS running annual average (RAA) projected in to the future with Baseline A and Baseline B.

California RWQCB, Santa Ana Region, Order No. R8-2008-0072 that amends Order No. R8-2007-0003 (NPDES No. CA8000326) Waste Discharge Requirements (WDR) limits the RAA of MWRP recycled water TDS to 720 mg/L with compliance monitored at MWRP effluent. Based on the previously described parameters, the RAA for Baseline A does not exceed 720 mg/L TDS through 2035 as shown in Figure 4-1. On the other hand, the RAA for Baseline B exceeds 720 mg/L on several occasions through 2035 with the largest predicted TDS being approximately 60 mg/L over the limit in 2034 and 2035.

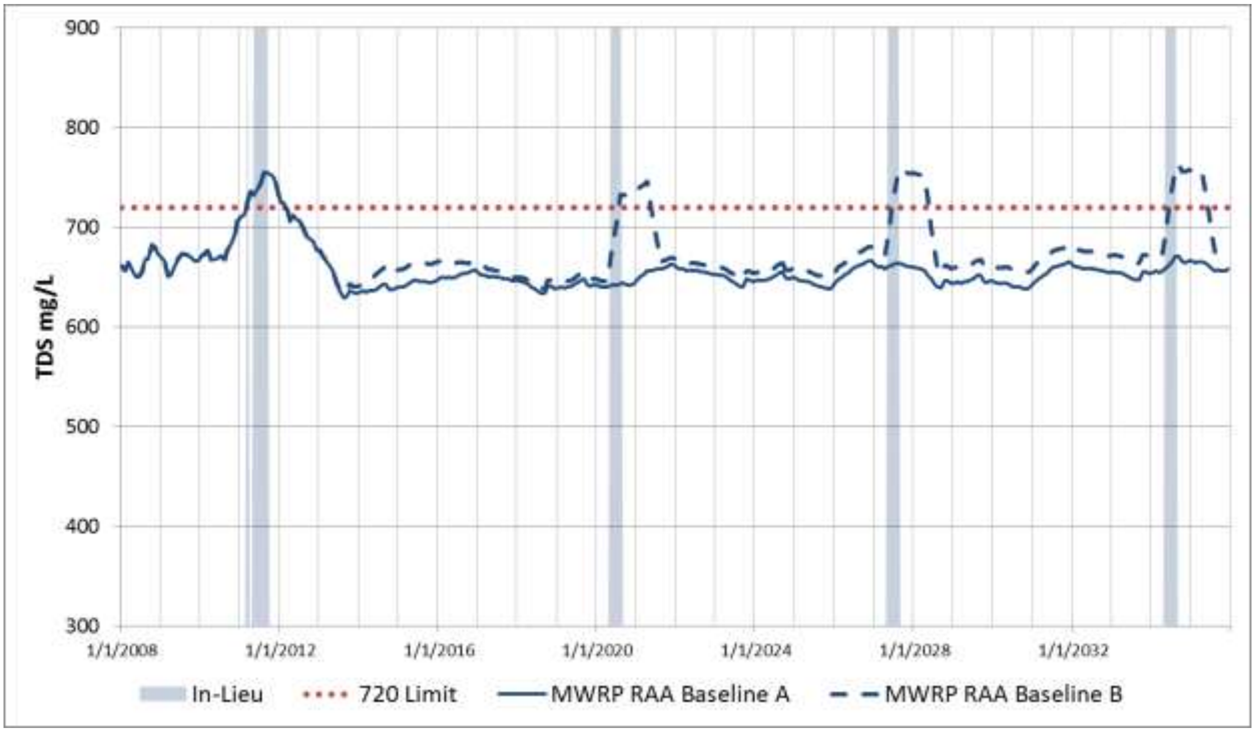


Figure 4-1. Future MWRP Effluent TDS RAA for Baseline A and Baseline B

In the future, Baseline B is generally below the TDS limit except during in-lieu periods, which the model estimates to occur every 7 years from May through September.

Both baselines show a gradual increase in TDS over time; however, the rate of TDS increase in Baseline B is about twice the rate of increase in Baseline A. This is the combined effect of the other parameters (BPP, RW Penalty, Colorado River, SWP, and Diemer blend) on the RAA, which are not as recognizable as in-lieu periods but have a steady impact on TDS.

Through 2035, both Baselines A and B would not exceed the TDS limit of 720 mg/L RAA if IRWD did not participate in the in-lieu program. However, the in-lieu program benefits IRWD by reducing groundwater pumping and allowing the groundwater basin to recharge faster. For Baseline A, the RAA is about 660 mg/L in 2035, which gives IRWD a TDS buffer of 60 mg/L before they exceed their permit limit of 720 mg/L. For Baseline B, the RAA is about 670 mg/L in 2035 during a non in-lieu period, which gives IRWD a TDS buffer of 50 mg/L before they would exceed their permit limit. Changes to or within IRWD's system that increase or decrease TDS would likewise affect the District's available buffer.

4.2.1 LAWRP Impact on Projected TDS RAA of Non-Potable System

Unlike MWRP, LAWRP has access to the Aliso Creek Ocean Outfall (ACOO). When additional recycled water is needed, LAWRP produces tertiary recycled water and discharges into the non-potable (NP) water system. When recycled water demand is low, LAWRP stops producing tertiary effluent and begins discharging secondary effluent to the ACOO. At times, LAWRP will simultaneously produce recycled water and discharge to the ACOO. The Santa Ana RWQCB Order No. 94-03 regulates reuse of LAWRP effluent in the Santa Ana Region. San Diego RWQCB Order No. 97-52 regulates reuse of LAWRP effluent in the San Diego Region and establishes a TDS limit of 1,000 mg/L RAA and 1,100 mg/L daily max. San Diego RWQCB Order No. R9-2012-0013, NPDES No. CA0107611 regulates discharge to the ACOO but does not establish TDS limits. In July 2015, both MWRP Region 8 Santa Ana and LAWRP Region 9 San Diego RWQCB WDR permits for recycled water were superseded by Order No. R8-2015-0024, NPDES No. CA8000326 with a 720 mg/L TDS RAA limit.

In the model, LAWRP produces recycled water when certain conditions are met in regards to recycled water demand, available supply (from MWRP, NP wells, and storage reservoirs), and typical LAWRP operational period based on discussions with IRWD staff and shown in the following argument.

For a given month, if $V_{NP\ Demand} \geq V_{MWRP} + V_{NP\ Wells} + V_{Reservoirs} + 0.5\ V_{LAWRP}$,
then LAWRP produces recycled water (where V is the monthly volume).

LAWRP will produce recycled water for a given month when the recycled water monthly demand ($V_{NP\ Demand}$) is greater than the monthly supply from MWRP (V_{MWRP}), monthly supply from NP wells ($V_{NP\ Wells}$), monthly storage volume in the non-potable reservoirs ($V_{Reservoirs}$), and half of LAWRP’s monthly production (V_{LAWRP}) with 5.5 MGD capacity.

Based on these operational conditions and future demand-supply projections, the model predicts that LAWRP will typically produce recycled water for one or two summer months of the year. From 2013 to 2035, the Baseline A predicts that 11 of the 23 years will not require LAWRP to produce recycled water. When LAWRP does produce recycled water (i.e., LAWRP on), it results in relatively little difference in the recycled water concentration. As presented in Figure 4-2, the projected monthly non-potable system TDS for Baseline A with LAWRP on (solid dark blue) and with LAWRP off (solid light blue) are nearly equal. The difference in TDS between the monthly non-potable TDS with LAWRP on versus LAWRP off is reflected by the solid purple line on the secondary vertical axis. Although the TDS difference with LAWRP on or off appears significant on a month-to-month basis (solid purple), the contribution of flow from LAWRP is relatively minor and therefore increases the non-potable system RAA by only about 4 mg/L TDS (dashed purple). The scale for the purple lines only is shown on the secondary y-axis on the right side of the graph.

Similarly results for Baseline B are shown in Figure 4-3; the monthly TDS increase in the non-potable system between LAWRP producing versus not producing recycled water is plotted with the solid purple line on the secondary vertical axis. When LAWRP discharges recycled water into the non-potable system, the TDS increases by about 45 mg/L (solid purple). However, because LAWRP does not produce a significant amount recycled water for an extended duration the projected TDS RAA increase is only about 7 mg/L (dashed purple). The scale for the purple lines only is shown on the secondary y-axis on the right side of the graph.

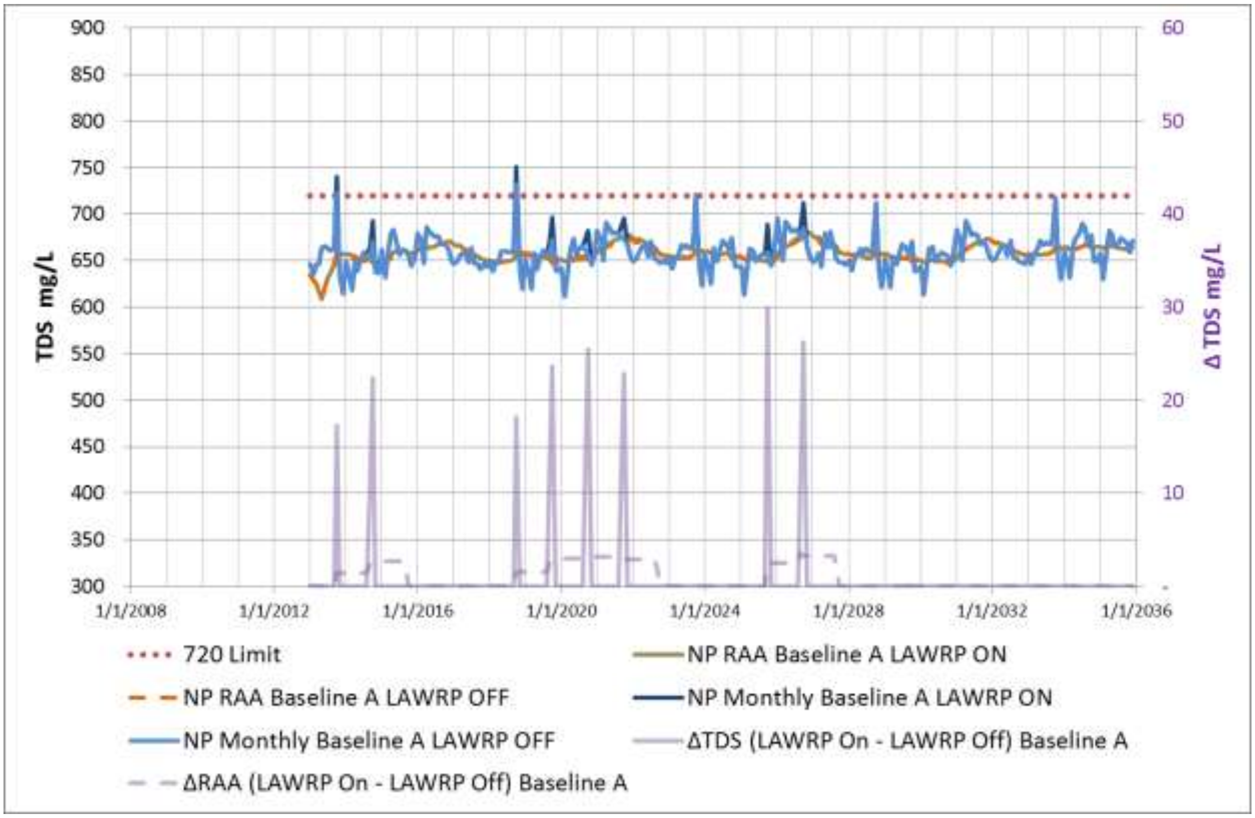


Figure 4-2. Impact of LAWRP Recycled Water Production on the Non-Potable System for Baseline A

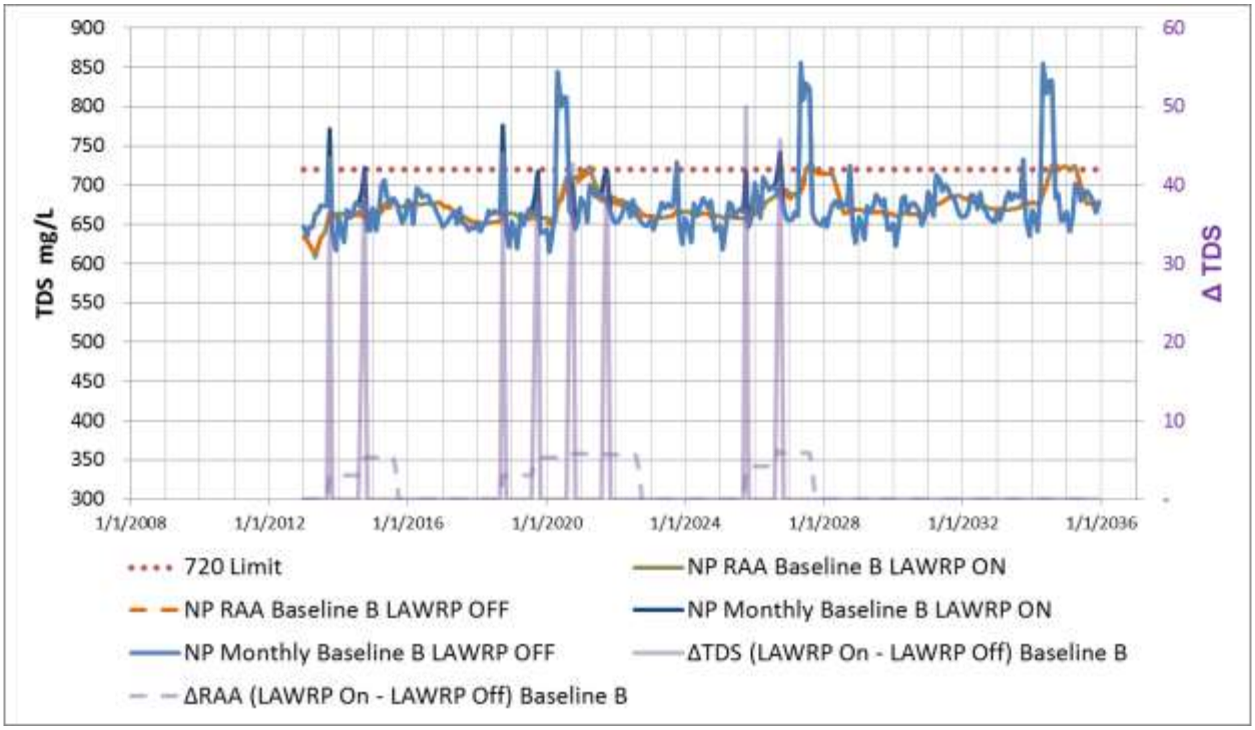


Figure 4-3. Impact of LAWRP Recycled Water Production on the Non-Potable System for Baseline B

Due to these reasons and the fact that MWRP has a greater impact on TDS in the non-potable system than LAWRP, the goal to mitigate TDS and develop scenarios focused on compliance with MWRP effluent discharge requirements.

4.3 Future Salt Scenarios

IRWD identified five future scenarios that could impact the District's TDS concentrations in the non-potable water system and are not included as part of the baseline, as shown in Table 4-4 below. The future TDS concentrations were evaluated by modeling each scenario separately for each baseline scenario to determine their relative impact and investigate a range of future salt management strategies.

Table 4-4. Summary of Future Scenarios

Scenario No.	Name	Description
1	Salt Removal at MWRP	IRWD incorporates salt removal into the MWRP treatment process
2	Brine Disposal to MWRP	IRWD customers dispose of brine into IRWD sewers
3	Poseidon HBDP	Poseidon Huntington Beach Desalination Plant comes online
4	Poseidon HBDP Max	Poseidon HBDP comes online and IRWD receives maximum available capacity
5	MBI	Mid-Basin Injection Phase II online and Centennial injection wells planned for future

Table 4-5 is a summary of the five scenarios including scenario criteria, TDS impact, and cost opinion. The fifth scenario was evaluated but not modeled, which is explained further in Section 4.3.5. The following sections in this chapter provide a more detailed description of the development and evaluation of each scenario. The cost opinion associated with each scenario is discussed in Chapter 5.

Note that because these future scenarios reflect different conditions, they should not be compared against each other. Furthermore, nearly all of the scenarios modeled for the best-case Baseline A condition did not exceed the 720 mg/L TDS limit through the end of the study period in 2035. Therefore, most of the evaluation and discussion for mitigating salt within the District's recycled water is related to maintaining TDS compliance in the more conservative Baseline B condition.

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Table 4-5. Summary of Future Scenarios and Cost

Name[a]	Scenario 1[c]	Scenario 2[c]	Scenario 3[c]	Scenario 4[c]	Scenario 5[c]
	Salt Removal at MWRP	**Brine Disposal to MWRP**	**Poseidon HBDP**	**Poseidon HBDP Max**	**Mid-Basin Injection**
Basis of Scenario[b]					
Salt Removal System Design Criteria	50 mg/L TDS MWRP Effluent	450 mg/L TDS Target 1 Sensitive User 640 AFY Each User 0.57 MGD Demand for 1 User	500 mg/L High TDS Expected Poseidon 1,500 AFY Poseidon enters IRWD (Average) 100 - 2,000 AFY Poseidon enters IRWD 0.09 - 1.8 MGD Poseidon enters IRWD	500 mg/L High TDS Expected Poseidon 48,350 AFY Poseidon enters IRWD (Average) 100 - 48,500 AFY Poseidon enters IRWD 0.09 - 43.3 MGD Poseidon enters IRWD	43 mg/L TDS 1.5 MGD MBI-1 Well Injection 3 MGD/Future Well Injection 8-10 Anticipated Future Wells
Total User Treatment System					
Influent		0.31 MGD 720 mg/L TDS			
Effluent		0.25 MGD 100 mg/L TDS			
Brine		0.06 MGD 3,200 mg/L TDS			
User Brine Discharge To		MWRP			
MWRP Treatment System					
Influent	2.6 MGD 735 mg/L TDS	0.37 MGD 772 mg/L TDS			
Effluent	2.0 MGD 100 mg/L TDS	0.30 MGD 100 mg/L TDS			
Brine	0.5 MGD 3,280 mg/L TDS	0.07 MGD 3,325 mg/L TDS			
MWRP Brine Discharge To	OCSD	OCSD			
Water Quality (in 2034-2035)					
MWRP Effluent					
Δ TDS	(50) mg/L TDS	(7) mg/L TDS	0 mg/L TDS	160 mg/L TDS	Expected reduction in TDS
Improved Water Quality for:	All Non-Potable Users	Sensitive User Only	No Effect	All Non-Potable Users	All Non-Potable Users
Sensitive User Water Quality					
Δ TDS		(270) mg/L TDS			
Life Cycle (2015-2035)[c]					
Net Present Value (2015 dollars)	$ 27,700,000 [d]	$ 4,600,000	$ -	$ -	$ -
Capital Cost (2015 dollars)	$ 3,400,000	$ 1,000,000	$ -	$ -	$ -
Total Salt (20 years)	102,100,000 lbs Removed	15,100,000 lbs Added for 1 User	0 lbs	- lbs	- lbs
Total Salt per Year[e]	5,105,000 lbs Removed	800,000 lbs Added for 1 User	0 lbs	- lbs	- lbs
Unit Cost	$ 0.27 per lb Salt	$ 0.30 per lb Salt	$ -	$ -	$ -
Annual Cost	$ 1,385,000 per year	$ 244,000 per year for 1 User	$ -	$ -	$ -

NOTES:

a Scenarios should not be compared to each other. Each scenario represents a different situation.

b All scenarios are based on projected future Baseline B during worst out of compliance period (2034-2035), where MWRP Effluent TDS RAA is 780 mg/L at 28 MGD.

c Scenario 1 estimates unit cost for IRWD to construct and operate salt removal (RO) system at MWRP.
Scenario 2 estimates unit cost to generate revenue for IRWD to construct and operate a future salt treatment system (RO) at MWRP to remove the additional brine discharged from 1 User Treatment System(s).
Scenario 3 estimates unit cost to IRWD to receive 100 - 2,000 AFY Poseidon HBDP water to supply Newport Coast. Newport Coast sewershed discharges to OCSD. IRWD does not plan to purchase Poseidon water.
Scenario 4 estimates TDS changes to IRWD if they receive the max 48,500 AFY of Poseidon HBDP water as part of the purchase and exchange program with other agencies. Unit costs could not be determined.
Scenario 5 was evaluated qualitatively and a reduction in total Salts is anticipated at no direct cost to IRWD. This scenario was not modeled.

d Assumes unit cost to discharge brine to OCSD is $1,290 per MG.

e Assumes even distribution of salt load per year.

f Average local and imported chloride concentration are 25 and 90 mg/L, respectively. Per Poseidon HBDP WQ specifications the mean and maximum chloride concentration are 75 and 100 mg/L, respectively.

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4.3.1 Scenario 1 – Salt Removal at MWRP

Scenario 1 – Salt Removal at MWRP evaluates the facilities and costs required to reduce TDS concentrations by installing a reverse osmosis (RO) process to treat a portion of the plant's effluent. As presented in Figure 4-4, following the MWRP Phase 2 expansion, the treatment plant will have two treatment trains: a new 10.6-MGD capacity Membrane Bioreactor (MBR) and with Ultraviolet (UV) disinfection and the existing 16.5-MGD capacity Activated Sludge Process with sodium hypochlorite disinfection. The ultrafiltration membranes in the Phase 2 MBR expansion provide an excellent pretreatment step to RO.

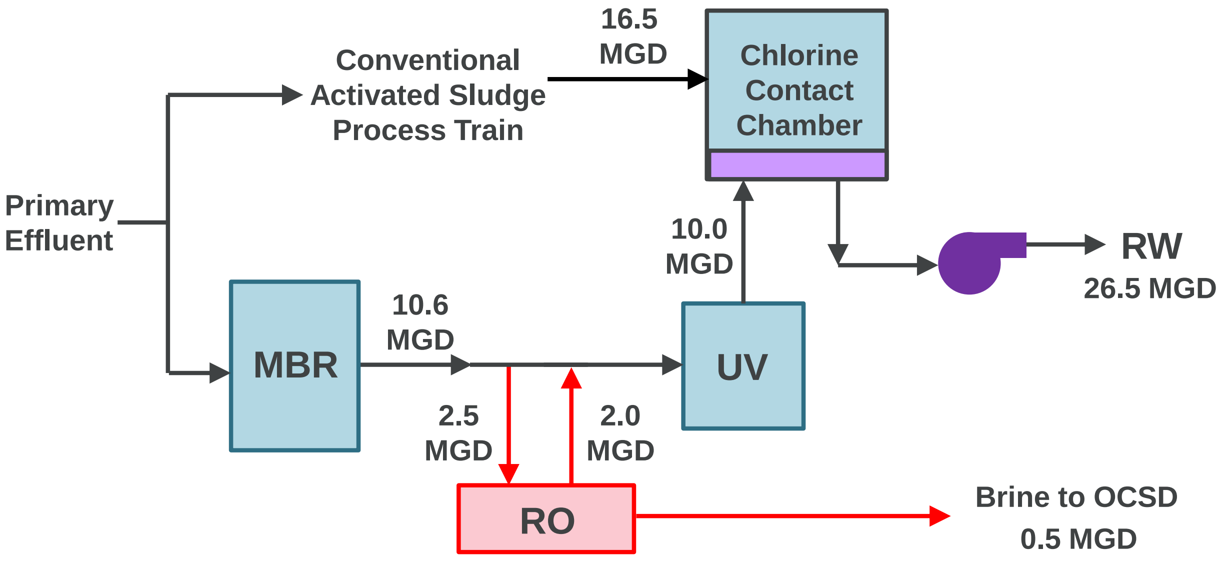

Figure 4-4. Scenario 1 – Salt Removal at MWRP Process Flow Diagram for Phase 2 Expansion Capacity

As previously stated and shown in Figure 4-1, Baseline B is projected to exceed the 720 mg/L limit by approximately 50 mg/L TDS in 2034 and 2035 during an in-lieu period. In this scenario, the RO process is sized to treat and reduce the Baseline B projection to consistently meet the TDS RAA limit with an additional buffer The RO process has three primary streams: influent, effluent, and brine. Future RO inflows were calculated to be approximately 25% of the 10.6-MGD MBR process to meet the current discharge limit of 720 mg/L after blending under Baseline B. Future brine flows will be discharged to OCSD.

Key data for the RO system associated with this scenario are shown in Table 4-6.

This scenario includes the following:

- The objective is to produce a blended water quality at MWRP discharge point that is consistently less than 720 mg/L TDS for both Baselines A and B by installing an RO system at MWRP to reduce recycled water effluent TDS by about 50 mg/L for a 26.2-MGD (29,400 AFY) MWRP outflow.
- The above objective can be achieved by an RO system sized to accommodate future recycled water demands. The RO system must be able to treat 2.6 MGD (2,870 AFY) of 700 mg/L MBR permeate and produce 2.6 MGD effluent at

100 mg/L to be blended with remaining MWRP flows to discharge 25.7 MGD (28,800 AFY) of 720 mg/L recycled water.

- Typical RO treatment system recovery is 80% (e.g., for every 100 units treated, 80 units of product and 20 units of brine are produced).
- Brine disposal to OCSD is 0.5 MGD (570 AFY) with 2,933 mg/L TDS.
- The RO influent TDS concentration reflects the estimated TDS from MBR permeate, which is the difference in TDS between the MWRP effluent and chemical addition.
- Additional process components were included in the cost for this scenario:
  - RO influent booster pumps
  - Brine discharge pumps

Table 4-6. Scenario 1 – Salt Removal at MWRP – RO Treatment and Blended Data

	Flow (MGD)	Flow (AFY)	TDS (mg/L)
RO Influent	2.5	2,866	735
RO Effluent	2.0	2,293	100
RO Brine Discharged to OCSD	0.5	573	3,277
Blended Supply	26.2	29,400	735
Total (Blended) Flow	25.7	28,800	712

Results Discussion – Scenario 1 – Salt Removal at MWRP

Figure 4-5 and Figure 4-6 show the impact of a salt removal system at MWRP on the TDS RAA over time for Baseline A and Baseline B, respectively. For both baselines, Scenario 1 – Salt Removal at MWRP reduces TDS in recycled water effluent, which increases IRWD’s TDS buffer.

The following are key observations:

- Scenario 1 – Salt Removal at MWRP reduces TDS in MWRP recycled water effluent by 40 mg/L for Baseline A and 50 mg/L for Baseline B (solid purple), which benefits all recycled water customers. The scale for the purple line only is shown on the secondary y-axis on the right side of the graph.
  - For Baseline A, MWRP TDS RAA reduces to 620 mg/L and increases the TDS buffer to 100 mg/L in 2035 (solid light blue).
  - For Baseline B, MWRP TDS RAA reduces to 630 mg/L and increases the TDS buffer to 90 mg/L in 2035 (solid light blue).
- Implementing a treatment system to remove salt from recycled water will allow MWRP to maintain compliance with the 720 mg/L TDS discharge limit for both Baseline A and B.
  - Baseline A and B do not exceed the 720 limit through 2035 and maintains a minimum 10 mg/L TDS buffer during in-lieu periods (solid light blue).

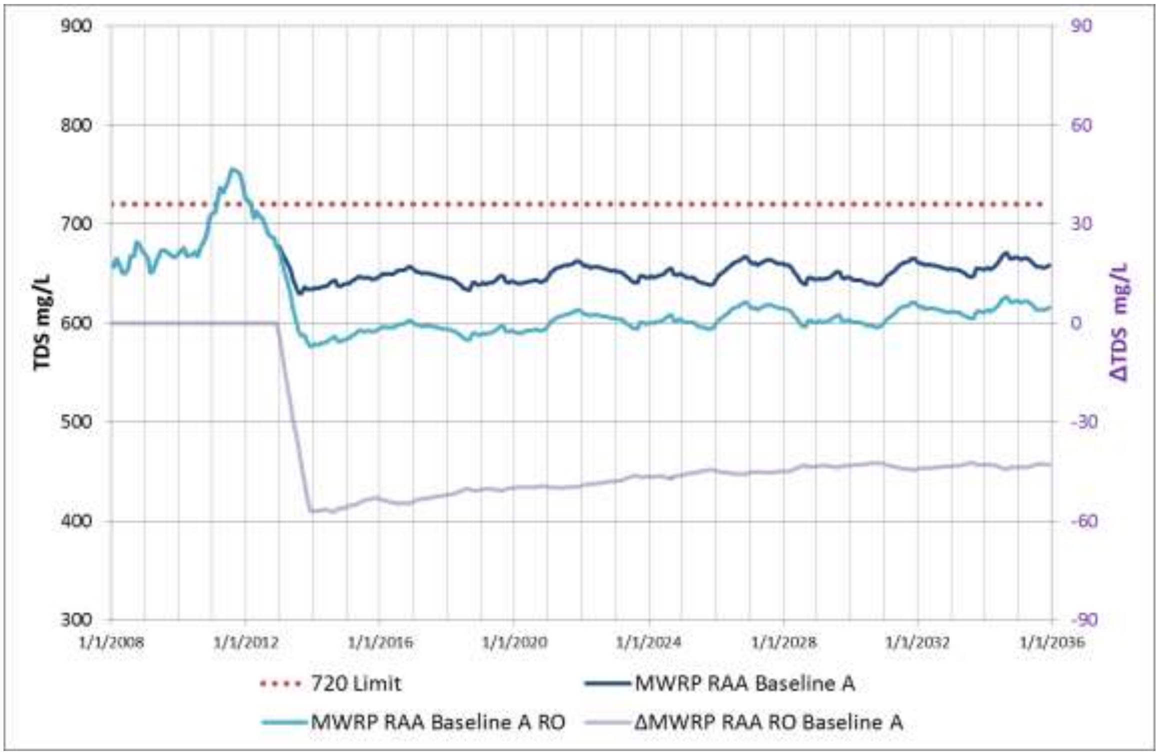

Figure 4-5. Impact of Scenario 1 – Salt Removal at MWRP on MWRP Effluent Baseline A

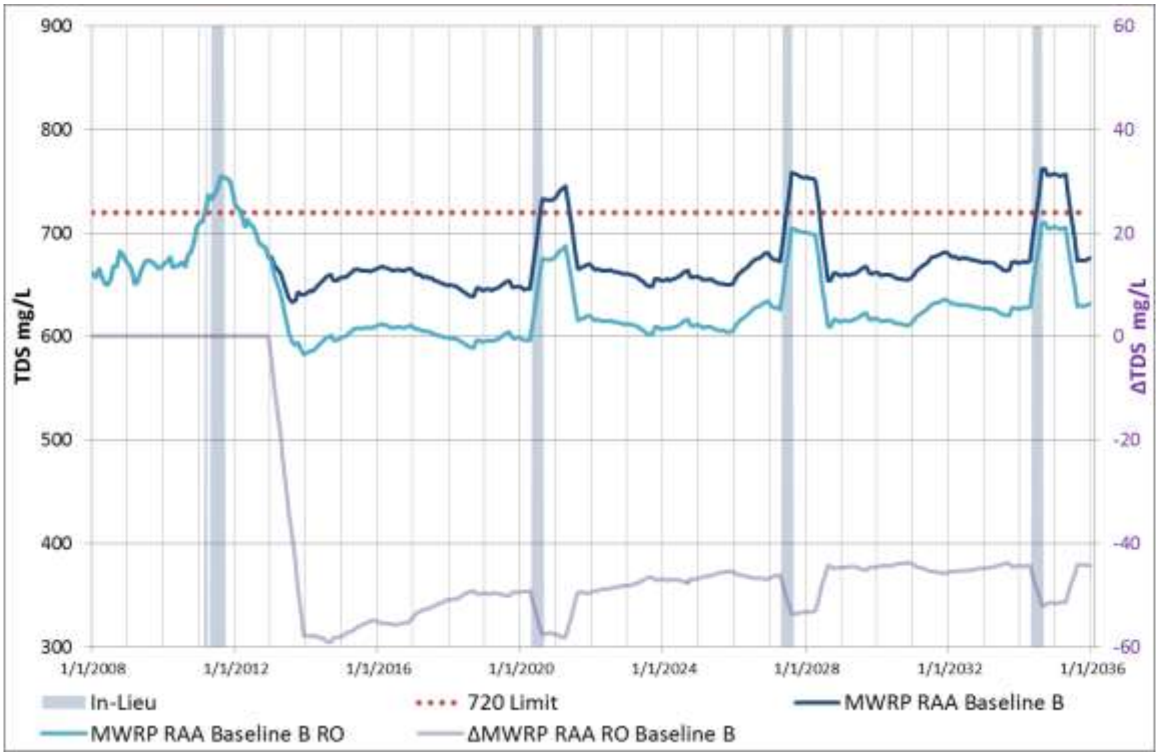

Figure 4-6. Impact of Scenario 1 – Salt Removal at MWRP on MWRP Effluent Baseline B

4.3.2 Scenario 2 – Brine Disposal to MWRP

Scenario 2 – Brine Disposal to MWRP evaluates the facilities and costs associated with accepting new discharges to MWRP that contains relatively high concentrations of TDS. In this scenario, this new discharger installed a private RO system to treat a portion of their non-potable supply and discharge the brine resulting from this process into the IRWD collection sewer. Other possible sources of a new discharge, other than a private RO system, that might contain relatively high concentrations of TDS include a new industry or dewatering project. Key data for the RO system for a non-potable water user associated with this scenario are shown in Table 4-7.

Table 4-7. Scenario 2 – Brine Disposal to MWRP – User Demand and RO Treatment Data

	Flow (MGD)	Flow (AFY)	TDS (mg/L)
RO Influent	0.31	348	720
RO Effluent	0.25	278	100
RO Brine Discharged to MWRP	0.06	69	3,200
Untreated Non-Potable Supply [a]	0.32	361	720
Water Demand	0.57	640	450
Total Non-Potable Water Supply	0.63	709	720

[a] Untreated non-potable supply is the portion of non-potable water withdrawn from the distribution system to be mixed with RO effluent to fulfill the user’s water demand. This means that:
Untreated Non-Potable Supply + RO Effluent = Water Demand, AND
Untreated Non-Potable Supply + RO Influent = Total Non-Potable Water Supply

This scenario includes the following:

- The objective is to produce 0.57 MGD (640 AFY) of 450 mg/L TDS non-potable water for a sensitive user by installing an RO system and blending its effluent with untreated non-potable supplies.
- The above objective can be achieved by an RO system that treats 0.31 MGD (350 AFY) of 720 mg/L non-potable water and produces 0.25 MGD (280 AFY) effluent at 100 mg/L and blending it with 0.32 MGD of 720 mg/L non-potable water.
- The user owns, operates, and maintains the RO treatment system, booster pump station, and other appurtenances.
- The user RO influent TDS concentration does not exceed 720 mg/L and reflects the TDS concentration in the non-potable system with complete mixing of MWRP effluent, non-potable wells, non-potable reservoirs, and imported untreated water.
- Typical RO treatment system recovery is 80% (e.g., for every 100 units treated, 80 units of product and 20 units of brine are produced).
- RO product water is about 280 AFY with a TDS of 100 mg/L.
- Brine disposal to MWRP is 0.06 MGD (70 AFY) with 3,200 mg/L TDS.
- User RO treatment system capacity is sized for continuous operation (24 hours per day, 7 days per week).

- There is a potential for at least 10 sensitive users to implement this type of treatment system of similar size and treatment goals in various sewersheds. This scenario considers the effect of one user discharging brine to MWRP.

Results Discussion – Scenario 2 – Brine Disposal to MWRP

Figure 4-7 and Figure 4-8 show a small increase in MWRP TDS RAA caused by Scenario 2 – Brine Disposal to MWRP by one sensitive user for both Baseline A and Baseline B, which reduces IRWD's TDS buffer.

The following are key observations:

- Scenario 2 – Brine Disposal to MWRP increases TDS in MWRP recycled water effluent by 6 to 7 mg/L for Baseline A and Baseline B (solid purple), which adversely affects all recycled water customers. The scale for the purple line only is shown on the secondary y-axis on the right side of the graph.
    - For Baseline A, MWRP TDS RAA increases to 670 mg/L and reduces the TDS buffer to 50 mg/L in 2035 (solid green). However, the 720 mg/L permit limit is not exceeded through 2035 and a minimum 40 mg/L buffer is maintained.
    - For Baseline B, MWRP TDS RAA increases to 680 mg/L and reduces the TDS buffer to 30 mg/L in 2035 (dashed green). The 720 mg/L permit limit is exceeded during in-lieu periods.
- The TDS increase is due to the high concentration of brine continuously discharged into IRWD's collection system.
- This scenario determined the TDS impact on MWRP effluent if the non-potable water quality to the customer did not exceed 720 mg/L TDS, which would otherwise instigate action to lower TDS back to 720 mg/L. Additional analysis is required to determine the potential for a cumulative impact on recycled water salinity as the non-potable water user begins to receive a product with escalating salinity over time. This potential for a cumulative impact may be dampened if the use and subsequent brine disposal is seasonal with peak flows and corresponds with periods when the District's potable water quality has a lower salinity content.
- Although only one sensitive user was evaluated for this scenario, there is a potential for at least 10 similar sensitive users to implement this type of treatment system. Several brine discharges of similar volume and quality would proportionally multiply the TDS impact and create a situation where the TDS RAA limit was exceeded.

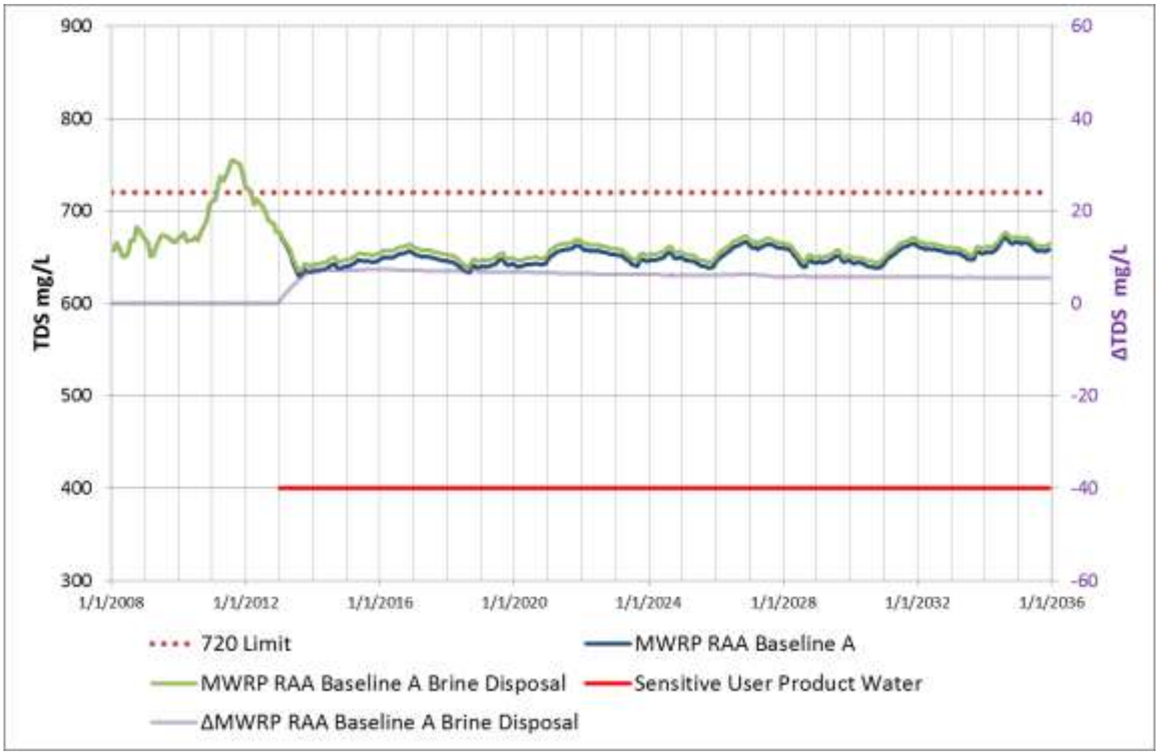

Figure 4-7. Impact of Scenario 2 – Brine Disposal to MWRP by a Sensitive User on MWRP Effluent Baseline A

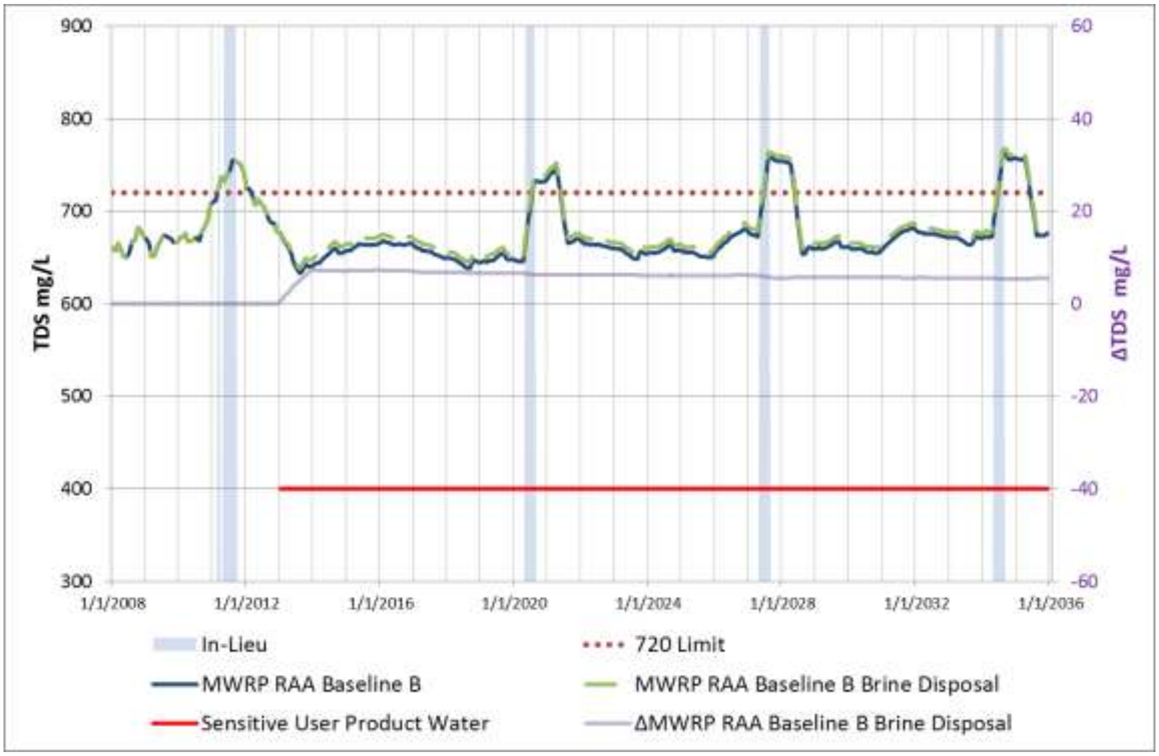

Figure 4-8. Impact of Scenario 2 – Brine Disposal to MWRP by a Sensitive User on MWRP Effluent Baseline B

4.3.3 Scenario 3 – Poseidon Huntington Beach Desalination Plant

This scenario evaluates the Poseidon Huntington Beach Desalination Plant (HBDP) providing product water to IRWD as part of a purchase and exchange program and delivering water to South Orange County agencies. IRWD may purchase up to 100 AFY of the project's yield; however, HBDP supplies are expected to be significantly more expensive than other water supplies. HBDP might deliver significantly more water to IRWD and potentially impact the District's recycled water quality, if IRWD participates in an exchange program to deliver additional supplies to southern Orange County. Additionally, Poseidon HBDP may convey desalinated water to South Orange County agencies via feeders passing through the IRWD service area. Any withdrawal from those pipeline feeders will be HBDP product water. The Newport Coast is an IRWD sewershed that typically withdraws water from these feeders throughout the year. Scenario 3 – Poseidon HBDP evaluates the TDS impact due to limited IRWD participation in the purchase and exchange program up to the demand of the Newport Coast sewershed (100 AFY to 2,000 AFY). It does not include the transfer of any of IRWD's local groundwater supplies to South Orange County.

Poseidon Water has plans to construct a desalination plant in Huntington Beach. If completed, recent correspondence indicates the HBDP will produce 50 MGD (56,000 AFY) of potable water through the treatment of seawater at a cost of approximately $1,847 per AF. IRWD anticipates receiving the full amount for the MWD Local Resources Program (LRP) Subsidy upon acceptance of Poseidon water at $340 per AF. MWD 2015 rates for full service treated Tier I water is $1,003 per AF and includes the MWD readiness-to-serve and capacity charge of $80 per AF. The LRP subsidy reduces the cost of Poseidon water to $1,507 per AF; however, MWD full service treated water still costs less at $1,003 per AF. Therefore, IRWD is unlikely to purchase Poseidon water while IRWD demand continues to be met by other source waters (e.g., local groundwater, local surface water, MWD water, and water banking activities) and these sources continue to be more economical. The "Poseidon Resources Huntington Beach Ocean Desalination Project Information and Update" (submitted by OCWD staff during the January 8, 2014 OCWD Board Meeting) states the following:

> *Based upon historical MWD rate increases, it is reasonable to assume the unit cost of MWD water will eventually exceed the cost of Poseidon desalination water. However, there are too many variables and uncertainties to predict when that will happen or to guarantee it will happen.*

Available literature and discussions with IRWD staff indicate several potential entry points of HBDP product water. Scenario 3 – Poseidon HBDP evaluates the one probable surface entry point of HBDP product water into IRWD's potable water system through the OC-44 pipeline. The capacity of the OC-44 is limited in the western reaches with pipe diameters of 24- and 16-inch while the eastern reaches have a larger diameter at 42 -inch. To connect the HBDP to the OC-44, Poseidon would have to construct a new 42 to 48-inch force main, construct booster pump stations, and upsize portions of the existing OC-44. In this case, Poseidon water would then be available to supply the southern portion of the EOCF #2 (see Figure 4-9).

This scenario includes the following:

- IRWD participates in the purchase and exchange program.
    - IRWD's participation in the purchase and exchange program is limited to IRWD's imported water demand. This means that Poseidon water will not replace water supplied from IRWD's local sources.
- HBDP will provide product water to IRWD from OC-44. The annual supply includes IRWD's participation in the purchase and exchange program from 100 AFY and up to the future IRWD demands from MWD for the southern IRWD service area, which is limited to the Newport Coast sewershed (2,000 AFY).
    - For the southern portion of the IRWD service area, IRWD only withdraws imported water from the EOCF #2 turnout DOC063 to supply potable water to the Newport Coast sewershed under normal conditions.
        - During in-lieu periods, IRWD may withdraw water from EOCF #2 through the DOC039 turnout.
        - The potable water demand of the Newport Coast is 61,465 AFY in 2013 and grows to 83,807 AFY in 2035.
- The quality of Poseidon water supplied by the HBDP must be the same or better than MWD imported water. HBDP product water quality specifications and typical MWD water quality are presented in Table 4-8. According to the water quality specifications provided by Poseidon, HBDP water will have less TDS than MWD water and similar chloride concentration.
    - The model estimates a worst-case scenario where HBDP water quality must be equal to or less than MWD water quality. Poseidon specifies a maximum of 500 mg/L TDS in HBDP product water and will not exceed this at any time; therefore, 500 mg/L is the worst-case scenario that was modeled for HBDP TDS.
- MWD imported water rates increase 5 percent per year.
- Poseidon water rates increase 2.5 percent per year.

Table 4-8. HBDP Product Water Quality Specifications and MWD Water Quality

Parameter	Units	HBDP Concentration Limit			MWD
		Average [a,b]	Maximum [a,c]	Worst-Case [d]	
TDS	mg/L	350	500	500	544 [e]
Chloride	mg/L	75	100	-	89 [e]

[a] HBDP product water quality from OCWD Board Meeting Agenda (3/18/2015) Draft Poseidon Term Sheet.

[b] Average – not to exceed (or go below for certain of the Quality Parameter) the average over the one-year sampling period for weekly grab samples.

[c] Maximum Concentration Limit – cannot be exceeded at any time.

[d] Maximum acceptable to IRWD for HBDP product water quality (i.e., modeled worst-case scenario).

[e] Median values from MWDOC Diemer WTP monthly effluent data 2008 to 2014.

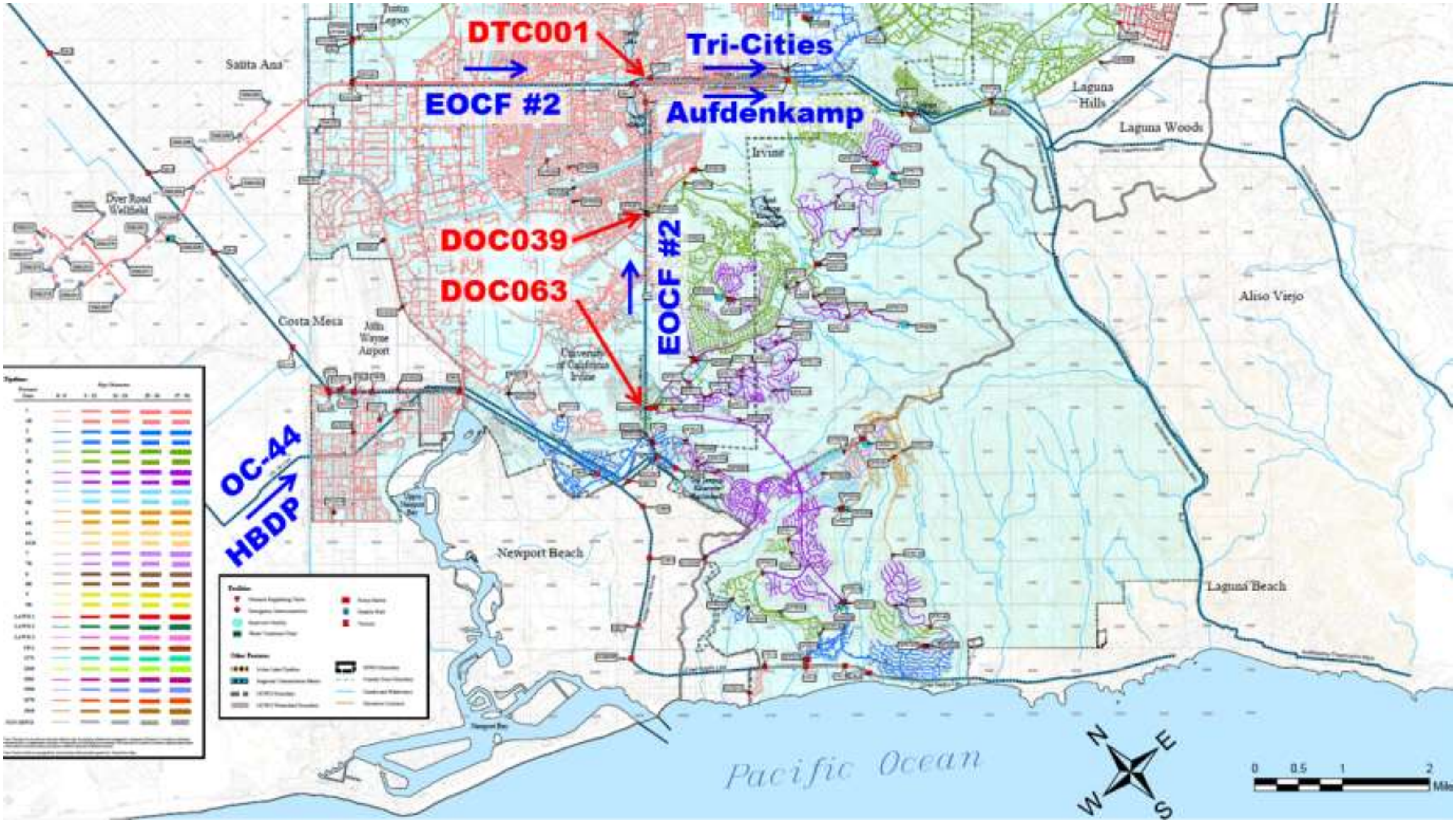

Figure 4-9. Poseidon HBDP Imported Water in IRWD Service Area

Results Discussion – Scenario 3 – Poseidon HBDP

Figure 4-10 and Figure 4-11 reflect a near zero impact scenario on recycled water TDS for Baseline A and Baseline B based on the Scenario 3 – Poseidon HBDP conditions (provided above) that require Poseidon to meet strict water quality standards for IRWD to accept HBDP product water and supply is limited to the Newport Coast sewershed, which does not typically discharge to MWRP or LAWRP.

The following are key observations:

- Scenario 3 – Poseidon HBDP has near-zero effect on TDS in MWRP recycled water effluent for Baseline A and Baseline B (solid purple), which has no effect on recycled water customers. The scale for the purple line only is shown on the secondary y-axis on the right side of the graph.
  - For Baseline A, MWRP TDS RAA and buffer are maintained at 660 mg/L and 60 mg/L, respectively, in 2035 (solid green).
  - For Baseline B, MWRP TDS RAA and buffer are maintained at 670 mg/L and 50 mg/L, respectively, in 2035 (solid green). The 720 mg/L permit limit is exceeded during in-lieu periods.
- IRWD only imports MWD potable water to supply the Newport Coast sewershed in the southern portion of the IRWD service area. Newport Coast discharges sewer flows to OCSD.
  - In this scenario, HBDP water that replaces MWD water is limited to the Newport Coast sewershed demand, which does not return sewer flow to MWRP, and consequently, has no effect on IRWD recycled water TDS.
- During in-lieu periods, HBDP water may enter IRWD through DOC039 in the Irvine South and University sewersheds, which sends sewage to MWRP. This is projected to have a small effect on MWRP recycled water TDS (solid purple):
  - 4 mg/L TDS reduction (HBDP worst-case water quality of 500 mg/L)
  - 6 to 7 mg/L TDS reduction (HBDP average water quality of 350 mg/L)
- Poseidon HBDP specifications expect the product water average TDS to be 350 mg/L, which is lower than the average TDS of MWD imported water. Figure 4-12 and Figure 4-13 show that the impact of this improved HBDP water does not significantly affect MWRP effluent TDS because the imported MWD water replaced by Poseidon water occurs in the Newport Coast sewershed and does not go to MWRP except during in-lieu.

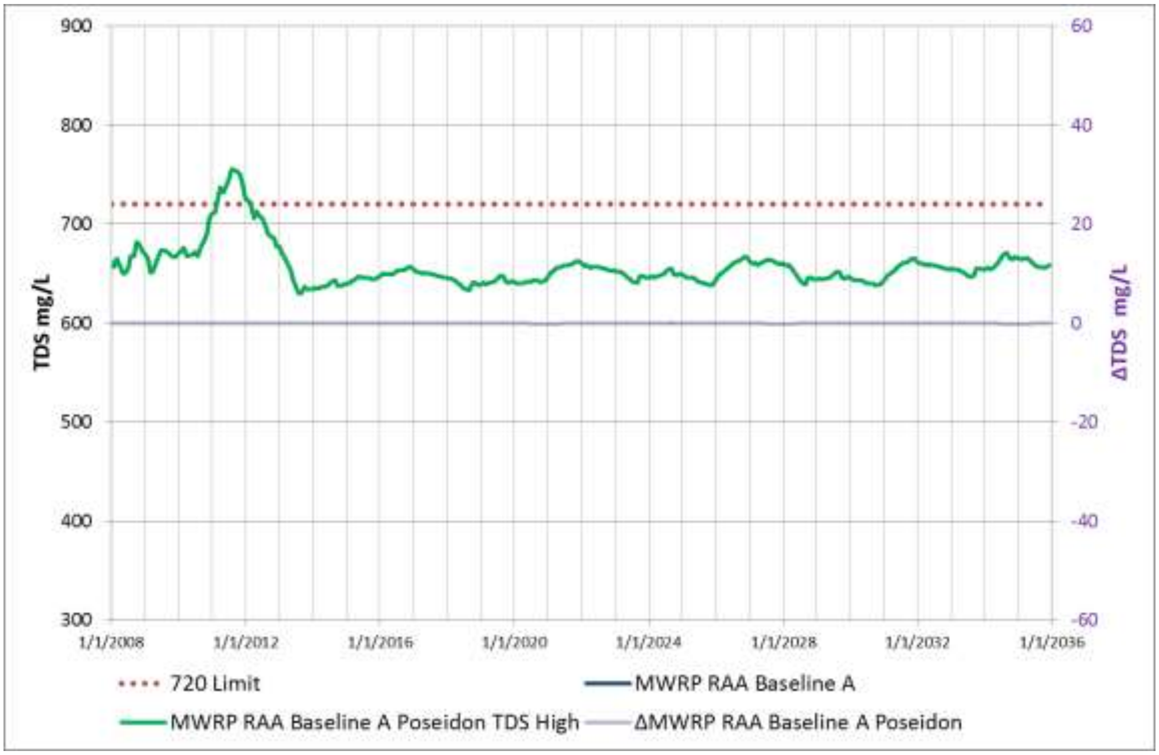

Figure 4-10. Impact of Scenario 3 – Poseidon HBDP (Worst-Case TDS) on MWRP Effluent Baseline A

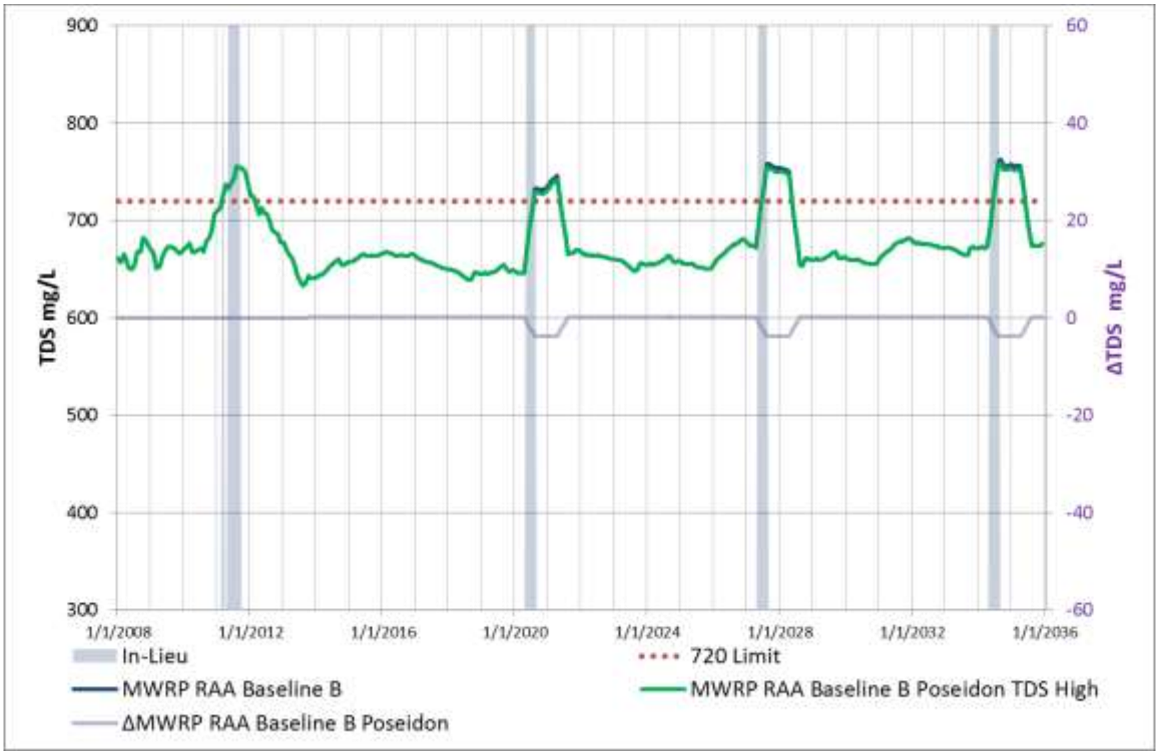

Figure 4-11. Impact of Scenario 3 – Poseidon HBDP (Worst-Case TDS) on MWRP Effluent Baseline B

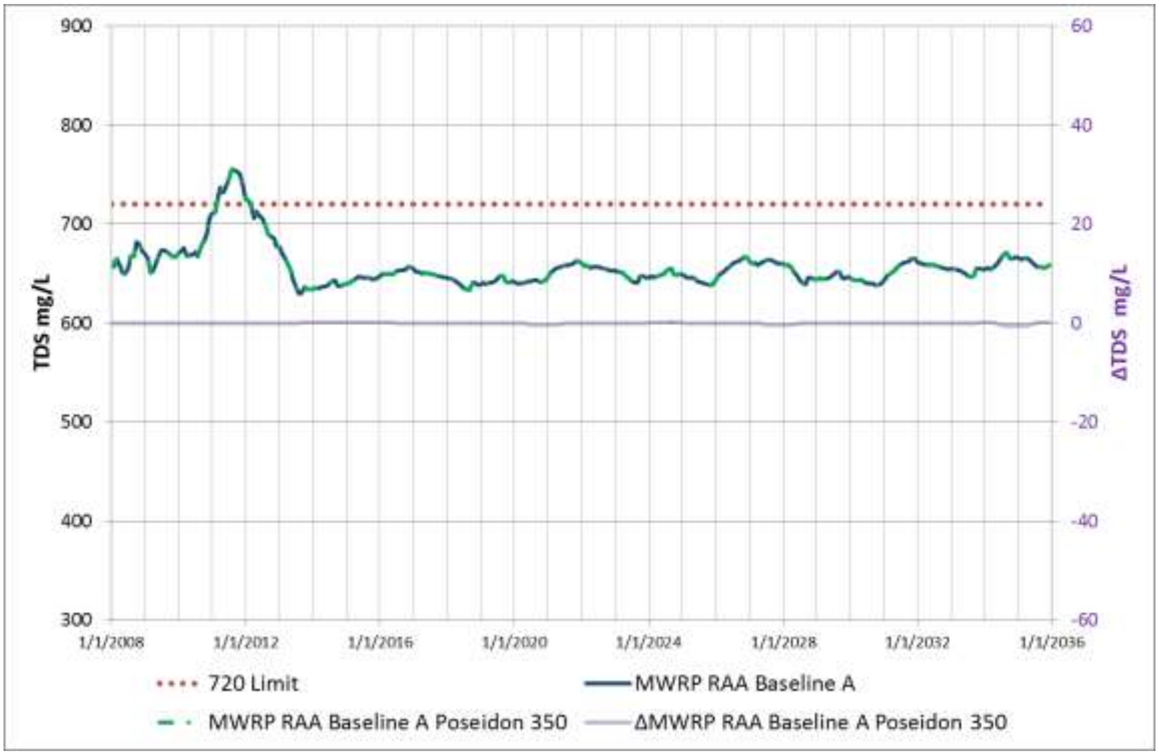

Figure 4-12. Impact of Scenario 3 – Poseidon HBDP (Average TDS) on MWRP Effluent Baseline A

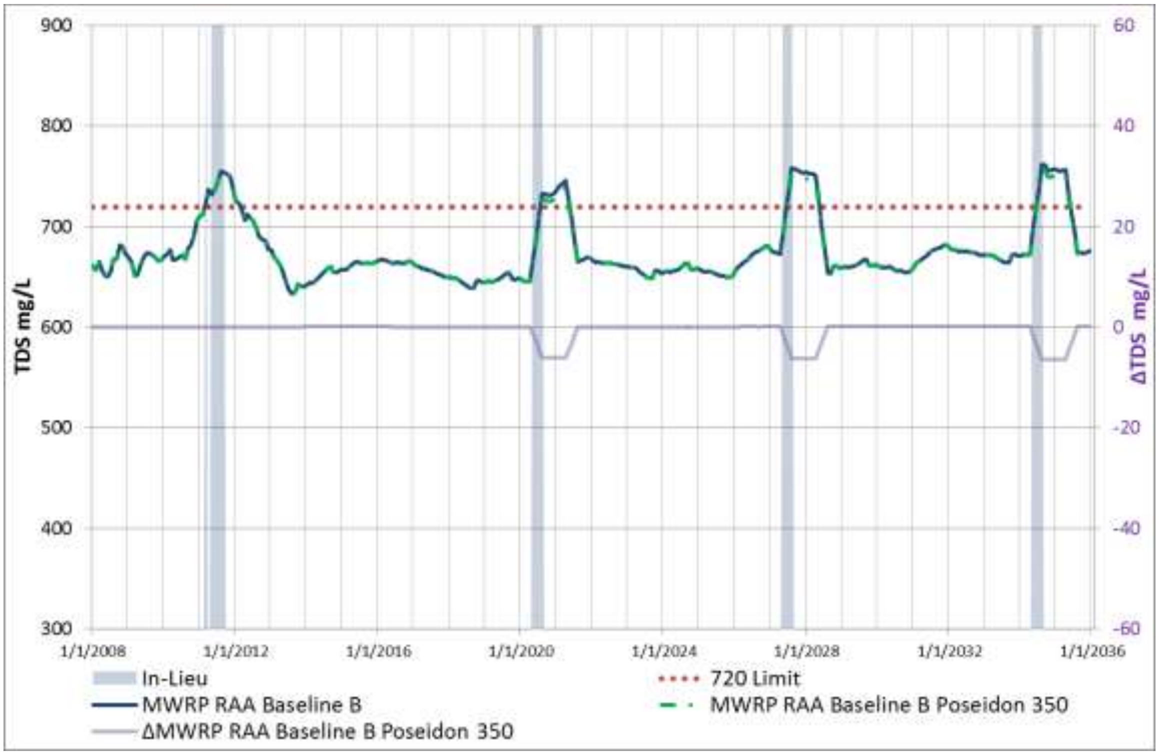

Figure 4-13. Impact of Scenario 3 – Poseidon HBDP (Average TDS) on MWRP Effluent Baseline B

4.3.4 Scenario 4 – Poseidon HBDP Max

Similar to Scenario 3, this scenario evaluates the TDS impact of Poseidon Huntington Beach Desalination Plant providing potable water to IRWD. The difference is that IRWD will import as much Poseidon HBDP water as possible in this scenario. IRWD does not intend to purchase HBDP water because it is currently projected to be more expensive than other water supplies. However, if IRWD participates in an exchange program to deliver additional supplies to southern Orange County, HBDP might deliver significantly more water to IRWD and potentially impact the District's recycled water quality. Additionally, if local groundwater supplies were drastically reduced due to availability or basin management strategies, then IRWD may have to accept HBDP water. Scenario 4 – Poseidon HBDP Max evaluates the TDS impact on MWRP recycled water effluent and IRWD's non-potable system due to IRWD accepting Poseidon HBDP water to its maximum capacity available.

This scenario is based on an upsized OC-44 line that would be able to convey 43.2 MGD flow from HBDP (50-MGD HBDP production excluding the City of Huntington Beach's flow demand) to IRWD and South County agencies. IRWD can withdraw up to 43.3 MGD of HBDP water conveyed through the OC-44 at three turnouts on the East Orange County Feeder #2 and Orange County Feeder. This is summarized in Table 4-9 below.

Table 4-9. Scenario 4 – Poseidon HBDP Max – Available Poseidon Supply and IRWD Capacity Data

	Flow (MGD)	Flow (AFY)	Flow (cfs)
Poseidon HBDP Production	50.0	56,000	77.4
City of Huntington Beach Demand [a]	6.8	7,610	10.5
Poseidon HBDP Available Supply	**43.2**	**48,390**	**66.8**
OC-39 Capacity (from EOCF #2)	25.9	28,960	40.0
OC-63 Capacity (from EOCF #2)	12.9	14,480	20.0
OC-7 Capacity (from OCF)	4.5	5,070	7.0
IRWD Available Capacity	**43.3**	**48,510**	**67.0**

[a] "Draft Feasibility Study to Provide Desalinated Water Supplies to Huntington Beach and the West Orange County Water Board Feeder Pipelines" (revised April 30, 2010) prepared for Poseidon Resources Corporation.

From these turnouts, HBDP water would be distributed in IRWD's potable water system in several sewersheds. This changes the source water allocation within each sewershed which may affect the TDS in MWRP recycled water effluent and IRWD's non-potable system. The potable water quality supplied by the HBDP must be the same or better than imported water supplied by MWD. Poseidon's water quality specifications indicate that the annual average 350 mg/L TDS in HBDP water is equivalent to that of local groundwater. However, if HBDP water TDS approaches their maximum 500 mg/L, which is closer to imported MWD water, then that could significantly impact the TDS in the non-potable system. This is because HBDP water would supply several IRWD sewersheds that were formerly using local groundwater supplies.

This scenario includes the following:

- IRWD receives maximum available supply of Poseidon HBDP product water (43.2 MGD or 48,390 AFY) through turnouts on the EOCF #2 and OCF.
    - IRWD's participation in the purchase and exchange program is not limited to IRWD's imported water demand.
    - Local groundwater supplies were drastically reduced due to availability or basin management strategies. This does not impact exempt groundwater supplies.
- Poseidon HBDP water must replace all imported MWD supply before HBDP water may replace the District's local water supplies.
- The quality of Poseidon water supplied by the HBDP must be the same or better than MWD imported water. HBDP product water quality specifications and typical MWD water quality are presented in Table 4-8. According to the water quality specifications provided by Poseidon, HBDP water will have less TDS than MWD water and similar chloride concentration.
    - The model estimates a worst-case scenario where HBDP water quality must be equal to or less than MWD water quality. Poseidon specifies a maximum of 500 mg/L TDS in HBDP product water and will not exceed this at any time; therefore, 500 mg/L is the worst-case scenario that was modeled for HBDP TDS.
- MWD imported water rates increase 5 percent per year.
- Poseidon water rates increase 2.5 percent per year.

Results Discussion – Scenario 4 – Poseidon HBDP Max

Figure 4-14 and Figure 4-15 show a significant increase in MWRP TDS RAA for Baseline A and Baseline B based on the Scenario 4 – Poseidon HBDP Max conditions (provided above) for a worst-case scenario regarding Poseidon HBDP water quality specifications.

The following are key observations:

- Scenario 4 – Poseidon HBDP Max (HBDP worst-case water quality of 500 mg/L) increases TDS in MWRP recycled water effluent by 100 to 150 mg/L for Baseline A and 60 to 150 mg/L for Baseline B (solid purple), which adversely affects all recycled water customers. The scale for the purple line only is shown on the secondary y-axis on the right side of the graph.
    - For Baseline A, MWRP TDS RAA increases to 773 mg/L in 2035 (solid green). The 720 mg/L permit limit is exceeded almost immediately; there is no TDS buffer.
    - For Baseline B, MWRP TDS RAA increases to 773 mg/L in 2035 (solid green). The 720 mg/L permit limit is exceeded almost immediately; there is no TDS buffer.
- The TDS increase is due to replacing a large portion of low salinity local groundwater sources with higher salinity Poseidon HBDP product water that is discharged to IRWD water recycling plants.

- Poseidon HBDP water replaces all imported MWD supply before HBDP water replaces the District's local water supplies.
    - Scenario 4 – Poseidon HBDP Max replaces up to 43.2 MGD (48,500 AFY) of IRWD water supplies. In 2035, Poseidon HBDP water makes up an average 75% of total IRWD service area demand. On a monthly basis in the same year, IRWD potable water is 48 to 90% Poseidon HBDP water, which returns sewer flow to MWRP and has a large effect on IRWD recycled water TDS.
- The worst-case HBDP water (500 mg/L TDS) typically has a lower TDS than imported MWD water. Therefore, the typical increase in the MWRP TDS RAA due to in-lieu periods is not as significant with Poseidon HBDP water as it is with imported MWD water for Baseline B. This is shown by the smaller peaks in the solid green line and the dips in the solid purple line in Figure 4-15.
    - During in-lieu periods, the TDS increase is 30 mg/L smaller with Poseidon HBDP worst-case water quality (500 mg/L) than imported MWD water.
    - During in-lieu periods, the TDS increase is 60 mg/L smaller with Poseidon HBDP average water quality (350 mg/L) than imported MWD water.
- Scenario 4 – Poseidon HBDP Max (HBDP average water quality of 350 mg/L) increases TDS in MWRP recycled water effluent by 10 to 60 mg/L for Baseline A (solid purple), which adversely affects all recycled water customers. The scale for the purple line only is shown on the secondary y-axis on the right side of the graph.
    - For Baseline A, MWRP TDS RAA increases to 700 mg/L and reduces the TDS buffer to 35 mg/L in 2035 (solid green). However, the 720 mg/L permit limit is not exceeded.
- Scenario 4 – Poseidon HBDP Max (HBDP average water quality of 350 mg/L) initially increases TDS in MWRP recycled water effluent by 25 mg/L, and then decreases TDS by up to 36 mg/L during In-Lieu periods for Baseline B (solid purple), which benefits all recycled water customers over time. The scale for the purple line only is shown on the secondary y-axis on the right side of the graph.
    - For Baseline B, MWRP TDS RAA increases to 685 mg/L and decreases the TDS buffer to 36 mg/L in 2035 (solid green). The 720 mg/L permit limit may be exceeded initially and during the 2034 in-lieu period, but TDS is generally below the permit limit. The TDS buffer is lost initially, then recovered, and increased through 2035.
- For both Baseline A and Baseline B, the change in TDS from the baseline condition decreases over time (as shown by downward trend of the purple line). In the baseline condition, imported MWD water with a higher salinity would typically supplement the increasing potable demand. However, this imported MWD water is being replaced with HBDP water, which has lower salinity for both worst-case and average water qualities. The scale for the purple line only is shown on the secondary y-axis on the right side of the graph.

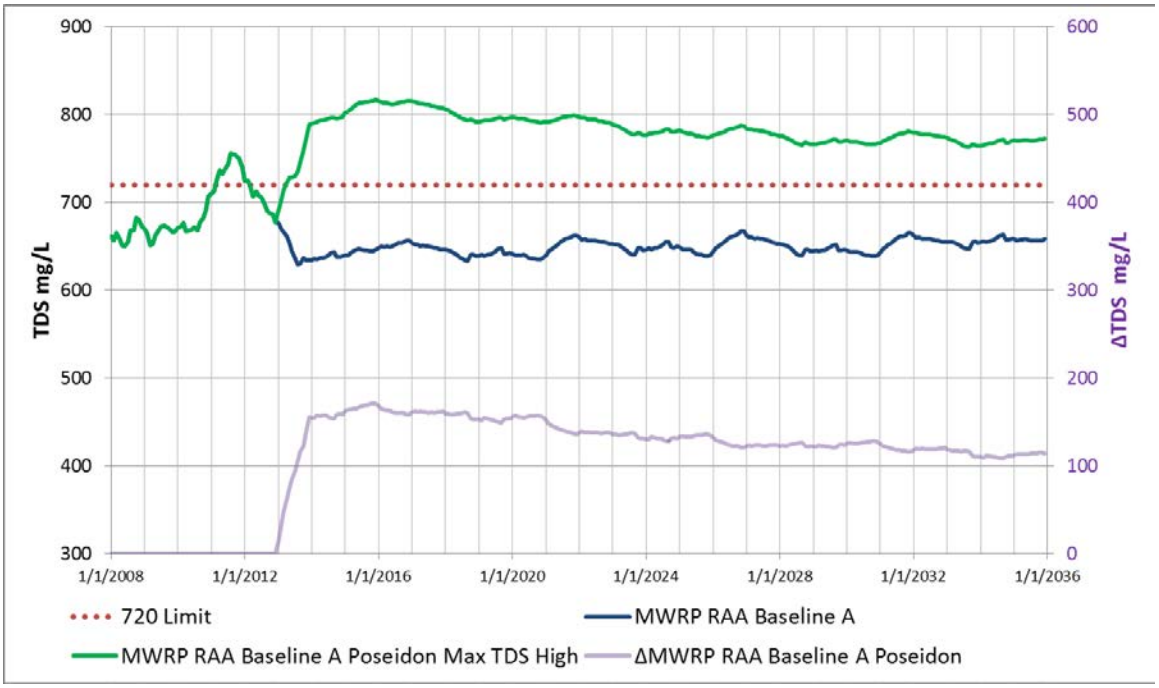

Figure 4-14. Impact of Scenario 4 – Poseidon HBDP Max (Worst-Case TDS) on MWRP Effluent Baseline A

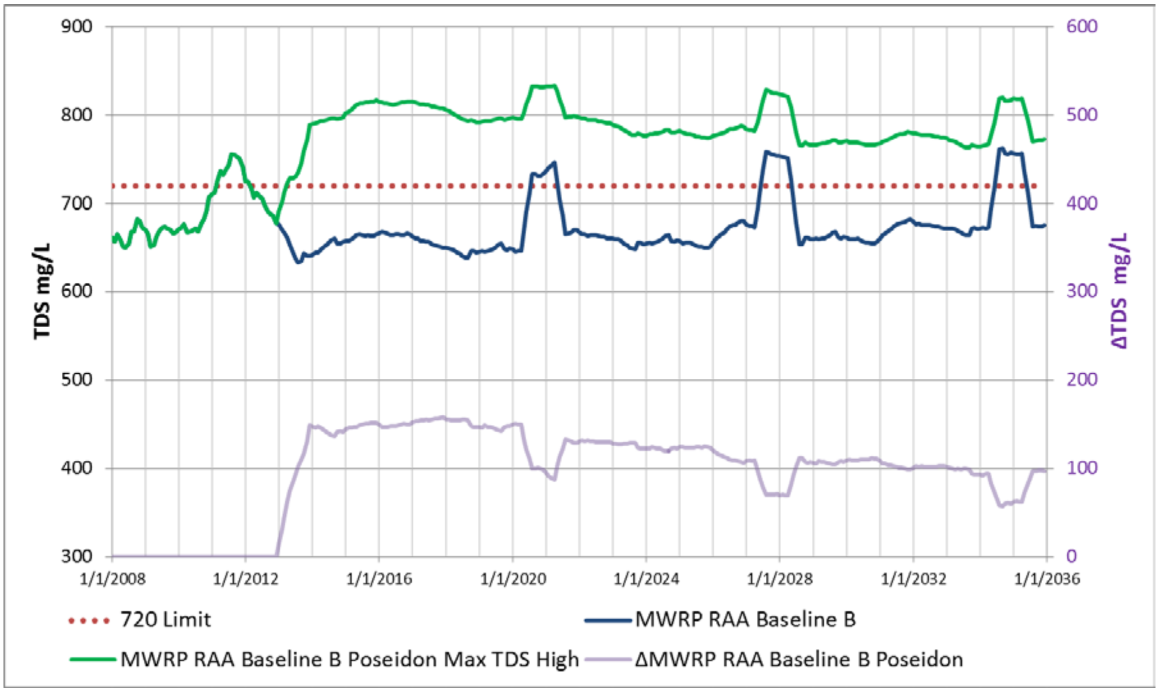

Figure 4-15. Impact of Scenario 4 – Poseidon HBDP Max (Worst-Case TDS) on MWRP Effluent Baseline B

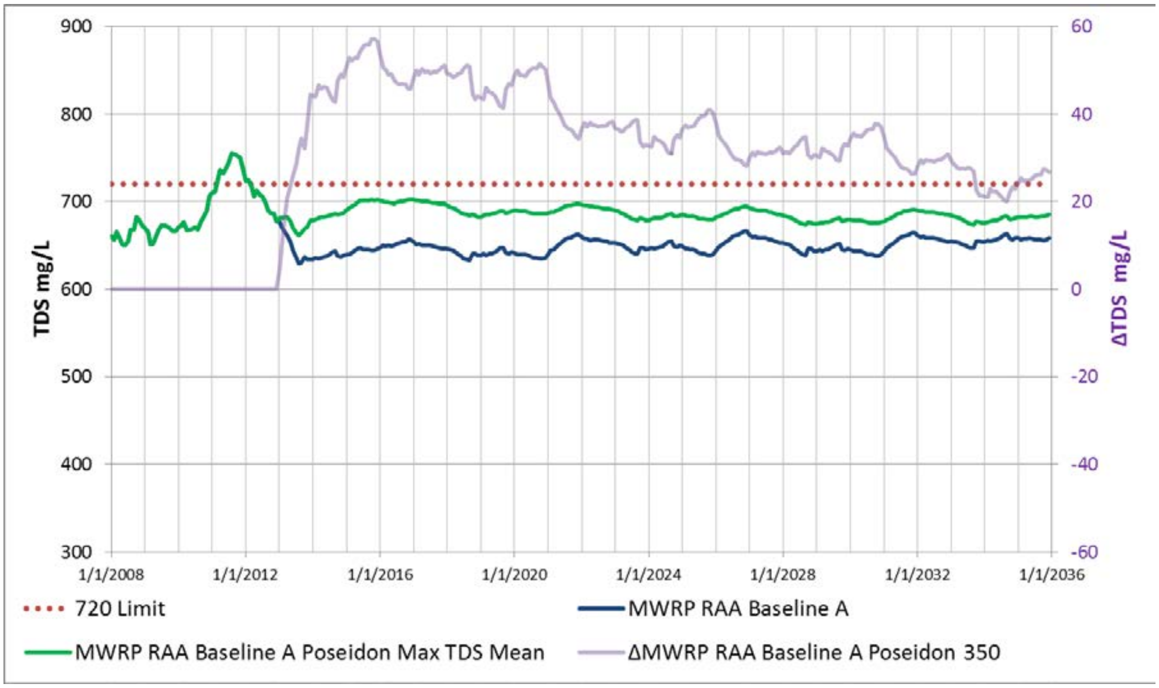

Figure 4-16. Impact of Scenario 4 – Poseidon HBDP Max (Average TDS) on MWRP Effluent Baseline A

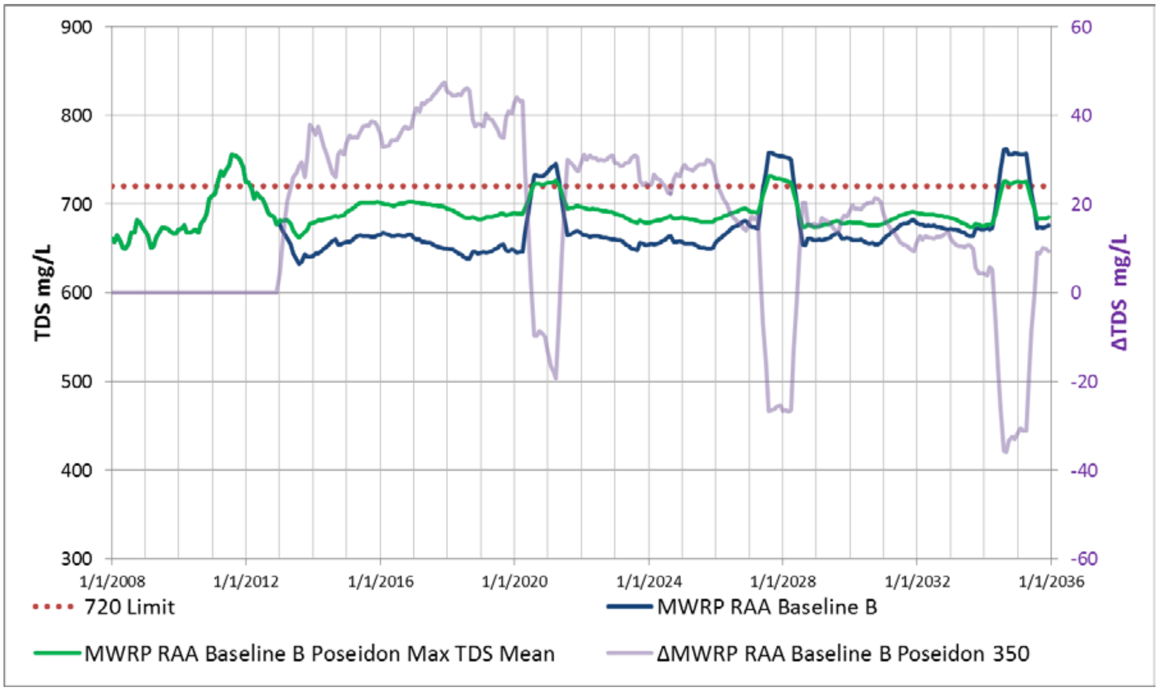

Figure 4-17. Impact of Scenario 4 – Poseidon HBDP Max (Average TDS) on MWRP Effluent Baseline B

4.3.5 Scenario 5 – Mid-Basin Injection

This scenario evaluates the impact of OCWD’s Mid-Basin Injection (MBI) project on IRWD TDS. Mid-Basin Injection Phase II was completed in April 2015, which made the MBI-1 injection well operational and able to sustainably inject 1.5 MGD (1,680 AFY) of Groundwater Recharge System (GWRS) product water into the groundwater basin in the Principal aquifer (depth of 1,200 feet). Injection capacity of the MBI-1 well is 3 MGD (3,360 AFY). Mid-Basin Injection is located on the northwest intersection of Edinger Avenue and the Santa Ana River in the city of Fountain Valley. The MBI-1 injection well is about 4,000 feet away from the nearest well (IRWD-12) associated with the Dyer Road Well Field, which is IRWD’s major local groundwater supply. IRWD-17 is the next closest DRWF well. OCWD is seeking approval to expand the Mid-Basin Injection project to construct four more injection wells (3 MGD capacity each) in Centennial Regional Park on the opposite side of the river. OCWD’s 2014 Long-Term Facilities Plan describes a potential for 8 to 10 MBI injection wells, but the ultimate MBI injection capacity has not yet been determined.

Regardless of the number of injection wells or the ultimate capacity, the Mid-Basin Injection project will only improve the salt content in IRWD’s system because GWRS product water has a TDS concentration of 43 mg/L. This is much lower than the TDS concentration of local groundwater and imported water. Injecting GWRS product water into the Principal aquifer will improve the local groundwater quality for TDS, which will eventually reach the DRWF wells and be withdrawn and used as potable water in the IRWD service area.

This scenario was not modeled because the specific impact on the TDS withdrawn from the DRWF wells is not currently known. The Mid-Basin Injection project will improve IRWD recycled water TDS and has no direct cost to IRWD.

5 Cost Model

5.1 Cost Estimating Methodology

Capital and operating costs were developed for each of the final scenarios. Based on these costs, life-cycle costs were developed using two methods: present value and cumulative costs. The cost estimates presented in this report are comparative, planning-level opinions of construction and operating costs based on conceptual sizing, without detailed engineering or site-specific data. Estimates of this type are defined by the AACE Cost Estimate Classification System as Class 4 with an accuracy of 50% more than to 30% less than the actual final project costs.

This section presents the methodology used to develop the various cost components. It is organized into the following areas:

- Capital Costs
- Operating Costs
- Net Present Value
- Cumulative Capital and O&M Costs

5.1.1 Capital Costs

Capital costs were developed using conceptual facility sizing and layout to determine approximately quantities of materials required. Unit costs were derived from RS Means and recent project construction data. In addition, equipment costs were provided through budgetary quotes from equipment vendors.

Estimates of direct costs were developed in 17 divisions based on the type of work. Table 5-1 below summarizes the divisions of work and the basis of estimate.

Table 5-1. Basis of Capital Estimate Summary

Division		Basis
01	General Requirements	1% of Cost for Divisions 02-17
02	Site Work	Quantity estimates and unit rates
03	Concrete	Quantity estimates and unit rates
04	Masonry	Quantity estimates and unit rates
05	Metals	Quantity estimates and unit rates
06	Wood And Plastics	Quantity estimates and unit rates
07	Thermal & Moisture Protection	Quantity estimates and unit rates
08	Doors & Windows	Quantity estimates and unit rates
09	Finishes	Quantity estimates and unit rates
10	Specialties	Quantity estimates and unit rates
11	Equipment	Vendor quotes and estimated installation
12	Furnishings	Quantity estimates and unit rates
13	Special Construction	Quantity estimates and unit rates
14	Conveying Systems	Quantity estimates and unit rates
15	Mechanical	Quantity estimates and unit rates
16	Electrical	6% of Cost for Divisions 02-15
17	Instrumentation & Controls	4% of Cost for Divisions 02-15

Additional costs were estimated as a percentage of direct costs:

- Mobilization and Insurance – 10%
- General Conditions – 10%
- Contractor Profit – 8%
- Bonds – 2%
- Contingency – 20%

5.1.2 Operating Costs

Operating costs were developed for the following categories:

- Power
- Chemicals
- Repair and Rehabilitation
- Labor
- Solids Disposal

Power

Power costs were calculated using motor horsepower, voltage, drive type, power demand, and hours of service for expected equipment. For electrical power, a unit cost of $0.12/kW-hr was used. For Scenarios that include an RO packaged system, the estimated power use was based on vendor-supplied data from prior projects of similar size and scope. Power usage from these sample projects were used to calculate unit power cost relative to the volume of treated water produced. Annual Power unit costs were calculated for each scenario and are provided in Appendix E.

Chemicals

Chemical costs were calculated based on usage estimates provided by the equipment manufacturer and the 2015 purchase price of the chemicals used. Chemical cost information was provided by MWRP Operations staff based on the current chemical contract in place through South Orange County joint agencies. Chemical usage and cost were used to calculate the unit chemical cost relative to the volume of treated water produced. Annual chemical unit costs were calculated for each scenario and are provided in Appendix E.

Repair and Rehabilitation

Repair and Rehabilitation (R&R) costs were calculated for the capital facilities to account for facility repair and equipment replacement. Annual R&R costs were determined using estimates provided by equipment vendors based on prior projects of similar size and scope. R&R costs from these sample projects were used to calculate unit R&R cost relative to the volume of treated water produced. Annual R&R unit costs were calculated for each scenario and are provided in Appendix E.

Labor

Labor costs were estimated based on anticipated operational time requirements for each Scenario. Required labor was determined using information provided by system suppliers and engineering judgment. Table 5-2 below summarizes labor rates used in developing the labor operating cost.

Table 5-2. Fully Loaded Labor Rates for IRWD Staff

Labor Category	Average Fully Loaded Rate ($/hour)
Operator I	71.94
Operator II	88.67
Operator III	93.69
Operations Supervisor	112.10

Solids Disposal

Solids disposal costs for scenarios that require disposal of brine to OCSD were included in the Operating costs. Disposal costs ($1,290 per MG) were estimated based on cost to send sewage to OCSD for secondary treatment and ocean outfall discharge as identified in the IRWD non-potable mass balance model, with a 4% annual escalation of costs.

5.1.3 Life-Cycle Cost

Life-cycle costs were developed for 20 years (between 2015 and 2035). The life-cycle costs are presented in two ways: cumulative costs and net present value.

The following escalation factors were used for the various cost components:

- Capital: 3% (for the scenarios presented, all capital costs occur the first year of the period, therefore the capital escalation factor does not impact the life-cycle cost)
- Energy: 4%
- Chemicals: 4%
- Labor: 3%
- R&R: 3%
- Solids Disposal: 4%

Cumulative Costs

Cumulative costs represent the cumulative capital and operating costs from 2015 to 2035. The various costs are escalated based on the year in which they occur. No discount rate is applied. In this report, capital costs were based on a one-time cash payment and were not amortized. Cumulative costs provide a visual comparison of scenarios and illustrate the anticipated payback year.

Net Present Value

In this study, the term life-cycle cost refers to the present value of all capital and operating costs between 2015 and 2035. Present value costs are expressed in 2015 dollars. Present value was calculated using a discount rate of 4.0%.

5.2 Scenarios Cost Development

The following sections describe the methodology and criteria used to develop the life-cycle cost for each scenario.

5.2.1 Scenario 1 – Salt Removal at MWRP

Scenario 1 – Salt Removal at MWRP evaluates the facilities and costs required to reduce TDS concentrations by installing a RO process to treat a portion of the plant's effluent.

The 2.6-MGD RO facility will produce 2.0 MGD of RO permeate with an annual treated volume of 731 MG. The resultant brine flow rate is 0.5 MGD with an annual brine volume of 183 MG. Annual operating costs were estimated based on the annual treated volume and the annual brine volume. Capital and Operating costs were used to produce the life cycle costs included in Appendix E.

5.2.2 Scenario 2 – Brine Disposal to MWRP

Scenario 2 – Brine Disposal to MWRP determines the rate fee to a single brine discharger to MWRP. The fee was determined by developing the life-cycle cost for treating the resultant increase in TDS to baseline levels and expressing the cost on a per pound of salt basis.

Unlike other scenarios, the Capital and Operating "costs" for this scenario are based on the construction and operation of a 0.30-MGD RO facility at MWRP (upstream of UV) sized to treat a portion of MBR permeate and mitigate the TDS impact from a brine discharger. The facility will produce 0.30 MGD of RO permeate with an annual treated volume of 110 MG. The resultant brine flow rate is 0.07 MGD with an annual brine volume of 26 MG.

Table 5-3 and 5-4 summarize the calculation.

Table 5-3. Scenario 2 – Brine Disposal to MWRP – Brine Discharger and MWRP RO Treatment Data

	Flow (MGD)	Flow (AFY)	TDS (mg/L)
User RO Brine Discharged to MWRP	0.06	70	3,200
MWRP RO Influent	0.37	350	772
MWRP RO Effluent	0.30	280	100
MWRP RO Brine Discharged to OCSD [a]	0.07	84	3,325
MWRP Blended Supply	25.9	28,200	772
MWRP Total (Blended) Flow	26.2	29,400	745

[a] Estimated unit cost to discharge MWRP RO brine to OCSD is $1,290 per MG.

The estimated capital and life-cycle costs for the MWRP RO Treatment system were used to develop a treatment unit cost per pound of salt discharged to MWRP (see Table 5-4). The actual unit cost to IRWD will depend on the number of users discharging to IRWD and consequently the total volume and concentration of the brine discharged. The unit treatment cost will decrease as the volume of brine discharged to MWRP increases, because the capital cost of the installed treatment system is not scalable relative to flow. While the membrane equipment is modular, the appurtenant construction (site civil, yard piping, and structural) is not scalable.

Table 5-4. Unit Rate Development – Brine Disposal

Estimated Salt Discharge	1,660	lbs/day
Estimated Salt Discharge	12,118,000	Total lbs for System Life
Estimated Capital	$1,000,000	
Cumulative Capital and O&M Costs	$6,583,000	
Net Present Value	$4,611,000	
Unit Rate (Fee) for Brine Dischargers	**$304.64**	**/ 1,000 lbs of salt**

5.2.3 Scenario 3 - Poseidon HBDP

IRWD does not intend to purchase HBDP water. Any exchange program purchases from other agencies through IRWD is not expected to have a cost impact to IRWD. Therefore, there is no cost to IRWD with Scenario 3.

Should IRWD choose the purchase HBDP water, it will offset the purchase of MWD water. The estimated $540/AF unit rate to IRWD is presented in Table 5-5.

Table 5-5. Unit Rate Development – Poseidon

Cost Item	Usage	Unit Cost	Annual Cost
Poseidon Water	0 AF	$1,850/AF	$0
MWD Subsidy	0 AF	-$340/AF	$0
MWD Water Offset	0 AF	-$970/AF	$0
TOTAL	**0 AF**	**$540/AF**	**$0**

5.2.4 Scenario 4 - Poseidon HBDP Max

Scenario 4 – Poseidon HBDP Max evaluates the impact of accepting the maximum available HBDP water into the IRWD system. An estimate of the actual cost impact of this scenario is not feasible given that some components of the cost are beyond IRWD’s control and based partially on factors not relevant to the use of HBDP water.

A summary of the cost impacts is provided below:

- Cost to purchase Poseidon HBDP water
    - Estimated at $1,850/AF.
    - Subject to escalation and final negotiations.
- MWD Subsidy
    - The three LRP incentive payment structure options include sliding scale incentives up to $340/AF over 25 years, sliding scale incentives up to $475/AF over 15 years, or fixed incentive up to $305/AF over 25 years.
    - In Scenario 3 – Poseidon HBDP, the MWD subsidy of $340/AF was used, however, this will be based on the IRWD application for the Local Resources Program (LRP).
- MWD Treated Water Offset

    - Savings associated with avoiding purchase of MWD Treated Water - $970/AF.
    - Poseidon HBDP water would first be used to offset imported treated water.
- MWD Untreated Water Offset
    - Savings associated with avoiding purchase of MWD Untreated Water for use at Baker Water Treatment Plant (BWTP).
    - Following the offset of all imported treated water, Poseidon HBDP water would next be used to offset untreated water supply to BWTP.
- Groundwater Offset
    - Savings associated with avoiding pumping of groundwater sources.
    - Following offset of all imported water (treated and untreated to BWTP), Poseidon HBDP water would next be used to offset non-exempt potable water sources, followed by exempt potable water sources.
- Replenishment Assessment
    - Costs associated with increased charges under OCWD's Replenishment Assessment. The actual assessment value in unknown.

5.2.5 Scenario 5 - Mid-Basin Injection

Scenario 5 – Mid-Basin Injection evaluates the impact of OCWD's Mid-Basin Injection (MBI) project on IRWD TDS. While the project will improve IRWD recycled water TDS, there is no direct cost to IRWD beyond the replenishment assessment that would be in place regardless of the projects implementation. The amount of the replenishment assessment is beyond IRWD's control.

5.3 Summary

The life-cycle cost for each scenario is summarized in Table 5-6 below, including a calculated cost per pound of TDS removed from the system. However, TDS Removal Costs should not be used for comparison between Scenarios because the basis of each scenario is not equivalent.

Positive net present values represent costs to IRWD; negative values represent revenue to IRWD. Positive TDS Removed values represent pounds of salt removed from the system; negative TDS Removed values represent pounds of salt added to the system.

Table 5-6. Summary of Scenarios

Scenario	Facility Production Capacity	Net Present Value [a]	TDS Removed (lbs) [b]	TDS Removal Cost ($/lb)
Baseline A, Scenario 1 - Salt Removal at MWRP	2.0 MGD	$27,700,000	89,300,000	$0.31 [c]
Baseline B, Scenario 1 - Salt Removal at MWRP	2.0 MGD	$27,700,000	102,100,000	$0.27 [c]
Scenario 2 - Brine Disposal to MWRP	0.3 MGD	-$4,600,000	-15,100,000	$0.30
Scenario 3 - Poseidon HBDP	No treatment	$0	0	$0.00
Scenario 4 - Poseidon HBDP Max	No treatment	$0	0	$0.00
Scenario 5 - MBI	No treatment	$0	Unknown	$0.00

[a] In 2015 dollars.

[b] Total pounds of TDS removed during the life cycle period (2015-2035).

[c] The mass of TDS removed for Scenario 1, Baselines A and B differ because the background TDS concentration is different. The size of the treatment system is based on the worst-case condition, which is similar for both Baselines, resulting in the same net-present value for both. This results in different TDS removal unit costs.

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6 Findings and Policy Considerations

Using IRWD's Salt Balance Model, specific scenarios were tested to determine the impact on the salinity of recycled water produced. Through that testing process a number of general observations were made that could impact IRWD operations and policies. This chapter recaps the District's operational objectives and key findings of this study and then sets forth for consideration a number of policy and operational strategies that may be implemented by District staff and board members to improve or protect the quality of the District's recycled water.

6.1 Operational and Salt Modeling Objectives

The District's operational objectives for recycled water are to stay under the TDS RAA limit of 720 mg/L and to meet the salinity needs of some of its most salt-sensitive customers. In order to do that, the impact of operational strategies on salinity of the recycled water produced at the MWRP must be fully understood and managed. In recent years, the salt content of the District's recycled water has been exhibiting an increase over time with a TDS running annual average (RAA) of 661 mg/L in January 2008 to 675 mg/L in January 2013. By introducing in-lieu periods, when more imported potable water is being used while the groundwater basin is allowed to recharge, the TDS may temporarily increase. During the most recent in-lieu period, from March to September 2011, MWRP exceeded its permitted TDS limit of 720 mg/L for recycled water. This event triggered the need for the District to better understand how its operational strategies can be used to prevent future exceedances.

Although the buffer between the actual RAA and the permit limit fluctuates over time, it can quickly erode if not managed with care and foresight. The IRWD Salt Balance Model is intended to help provide that foresight by identifying potential trends of TDS quality under different operating scenarios.

6.2 Salt Balance Model Findings

To trace the source of salinity and identify mitigation measures to manage potentially increasing salinity concentrations, IRWD's Salt Balance Model was developed to perform a mass balance of flow and salinity loads throughout the IRWD service area.

Two baselines were developed to simulate possible futures. In general, Baseline A represents a best case that will produce relatively low future TDS levels, with a BPP of 70 to 75%, expiration of recycled water penalty, average imported water TDS, and no in-lieu periods. Baseline B is a more conservative case, assuming only a 65% BPP, no expiration of recycled water penalty, high imported water TDS, and an in-lieu period every 7 years. Both baselines show a gradual increase in TDS over time; however, as shown in Figure 6-1, the rate of TDS increase in Baseline B is about twice the rate of increase in Baseline A. This increase in Baseline A is the combined effect of the other parameters (BPP, RW Penalty, Colorado River, SWP, and Diemer blend) on the RAA, which are not as recognizable as in-lieu periods but have a steady impact on TDS. In both cases, the TDS buffer begins to erode over time and that buffer can be completely used up or exceeded during in-lieu periods. As previously indicated, the IRWD's Salt

Balance Model may be used to forecast trends. In 2035, the model shows that Baseline A has a buffer of 60 mg/L before IRWD would exceed their permit limit. Under modeled conditions, this buffer is reduced much more quickly under Baseline B conditions to 50 mg/L.

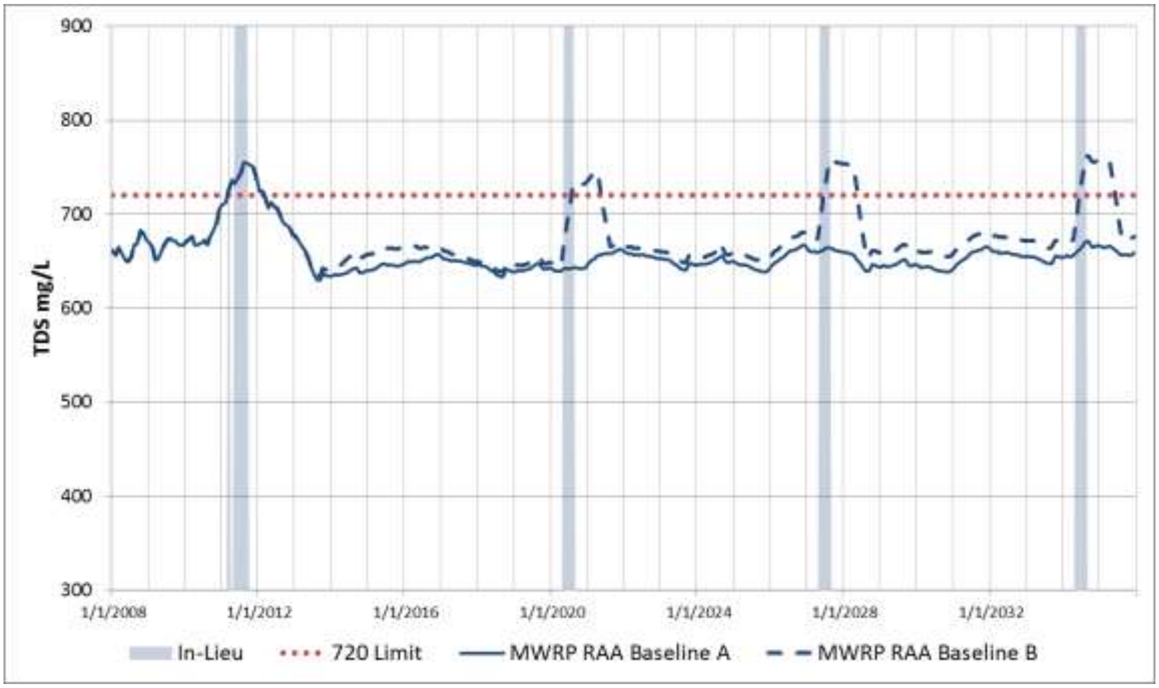

Figure 6-1. Projected MWRP Effluent TDS RAA for Baseline A and Baseline B

Through 2035, both Baselines A and B would not exceed the TDS limit of 720 mg/L RAA, if IRWD did not participate in the in-lieu program. However, the in-lieu program benefits IRWD by reducing groundwater pumping and allowing the groundwater basin to recharge faster. Future participation in the in-lieu program should take into account both policy and operational considerations in managing the salinity of the recycled water.

6.3 Operational Strategy and Policy Considerations

Based on the findings of IRWD’s Salt Balance Model analysis, the following operational strategies or Board policies are presented for consideration.

6.3.1 Operational Strategies

Operational strategies can have a large impact on the ability to continuously meet the TDS running annual average permit limit of 720 mg/L as evident from IRWD’s Salt Balance Model results. Key considerations moving forward include the following:

- **Closely monitor TDS of imported water.** The blend of State Water Project and Colorado River Water at the Diemer Water Treatment Plant has a significant impact on salinity. As more Colorado River Water is introduced into the potable water system, the salinity increases. Awareness of this potential trend may help District staff offset the salinity impacts in time to protect their TDS buffer by taking mitigating steps such as increasing the blend of groundwater. Imported water

TDS should be considered when determining IRWD participation in the in-lieu program to evaluate the potential impact on the District's TDS buffer.

- **Use model to evaluate participation in the in-lieu program.** Modifications to participation in the program such as partial participation or alternating month participation may help offset increased salinity loads that typically drive the RAA up during in-lieu periods.
- **Management of return flows from Sand Canyon Reservoir to MWRP.** When Sand Canyon Reservoir is drained, the dechlorinated non-potable water returns to MWRP upstream of the tertiary filters and is an additional salt load affecting the TDS compliance point. The District's TDS RAA and Sand Canyon TDS should be considered in the decision to drain Sand Canyon Reservoir.
- **Use model to understand impact of introduction of new salt loads.** Desalinated water from the HBDP must meet salinity standards equivalent to those of imported water, but as seen above, that mix of water supply sources can impact the TDS RAA at MWRP and erode the buffer. In considering the introduction of desalinated water into the IRWD system, potential mitigation measures and contractual/operational requisites should be addressed to protect the quality of the District's recycled water.
- As always, **continue to work with recycled water customers to maximize mutual benefits.**

6.3.2 Policy Considerations

IRWD Board decisions can have direct or indirect consequences when it comes to impacting salinity in the recycled water system. Awareness of those potential issues ahead of time and instituting policies to address those issues help the Board make informed decisions. Findings from IRWD's Salt Balance Model indicate the potential need for policy considerations on the following issues:

- **Accepting brine disposal from offsite RO systems.** IRWD's Salt Balance Model clearly indicates that brine disposal from RO at customer sites will have an impact on the salinity of the recycled water and if a number of units are installed, the salinity may increase in an order of magnitude that would erode the TDS buffer completely and put IRWD in danger of exceeding their permit limit. For TDS contributors (brine dischargers) whose flows are accepted, consider collecting a brine disposal fee to fund the design and construction of an RO project at MWRP or alternative methods of brine disposal, such as a brine line, conveyance to OCSD, hauling, or evaporative ponds.
- **Accepting desalinated water in areas beyond Newport Coast.** IRWD's Salt Balance Model showed the impact that Poseidon HBDP could have on the salinity of the recycled water if IRWD accepted the maximum desalinated water supply available. HBDP product water has the potential to meet more than half of IRWD's annual demand, which makes IRWD particularly susceptible to HBDP water quality. IRWD should consider contractual agreements that require Poseidon HBDP product water quality to adhere to their specified 12-month average TDS of 350 mg/L including financial penalties and/or required mitigation

measures if they do not comply with their specification. During in-lieu periods, IRWD should consider accepting Poseidon HBDP water instead of MWD water.

6.4 Ongoing Use of Model

IRWD's Salt Balance Model will continue to be used by the District to determine the TDS impact from additional changes to IRWD's system. IRWD intends to implement a second phase of model development that will refine the model's capabilities to address cumulative impacts of potential brine discharges to the District's collection system on recycled water quality.

6.4.1 Potential Scenarios to be Modeled in Phase 2

Phase 2 will include running additional scenarios that have been identified as having potential near term impacts on salinity. The following scenarios may be considered for future analysis and evaluation:

- Brine disposal to MWRP cumulative TDS impact
- Discharge of Irvine Desalter Project – Shallow Groundwater Unit treated water to MWRP
- Discharge of Irvine Desalter Project – Potable Treatment Plant brine to MWRP
- Diversion of Irvine Business Complex sewershed diversion to MWRP

As part of Phase 2, IRWD staff will receive training to use the model in order to assist in future scenario assessments, identify impacts of those plans on recycled water salinity, and help make important operational and policy decisions to protect the TDS buffer.

6.4.2 Potential for Model Refinement beyond Phase 2

During the course of the project, HDR staff identified several aspects of the data collection effort, model parameter estimation, and model development that could be refined. These refinements could potentially improve the data and Salt Balance Model analysis, or modify the model to allow analysis of additional alternatives or scenarios. These include the following potential refinements:

1. **TDS Sample Collection Effort:** Available TDS data was limited or inconsistent during the historical period, which necessitated engineering judgment to provide estimations. Additional flow-composite TDS samples, regular sampling periods, and sampling at specific locations would improve accuracy or provide additional support for estimated parameters.
    a. Potable water sources
    b. MWRP and LAWRP (influent, effluent, chemicals, and sludge)
    c. Non-potable reservoirs (influent, effluent, and chemicals)
    d. Non-potable groundwater wells
    e. Residential, commercial, institutional, and industrial users (potable water and sewer)

   f. Major trunk sewers (preferably by sewershed)

2. **Updated Historical Data:** Development for IRWD's Salt Balance Model began in 2013 and is based on five years of historical data from 2008 to 2012. Model development was completed in 2015. Therefore, additional data from 2013 to 2015 is now available to be incorporated into the model to refine model estimates and more accurately reflect any changes in IRWD's system.

3. **Updated IRWD Sewer Collection System Master Plan:** IRWD's Salt Balance Model is based on the 2006 SCSMP, which projects future sewer flows and land development through 2025. IRWD's Salt Balance Model projects through 2035; however, the flow distribution between the sewersheds from 2025 to 2035 is modeled to be static. The model should be updated to reflect any changes in modeling parameters, such as flow volume, distribution, and quality, that result from an update in the District's new Sewer Master Plan.

4. **Updated IRWD Groundwater Workplan:** IRWD's Salt Balance Model is based on the 2013 Groundwater Workplan that identified water demand and supplied from potable and non-potable groundwater wells. Changes to the Groundwater Workplan would also change IRWD's Salt Balance Model. The design of the workbook has changed since 2013 in part of its operational method and considered facilities. Changes to this design are not currently reflected in this model. The model may be updated to reflect any changes in modeling parameters (particularly BPP or water quality parameters) that result from an update in the Groundwater Workplan.

5. **Develop new data and algorithms:** There are key model parameters identified in Table 3-1 that could potentially be refined when the model is applied in a predictive mode. For example, if a relationship were developed for each sewershed to estimate the percent of the water supply used for irrigation to be a function of the land use, monthly temperature, and monthly precipitation, then the predicted calibration and future predictions may be significantly improved. Additionally, an improved estimation of the source water distribution by sewershed may also improve the predicted calibrations and future estimates.

6. **Separate non-potable distribution system by pressure zone:** IRWD's Salt Balance Model incorporates the non-potable distribution system and reservoirs as a completely mixed system. The non-potable distribution system could be separated by pressure zone in the model, to evaluate the likely water quality that certain users are receiving. Additional sampling would be required.

7. **Reverse Osmosis (RO) vs. Electrodialysis Reversal (EDR):** RO and EDR are advanced treatment technologies capable of removing salt; RO is generally more prevalent. However, EDR may be a more attractive alternative because it has a higher percent recovery and generates less brine for disposal than RO. This could reduce salt removal treatment costs due to decreased brine disposal costs.

8. **Confirm TDS contribution from MWRP Biosolids and Energy Recovery Facilities Project:** The Biosolids facility currently under construction at MWRP will discharge centrate and other liquid waste flows to MWRP. The TDS impact due to these additional flows is estimated. Once the facility is online and operating consistently, these waste streams could be sampled to provide actual data on flow and TDS that could be incorporated into the model to improve accuracy of the findings.

9. **Confirm TDS contribution from O&M of MWRP Phase 2 Membrane Bioreactor and Ultraviolet Systems:** The MWRP Phase 2 expansion was recently completed with new MBR and UV treatment systems. These technologies have not been in operation long enough to accurately determine the TDS loading due to cleanings and other O&M activities. Once the facility is operating consistently, these waste streams could be sampled to provide actual data on flow and TDS that could be incorporated into the model to improve accuracy of the findings.