CITY OF VENTURA

ESTUARY SPECIAL STUDIES PHASE 2: FACILITIES PLANNING STUDY FOR EXPANDING RECYCLED WATER DELIVERY

DRAFT

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2700 YGNACIO VALLEY ROAD, SUITE 300 • WALNUT CREEK, CALIFORNIA 94598 • P. 925.932.1710 • F. 925.930.0208
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City of Ventura

PHASE 2 RECYCLED WATER STUDY

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EXECUTIVE SUMMARY

BACKGROUND

The City of San Buenaventura (City or Ventura) is located 62 miles north of Los Angeles and 30 miles south of Santa Barbara along the California coastline. The City currently occupies about 21 square miles and is and bound by the City of Oxnard to the south, by unincorporated Ventura County to the east and north, and by the Pacific Ocean to the west.

The City provides water and wastewater services. These services are provided by the City's water utility, Ventura Water. Ventura Water operates the Ventura Water Reclamation Facility (VWRF). The "City of Ventura Estuary Special Studies Phase 2: Facilities Planning Study for Expanding Recycled Water Delivery" (Phase 2 Recycled Water Study) is sponsored by the City of Ventura and the City contracted with Carollo Engineers to provide engineering services for the study. The two key objectives of the Phase 2 Recycled Water Study are::

- to better define projects for expanding recycled water for the purpose of offsetting potable uses, recharging groundwater basins, offsetting agricultural use and to create wetlands that would serve as a public amenity and environmental enhancement to the community; and
- to determine the effects of any remaining discharge levels on the receiving water body, the Santa Clara River Estuary (SCRE), in terms of beneficial uses and nutrients, the key constituents for evaluation of the physical water quality conditions of the SCRE.

Previous Studies

The VWRF has been granted a NPDES permit to discharge tertiary treated wastewater to the Estuary through the Los Angeles Regional Water Quality Control Board (LARWQCB). However, under the Water Quality Control Policy for the Enclosed Bays and Estuaries of California, discharges of municipal wastewater to enclosed bays and estuaries are to be phased out except in circumstances where the discharge is shown to enhance the quality of receiving waters. To address this issue regarding a finding of enhancement, the LARWQCB required the City to complete the "Special Studies for the Santa Clara River Estuary" as a condition of the City's NPDES discharge permit (CA0053651).

The work conducted for the three studies included the following:

- Estuary Subwatershed Study
- Treatment Wetlands Feasibility Study
- Recycled Water Market Study

The three Special Studies have been completed and submitted to the LARWQCB, and a series of six stakeholder workshops were held from 2009 to August 2011 to evaluate study methods and the results. The major findings of the three studies were:

1. Existing VWRF discharges to the SCRE provide a fuller realization of beneficial uses as compared to a zero discharge scenario, however, modification to VWRF flow volume and nutrients input to the SCRE during the dry season (Alternative 5 in the assessment) would improve overall habitat conditions and further improve beneficial uses in the SCRE. Additional detail on this conclusion, and the data and analyses used to support this conclusion, are provided in the Recommendations Memorandum (Carollo Engineers and Stillwater Sciences, 2011) (
2. Treatment wetlands could provide additional nutrient reduction for the VWRF discharge thus improving the quality of the water that is discharged to the SCRE. In addition, wetlands could provide beneficial use through creation of wetland habitat.
3. Additional recycled water markets exist such that additional flows could be diverted from the estuary to be used for recycled water. However, more study was required to assess feasibility and further define water quality targets, treatment requirements, and infrastructure needs.

Directly following Phase 1, Phase 2 of the special studies was initiated to: (1) develop additional information (more hydrologic and water quality data) to improve the understanding of SCRE functioning and help assure protection of the sensitive wildlife and aquatic resources and habitats within the SCRE; and (2) integrate the conclusions of all three of the Phase 1 Studies into a process for selection, environmental review, and design of a preferred VWRF discharge/diversion alternative or combination of alternatives to create a discharge regime that further optimizes beneficial uses of the SCRE.

Key recommendations for Phase 2 studies identified at the end of Phase 1 included developing a suite of feasible VWRF effluent discharge reduction and/or improvement alternatives that utilize treatment wetland and recycled water approaches (i.e., variations of the Phase 1 Alternative 5) and assessing the impact of these alternatives on beneficial uses of the SCRE by assessing their impacts on SCRE habitat conditions and ecosystem functions using the developed predictive tools and SCRE stage-habitat area relationships (see Carollo Engineers and Stillwater Sciences 2011). Through close collaboration with the City, project Stakeholders, and other local entities, effluent discharge reduction and/or improvement alternatives were identified and evaluated as summarized in this report.

Legal Actions

Coincident with Regional Board’s approval of the most recent VWRF NPDES permit, Heal the Bay and Wishtoyo Foundation's Ventura Coastkeeper Program pursued administrative challenges and legal actions to compel the City to discontinue releasing water to the SCRE. To resolve these challenges and actions, the City entered into a Tertiary Treated flows Consent Decree and Stipulated Dismissal with Heal the Bay and Ventura Coastkeeper,

effective March 30, 2012. The settlement sets a goal to identify, select, plan, design engineer, environmental review, permit and construct infrastructure projects that have the capacity to reduce, by 2025, the amount of water entering the SCRE by 50 percent to 100 percent by diverting it to other recycled and reclaimed water uses, including uses that improve local supply and enhance conservation . At the same time, however, the Consent Decree obligates and allows the City to reduce discharges to the SCRE only by that amount approved and permitted by state and federal regulatory agencies with jurisdiction over discharges, the SCRE, and the endangered and threatened species and habitats it provides. The parties to the settlement have agreed to, among other points, to "use the best available science to determine the appropriate discharge reduction and diversion volumes,." or the maximum ecologically protective diversion volume. The scientific analysis, or the best available science, will be provided by the Phase 1 and Phase 2 Special Studies, as well as future additional phases of these Special Studies.

ORGANIZATION OF THIS REPORT

The development of this report was financially supported by the City as well as grants from the State Water Resources Control Board Water Recycling Funding Program and the US Bureau of Reclamation Title XVI Water Reclamation and Reuse Program. Obtaining grant funding for the recycled water study phases, better positions the City for future funding for the construction phase. Each of these grant funding agreements comes with stipulations for what shall be included in the development of a facilities plan. Obtaining grant funding agreements to supplement Ventura Water funding sources is critical to Ventura Water's strategy for developing, mixing and matching a variety of diverse funding sources to finance full implementation of its integrated water management approach. Therefore, this report contains sections and descriptions that are required by these grants. An outline of the report chapters is as follows:

- Chapter 1 – Background, Study Area Characteristics
- Chapter 2 - Water Supply Characteristics and Facilities
- Chapter 3 - Wastewater Characteristics and Facilities
- Chapter 4 - Treatment Requirements for Discharge and Reuse
- Chapter 5 - Potential Recycled Water Market
- Chapter 6 - Preliminary Alternative Analysis and Screening
- Chapter 7 - Viable Alternative Development and Comparison
- Chapter 8 – Stakeholder Input and Recommendations
- Chapter 9 – Financial Plan/Capabilities and Next Steps
- Chapter 10 – Research Needs

Because this version of the report is a draft for stakeholder review and input, Chapters 8 and 9 are not developed yet as there has not been a decision as to the recommended project or combination of projects. The outline for these chapters is included so stakeholders can see what the eventual content of the report will be.

MAJOR FINDINGS OF PHASE 2 STUDY

The preliminary screening analysis, detailed in Chapter 6, led to a number of alternatives that were identified for further consideration, including:

- Northern Decentralized Treatment Plant with Urban and Agricultural Irrigation
- Direct Potable Reuse (DPR)
- Conveyance to the Oxnard WWTP/AWPF
- Groundwater Recharge of the Mound Basin (Indirect Potable Reuse or IPR)
- Groundwater Recharge/Irrigation at United Water Conservation District (UWCD) Facilities
- Treatment Wetlands Onsite and at City Owned Property

In addition, urban irrigation and agricultural irrigation are selected as alternatives that could be combined implemented along with other alternatives. Chapter 7 provides additional information, analysis, and evaluation of these alternatives.

Each alternative was evaluated as to the amount of flow that could be diverted for reuse, the cost for the alternative and the resulting effect of the remaining effluent discharged to the estuary. Based on stakeholder feedback at the Oct 31, 2012 meeting, treatment wetlands were added to each recycled water alternative for any flow that would still be discharged to the estuary with the goal of further improving the beneficial uses of the SCRE, taking into account physical water quality and habitat conditions for endangered and threatened species within the SCRE.

Impacts of Alternatives on SCRE Beneficial Uses Related to Habitat and Ecosystem Function

The Phase 1 Estuary Study assessed habitat/ecosystem function affected by each alternative during the dry season (June through September) by using the SCRE water balance, nutrient balance, and SCRE stage modeling tools. These tools developed during Phase 1 predicted future SCRE focal species habitat conditions while accounting for climate change and various alternatives for modifications to VWRF effluent discharges. Habitat conditions were assessed as a function of modeled SCRE stage, water depth, and associated mouth breaching timing, modeled average nitrogen levels, and habitat areas (as a function of SCRE stage) and habitat needs of for each listed focal species (Steelhead,

Tidewater goby, California least tern, and Western snowy plover) associated with each VWRF discharge alternative. Stillwater Sciences (2011) includes a comprehensive analysis of the habitat/area relationship and water quality conditions to support the focal species. In the Phase 2 studies, these established conditions were used as the basis for evaluating the impacts of alternatives on SCRE beneficial uses related to habitat and ecosystem function.

Based on Stakeholder feedback received following the Phase 1 alternatives assessment, additional data was collected for Phase 2 and used to update both the water balance and nutrient balance tools. The additional data collected for Phase 2 led to several modifications to the water and nutrient balances, as described in Stillwater Sciences (2013) (provided in Appendix B) Key changes to the water and nutrient balances include:

- A SCRE mouth breaching elevation of 12.5 feet (NAVD88).
- Total inorganic nitrogen (TIN) concentration of 8 mg-N/L in the VWRF effluent
- Groundwater data from new wells on the north side of the SCRE provided groundwater quality information (TIN concentrations as high as 15 mg-N-L).

The Phase 2 alternatives assessment included developing SCRE stage/depth estimates for both dry and wet water year types. The Stillwater Sciences (2013) technical memo (Appendix B) describes the analysis of the effects of the alternatives on SCRE beneficial uses based upon impacts to the focal species' habitat and ecosystem function. In the Phase 1 study, the recreational camping opportunities at McGrath State Park, were considered in the evaluation of alternatives. However, in recognition that McGrath State Park is in the 100 year floodplain and there is potential for future closure and/or relocation, this recreational opportunity was considered to be less important in the Phase 2 studies. However, the bird watching recreational benefit of the SCRE remains an important evaluation criterion and is incorporated into the analysis through evaluation of the foraging and nesting habitat of the focal species.

The effects of the remaining discharge for each alternative on the SCRE were evaluated for both the existing and future VWRF flow conditions. The discharge to the SCRE under current and future conditions was calculated based on a water balance for the treatment plant and existing Wildlife Ponds. The loss of water through evaporation and percolation through the wetlands was estimated based on the observed losses from the existing Wildlife Ponds.

Based on the influent flow to the treatment wetlands, the wetland effluent (discharge from the treatment wetlands to the SCRE) nitrate concentrations were estimated based on estimates of hydraulic residence time, water temperature, and dentirification rate constants, as well as other inputs and parameters. The removal of nitrate in a wetland is variable, and is dependent on temperature and vegetation conditions. A range of nitrate concentrations was estimated for each of the alternatives and the upper end of this range was used as input to the nutrient balance. For the future condition for the north decentralized treatment

plant the estimated nitrate concentration is 5 mg-N/L. The ability of the wetlands to achieve a nitrate concentration of 4 mg-N/L or less is limited by the relatively large flow volume of 9.2 mgd and the available space for a treatment wetlands on the combined onsite and City-owned properties. The flow from the wetlands to the SCRE was estimated to have a nitrate concentration of 4 mg-N/L or less for all other alternatives.

The flow and water quality conditions for the alternatives are summarized in Table ES.1. The discharge flows from the treatment wetlands to the SCRE range from 0 to 8 mgd, and the nitrate concentrations of the discharge to the SCRE range from 4 mg-N/L to 5 mg-N/L. For each of the alternatives with remaining VWRF effluent flow, the effluent would be conveyed to a treatment wetland to further improve water quality. Depending on the remaining VWRF effluent flow, the wetlands would be the “onsite” Wildlife Ponds with modifications and/or the modified Wildlife Ponds in combination with the offsite City-owned property. The “no action” alternative represents the discharge from the Wildlife Ponds and existing flows. Each of the existing and future conditions for the alternatives, dry and wet year hydrologic conditions were evaluated. The analysis is limited to the critical summer period, June through September, when the SCRE mouth is typically closed. Alternatives with the same discharge conditions have been grouped to simplify Table ES.1.

The analysis of alternatives’ impact to the SCRE also included an assessment of hydrology and stage, water quality, and SCRE habitat. The results are summarized as follows.

Estuary Hydrology and Stage

- For 0 mgd effluent discharge alternatives, the maximum modeled equilibrium stage range for dry and wet water year conditions was the lowest of all the alternatives considered (8.0 – 8.5 ft NAVD88) and the average unmeasured groundwater inflow range (which is driven by SCRE stage) for the modeled period was the highest (2.3 – 3.4 mgd).

- Increasing the effluent discharge rate resulted in a progressive increase in SCRE equilibrium stage and associated decrease in unmeasured groundwater flow rate.

- The maximum equilibrium stage for the 8 mgd effluent discharge alternative was 11.5 ft NAVD88, which is considered to be below the current breaching threshold indicated by summer/fall 2012 SCRE stage data (12.5 ft NAVD88) but is above the breaching threshold during the Phase 1 alternatives assessment (11.0 ft NAVD88). For this alternative, the 8 mgd flow will result in stage conditions with greater likelihood of leading to unseasonal breaching, relative to the other alternatives.

Table ES.1 Estimated Average Dry Season (June - September) Flows and Nitrate Concentration for each Alternative
Phase 2 Recycled Water Study
City of Ventura

Alternative	Treatment Wetland	Flow Components (mgd)					Discharge to SCRE (from Treatment Wetlands) Nitrate Concentration (mg-N/L)
		VWRF Effluent	Diverted Effluent Capacity	Influent to Treatment Wetland	Evaporation/ Percolation Estimate (2)	Approximate Discharge to SCRE from the Treatment Wetlands	
Existing Flows							
No Action	None	7.3	-	-	1	6.3 (5)	8
North decentralized plant (Irrigation or DPR)	Onsite + City-Owned	7.3	2.0(4)	5.3	1.3	4	4
Conveyance to Oxnard or Recharge/Ag supply for UWCD	Onsite	7.3	>7.3 (1)	0	-	0	0
Ag supply for UWCD	Onsite	7.3	>7.3 (1)(3)	0	-	0	0
Mound Basin IPR & DPR (3.6 mgd)[3]	Onsite	7.3	4.5	2.8	1	2	4
Mound Basin (6.3)	Onsite	7.3	>7.3 (1)	0	-	0	0
Future Flows							
North decentralized plant (Irrigation or DPR)	Onsite + City-Owned	11.2	2.0(4)	9.2	1.3	8	5
Conveyance to Oxnard or Recharge/Ag supply for UWCD	Onsite	11.2	>11.2	0	-	0	0
Ag supply for UWCD	Onsite + City-Owned	11.2	7.7(3)	3.2	1.3	2	4
Mound Basin IPR & DPR (3.6 mgd)[3]	Onsite + City-Owned	11.2	4.5	6.7	1.3	5	4
Mound Basin IPR (6.3 mgd)	Onsite + City-Owned	11.2	7.9	3.3	1.3	2	4

Notes:
(1) Capacity for the diverted flow is greater than the VWRF effluent flow. The VWRF effluent flow was used for the calculations.
(2) Estimated as 1 mgd for the onsite wetlands (modified Wildlife Ponds) and 1.3 mgd for the combination of the Modified Wildlife Ponds and the City-Owned Property Wetlands.
(3) There is significant variability in the diverted capacity since the diverted flow depends on the diverted SCR flow.
(4) The effluent flow diverted for Irrigation and DPR are 2 mgd and 2.5 mgd respectively. The lower value of 2 mgd was used.
(5) In this alternative treatment wetlands would not be constructed and therefore approximately 6.3 mgd would discharge from the Wildlife Ponds to the SCRE.

Estuary Water Quality

- Because recent water quality monitoring results show relatively high TIN levels in shallow groundwater along the north side of the SCRE that were previously un-identified, the current results show that in the absence of VWRF discharge, TIN levels of the SCRE will approach levels in the groundwater. Alternatives with no discharge to the SCRE result in the greatest SCRE nitrate concentrations.

- The lowest TIN levels in the SCRE were achieved for alternatives that resulted in discharges to the SCRE of 4 to 8 mgd with nitrate concentrations ranging from 4 mg-N/L to 5 mg-N/L.

Assessment of Impacts to Estuary Habitat Conditions

- The highest discharge to the SCRE (8 mgd) resulted in the highest average depth and wetted area.

- Steelhead habitat area increased with increasing discharge to the SCRE, reaching the maximum value of approximately 157 acres for all alternatives under the 8 mgd discharge scenario.

- The California least tern foraging habitat area remained fairly static at approximately 130 acres for all alternatives.

- Tidewater goby and habitat was essentially static at approximately 110 acres for the zero through 5 mgd alternatives then dropped considerably to approximately 85 acres for alternatives with a discharge of 8 mgd to the SCRE.

- California least tern/western snowy plover nesting habitat was essentially static at approximately 180 acres for the zero through 5 mgd alternatives then dropped considerably to approximately 160 acres for alternatives with a discharge of 8 mgd to the SCRE.

- A discharge of about 4 mgd to 5 mgd provides the most habitat benefit considering the key factors that impacts habitat conditions, including SCRE nitrate concentrations and estuary stage/habitat area.

The alternatives result in 5 different combinations of SCRE discharge flow and nitrate concentration. The “no action” alternative is also included in Table ES.2. Table ES.2 presents the results of the analysis for these conditions, and therefore brackets the range of results that would occur as a result of implementing the alternatives. The color gradations in Table ES.2 represent a relative comparison of the results with the lightest shades representing the lowest water quality/habitat and the darkest shades representing the highest quality and habitat. California least tern foraging habitat is not included because the results were constant across the discharge flow and nitrate concentrations. Table ES.2

suggests that a discharge flow into the SCRE of 4 to 5 mgd, with a nitrate concentration of 4 mg-N-L (or less) would result in the lowest concentrations of nitrate in the SCRE and would provide a the greatest (or near greatest) habitat for the four focal species.

Table ES. 2 Estimated Average Dry Season (June through September) Flows and Nitrate Concentration for each Alternative
Phase 2 Recycled Water Study
City of Ventura

Discharge from the treatment wetlands to the SCRE – Flow and Water Quality		Predicted SCRE Nitrate Concentration Range[(1)(3)] (mg-N/L)	Predicted Habitat (acres)		
Flow (mgd)	**Nitrate Concentration (mg-N/L)**		**Steelhead**	**Tidewater Goby**	**CLT and WSP nesting [(2)(3)]**
No Action (6.3)	8	6.2 – 7.7	148	101	167
0	0	9.6 – 12.5	58	107	183
2	4	4.5 - 8	78	110	183
4	4	3 – 5.2	115	111	182
5	4	2.8 – 4.7	132	110	177
8	5	3.5 – 4.9	157	85	160

Notes
(1) Concentration range is based on range of denitrification rates and wet and dry hydrologic conditions.
(2) CLT = California least tern; WSP = Western snowy plover
(3) Color gradations for SCRE nitrate concentrations and habitat area show lowest quality/habitat in the light shades and the highest quality/habitat in the darkest shades. For similar numbers the same color shading was applied.

As stated in the Phase 1 Estuary Subwatershed Study (Stillwater Sciences 2011), because significant levels of TIN are present in local groundwater and the Santa Clara River, it should be noted that reductions in nitrate levels under one or more alternatives may not result in substantially reduced algal levels and continued algal bloom episodes are likely to occur under all alternatives. Nevertheless, it is expected that the frequency and duration of algal blooms should decrease with reduced inorganic nitrogen levels in the SCRE approaching the 1.5–4.5 mg-N/L range identified for algal growth limitation (see Stillwater Sciences 2011 for more detail).

As discussed in Stillwater Sciences (2011), unseasonal breaching of the SCRE mouth has potential adverse impacts on tidewater goby and steelhead. Estimated stages for a discharge into the SCRE of 4 mgd and 5 mgd are 9.5 feet NAVD88 and 10.5 feet NAVD88 respectively. Both of these stage estimates are below both the Phase 1 and Phase 2

estimates of breaching stage (11.0 ft NAVD88 and 12.5 feet NAVD88, respectively). The alternatives with discharges into the SCRE of 4 mgd to 5 mgd will result in increased breaching potential relative to alternatives with lower discharges in to the SCRE, but reduced breaching potential relative to alternatives with greater discharge into the SCRE.

It is important to understand that the alternatives do not need to be implemented at their full diversion capacity shown in this study. Several alternatives could be implemented at a capacity for diversion that would lead to increased water recycling, and local supply benefits, while continuing a discharge to the SCRE of between 4 to 5 mgd. At these flow levels, the combination of the modified Wildlife Ponds and the City-Owned Property would be used for treatment wetlands to achieve a nitrate concentration of approximately 4 mg-N/L (outflow from the treatment wetlands to the SCRE)

Cost Estimates

Common to all of the alternatives, is the additional cost of treatment wetlands, as the approach is to combine each of the alternatives with treatment wetland for any remaining flow that the alternative does not provide the capacity to divert for reuse. Considering the additional cost of treatment wetlands as common to all alternatives also assures that additional water quality treatment and habitat benefits associated with the treatment wetlands are provided should it be determined appropriate to implement one or more alternatives at less than full diversion capacity for purposes of assuring some continued discharge to the SCRE to control TIN values. Costs are included to construct vegetated zones in the existing Wildlife Ponds as well as constructing new treatment wetlands at the City-Owned Property adjacent to the VWRF.

Several of the alternatives require implementation of reverse osmosis, which will result in a brine that has to be disposed. There are a number of brine treatment and disposal alternatives that could be considered. Constructing pipeline to the Calleguas SMP is one of the more promising alternatives since the Calleguas SMP is an existing pipeline. The estimated cost for the pipeline between the VWRF and the Calleguas SMP is approximately $22 million. The costs for the alternatives that require brine disposal include the cost ($22 million) of the pipeline to convey the brine from the VWRF to the Calleguas SMP.

The project cost estimates for the alternatives are presented in Table ES.3. The table shows a breakdown of the treatment costs and infrastructure associated with each alternative.

SUMMARY AND NEXT STEPS

Based on the findings of this Phase 2 study there are many opportunities for diverting water from the Estuary for the purposes of recycling the water and benefitting the local communities' water supply. However, there is a significant cost associated with these alternatives and the City must carefully consider the larger water supply and integrated

water management benefits associated with any of these alternatives to maximize the benefits of any investment.

Based on the currently available data collected for the Phase 1 and Phase 2 studies, it appears that the Estuary water quality and habitat function is most benefited by some discharge remaining in the estuary. The results of this Phase 2 study will be discussed at the February 21, 2013 stakeholder workshop and written comments will be solicited to determine recommendations for additional data collection or analysis, project implementation and next steps. This report will be submitted to the RWQCB on March 6, 2013 as a condition of the NPDES permit requirements.

Table ES.3 Alternatives Comparison Summary
Phase 2 Recycled Water Study
City of Ventura

Alternative	Effluent Diversion Capacity	Treatment Processes	Project Cost Components ($M)					CEQA and Permitting	Total Project Cost ($M)	Total Project Unit Cost ($/gal) – Diverted Flow Basis (1)	Total Project Unit Cost ($/gal) – Water Supply Flow Benefit(2)	Total O&M Cost ($ thousands/year)(3)
			Wastewater Treatment	Brine Disposal	Conveyance/Storage/Injection	Recycled Water Distribution System	Wetlands					
North decentralized plant - Irrigation	2	MBR Plant	21			3.5	6.8	1.5	33	13	107	900
Conveyance to Oxnard(4)	13	Disinfection Improvements	5		41		6.8	2.0	54	4	None	16,200
Conveyance to Oxnard(5)	13	AWPF Expansion and Disinfection Improvements	45		41		6.8	2.0	95	7	None	5,200
Recharge/Ag supply for UWCD	11	MF/UF and RO	41	22	27		6.8	2.5	100	9	None	5,600
Ag supply for UWCD	7	MF/UF and RO	16	22	27		6.8	2.5	74	9	None	2,100
Mound Basin IPR (3.6 mgd)	4.5	MF/UF, RO, advanced oxidation	32	22	30		6.8	2.5	94	19	24	3,200
Mound Basin IPR (6.3 mgd)	7.9	MF/UF, RO, advanced oxidation	52	22	39		6.8	2.5	122	15	18	5,300
North decentralized plant - DPR	2.3	MBR, RO, advanced oxidation	38		4		6.8	3.0	52	20	25	2100
DPR (3.6 mgd)	4.5	MF/UF, RO, advanced oxidation	32	22	16		6.8	3.0	80	16	20	3,000

Notes:
(1) Project unit costs based on the effluent diversion capacity of the alternative, and does not include the wetland costs.
(2) Project unit costs based on the product water that would benefit the City's water supply, and does not include the wetland costs.
(3) For alternatives with brine treatment, the cost of disposal at the SMP is included.
(4) City of Oxnard pays for the AWPF expansion. Treatment and conveyance capital costs, and O&M costs are from Kennedy Jenks (2013).
(5) City of Ventura pays for the AWPF expansion. Treatment and conveyance capital costs, are from Kennedy Jenks (2013). O&M costs estimated as part of this study.

BACKGROUND, STUDY AREA CHARACTERISTICS, STATEMENT OF PROBLEM AND NEEDS

1.1 BACKGROUND

The City of San Buenaventura (City of Ventura) (referred to as City, in this report) provides water and wastewater services. These services are provided by the City's water utility, Ventura Water. Ventura Water operates the Ventura Water Reclamation Facility (VWRF). The "City of Ventura Estuary Special Studies Phase 2: Facilities Planning Study for Expanding Recycled Water Delivery" (Phase 2 Recycled Water Study) is sponsored by the City. The purpose of the Phase 2 Recycled Water Study is to better define projects for expanding recycled water for the purpose of offsetting potable uses, recharging groundwater basins, offsetting agricultural use and to create wetlands that would serve as a public amenity and environmental enhancement to the community.

1.1.1 Previous Studies

The VWRF has been granted a National Pollutant Discharge Elimination System (NPDES) permit to discharge tertiary treated wastewater to the Santa Clara River Estuary (SCRE) through the Los Angeles Regional Water Quality Control Board (LARWQCB). However, under the Water Quality Control Policy for the Enclosed Bays and Estuaries of California, discharges of municipal wastewater to enclosed bays and estuaries are to be phased out except in circumstances where the discharge is shown to enhance the quality of receiving waters. To address this issue regarding a finding of enhancement, the LARWQCB required the City to complete the "Special Studies for the Santa Clara River Estuary" as a condition of the City's NPDES discharge permit (CA0053651).

The work conducted for the three studies included the following:

- Estuary Subwatershed Study –A synthesis of information regarding the SCRE ecosystem functioning under existing conditions (characterized by tertiary treated VWRF flows discharged to the Wildlife/Polishing Ponds and then to the SCRE) to determine if the current discharge results in fuller realization of beneficial uses within the SCRE. In addition, this study included a thorough assessment of a range of representative potential future VWRF effluent discharge alternatives and management measures that could be implemented to achieve further improvement in, and/or optimization of beneficial uses using water balance and water quality predictive tools developed with existing and newly-collected data.
- Treatment Wetlands Feasibility Study – Evaluation at a planning concept level the feasibility of implementing a constructed treatment wetland to achieve additional reductions in nutrients, copper and other metals in the VWRF tertiary treated discharge to further promote improvements in receiving water for beneficial uses.
- Recycled Water Market Study – Evaluation and quantification at a conceptual planning level the feasibility of expanding the City's existing reclaimed water system

through evaluation of potential users within a five-mile radius of the VWRF for purposes of providing an alternative to discharging VWRF effluent flow to the SCRE.

The three Special Studies have been completed and submitted to the LARWQCB, and a series of six stakeholder workshops were held from 2009 to August 2011 to evaluate study methods and the results. The major findings of the three studies were:

1. Existing VWRF discharges to the Estuary provide a fuller realization of beneficial uses as compared to a zero discharge scenario, however, modification to VWRF flow volume and nutrients input to the SCRE during the dry season (Alternative 5 in the assessment) would improve overall habitat conditions and further improve beneficial uses in the SCRE. Additional detail on this conclusion, and the data and analyses used to support this conclusion, are provided in the Recommendations Memorandum (Carollo Engineers and Stillwater Sciences, 2011).
2. Treatment wetlands could provide additional nutrient reduction for the VWRF discharge thus improving the quality of the water that is discharged to the SCRE. In addition, wetlands could provide beneficial use through creation of wetland habitat.
3. Additional recycled water markets exist such that additional flows could be diverted from the estuary to be used for recycled water. However, more study was required to assess feasibility and further define water quality targets, treatment requirements, and infrastructure needs.

Directly following Phase 1, Phase 2 of the special studies was initiated to: (1) develop additional information (more hydrologic and water quality data) to improve the understanding of SCRE functioning and help assure protection of the sensitive wildlife and aquatic resources and habitats within the SCRE; and (2) integrate the conclusions of all three of the Phase 1 Studies into a process for selection, environmental review, and design of a preferred VWRF discharge/diversion alternative or combination of alternatives to create a discharge regime that further optimizes beneficial uses of the SCRE.

Key recommendations for Phase 2 studies identified at the end of Phase 1 included developing a suite of feasible VWRF effluent discharge reduction and/or improvement alternatives that utilize treatment wetland and recycled water approaches (i.e., variations of the Phase 1 Alternative 5) and assessing the impact of these alternatives on beneficial uses of the Estuary by assessing their impacts on SCRE habitat conditions and ecosystem functions using the developed predictive tools and SCRE stage-habitat area relationships (see Carollo Engineers and Stillwater Sciences 2011). Through close collaboration with the City, project Stakeholders, and other local entities, effluent discharge reduction and/or improvement alternatives were identified and evaluated as summarized in this report.

1.1.2 Legal Actions

Coincident with Regional Board’s approval of the most recent VWRF NPDES permit, Heal the Bay and Wishtoyo Foundation's Ventura Coastkeeper Program pursued administrative challenges and legal actions to compel the City to discontinue releasing water to the

Estuary. To resolve these challenges and actions, the City entered into a Tertiary Treated flows Consent Decree and Stipulated Dismissal with Heal the Bay and Ventura Coastkeeper, effective March 30, 2012. The settlement sets a goal to identify, select, plan, design engineer, environmental review, permit and construct infrastructure projects that have the capacity to reduce, by 2025, the amount of water entering the Estuary by 50 percent to 100 percent by diverting it to other recycled and reclaimed water uses, including uses that improve local supply and enhance conservation . At the same time, however, the Consent Decree obligates and allows the City to reduce discharges to the Estuary only by that amount approved and permitted by state and federal regulatory agencies with jurisdiction over discharges, the Estuary, and the endangered and threatened species and habitats it provides. The parties to the settlement have agreed to, among other points, to "use the best available science to determine the appropriate discharge reduction and diversion volumes,." or the maximum ecologically protective diversion volume. The scientific analysis, or the best available science, will be provided by the Phase 1 and Phase 2 Special Studies, as well as future additional phases of these Special Studies.

The regulatory issues and legal challenges associated with the discharge to the Estuary are an important driver for investigating recycled water opportunities for the purpose of reducing the volume of the discharge. However, the City recognizes that implementing recycled water offers opportunities to offset potable demands and to provide a benefit to the City's potable source water supplies.

1.1.3 Organization of this Report

The following chapters discuss the City's water supply characteristics and facilities (Chapter 2), wastewater characteristics and facilities (Chapter 3), treatment requirements for discharge and reuse (Chapter 4), potential recycled water market (Chapter 5), preliminary alternative analysis and screening (Chapter 6),and viable alternative development and economic analysis (Chapter 7). Chapter 8 (Stakeholder Input and Recommendations) and Chapter 9 (Financial Plan/Capabilities and Next Steps) have not yet been developed for this draft version of the report.

Information from numerous past reports was used to develop the content for the background information on the water, wastewater and recycled water systems. In addition, the technical analyses and findings of past studies were used to for the basis of the some of the technical analysis conducted for this study. All references used for this study are included in the References section of this report.

1.2 STUDY AREA CHARACTERISTICS

The City is located 62 miles north of Los Angeles and 30 miles south of Santa Barbara along the California coastline. The City currently occupies about 21 square miles and is and bound by the City of Oxnard to the south, by unincorporated Ventura County to the east

and north, and by the Pacific Ocean to the west. The City is located within the County of Ventura. A vicinity map is presented in Figure 1.1.

1.3 HYDROLOGIC CHARACTERISTICS

1.3.1 Surface Watersheds

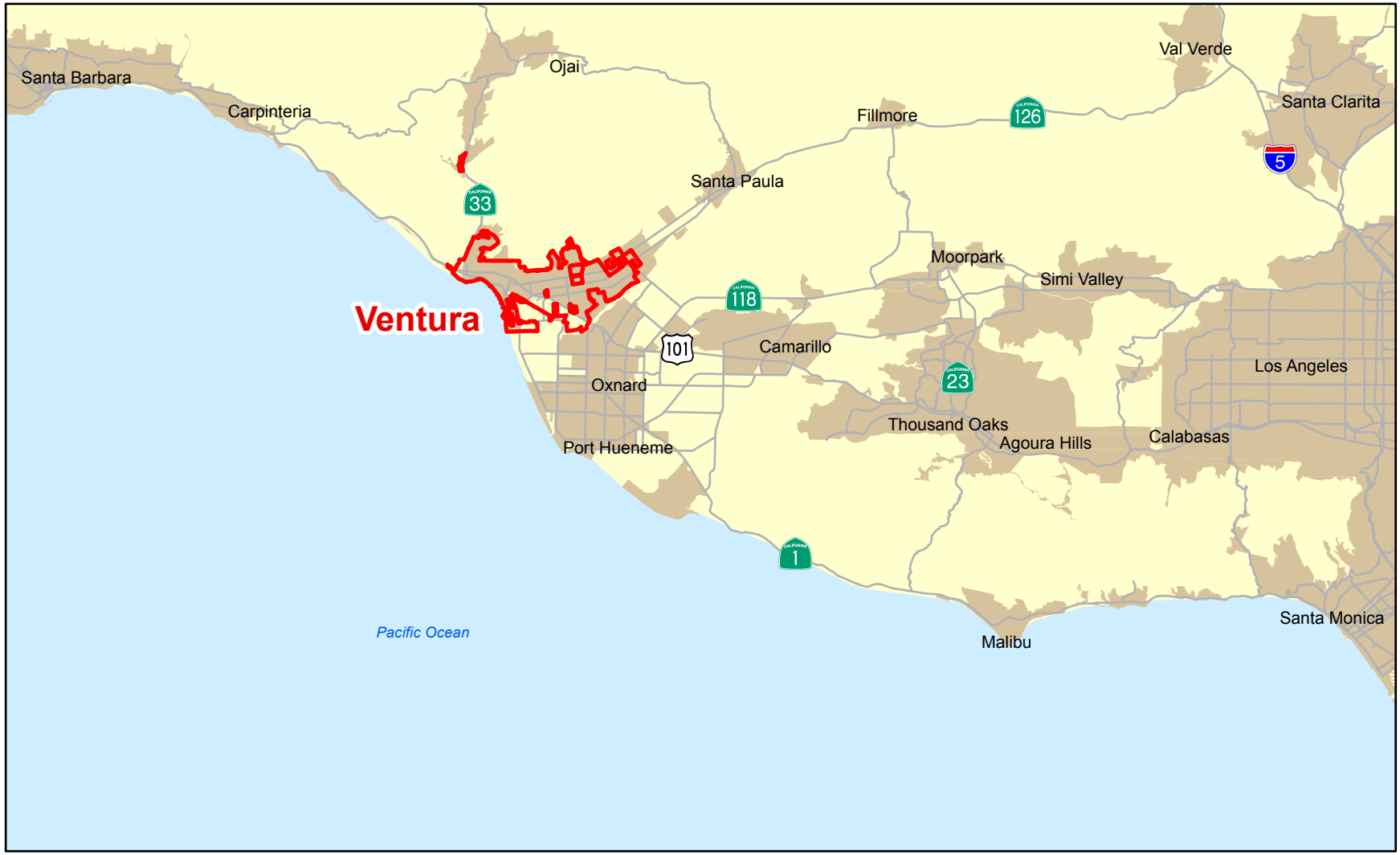
The City lies within both the Santa Clara River Watershed and the Ventura River Watershed. The majority of the City is within the Santa Clara River watershed, with only the northern most region of the City in the Ventura River Watershed. Figure 1.2 shows the City and watershed boundaries.

The Santa Clara River watershed is approximately 1,634 square miles and extends from the San Gabriel Mountains to the Pacific Ocean. The City is located on the north side of the Santa Clara River, at the most downstream end of the watershed. Portions of the City are adjacent to the Santa Clara River Estuary, which is the interface between the Santa Clara River and the Pacific Ocean.

When compared with many southern California coastal watersheds, the Santa Clara River watershed is relatively undeveloped; over 50 percent of the watershed is National Forest land (Angeles National Forest and Los Padres National Forest). Land cover in upland areas of the Santa Clara River watershed is dominated by scrub/shrub (chaparral) vegetation; grasslands and mixed, deciduous, and evergreen woodlands compose the remainder of upland land cover. Along floodplain and valley bottom areas of the Santa Clara River Valley, orchard and row crop agriculture is the dominant land use, with significant urban areas in the upper (Santa Clarita, Newhall) and lower (Santa Paula, Fillmore, Oxnard) valley areas (Stillwater Sciences, 2011) In the lower Santa Clara River below the confluence with Sespe Creek, agricultural and urban use account for 22 percent and 9 percent of land cover, respectively (Warrick 2002).

For this project, the most important stretch of the Santa Clara River, is the section between the Freeman Diversion and the Pacific Ocean. River flow into the SCRE is characterized by long durations of little to no flow punctuated by high flow events caused by short-duration, high-intensity precipitation events that travel quickly through the watershed (Stillwater Sciences 2011). In general, flows in the river are influenced by natural processes and variability in hydrologic conditions as well as anthropogenic activities/infrastructure including agricultural irrigation, water supply dams, and urbanization.

Flow gages at the Highway 101 bridge neat Montalvo (USGS 11114000, WY 1927-2004) and at the Victoria Avenue bridge (VCWPD 723, WY 2008-2009), suggest that the flow is highly variable. The 80 year period of record indicates that flows ranged from 0 to over 90,000 cfs (Stillwater Sciences, 2011). Analysis of these data show that mean daily discharge over the course of a water year (WY), or the period from October through the



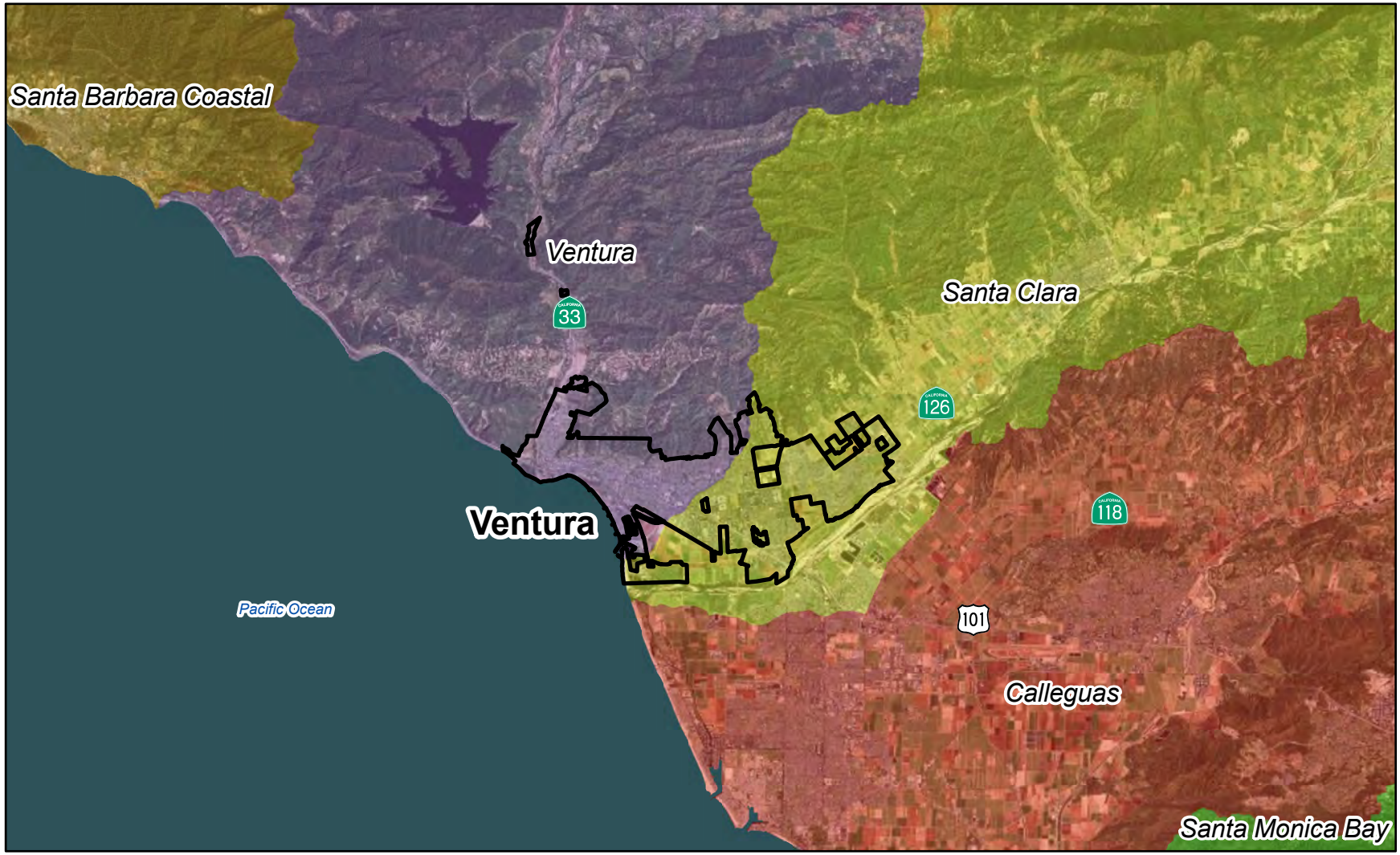
Legend

- Major Roads
- City of Ventura
- Urban Areas
- Rural Areas
- Ocean

N

0 4 8 Miles

Figure 1.1
CITY OF VENTURA VICINITY MAP
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA



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City of Ventura

Watersheds

Calleguas

Santa Barbara Coastal

Santa Clara

Santa Monica Bay

Ventura

N

0 10,000 20,000 Feet

Figure 1.2
VENTURA WATERSHEDS
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

following September, is less than 1 cfs approximately 70 percent of the time and rarely exceeded 100 cfs. Monthly average daily mean discharge indicate that river flow into the SCRE is consistently low from May through December and reaches the annual maximum in February as a result of intense winter storms (Stillwater Sciences, 2011). Additional hydrologic analyses of the Santa Clara River are included in Stillwater Sciences (2011) and Nautilus Environmental (2005).

The SCRE is located at the interface between the Santa Clara River and the Pacific Ocean. For this project, the SCRE subwatershed is defined as the surrounding floodplain area where estuary infilling during closed-mouth, low river flow conditions is known to affect water-table elevation and influence sensitive habitat and human recreation (Stillwater Sciences 2011). This includes areas where the ground surface is equal or less than an elevation of approximately 3 m (10 ft) NAVD88, or the maximum SCRE stage currently reached during closed-mouth, low-flow conditions (Stillwater Sciences 2011). This area extends north to the VWRF and Ventura Harbor inlet, south into McGrath State Beach and to the southern edge of McGrath Lake, and east approximately 1.4 km (0.8 miles) upstream of Harbor Blvd. bridge (Figure 1.3).

The Ventura River watershed is approximately 228 square miles and extends from the San Rafael, Topatopa, Suphur and Santa Ynez mountains to the Pacific Ocean. The main stem of the river flows southward, approximately 16.5 miles from the confluence of Matilija Creek and North Fork Matilija Creek, to the river mouth at the Emma Wood State Beach in the City (Cardno ENTRIX 2012). Over 75 percent of the Ventura River Watershed is classified as rangeland covered with shrub and brush and 20 percent of the basin is classified as forested (Cardno ENTRIX 2012).

1.3.2 Groundwater Basins

The City and surrounding region are within the Ventura River Valley Groundwater Basin (DWR Basin 4-3) and the Santa Clara River Valley Groundwater Basin (DWR Basin 4-4). Groundwater Subbasins in the area include the Lower Ventura River Valley Subbasin (DWR Subbasin 4-3.02), and the Oxnard, Mound and Santa Paula Basins (DWR Subbasins 4-4.02, 4-4.03 and 4-4.04, respectively). Figure 1.4 shows the approximate delineations of these groundwater basins.

The City relies on several of these basins for potable water supply (see Chapter 2), and several of the alternatives evaluated in this study include a component of groundwater recharge, either via recharge basins/ponds or via injection wells. For this reason, additional detail on the subsurface characteristics of these Mound, Oxnard Plain and Santa Paula Basins is provided.

1.3.2.1 <u>Mound Basin</u>

The Mound Groundwater Subbasin is bounded on the north by the Santa Ynez and Topatopa Mountains, on the south by the Oak Ridge and Saticoy faults, on the northeast by

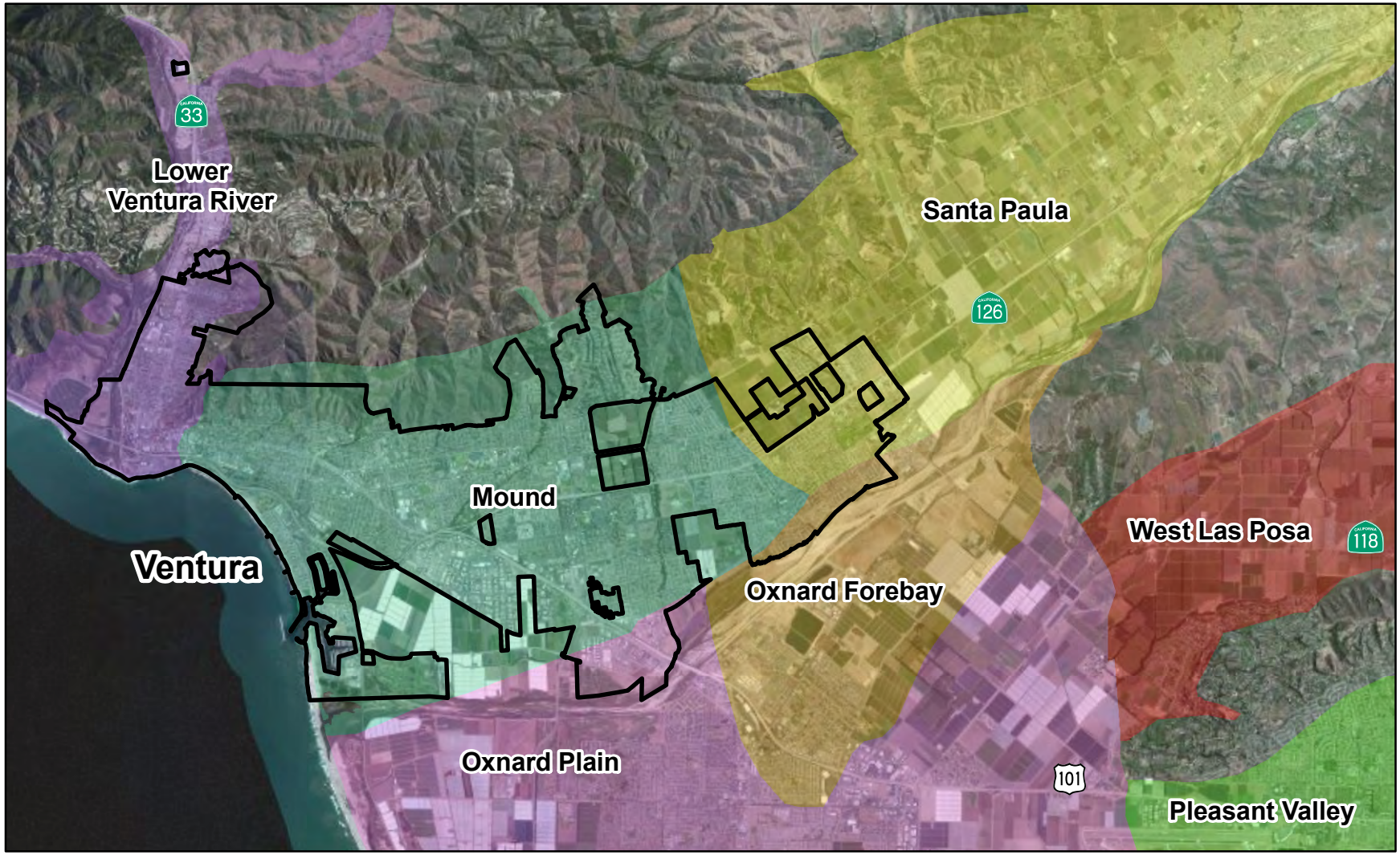
Legend

SCRE Boundary

N

0 1,500 3,000 Feet

Figure 1.3
SCRE BOUNDARY
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA



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City of Ventura

Groundwater Basins

Lower Ventura River

Mound

Oxnard Forebay

Oxnard Plain

Pleasant Valley

Santa Paula

West Las Posa

N

Feet

0 4,500 9,000

Figure 1.4
GROUNDWATER BASINS
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

the Santa Paula Subbasin, and one the west by the Pacific Ocean (DWR, 2003). The 10,000 acre subbasin forms an elongated east-west trending ellipsoid with a maximum aquifer thickness along the syncline axis that generally parallels State Highway 126 (Fugro West 1996).

The main fresh water-bearing strata of the Mound Basin are the upper units of the San Pedro Formation and the overlying Pleistocene deposits, which is approximately 300 feet in thickness.

Groundwater generally flows from east to west with eventual discharge to the Pacific Ocean (Fugro 1996). DWR (2003) reports that sources of recharge to the subbasin include percolation of surface flow in the Santa Clara River, subsurface flow from the Santa Paula Subbasin, percolation of direct precipitation into the San Pedro Formation which crops out along the northern edge of the subbasin, and irrigation return flow.

The documentation and evaluation of groundwater levels within the basin is complicated by the location of the monitoring wells, which are predominantly in the southern and western portion of the basin. Since they are not evenly distributed across the basin, conclusive trends in the water levels throughout the basin are hard to determine. (UWCD, 2011)

Municipal pumping in the Mound Basin peaked in 2003 but has been on a steady decline in recent years with the 2011 total at 1,525 acre-feet. Agricultural pumping has predominated since 2007 with an average rate of 4,200 acre-feet per year and a total of 3,120 acre-feet in 2011.

Water quality is highly variable between wells but generally, the basin has elevated levels of TDS, sulfate, hardness and other analytes. Municipal wells constructed in the central portion of the basin have experienced degrading water quality, through increased TDS values over recent years. About half of that TDS is attributable to sulfate. (UWCD, 2011).

1.3.2.2 Oxnard Plain

The Oxnard Plain Groundwater Basin is identified in DWR Bulletin 118, 2003 Update as the Oxnard Subbasin of the Santa Clara River Valley Basin (Basin No. 4-4.02), located in southern Ventura County. The basin is bounded on the north by the Oak Ridge fault, the south by the Santa Monica Mountains, the east by the Pleasant Valley and Las Posas Valley Basins, and the west by the Pacific Ocean (UWMP, 2010).

The Oxnard Plain Basin is recharged primarily with underflow from the Oxnard Forebay as opposed to deep percolation of water from surface sources. Vertical gradients also exist between the aquifer units on the Oxnard Plain resulting in substantial leakage of upper aquifer water into lower aquifer water. (UWCD, 2011)

In 2011, 60,300 acre-feet was pumped from the Oxnard Plain Basin, as sharp decline from the peak in 1990 of 103,000 acre-ft. Municipal and industrial pumping has been subject to

cutbacks mandated by the Basin's management authority beginning with 5 percent in 1992 and currently at 25 percent.

In the early 1870s, the Oxnard Plain Basin was home to a number of Artesian wells. Today, however, due to pumping demands on the aquifer, those wells now are equipped with pumping to bring water to the surface. Saltwater intrusion into this groundwater basin has been a concern since the 1930s. In areas not impacted by seawater, the water quality is acceptable for most agricultural and municipal/industrial uses. Elevated nitrate levels have been found in wells in the northern portion of the basin, which is likely a result of the vertical groundwater gradient that exists in this area. (UWCD, 2011)

1.3.2.3 Santa Paula Basin

The Santa Paula Groundwater Basin is identified in DWR Bulletin 118, 2003 Update as the Santa Paula Subbasin (Basin No. 4-4.04). The basin is bound on the north by the Topatopa Mountains, the south by the Oak Ridge and South Mountain, the Oak Ridge fault, and the Saticoy fault, the east by a bedrock constriction, and the west by the Oxnard Plain and Mound subbasins. (UWMP, 2010)

The main fresh water-bearing strata of the Santa Paula Basin are the Pleistocene San Pedro Formation Pleistocene river deposits of the ancient Santa Clara River, alluvial fan deposits from uplifted mountain blocks and recent river and stream sediments deposited locally along the Santa Clara River and its tributaries.

The Santa Paula Basin is thought to be in hydraulic connection with the Fillmore Basin and to a lesser degree the Mound Basin. Underflow from the Fillmore Basin is likely the main source of recharge for the Santa Paula Basin. Water levels in the Santa Paula Basin, however, are not as recoverable as the Fillmore Basin and have showed a steady long-term decline. (UWCD, 2011)

According to a 2003 study investigating the yield of the Santa Paul Basin, it was suggested that the yield of this basin was near 26,000 acre-feet per year, which is roughly equal to the historic average pumping rate. (UWCD, 2011)

Water quality in the basin is highly variable with the worst water quality in the western portion of the basin. TDS levels hover around 1000 mg/L with sulfates being a large contributor to that in the western portion of the basin. Deeper wells have elevated levels of iron and manganese concentrations. (UWCD, 2011)

1.4 BENEFICIAL USES AND WATER QUALITY

The SCRE is currently designated to support eleven of the twenty four beneficial uses protected under the water quality control plan (Basin Plan) for the Los Angeles Region (LARWQCB 1994), including:

- Navigation (NAV)
- Water Contact and Non-Contact Recreation (REC-1, REC-2)

- Commercial and Sport Fishing (COMM)
- Marine Habitat (MAR)
- Estuarine Habitat (EST)
- Wetland Habitat (WET)
- Rare, Threatened, or Endangered Species (RARE)
- Spawning, Reproduction, and/or Early Development (SPWN)
- Migration of Aquatic Organisms (MIGR)
- Wildlife Habitat (WILD)

In addition to the beneficial uses that are listed above, there are many ecosystem functions and services that the SCRE provides to the immediate and surrounding areas.

- **Flow regulation** – specifically storage and attenuation of floodwater delivered from the contributing watershed to the SCRE through large storm events; flood water storage can affect sediment deposition, upland and aquatic habitat maintenance, and groundwater recharge rates.
- **Sediment storage and beach building** – sediments deposited during storm events to the SCRE can help maintain existing vegetation and habitat, create new habitat, counteract soil compaction and ground subsidence as well as contribute to beach building.
- **Water quality regulation** – because of its location between freshwater outlets and the saline environment, the SCRE can provide a gradual transition between the freshwater and saline water qualities (often referred to as brackish)
- **Aquatic habitat maintenance** – provides suitable habitat for steelhead and tidewater goby.
- **Wildlife habitat maintenance** – provides suitable nesting and foraging habitat for the least tern and snow plover.
- **Recreational opportunities** – The estuary offers a number of activities such as camping (at adjacent McGrath State Beach), surfing, hiking, bird watching, nature observation and swimming; some of these activities (such as camping) can be adversely impacted depending upon water level in the SCRE.

The SCRE water quality was reviewed and summarized as part of an Estuary Study performed by Stillwater Sciences in 2011 (Stillwater, 2011). Water quality within the SCRE is monitored regularly both through in-situ grab sampling as well as continuous monitoring. Parameters routinely monitored include DO, pH, temperature, conductivity and turbidity. In addition to the routine monitoring within the estuary, the City conducts regular receiving water monitoring as part of their NPDES permit.

The City's VWRF meets its NPDES permit requirements for its receiving water including metals with only occasional exceedances of copper. However, there are some water quality concerns within the estuary that are now being investigated and addressed. The SCRE was been placed on the CWA 303(d) list for coliform bacteria, nitrate, and toxaphane (a pesticide) in 1998 and toxicity (due to elevated nitrate levels) in 2008. Though ammonia concentration in the estuary is low, elevated nutrient levels within the SCRE may be contributing to significant algal growth and resulting in dissolved oxygen (DO) fluctuations. Algal growth degrades the overall water quality of the estuary by introducing suspended solids and re-introducing nitrogen into the ecosystem.

As a condition of its NPDES Permit, the City has completed annual Benthic Macroinvertebrate (BMI) studies to investigate further the issue of toxicity within the SCRE and the VWRF's role in that. Due to sediment conditions and frequent flood scour events within the estuary, the likelihood of bioaccumulation to toxic levels within the ecosystem is relatively low.

1.5 CLIMATE

Carollo investigated potential effects of climate change on the SCRE by analyzing three specific impacts on the ecosystem: 1) local atmospheric temperature, 2) mean sea level and 3) precipitation patterns/events. (Carollo, 2011) The key results of that study are summarized in Table 1.1.

Table 1.1 Projected Climate Change Impacts for the SCRE
Phase 2 Recycled Water Study
City of Ventura

Climate Change Parameter	Project Impact, by 2050	Projected Impact, by 2100
Local Atmospheric Temperature	1.0 to 3.0 deg C, average of 2.0 deg C	1.1 to 5.0 deg C, average of 3.0 deg C
Mean Sea Level	0.7 to 2.0 feet	1.6 to 6.6 feet
Precipitation Patterns/Events	Frequency of extreme daily events increases by 2(1)	Frequency of extreme daily events increases by 3(1)

Note:
Source: Carollo, 2011
(1) Extreme daily event considered equivalent to a 24-hour storm.

1.6 LAND USE AND POPULATION

In 2005, the City adopted the 2005 Ventura General Plan to redirect future growth toward 'Infill First' with an emphasis on encouraging more intense development of housing alongside commercial uses. The 2005 General Plan outlines land use and population throughout the City which are summarized here.

1.6.1 Land Use

Land use in the City has changed over time and land that was predominantly agricultural land was annexed to the City and the became a mix of land uses including residential, commercial, industrial, and institutional areas. Table 1.2 summarizes the information on land use types and areas in the General Plan Boundary provided in the 2005 General Plan. Figure 1.5 shows the land use distribution as presented in the 2005 General Plan.

Table 1.2 Existing Land Use within City General Plan Boundary
Recycled Water Market Study-Phase 1 Report
City of Ventura

Land Use	Area (Acres)	Percentage of Total Area (%)
Neighborhood Low	4,629	17
Neighborhood Medium	1,061	4
Neighborhood High	303	1
Commerce	808	3
Industry	1,401	5
Public and Institutional	571	2
Park and Open Space	11,693	42
Agriculture	6,857	25
Downtown Specific Plan	307	1
Harbor District	254	1
Total	27,884	100

1.6.2 Population

The City's estimated population growth for the City is shown in Table 1.3. The population numbers include both the population within the City of Ventura limits as well as the population served by the public water system that is not within the City limits.

Included for comparison is the EIR population projection for 2025 reflecting the two possible growth scenarios: (1) 1.14 percent annual population growth, which is equivalent to the annual growth rate in the City from 1984 to 2004; and (2) 0.88 percent annual population growth, which is equivalent to the annual growth from 1994 to 2004.

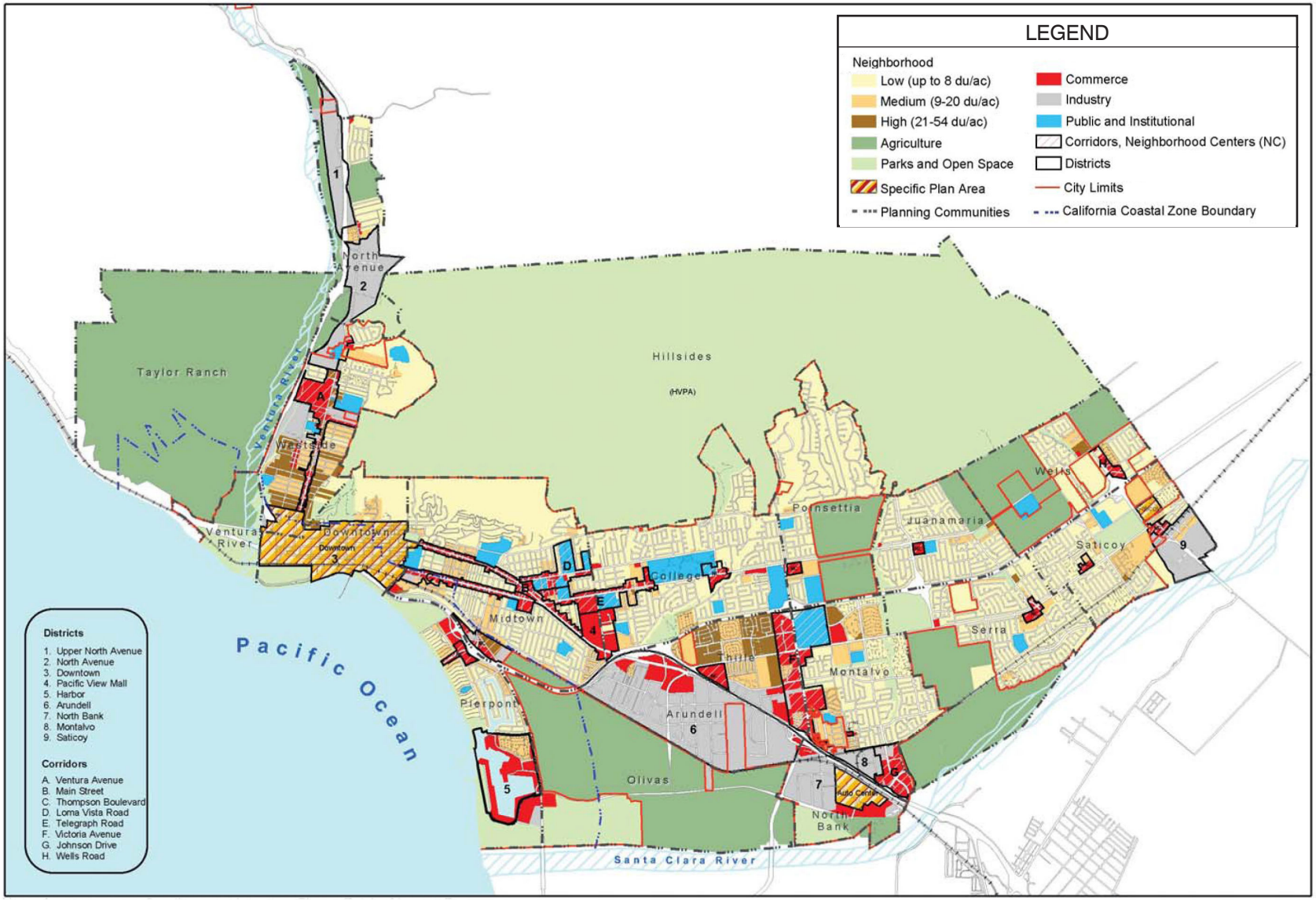

Figure 1.5
LAND USE (2005 GENERAL PLAN)
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

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Table 1.3	**Population Projections for the City Phase 2 Recycled Water Study City of Ventura**					
	2010	**2015**	**2020**	**2025**	**2030**	**2035**
Projected Planning Area Population	113,478	118,416	123,575	128,963	134,592	140,472
General Plan EIR(1) (0.88%)				126,153		
General Plan EIR(1) (1.14%)				133,160		

Note:

Source: UWMP, 2010.
(1) General Plan EIR only provides estimates for 2025.

WATER SUPPLY CHARACTERISTICS AND FACILITIES

2.1 OVERVIEW OF WATER SUPPLY SYSTEM

The City provides drinking water to more than 109,000 people through approximately 31,650 water service connections. The City's water service area includes all areas within the City limits, unincorporated areas within Ventura County, and the Saticoy Country Club area. To serve the water service area, the City owns and operates a water system consisting of more than 380 miles of distribution pipeline, three water treatment plants, 23 pump stations and 31 reservoirs. The City draws their drinking water from three main sources: 1) the Ventura River, 2) Lake Casitas, and 3) the local groundwater basins.

Details on the City's water system are included in the City's Water Master Plan (RBF, 2011).

In addition to the drinking water supply, the City provides reclaimed water from the VWRF to two municipal golf courses, a City Park, and landscape irrigation areas along the existing distribution alignment.

2.2 WATER SUPPLY SOURCES

As mentioned, the City's domestic water supply is derived from local groundwater basins, Lake Casitas, surface water from the Ventura River, and sub-surface water from the Ventura River. The City also has a 10,000 acre-foot per year allocation from the California State Water Project (SWP). To date, the City has not received any of this water because the City does not have the facilities needed to receive SWP water into the distribution system.

There are presently three main water sources that provide water to the City water system:

- Lake Casitas –Water is purchased from Casitas Municipal Water District (CMWD) and delivered to the City at two turnouts.
- Ventura River Surface Water – River water is withdrawn via shallow collection system and groundwater wells and is treated at the Ventura Avenue Treatment Plant.
- Groundwater Basins – Groundwater is drawn from three separate basins: Mound, Oxnard Plain, and Santa Paula. Water from the Santa Paula basin is treated at the Saticoy Conditioning Facility while water from the Oxnard Plain and Mound basins are treated at the Bailey Conditioning Facility.

Figure 2.1 shows the locations of the turnouts, the treatment plants and the groundwater wells.

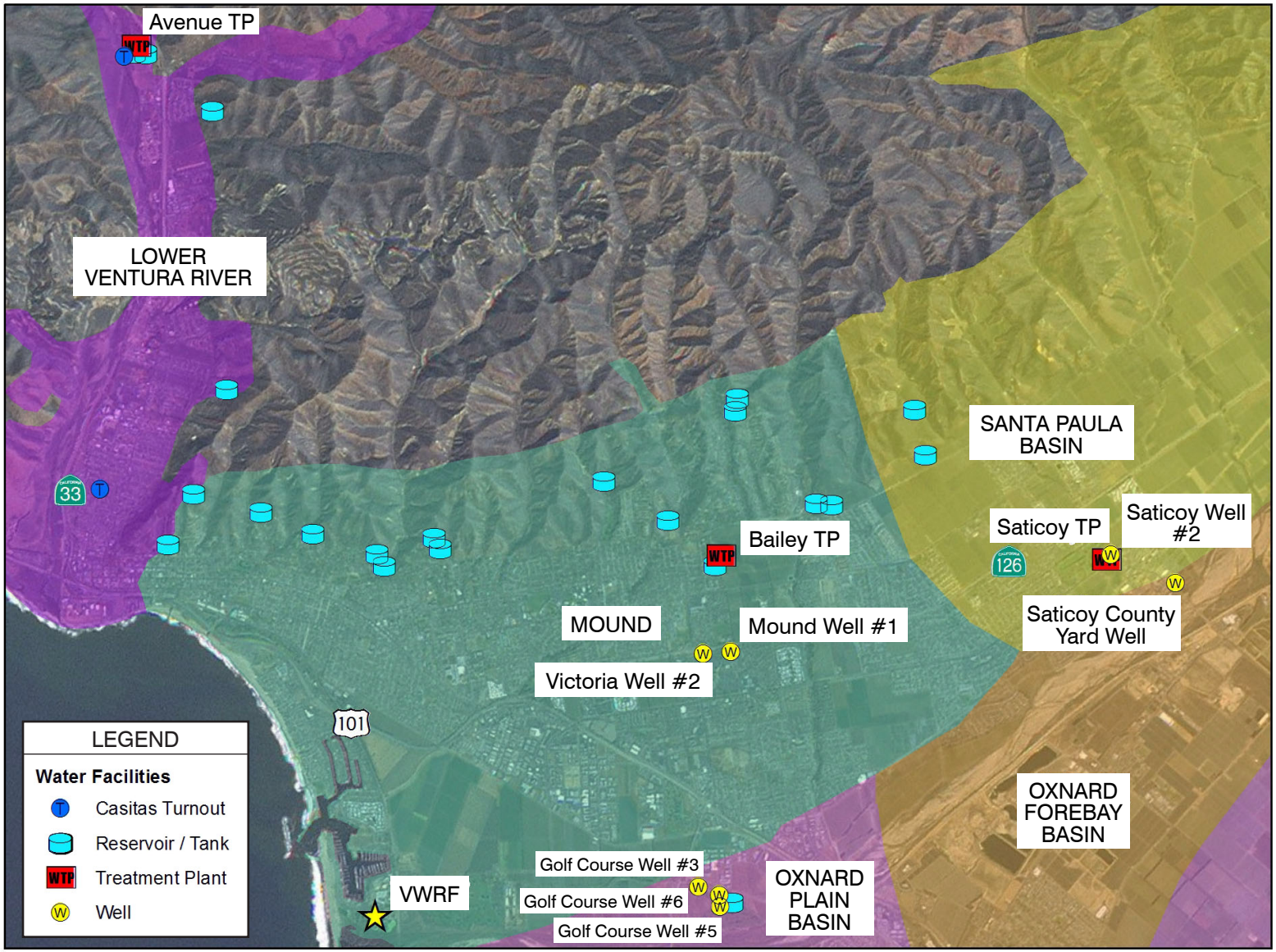

Figure 2.1
CITY OF VENTURA WATER SUPPLY FACILITIES
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

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In addition, potable water demands are offset with the use of recycled water by several customers.

Table 2.1 highlights the historical, present and planned water supply (including recycled water) for the City.

Table 2.1 Ventura Water Supply [in Acre-Feet per Year (AFY)]
Phase 2 Recycled Water Study
City of Ventura

Source	Historical Supply Projection(1)	Average Annual Supply(1)	Future (2020) Supply Projections(2)
Casitas Municipal Water District	4,960 – 8,000	6,200	5,000(2)
Ventura River Surface Water	4,200 – 6,700	4,200	6,700
Mound Basin	2,500-4,000	4,000	4,000
Oxnard Plain Basin	4,100	4,100	4,100
Santa Paula Basin	3,000	1,340	3,000
Recycled Water		700	700
Total	18,760 – 25, 800	20,540	23,500

Notes:
(1) 2011 City Water Master Plan.
(2) November 2012 Ventura Local Agency Formation Commission (LAFCo) Municipal Service Review.

Based on the City's 2010 Urban Water Master Plan (UWMP), it is anticipated that the City will have constructed an additional groundwater well in the Santa Paula groundwater basin by 2015, which will increase groundwater pumping bringing the total anticipated supply from the City's groundwater sources to 11,100 AFY. By 2020, the City also anticipates completion of wells near the Ventura River increasing the surface water supply by 2,500 AFY for a total of 6,700 AFY.

2.2.1 Groundwater Management

2.2.1.1 Mound Basin

The United Water Conservation District (UWCD) was formed in 1950 under the State of California's Water Conservation District Law of 1931, and is organized as a governmental special district. The UWCD boundary includes a 214,000 acre area that encompasses the Santa Clara River Valley and the Oxnard Coastal Plain. UWCD serves as the conservator of the groundwater resources that includes the Mound Groundwater Basin. UWCD does not produce water from the basin, but is authorized to engage in groundwater management of

the basin. The City operates two wells in the Mound Basin. In addition, historical agricultural and private wells have utilized this groundwater supply source.

2.2.1.2 Oxnard Plain Basin

The Fox Canyon Groundwater Management Agency (FCGMA) was created by state legislation in 1982 to manage local groundwater resources in a manner to reduce overdraft of the Oxnard Plain and stop seawater intrusion. A major goal of the FCGMA is to regulate and reduce future extractions of groundwater from the Oxnard Plain aquifers, in order to operate and restore the basin to a safe yield. In August 1990, the FCGMA passed Ordinance No. 5, which requires existing groundwater users to reduce their extractions by five percent every five years until a 25 percent reduction is reached by the year 2010. Long-term production will be about 4,100 AF per year. The City operates two wells in the Oxnard Plain Basin and has a third well that could be used as an emergency source.

2.2.1.3 Santa Paula Basin

In March 1996, the Superior Court of the State of California for the County of Ventura filed a stipulated judgment for the Santa Paula Basin. The Judgment recognized that all the parties have an interest in the Santa Paula Basin and in the proper management and protection of both the quantity and quality of this ground water supply. Members of the Santa Paula Basin Pumpers Association (an association of ranchers and businesses) and the City exercise rights to pump water from the basin. The City has one well in the Santa Paula Basin and is in the process of installing a second well. These two wells will be able to pump the City's allocation of 3,000 AFY from the Santa Paula Basin. The City is not limited to this allocation in any single year, but may produce seven times its average annual allocation (21,000 AF) over any running seven-year period.

2.3 WATER USE TRENDS AND DEMANDS

The City's water system provides potable water to residential, commercial, industrial, institutional, and irrigation customers. Recycled water is provided for landscaping in the Marina area as well as to two golf courses. The City has a raw water pipeline that has historically provided water for petroleum recovery operations and two irrigation customers. The City's water use sectors are generally described below.

- **Residential Sector** - The residential sector of the City is comprised of single family (SF) and multi-family (MF) residential customers. The residential sector represents approximately 61 percent of the City's total water consumption. Within the residential sector, single family accounts make up two thirds of the total residential demand.
- **Commercial Sector -** The City contains several different types of commercial customers, including gas stations, large shopping complexes, auto dealerships, restaurants, business parks, office buildings, hotels, and hospitals. The City includes several tourist-driven businesses such as hotels, which benefit from the high volume

of tourist traffic. The largest commercial sector users are hotels and hospitals. The commercial sector accounts for approximately 20 percent of the City's water consumption.

- **Industrial Sector -** The City contains a relatively small industrial sector. The industrial sector utilizes less than 1 percent of the City's water demand.
- **Institutional/Government Sector -** The City's institutional and governmental buildings as well as school facilities and churches are included in this sector. The Institutional/Government Sector utilizes approximately 3 percent of the water demand.
- **Landscape Sector -** The City's landscape metered uses include assessment districts, contract parks, City parks, and other large irrigation areas. Landscape accounts comprise of approximately 3 percent of total water use.
- **Recycled Water -** The City provides recycled water delivered from the City's Water Reclamation Facility to landscape areas in the Marina area and two (2) 18-hole tournament class public golf courses within the City's service area. This usage accounts for approximately 3 percent of total water demand.
- **Petroleum Recovery Operations -** The City provides water for petroleum recovery operations to a single customer, Aera Energy. The water is supplied through two separate services. One service is direct from the City's raw water pipeline and feeds Aera's operations east of Ventura Avenue. The other service provides treated water directly from the Casitas Municipal Water District mainline to Aera facilities west of Ventura Avenue near Shell Road. This demand has steadily decreased over the years as Aera Energy has developed ways to recycle this water and accounts for approximately 3 percent of total water consumption.
- **Other –** This category includes miscellaneous metered accounts (i.e., temporary construction, street sweeping and fire line meters), miscellaneous non metered usage (i.e. pipe/hydrant flushing, service leaks, main breaks, sewer maintenance, firefighting and training, hydrant knockouts, plant use, and tank maintenance) and unaccounted for water (estimated at 5.5 percent to total produced water).

2.3.1 Current Water Demand

According to the City's 2010 UWMP, the City's water demand was 17,351, AFY. This figure is substantially lower than historical demands, likely due to water conservation efforts in place during the drought conditions. In 2011-12, the estimated total demand was 17,242 AFY. Table 2.2 and 2.3 show current water demand and number of accounts broken out by type of use for 2005 and 2010, based on the City's 2010 UWMP.

Table 2.2 Past, Current and Project Water Demands (AFY)
Phase 2 Recycled Water Study
City of Ventura

Year	Single-Family	Multi-Family	Commercial	Industrial	Institutional /Governmental	Landscape	Petroleum Recovery	Other	Total
2005	7,483	3,887	4,279	163	541	1,079	930	2,447	20,808
2010	7,006	3,678	3,384	64	495	1,044	368	1,312	1,7351
2015	9,197	4,562	4,551	163	690	1,416	400	1,306	22,286
2020	9,615	4,761	4,749	170	720	1,478	400	1,363	23,256
2025	10,052	4,969	4,956	178	751	1,542	400	1,423	24,270
2030	10,508	5,185	5,173	185	784	1,610	400	1,485	25,330
2035	10,984	5,412	5,399	193	818	1,680	400	1,550	26,436

Note:
(1) Source: UWMP, 2011. 2005 and 2010 are actual demands. 2015 and beyond are projected.

Table 2.3 Number of Water Service Accounts
Phase 2 Recycled Water Study
City of Ventura

Year	Single-Family	Multi-Family	Commercial	Industrial	Institutional /Governmental	Landscape	Petroleum Recovery	Other	Total
2005	22,834	2,269	2,537	15	193	222	2	2,966	31,038
2010	23,158	2,372	2,536	4	185	258	2	3,131	31,646
2015	25,627	2,545	2,733	7	200	279	2	3,375	34,769
2020	24,953	2,481	2,664	7	195	272	2	3,291	33,865
2025	26,095	2,590	2,781	7	204	283	2	3,434	35,396
2030	27,288	2,703	2,902	7	213	296	2	3,584	36,994
2035	28,534	2,821	3,029	8	222	309	2	3,741	38,665

Note:
(1) Source: UWMP, 2011. 2005 and 2010 are actual accounts. 2015 and beyond are projected.

2.3.2 Projected Water Demand

2.3.2.1 City's 2010 UWMP

For demand projection purposes, the City assumes a daily per capita use of 168 gallons based on historical average demand from 2000-2009. Using that daily per capita value and the City's projected 2035 population of 140,272, the projected 2035 potable water demand would be 26,436 AFY. However, newly passed State legislation, Senate Bill 7 of Special Extended Session 7 (SBX7-7) was signed into law in November 2009, which calls for progress towards a 20 percent reduction in per capita water use statewide by 2020, however the targets are adjusted for different regions. The City has already implemented conservation measures and has a target of reaching a per capita consumption of 142 gpcd to satisfy SBX7-7. Therefore, assuming the required per capita reduction, the overall projected potable demand for 2035 is reduced to 22,345 AFY as shown in Table 2.4, per the 2010 UWMP.

Table 2.4 Target Water Demands (AFY)
Phase 2 Recycled Water Study
City of Ventura

Year	Baseline Water Demands	Recycled Water Use	Conservation Needed(1)	Target Water Demand
2015	22,286	700	(1,422)	20,163
2020	23,256	700	(2,899)	19,657
2025	24,270	700	(3,056)	20,514
2030	25,330	700	(3,220)	21,410
2035	26,436	700	(3,391)	22,345

Notes:
Source: UWMP, 2011.
(1) Conservation needed to meet SBX7-7 targets.

2.3.2.2 LAFCo 2012 Municipal Service Review

In 2012, the Ventura LAFCo completed the Municipal Service Review for nine Ventura County cities, including the City. LAFCOs are required to review, and as necessary, update the sphere of influence for each city or special district every five years. Prior to updating a sphere of influence, LAFCo is required to conduct a Municipal Service Review (MSR). MSRs consist of written determinations relating to seven different factors, one of which is the "present and planned capacity of public facilities, adequacy of public services, and infrastructure needs or deficiencies related to … municipal and industrial water… within or contiguous to the sphere of influence." The MSR for the City was accepted by the LAFCo Board on November 14, 2012. Lace's findings regarding the potable water system concluded the City's current potable water demand is 88 percent of the supply, with

"approved" development projects it increases to 94 percent of the supply, with proposed development projects it increases to 96 percent of the supply, and in drought conditions the normal water demand exceeds supply.

The City continues to update its demand and supply projections and recently commissioned a consultant to prepare a report to review the current water demand, estimated water supplies and the impacts of future planned development projects on each.

2.3.3 Potable Water Rates

All of the City's retail customers are metered and billed with commodity rates for both water and sewer service. The City does not have any unmetered services and all new connections are metered and billed volumetrically.

Residential water accounts are billed bimonthly on an increasing block rate schedule, nonresidential water accounts are billed with uniform rates (Table 2.5) and reclaimed water is charged a reduced, uniform rate. Since there is no direct measure of sewer discharge by residential customer, water use is used to estimate the sewer discharge.

Table 2.5 Current Water Rates(1)
Phase 2 Recycled Water Study
City of Ventura

Customer Class	July 2012 Rate ($/HCF)	July 2013 Rate ($/HCF)
Single Family		
Tier 1 – 0 to 14	$1.98	$2.15
Tier 2 – 15 to 30	$2.69	$2.92
Tier 3 – 30+	$4.41	$4.79
Multi-Family		
Tier 1 – 0 to 10	$1.98	$2.15
Tier 2 – 11 to 16	$2.69	$2.92
Tier 3 – 16+	$4.41	$4.79
Non-Residential	$2.48	$2.70
Institutional/Interruptible	$1.98	$2.15
Reclaimed Water	$0.64	$0.68
Untreated Water	$1.88	$2.04
Outside City Rates	Add $0.73/hcf	Add $0.76/HCF

Notes:
Source: Ventura Water, 2012.
(1) This does not include a bi-monthly service and fireline charges which are based on meter size.

2.4 QUALITY OF WATER SUPPLIES

The City's water system is operating in compliance with the Safe Drinking Water Act (SDWA) and California Department of Public Health (CDPH) drinking water regulations are identified in Titles 17 and 22 of the California Code of Regulations. There are several regulations that are currently under review by the EPA and CDPH, which may be enforced at a later date.

The City does consistently exceed the secondary MCL regarding the upper contaminant drinking water standard of 1,000-ppm for total dissolved solids (TDS) on the east side of the City. Blending is acceptable by CDPH to keep the TDS below the short-term secondary maximum contaminant level (SMCL) of 1,500 ppm on a continual basis as an interim measure pending construction of treatment facilities or development of acceptable new sources [Title 22, CCR Sec. 64449 (d)(3)].

Blending TDS below this SMCL has not been completely attainable due to the high TDS in the Mound Well when other wells are inoperable. The annual average on the east side of the City is about 1,300 ppm. The west side of the City is in compliance with the upper TDS limit and generally is between 500 to 700 ppm. The CDPH Water Supply Permit issued August 3, 2007 has required a TDS reduction study and a preliminary plan and schedule for complying with the upper contaminant level of 1,000 ppm in the water delivered to the public. The City must also apply for a waiver for the TDS secondary standards.

Casitas Municipal Water District (CMWD) operates Lake Casitas and treats their wholesale water and sells it to the City. Common lake turnover has been the source of short-term taste and odor concerns for customers. CDHP does not consider this biannual change in water quality to be a health hazard. The City has no direct control over the water received from CMWD. The City has no feasible or cost effective treatment capability or processes to improve the taste and odor.

2.5 WATER FACILITIES

As mentioned previously, the City owns, operates and maintains a water system consisting of more than 380 miles of transmission and distribution pipeline divided into 16 pressure zones, three water treatment plants, 23 pump stations, and 31 reservoirs and two turnouts. Figure 2.2 shows an overall map of the City's water system facilities and pressure zones.

2.5.1 Turnouts

The City distribution system receives a portion of its potable water supply from two turnout connections to the Casitas Municipal Water District (Casitas) system. Casitas Turnout No. 1 is located at the Avenue Treatment Plant with a capacity of 4,300 gallons per minute (GPM). Casitas Turnout No. 2, located at the intersection of Olive and Ramona Streets, fills the Hall Canyon Reservoirs at a capacity of 8,333 gpm.

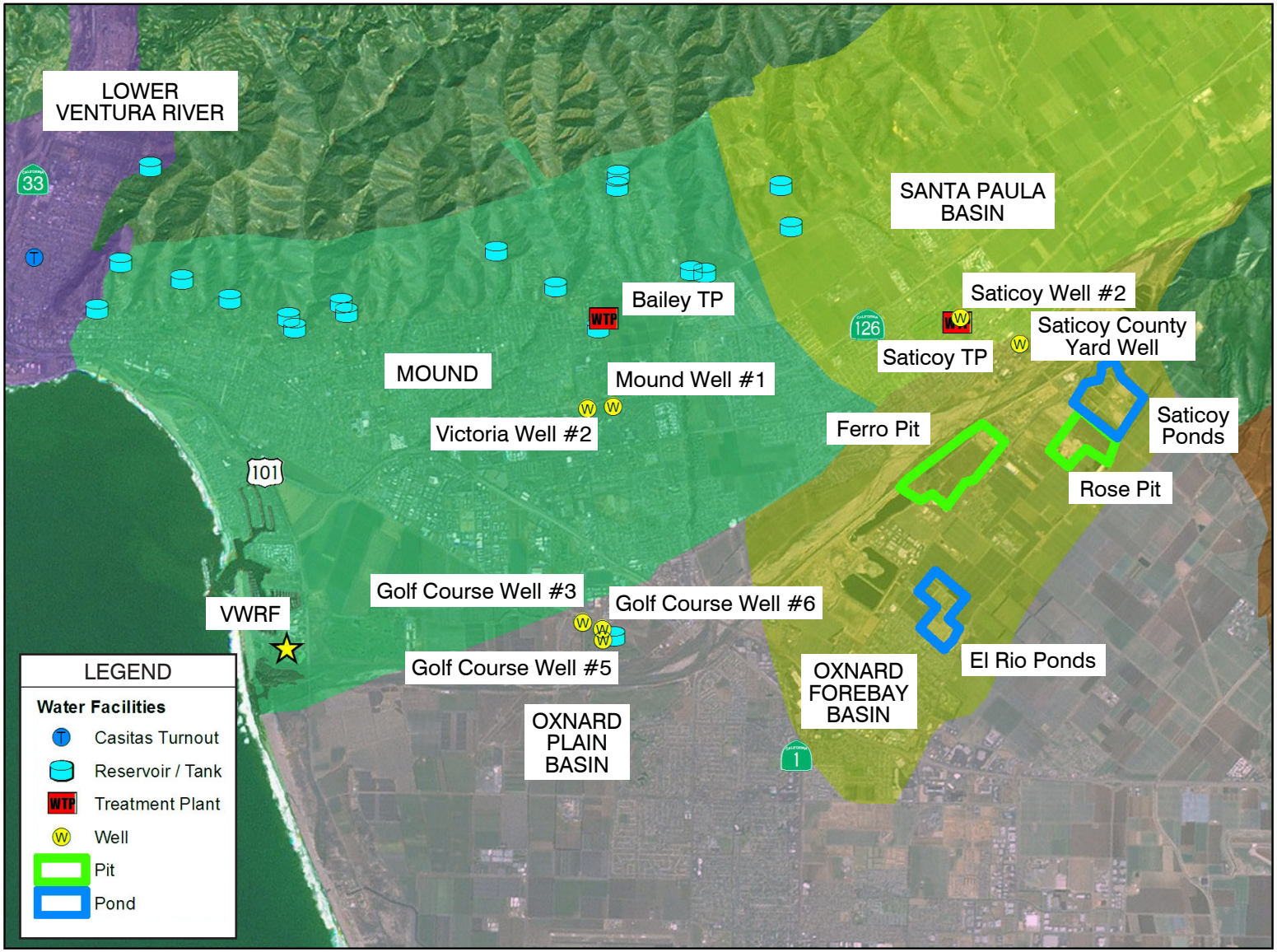

Figure 2.2
VENTURA WATER AND UWCD FACILITIES
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

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2.5.2 Treatment Plants

The City's three treatment plants have a combined capacity of 25 million gallons per day (mgd); the details of those three plant are highlighted below. A water supply analysis conducted as part of the Master Plan concluded that the City will need additional distribution system facilities (e.g., pipelines and wells) to provide reliability and redundancy for the distribution system when particular facilities or their associated supply source is unavailable and/or reduced. Many of these projects are currently in the City's CIP and will provide for the additional supply capacity.

2.5.2.1 Avenue Treatment Plant

The Avenue Treatment Plant is the City's main water treatment facility, treating and disinfecting water derived from the Ventura River. The facility is located off of North Ventura Avenue. The Avenue Treatment Plant recently underwent a major upgrade, which was completed in August of 2007. The new treatment plant consists of a state of the art in-line ultrafiltration membrane filter system that is capable of producing up to 10 mgd. The updated treatment process was designed to meet current and anticipated drinking water regulations and is expandable up to 15 mgd.

2.5.2.2 Bailey Conditioning Facility

The Bailey Conditioning Facility is one of two iron and manganese conditioning facilities within the distribution system. The Bailey Conditioning Facility conditions water derived from the Oxnard Plain and Mound groundwater basins. This facility is located off of Fremont Street. The Bailey Conditioning Facility has an existing capacity of 11.5 mgd and has space for an additional filter, which would increase the capacity to about 13.8 mgd.

2.5.2.3 Saticoy Conditioning Facility

The Saticoy Conditioning Facility is the other conditioning facility operated by the City. The Saticoy Conditioning Facility is an iron/manganese removal facility which conditions water derived from the Santa Paula groundwater basin. This facility is located off of Telephone Road near South Wells Road. The facility has an existing capacity of 3.5 mgd, and the City is evaluating the possible upgrade of this facility.

2.5.3 Pump Stations

The City operates twenty one (21) pump stations that supply water to various pressure zones within the City. The pumps range in type, size and capacity (from 349 to 8,300 gpm). Pump stations are used to boost water from a lower hydraulic gradient to a higher hydraulic gradient, as well as to move water from groundwater wells to upper hydraulic gradients.

2.5.4 Reservoirs

The City has a combination of both concrete reservoirs and steel tanks that provide storage for the distribution system. The City currently has four concrete reservoir sites in the distribution system, ranging in storage capacity from 1.12 million gallons (MG) to 14.68 MG, totaling approximately 32 MG. The City currently has 23 steel tanks in the distribution system, ranging in storage capacity from 0.08 MG to 2.54 MG, totaling approximately 20 MG. The reservoirs and tanks provide storage to meet peak demands and emergency storage for fire protection. Storage is utilized to minimize pumping requirements during on-peak energy (Southern California Edison) hours.

The results of both the existing system storage capacity evaluation and the near-term storage capacity evaluation indicate that all pressure zones, with the exception of the 210 Pressure Zone, are deficient in capacity. In the near-term demand condition, the citywide storage deficiency is 7.64 MG, assuming that the excess capacity in the 210 Pressure Zone can be utilized in other areas. The excess capacity available is all located in the 210 Zone, which is the lowest HGL in the system. Therefore, to utilize the excess storage, there must be excess pumping capacity available to move the water to the higher zones in need.

Seven pressure zones are considered to have significant deficiencies that require further evaluation and potential action. In order for the excess storage in the 210 Zone to be used by the higher zones, a reliable pumping supply with adequate excess pumping capacity must be available. To be conservative, it is assumed that those zones that can directly take suction from the 210 Zone will be able to tap into the excess storage available.

Based on the analysis conducted in the Master Plan, the City is evaluating potential improvements to the City's existing and future storage capacity of the system.

2.5.5 Pressure Reducing Stations

The City operates ten (10) pressure-reducing stations, which supply water from a higher pressure gradient to a lower pressure gradient. The pressure reducing stations consist of valves set to maintain a constant downstream pressure.

2.5.6 Pipelines

The City's distribution system is comprised of pipelines ranging in size from 2-inches to 36-inches. The majority of pipelines are 6, 8 and 12-inches in diameter. There are approximately 380 miles of pipeline within the distribution system.

2.5.7 Recycled Water Facilities

Flows from the City's wastewater collection system are treated at the City's VWRF. Average annual flows to the reclamation facility total about 9.3 mgd. Recycled water from the VWRF is used for general irrigation of the two golf courses, a City park and landscape irrigation areas located along the existing distribution alignment. A portion of the effluent is

pumped to these reclaimed water customers and a portion is lost to evaporation and percolation losses. The remaining effluent is discharged to the SCRE.

WASTEWATER CHARACTERISTICS AND FACILITIES

3.1 WASTEWATER ENTITIES AND FACILITIES

The City owns and operates the VWRF, which discharges tertiary treated municipal wastewater to the SCRE just south of the City near the mouth of the Santa Clara River. The location of the VWRF is shown in Figure 3.1.

The City provides sewer service to approximately 98 percent of City residences. The total area served includes a population over 109,000. Wastewater collection and treatment for McGrath State Beach Park and the North Coast Communities are also provided.

Approximately 9 million gallons (MG) of wastewater are generated per day and are carried by more than 375 miles of sewer mains and 14 lift stations to the VWRF.

3.1.1 Wastewater Facilities

The VRWF provides tertiary wastewater treatment for the community with processes consisting of screenings and grit removal, primary sedimentation, flow equalization, activated sludge nitrification and denitrification, tertiary filters, ammonia addition, and chlorination. The VRWF currently treats approximately 9.3 million gallons per day (mgd) of influent annual flow. In addition, solids processing consists of a primary sludge thickener, dissolved air flotation (DAF) secondary sludge thickener, anaerobic digestion, and dewatering. Figure 3.2 presents a schematic of the existing treatment plant processes.

Treated wastewater is conveyed to a 20-acre system of wildlife ponds prior to final discharge to the SCRE. Prior to entering the ponds, a portion of the treated wastewater is diverted as recycled water for landscape irrigation by several users. The remaining treated wastewater is conveyed via the effluent transfer station (ETS) to the wildlife ponds and flows from west to east through “Bone,” “Snoopy,” and “Lucy.” The effluent is discharged through the outfall junction structure (OJS) to the SCRE via an effluent channel.

3.1.2 Existing and Projected Wastewater Flows

The City evaluated the VWRF and determined future flow projections in its 2010 Wastewater Master Plan (Kennedy Jenks, 2010). A summary of the City’s existing and projected average dry weather influent wastewater flows are shown in Table 3.1, based on the Master Plan. Wastewater flow projections were developed in the Master Plan for near-term, and ultimate development levels. The ultimate buildout projection is for 13 mgd of influent flow assuming flows from the City service area as well as other tributary areas.

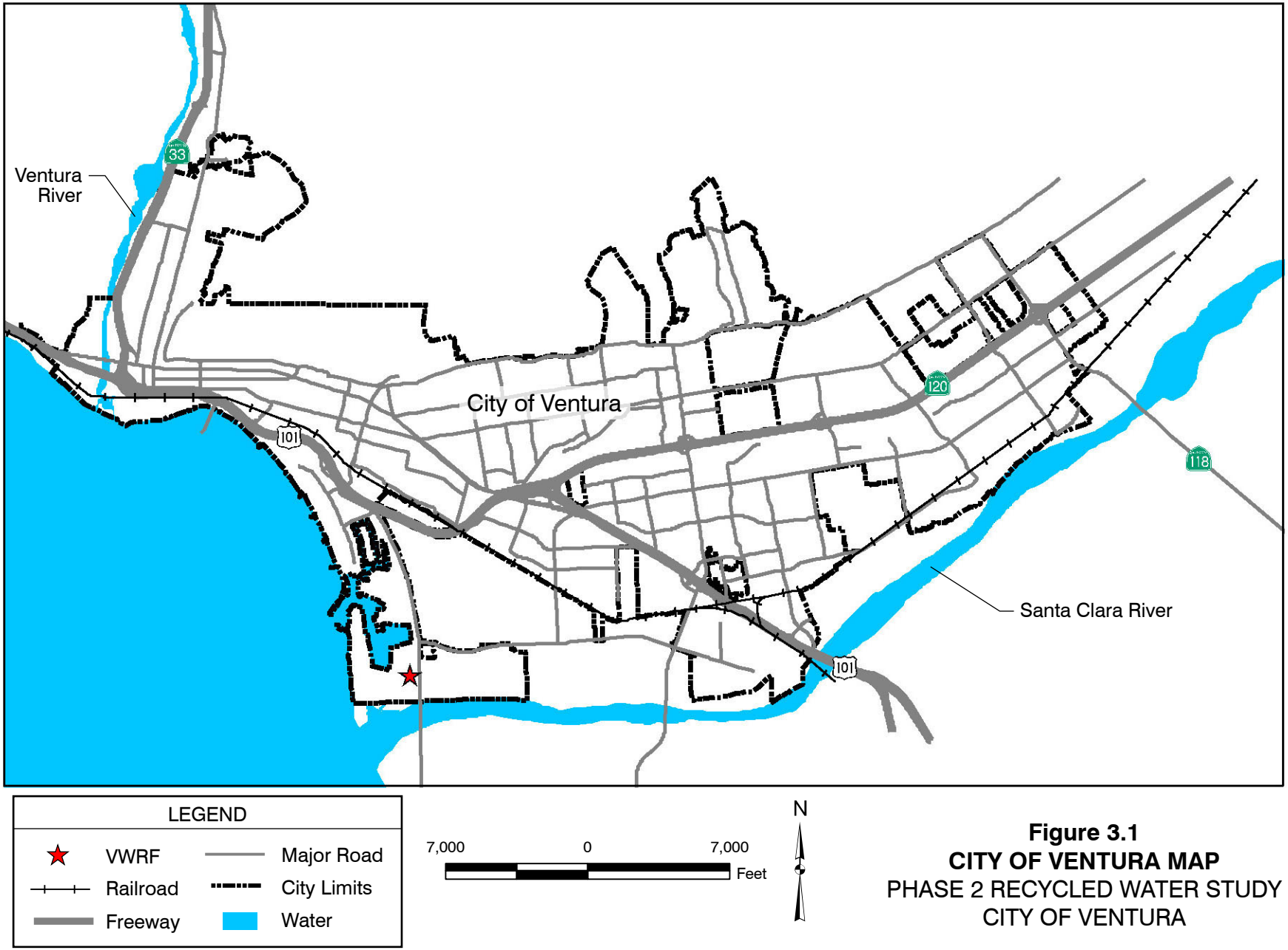

Figure 3.1
CITY OF VENTURA MAP
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

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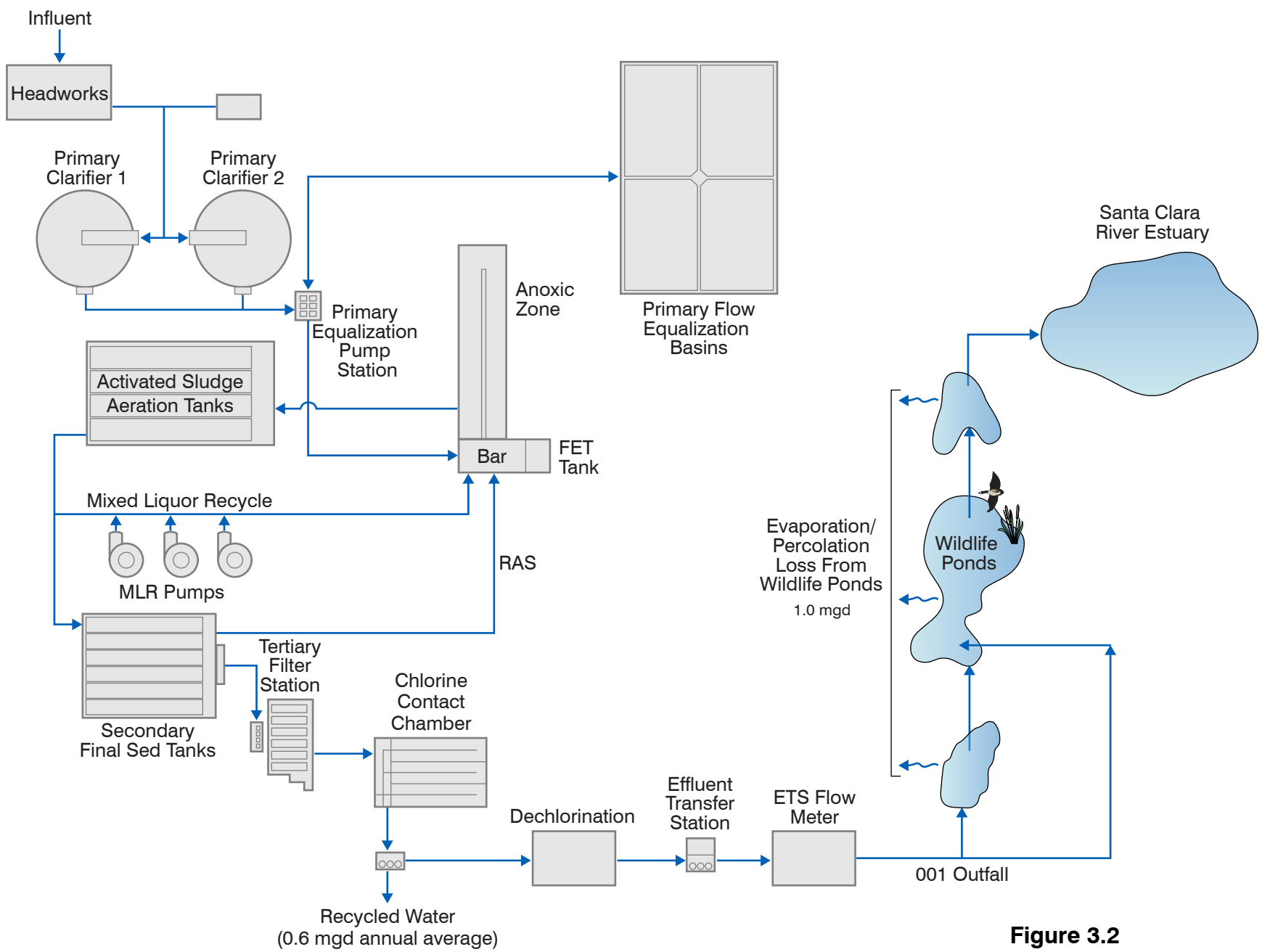

Figure 3.2
PROCESS FLOW SCHEMATIC
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

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Also shown in Table 3.1 is the current influent flows which are lower than flows during the development of the Master Plan. The other tributary area projections are shown in Table 3.2, including existing and anticipated flows from McGrath State Beach Park, the North Coast Communities, the Montalvo Municipal Improvement District, and the Saticoy Sanitary District.

Table 3.1 Historic and Projected Average Dry Weather Influent Flows
Phase 2 Recycled Water Study
City of Ventura

Development Condition	Study Area Flow, mgd	Other Tributary Areas, mgd	Total Flow, mgd
2004-2006 flow monitoring (1)	9.3	0.1	9.4
2010-11 average influent flow (2)	NA	NA	8.8
Near Term(1)	11.1	0.3	11.4
General Plan Buildout(1)	12.6	0.4	13.0

Notes:
(1) Based on 2010 Wastewater Master Plan.
(2) Based on 2010-2011 influent flow meter data.

Table 3.2 Outside Sources of Wastewater Flows
Phase 2 Recycled Water Study
City of Ventura

Tributary Area	Existing gpd	Near Term gpd	Ultimate gpd
McGrath(1)	5,000	21,000(2)	21,000 (2)
North Coast (3)	56,760	56,760 (3)	73,330 (4)
Montalvo	0	250,000 (5)	250,000 (6)e
Saticoy	0	0	50,000 (6)
Total	**61,760**	**327,7760**	**394,330**

Source – 2010 Wastewater Master Plan.
Notes:
(1) City's estimate of existing flows.
(2) From Sewerage Agreement.
(3) Average daily flow from monthly totals provided by the City from Jan 2002 to Aug 2007.
(4) From Sewerage Agreement (2.2 MG/month).
(5) Per January 2, 2007 letter from City.

Although the most recent VWRF flows are less than shown in the Master Plan report for existing flows, it was decided for the purposes of this report that the ultimate projection of 13 mgd was the best available information for potential future flows. Therefore, this buildout flow is used in subsequent chapters in determining available water supply for recycled water as well as for determining effluent discharge volumes.

3.2 EXISTING RECYCLED WATER

3.2.1 Recycled Water Facilities

The VWRF produces recycled water that has undergone tertiary filtration and disinfection, meeting the requirements of Title 22 for unrestricted reuse. This water is pumped into a pressurized recycled water system network. Figure 3.3 shows the alignment of the existing recycled water pipeline and the locations of recycled water meters, used to quantify use by the recycled water customers.

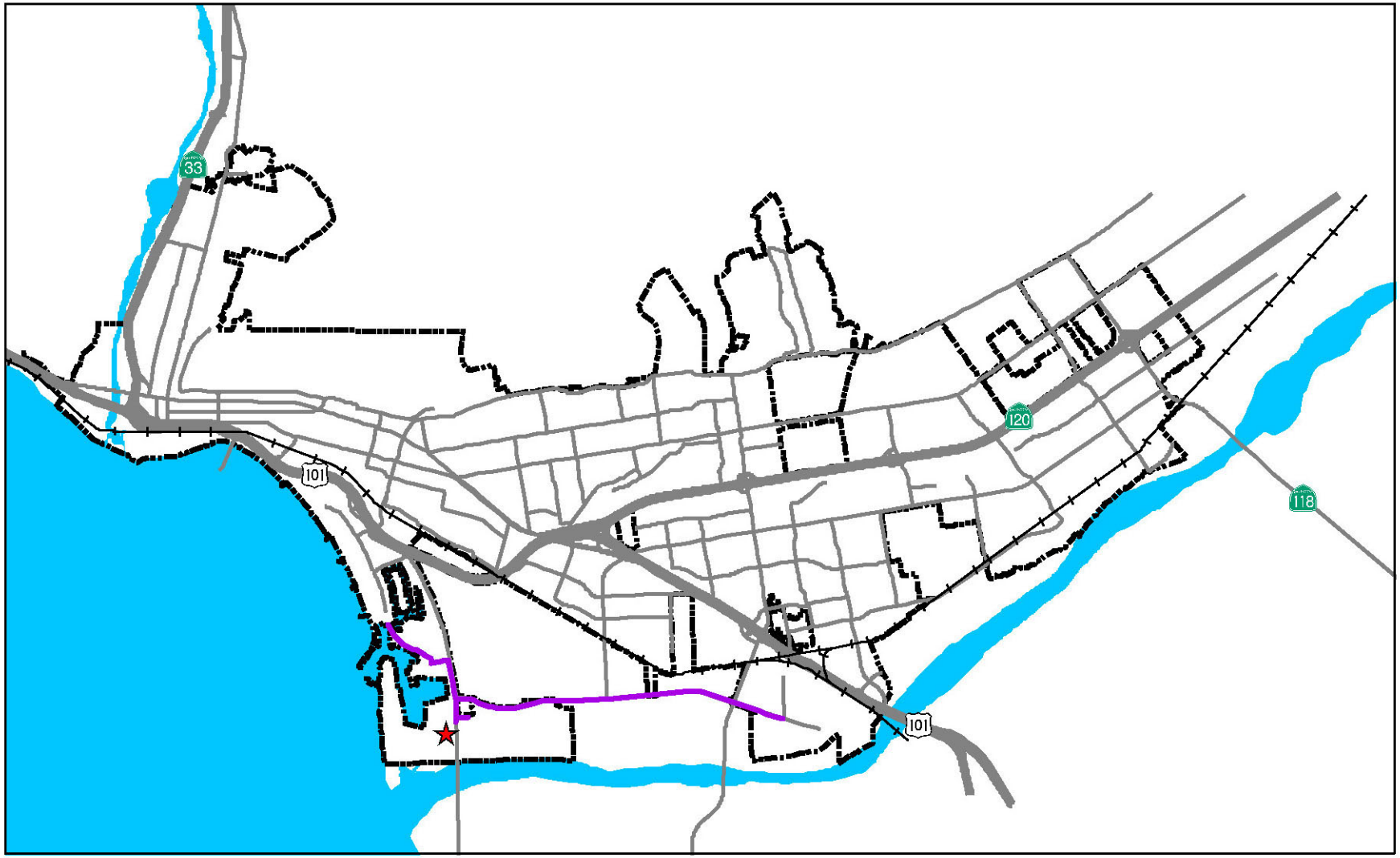
The existing recycled water system pipeline network consists of a 12-inch pipeline that extends west from the VWRF along Olivas Park Drive and a 4-inch pipeline that extends north from the VWRF to the Marina Park. The existing recycled water pump station provides pressurized water through these pipelines.

3.2.2 Current Users and Demands

Recycled water from the VWRF is used for general irrigation of golf courses, parks and similar landscape areas. Existing recycled water customers include:

- BuenaVentura Golf Course
- Olivas Links Golf Course
- MBL Golf Course LLC
- Harbortown Point HOA
- Vta Port District
- Harbor Island Hotel Grp LP
- Harbor Island Hotel
- Ventura Port District
- Marina Park
- Michael Viola
- MBL Olivas LLC
- MBL Olivas Project LLC
- Olivas Adobe

Figure 3.4 presents the total historical monthly average demands from 2009 through 2012. The recycled water demand varies with seasonally with minimum demands in the winter and maximum demands in the summer. Monthly demands range from approximately 0.06 mgd to 1 mgd, with an average demand of 0.5 mgd.



LEGEND

VWRF

Existing Recycled Water Pipeline

7,000 0 7,000 Feet

N

Figure 3.3
ALIGNMENT OF EXISTING RECYCLED WATER SYSTEM NETWORK
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

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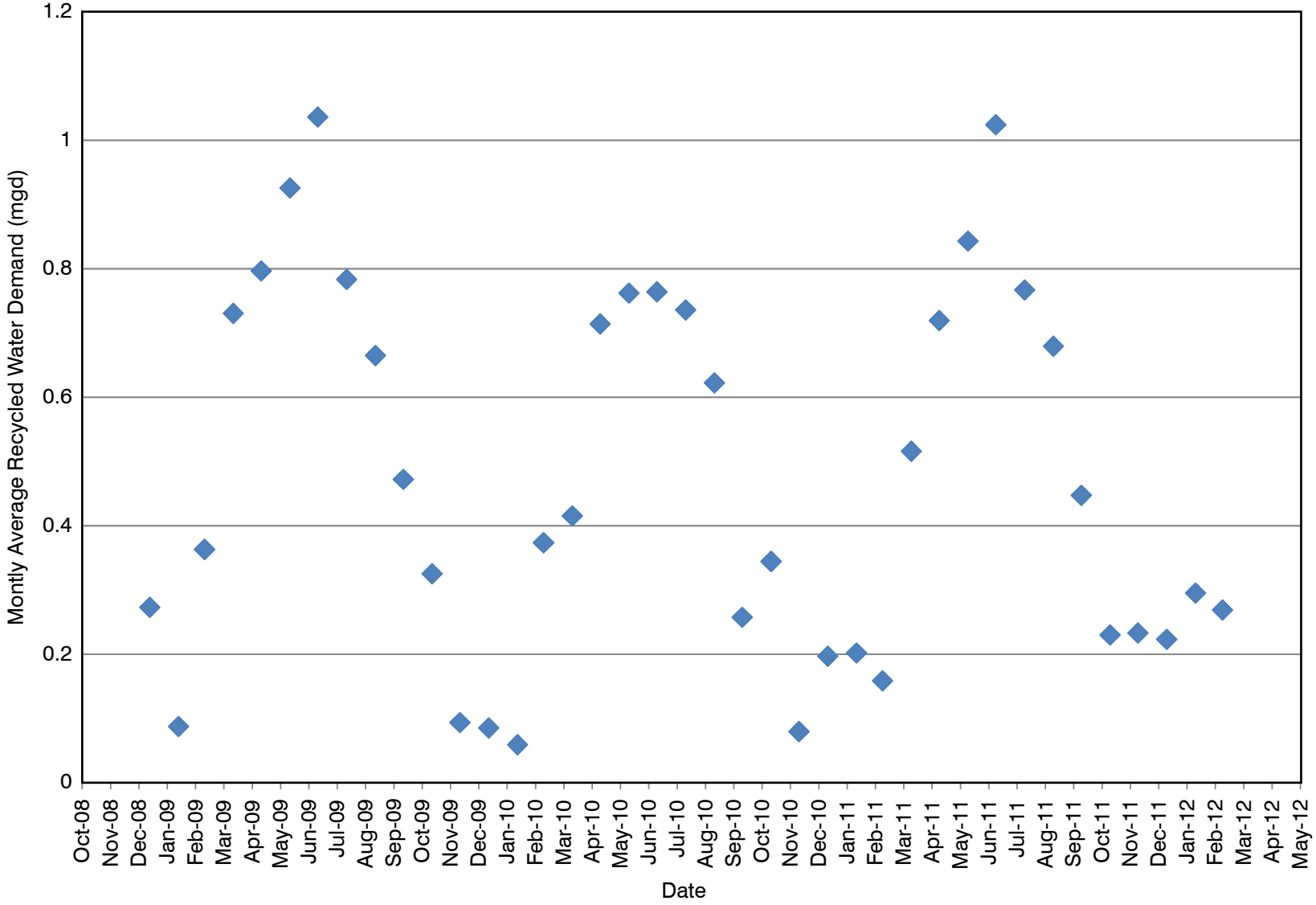

Figure 3.4
RECYCLED WATER DEMANDS FROM 2009 THROUGH 2012
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

ven113f7-8144.ai

3.3 RECYCLED WATER RIGHTS

The City owns the rights to their tertiary effluent and is able to enter into agreements with potential recycled water users, as needed. No other entities claim the rights to the City's recycled water.

3.4 POTENTIAL SOURCES OF RECYCLED WATER

The current source for recycled water for the City is water from the service area and treated by the VRWF. As discussed in section 3.2, the VWRF service area may be expanded in the future to incorporate smaller wastewater service areas (Montalvo and Saticoy). Flows from these areas would be routed to the VWRF for treatment. The VWRF already produces tertiary treated water that meets Title 22 requirements for unrestricted reuse and has adequate capacity to incorporate these additional flows.

The alternatives being considered in this report (see Chapters 6 and 7) include options to provide advanced treatment for reducing TDS and chloride for specific crop water quality needs as well as for potential groundwater recharge. Satellite or decentralized treatment plants located nearer to potential uses is also under consideration. These options would require new treatment facilities to be constructed to meet reuse requirements. The specific details on the additional treatment needed for each alternative are discussed in Chapters 6 and 7.

Chapter 4

REGULATORY REQUIREMENTS

4.1 OVERVIEW OF REGULATORY REQUIREMENTS

Wastewater discharges are governed by both federal and state requirements. The primary laws regulating water quality are the Clean Water Act (CWA) and the California Water Code. The primary regulation governing recycled water use is the California Water Code Regulations, Title 22 (Title 22).

Under the CWA, the Environmental Protection Agency (EPA) or a delegated State agency regulates the discharge of pollutants into waterways through the issuance of National Pollutant Discharge Elimination Systems (NPDES) permits. NPDES permits set limits on the amount of pollutants that can be discharged into the waters of the United States. The California Water Code and the Porter-Cologne Act, a provision of the Water Code, require the State to adopt water quality policies, plans, and objectives for the protection of the State's waters. The State Water Resources Control Board (SWRCB) and the nine Regional Water Quality Control Boards (RWQCBs) meet this requirement by establishing water quality criteria in regional Basin Plans, the Inland Surface Waters, Enclosed Bays and Estuaries Plan, the Thermal Plan, and the Ocean Plan. The SWRCB and the RWQCBs also have regulatory authority along with the California Department of Public Health (CDPH) over projects using recycled water.

The SWRCB establishes general policies governing the permitting of recycled water projects consistent with its role of protecting water quality and sustaining water supplies. The SWRCB also exercises general oversight over recycled water projects, including review of RWQCB permitting practices. The DPH is charged with protection of public health and drinking water supplies and with the development of uniform water recycling criteria appropriate to particular uses of water. The RWQCB is charged with protection of surface and groundwater resources and with the issuance of permits that implement DPH recommendations.

The VWRF is located in the Los Angles Region, and therefore the LARWQCB has authority to issue permits for wastewater discharge and recycled water use. The VWRF currently discharges to the Santa Clara River Estuary under existing NPDES permit (CA0053651) which was adopted by the LARWQCB on March 6, 2008. The NPDES permit is currently under review for a 2013 permit renewal. The VWRF also currently produces Title 22 tertiary quality water that is used for local landscape irrigation that is regulated by a separate Waste Discharge Requirements and Waster Recycling Requirements Order No. 87-45, CI No. 6190.

4.2 WASTEWATER DISCHARGE REQUIREMENTS

The VWRF's existing 2008 NPDES permit establishes discharge limits for conventional constituents, nutrients, metals, and organics. These limits are established to be protective of aquatic life and other beneficial uses of the receiving water. Table 4.1 provides a list of conventional constituents and metals, respectively, along with their permit limit.

Table 4.1 VWRF NPDES Permit Limits
Phase 2 Recycled Water Study
City of Ventura

Constituent (Units)	Averaging Period	Permit Effluent Limits
BOD_5 (mg/L)	Monthly	20
Total Suspended Solids (mg/L)	Monthly	15
Turbidity (NTU)	24-hour	<2
Total Coliform (MPN/100 mL)	7 day median	<2.2
Total Residual Chlorine (mg/L)	Monthly	0.1
pH	Instantaneous Minimum and Maximum	6.5 to 8.5
Ammonia Nitrogen (mg/L)	Monthly	0.045 May-Oct 0.079 Nov-Apr
Nitrate + Nitrite as Nitrogen (mg/L)	Monthly	10
Nitrite as Nitrogen (mg/L)	Monthly	1
Nitrate as Nitrogen (mg/L)	Monthly	10
Copper (µg/L)	Monthly	6.7
Mercury (µg/L)	Monthly	0.051
Silver (µg/L)	Monthly	0.71
Zinc (µg/L)	Monthly	45

In addition to the discharge limits on the constituents, nutrients, and metals provided above, there are additional receiving water and groundwater limitations that are required to be met based on water quality objectives contained in the Basin Plan. These additional limitations are listed in the NPDES permit.

4.3 RECYCLED WATER REGULATIONS

The SWRCB and the RWQCBs have regulatory authority along with the California Department of Public Health (CDPH) over projects using recycled water. The following sections summarize existing regulations that govern recycled water systems. The types of

recycled water under consideration include urban irrigation, agricultural irrigation, indirect potable reuse (groundwater recharge) and direct potable reuse.

4.3.1 Title 22 of the California Code of Regulations

CDPH is the State primary agency responsible for the protection of public health, the regulation of drinking water, and the development of uniform water recycling criteria appropriate to particular uses of water. CDPH has promulgated regulatory criteria in Title 22, Division 4, Chapter 3, Section 60301 et seq., California Code of Regulations (Title 22). Additional information on recycled water regulations and a link to Title 22 of the CCR can be found at http://www.cdph.ca.gov/CERTLIC/DRINKINGWATER/Pages/Lawbook.aspx.

Title 22 regulations define four types of recycled water determined by the treatment process and total coliform, bacteria, and turbidity levels. The four treatment types of recycled water that are currently permitted by CDPH under Title 22 regulations are summarized in Table 4.2.

Table 4.2 Approved Uses of Recycled Water
Phase 2 Recycled Water Study
City of Ventura

Treatment Level	Approved Uses	Total Coliform Standard (median)
Disinfected Tertiary Recycled Water	Spray Irrigation of Food Crops	2.2 / 100 ml
	Landscape Irrigation(1)	
	Nonrestricted Recreational Impoundment	
Disinfected Secondary - 2.2 Recycled Water	Surface Irrigation of Food Crops	2.2 / 100 ml
	Restricted Recreational Impoundment	
Disinfected Secondary - 23 Recycled Water	Pasture for Milking Animals	23 / 100 ml
	Landscape Irrigation(2)	
	Landscape Impoundment	
Undisinfected Secondary Recycled Water	Surface Irrigation of Orchards and Vineyards(3)	N/A
	Fodder, Fiber and Seed Crops	

Notes:
(1) Includes unrestricted access golf courses, parks, playgrounds, school yards, and other landscaped areas with similar access.
(2) Includes restricted access golf courses, cemeteries, freeway landscapes, and landscapes with similar public access.
(3) No fruit is harvested that has come in contact with irrigating water or the ground.

4.3.2 Recycled Water State Policy

The SWRCB recognizes that a burdensome and inconsistent permitting process can impede the implementation of recycled water projects. The SWRCB adopted a Recycled Water Policy (RW Policy) in 2009 to establish more uniform requirements for water recycling throughout the State and to streamline the permit application process in most instances.

The RW Policy includes a mandate that the State increase the use of recycled water over 2002 levels by at least 200,000 AFY by 2020 and by at least 300,000 AFY by 2030. Also included are goals for stormwater reuse, conservation and potable water offsets by recycled water. The onus for achieving these mandates and goals is placed both on recycled water purveyors and potential users.

Absent unusual circumstances, the RW Policy puts forth that recycled water irrigation projects that meet CDPH requirements, and other State or Local regulations, be adopted by Regional Boards within 120 days. These streamlined projects will not be required to include a monitoring component.

The RW Policy requires that salt/nutrient management plans for every basin in California be developed and adopted as Basin Plan Amendments by 2015. These Management Plans will be developed by local stakeholders and funded by the regulated community. Salt/nutrient management plans have not yet been developed in the Ventura area but are under initial development.

The SWRCB Staff has proposed an amendment to the RW Policy to add monitoring requirements for constituents of emerging concern (CECs) in recycled water. In 2009, in accordance with the Recycled Water Policy, the State Water Board convened a science advisory panel (Panel) to provide guidance on future actions related to monitoring CECs in recycled water. This Panel submitted a report titled: “Monitoring Strategies for Chemicals of Emerging Concern in Recycled Water – Recommendations of a Science Advisory Panel” (Panel Report). The Panel Report provided recommendations for monitoring specific CECs in recycled water used for groundwater recharge reuse. For recycled water used for landscape irrigation, the Panel did not recommend monitoring of CECs, but recommended monitoring of some surrogates. The State Water Board incorporated the Panel’s recommendations into a proposed amendment to the Recycled Water Policy, which consists of two parts. The first part revises the original Recycled Water Policy. The second part is a new Attachment A for the Recycled Water Policy. After a series of public workshops and public comment periods, the proposed amendment is now scheduled for consideration of adoption during the January 22, 2013, board meeting.

4.3.3 Groundwater Recharge Requirements

The CDPH published new draft regulations related to the replenishment of groundwater with recycled municipal wastewater (CDPH, 2011). The draft regulations were made

available to the public on November 21, 2011. The phrase “Groundwater Replenishment Reuse Project,” or GRRP, is now a defined term meaning a project using recycled municipal wastewater for the purpose of replenishment of groundwater that is designated a source of water supply in a Water Quality Control Plan, or which has been identified as a GRRP by the Regional Water Quality Control Board (RWQCB). GRRPs can employ surface spreading basins or subsurface injection methods, and there are separate regulations described for both methods. Both methods are considered to be “indirect potable reuse (IPR)”. On or before December 31, 2013, the State department shall adopt uniform water recycling criteria for indirect potable reuse for groundwater recharge. Until that time, the draft regulations are used to implement projects.

Full advanced treatment (FAT) is defined in the draft CDPH regulations as “the treatment of an oxidized wastewater […] using a reverse osmosis and an oxidation treatment process […]”. According to the draft CDPH regulations, FAT is the required treatment process for groundwater augmentation using direct injection, unless an alternative treatment has been demonstrated to CDPH as providing equal or better protection of public health and has received written approval from CDPH. Surface spreading requires treatment to tertiary recycled water standards.

The draft CDPH regulations for GRRPs also require a minimum “response retention time” or minimum groundwater travel time of two months. Groundwater travel time can be estimated by various methods, including intrinsic tracer studies, numerical modeling, or analytical modeling. Depending on the method used, the “response time credit” is discounted by a factor of 0.67 (for tracer tests) to 0.25 (for analytical modeling). The more rigorous the estimating approach, the more advantageous the discounting factor.

For many potable reuse projects in California, the purified recycled water is diluted with other potable water supplies prior to injection into the groundwater. The draft CDPH regulations require that the ratio of purified recycled water to the total injected water, known as the recycled water contribution (RWC), be determined periodically, and that it is not to exceed a value determined during the CDPH’s review of the engineering report and the results of public hearings (Article 5.2, Section 60320.216). Only water that is either a CDPH-approved drinking water, or meets certain quality criteria (e.g., does not exceed primary or secondary MCLs or notification levels) may be used as diluents water (Article 5.2, Section 60320.216). The new draft regulations allow, however, the RWC to be 100% if it can be demonstrated that sufficient protections are afforded within the total project design and proposed operational scheme.

Table 4.3 summarizes the key regulatory requirements for groundwater recharge or IPR projects as established by the 2011 Draft Groundwater Recharge Regulations. The draft regulation and additional information can found at http://www.cdph.ca.gov/healthinfo/environhealth/water/pages/waterrecycling.aspx .

Table 4.3	Summary of CDPH Recycled Water 2011 Draft Regulations for Groundwater Recharge Phase 2 Recycled Water Study City of Ventura	
	Type of Recharge	
	Surface Applications	**Subsurface Applications**
Treatment	Disinfected tertiary	100% RO and AOP treatment for the entire waste stream
Retention time(1)	Minimum 2 months (however addition treatment may be required for < 6 months)	Minimum 2 months
Recycled Water Max Initial Contribution (RWC_{max})	Up to 20% disinfected tertiary Up to 100% with RO & AOP	Up to 100% with RO & AOP
Total Nitrogen	Average <5 mg/L, Max 10 mg/L	
Total Organic Carbon	Mound < 0.5 mg/L ÷ RWC	< 0.5 mg/L
Dilution water compliance calculation	Based on 120-month running average	

Notes:
RO – reverse osmosis
AOP- advanced oxidation process
mg/L – milligrams per liter
(1) Must be verified by a tracer study.

4.3.4 Direct Potable Reuse

Direct potable reuse (DPR), is the incorporation of purified recycled water directly into the raw water supply of a community without the use of an environmental buffer such as an aquifer or a surface water. Thus, DPR allows for potable reuse and avoids the problems related to groundwater injection and extraction. DPR has become a reality in the United States, with two projects now starting operation (Big Springs Texas and Cloudcroft New Mexico). In California, the state legislature has directed the CDPH to develop a regulatory framework for DPR by December 31, 2016. Further, there is ongoing research on how to properly implement DPR projects in California and nationally. It is anticipated that treatment technologies similar to FAT will be required for DPR and online monitoring will be a critical component of DPR.

4.4 WATER QUALITY-RELATED REQUIREMENTS

Water quality related requirements of the RWQCB to protect surface or groundwater from problems resulting from recycled water use are discussed herein. Potential groundwater quality impacts is a considerations for this project since the City overlays one of the main

drinking water basins, the Mound Basin. In addition, several of the alternatives being considered propose to recharge one of the several groundwater basins in the study area.

4.4.1 Specific Water Quality Requirements

Specific water quality requirements may be established based on the specific use of recycled water or based on the objectives established in the Basin Plan to be protective of the groundwater.

For agricultural reuse applications, advanced treatment for TDS and chloride would be required to meet crop specific water quality thresholds. Strawberries are the most sensitive crop (grown in the study area) to chloride concentrations in irrigation water. The Upper Santa Clara River Chloride TMDL, established a maximum chloride concentration of 117 mg/L to be protective of agricultural beneficial uses (irrigation of salt sensitive crops) (LARWQCB Final Basin Plan Amendment (TMDL), 2008).

In addition, there are specific water quality objectives established in the Basin Plan, including the several relevant objectives discussed herein. The water quality objectives for the Oxnard Forebay include TDS and chloride concentrations of 1200 mg/L and 150 mg/L , respectively. The on going development and adoption of a Salt and Nutrient Management Plan for the Lower Santa Clara River will result in a Basin Plan amendment that could establish water quality requirements for recycled water projects.

4.4.2 Incidental Runoff

The City's recycled water permit will establish requirements to prevent runoff of recycled water into surface water bodies. The RW Policy defines incidental runoff as unintended small amounts of runoff from recycled water use areas, such as unintended, minimal over-spray from sprinklers that escapes the recycled water use area. Water leaving a recycled water use area is not considered incidental if it is part of the following:

- Facility Design.
- Excessive Application.
- Intentional Overflow or Application.
- Negligence.

Incidental runoff may be regulated by waste discharge requirements, or when necessary, through a NPDES permit. Regardless of the regulatory instrument, the project shall include the following practices:

- Implementation of an operations and management plan that provides for detection of leaks, and correction within 72 hours of learning of the runoff, or prior to the release of 1,000 gallons, whichever occurs first.
- Proper design and aim of sprinkler heads.

- Refraining from application during precipitation events.
- Management of any ponds containing recycled water such that no discharge occurs unless discharge is a result of a 25-year, 24-hour storm event or greater, and there is notification of the appropriate Regional Water Board Executive Officer of the discharge.

4.4.3 Title 22 Use Area Requirements

Title 22 has two main requirements that could affect a project and will need to be considered during the design phase. There are a number of drinking water wells that exist throughout the study area owned by the City. Per Title 22, no irrigation with disinfected tertiary recycled water shall take place within 50 feet of any domestic water supply well unless the well meets certain criteria such as:

- An annular seal.
- Well housing to prevent recycled water spray from contacting the wellhead.
- The City approves of the elimination of the buffer zone, etc.

Also per Title 22, no impoundment of disinfected tertiary recycled water shall occur within 100 feet of any domestic water supply well. This will need to be considered during design.

4.4.4 General Irrigation Use Guidelines

Water quality guidelines for general landscape irrigation are based on practical limits for using different types of irrigation approaches as well as the tolerance of various plants for specific constituents found in irrigation water. Table 4.4 includes a comparison of constituent guidelines/criteria and the VWRF recycled water quality.

The constituents that can impact use of recycled water for general landscape irrigation primarily include minerals and nutrients. The shaded criteria ranges in Table 3 indicate that the VWRF effluent concentrations fall within the shaded range. In general, comparison of most constituents suggests that there may be slight restrictions in the use of VWRF effluent for general landscape irrigation. The SAR level and hardness concentrations indicate that there could be severe restrictions for landscape irrigation use. However, existing use of the VWRF effluent for landscape irrigation suggests that the water quality is sufficient for this type of use.

Table 4.4 Comparison of VWRF Effluent with Irrigation Water Quality Criteria
Phase 2 Recycled Water Study
City of Ventura

Parameter	Units	Established Criteria: Degree of Use Restriction[1,2] None	Slight	Severe	VWRF Effluent (Median Value)[4]
Salinity					
Electrical Conductance	µS/cm	<700	700-3000	>3000	2240
Total Dissolved Solids (TDS)	mg/L	<450	450-2000	>2000	1489
Permeability					
SAR[3] = 0 - 3 and EC		700	700-200	<200	
= 3 - 6 and EC		≥1200	1200-300	<300	
= 6 - 12 and EC		≥1900	1900-500	<500	SAR = 10.1, EC = 2240
= 12 - 20 and EC		≥2900	2900-1900	<1900	
= 20 - 40 and EC		≥5000	5000-2900	<2900	
Sodium					
Root Absorption	SAR	<3	3-9	>9	10.1
Foliar Absorption	mg/L	<70	>70	-	258
Chloride					
Root Absorption	mg/L	<140	140-355	>365	290
Foliar Absorption	mg/L	<100	>100	-	290
Boron	mg/L	<0.7	0.7-3.0	>3.0	0.7
Total Alkalinity (as $CaCO_3$)	mg/L	<90	90-500	>500	201
pH	–	6.5-8.4 (normal range)			7.3
Ammonia (NH_4-N)	mg/L	(see total N values below)			1.4
Nitrate (NO_3-N)	mg/L	(see total N values below)			14.6
Nitrate (NO_2-N)	mg/L	(see total N values below)			-
Total Nitrogen	mg/L	<5	5-30	>30	17.6
Hardness (as $CaCO_3$)[5]	mg/L	<90	90-500	>500	701

Notes:
(1) Adapted from University of California Committee of Consultants (1974) and Water Quality for Agriculture (Ayers and Westcot 1985).
(2) Definition of the "Degree of Use Restriction" terms:
None = Reclaimed water can be used similar to the best available irrigation water
Slight = Some additional management will be required above that with the best available irrigation water in terms of leaching salts from the root zone and/or choice of plants
Severe = Typically cannot be used due to limitations imposed by the specific parameters
(3) SAR = Sodium absorption ratio. SAR is a ratio of the sodium concentration to the calcium and magnesium concentrations.
(4) Median VWRF concentrations based on data from 2006 through 2008
(5) Presence of bicarbonate can result in unsightly foliar deposits.

In addition, there are operational techniques for the use of recycled water for landscape irrigation that can improve and sustain a specific use. The successful long-term use of irrigation water depends on rainfall, leaching, soil drainage, irrigation water management, salt tolerance of plants, soil management practices, as well as water quality. Since salinity problems may eventually develop from the use of any water, the following guidelines are given, should they be needed, to assist water users to better manage salinity:

- Irrigate more frequently to maintain an adequate soil water supply.
- Select plants that are tolerant of an existing or potential salinity level.
- Routinely use extra water to satisfy the leaching requirements and to drive salts below the root zone.
- If possible, direct the spray pattern of sprinklers away from foliage. To reduce foliar absorption, try not to water during periods of high temperature and low humidity or during windy periods. Change time of irrigation to early morning, late afternoon, or night.
- Maintain good downward water percolation by using deep tillage or artificial drainage to prevent the development of a perched water table.
- Salinity may be easier to control under sprinkler and drip irrigation than under surface irrigation. However, sprinkler and drip irrigation may not be adapted to all qualities of water and all conditions of soil, climate, or plants.

RECYCLED WATER MARKET

5.1 RECYCLED WATER MARKET ASSESSMENT

There have been several efforts to quantify potential recycled water opportunities in the last few years. In addition to this project, the following reports provide additional information:

- Recycled Water Market Study Phase 1 Report (Carollo, March 2010) http://www.cityofventura.net/files/file/public-works/Recycled%20Water%20Market%20Study_Final,March2010.pdf
- Treatment Wetlands Feasibility Study (Carollo, March 2010) http://www.cityofventura.net/files/file/public-works/Treatment%20Wetlands%20Feasibility%20Study%20Report_Final,March2010.pdf
- Potential Recycled Water Market within the City of Ventura (K/J, 2007)
- Phase 1 Recycled Water Master Plan for the City of Oxnard (K/J, 2009).
- Draft Ventura-Oxnard Recycled Water Interconnect Feasibility Study (K/J, 2012)

5.1.1 2010 Recycled Water Market Assessment

The recycled water opportunities within a 5-mile radius from the VWRF were evaluated in the Recycled Water Market Study Phase 1 Report (Phase 1 Recycled Water Report), dated March 2010. The March 2010 study used GIS layers including land use and planning designations, and City water billing records, to do an initial assessment of the different types of potential recycled water use in the 5 mile radius from the VWRF. In addition, the previous studies were referenced and used in the development of the Phase 1 Report. The following three types of potential recycled water usage were identified in the study area:

- Urban Uses - These uses include general landscape irrigation of parks, golf courses, recreational fields, municipal areas, churches, roadway medians, cemeteries, and other landscaped areas. In addition, these uses include commercial entities and industries.
- Agricultural Uses - This use involves spray or drip irrigation of various types of crops grown in the region.
- Groundwater Recharge - This use involves percolation or injection of recycled water into underlying groundwater aquifers. This study focused on the potential for groundwater recharge at the United Water Conservation District (UWCD) Facilities, where the groundwater recharge via spreading ponds (i.e. percolation) is currently practiced. While UWCD is located more than 5 miles from the VWRF, the Phase 1

Recycled Water Study focused on this opportunity because of the existing facilities, an existing source of diluent water, and potential available capacity.

The results presented in the Phase 1 Recycled Water Report are shown in Table 5.1 and in Figures 5.1, 5.2 and 5.3. These results were used as a starting point for this study, which focused on investigating these options and others in more detail.

Table 5.1 Summary of Urban Irrigation, Agricultural Irrigation and Groundwater Recharge Opportunities (as presented in Phase 1 Recycled Water Report) Phase 2 Recycled Water Study City of Ventura

Recycled Water Use	Potential Demand (mgd)	Cost (millions of dollars)	Treatment Requirements	Challenges
Urban Irrigation	2.2 Annual Ave 3.7 Max Month	62	None	• Demand varies seasonally (1 mgd in winter to 3.7 in summer) • Extensive pipeline network • Feasibility of serving the River Ridge Golf Course is unknown
Agricultural Irrigation	6.5 Annual Ave 11 Max Month	145	MF and RO	• Demand varies seasonally (1.6 in winter to 11 in summer) • Requires brine treatment and disposal • Requires conversion of wildlife ponds to recycled water storage reservoirs • Requires agreement by growers
Groundwater Recharge at UWCD	7 Annual Ave 12.6 Max Month	36 (1)	Possibly MF and RO	• Assuming a partial year diversion scenario the demand varies seasonally with more potential in fall, winter and spring (ranges from 0 mgd in summer to 12.6 winter) • May require additional treatment (MF/RO and brine treatment • Requires agreement with UWCD • Requires long term monitoring effort

Note:

This is a minimum cost because treatment costs for TDS and chloride removal are not included.

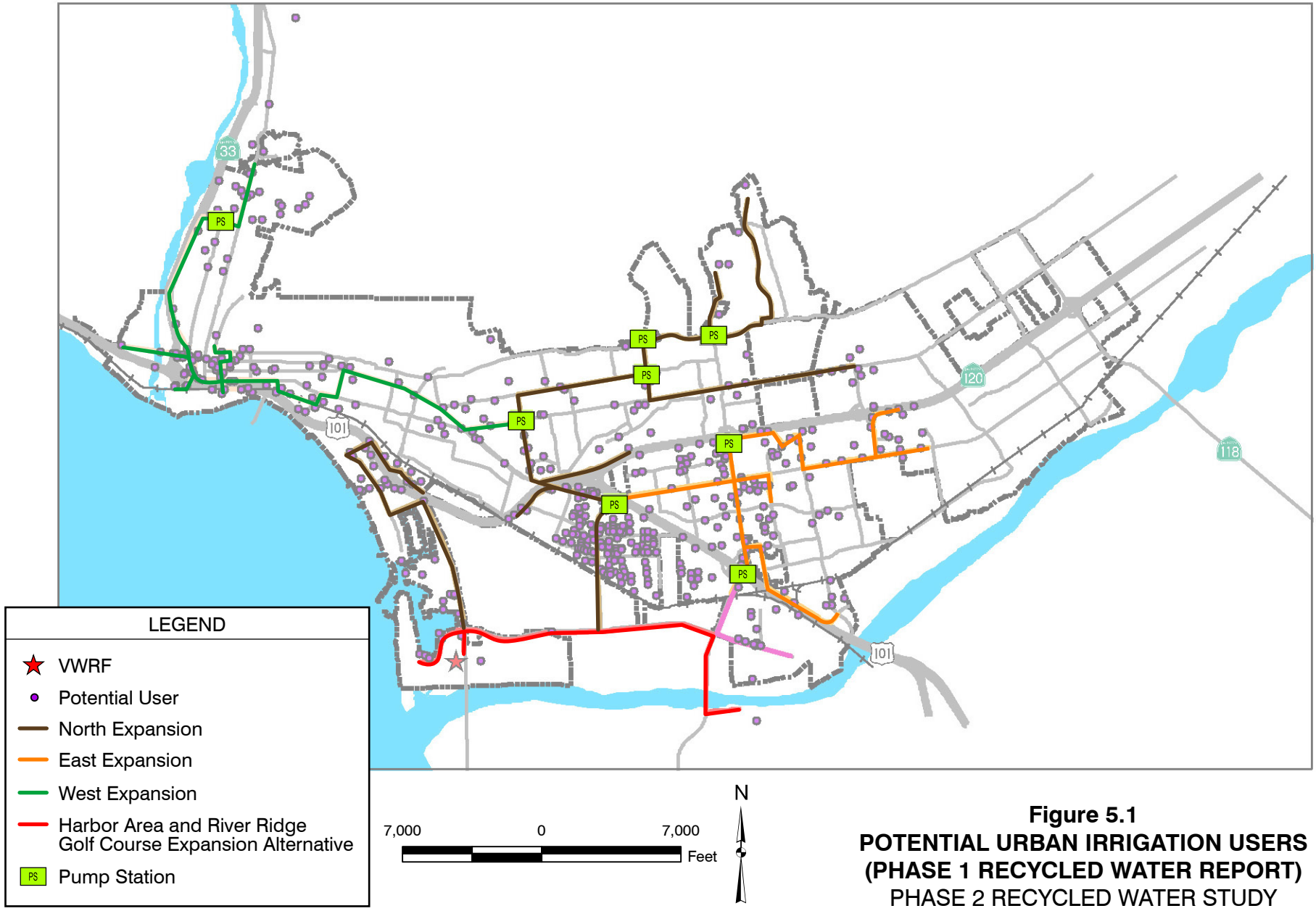

Figure 5.1
POTENTIAL URBAN IRRIGATION USERS
(PHASE 1 RECYCLED WATER REPORT)
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

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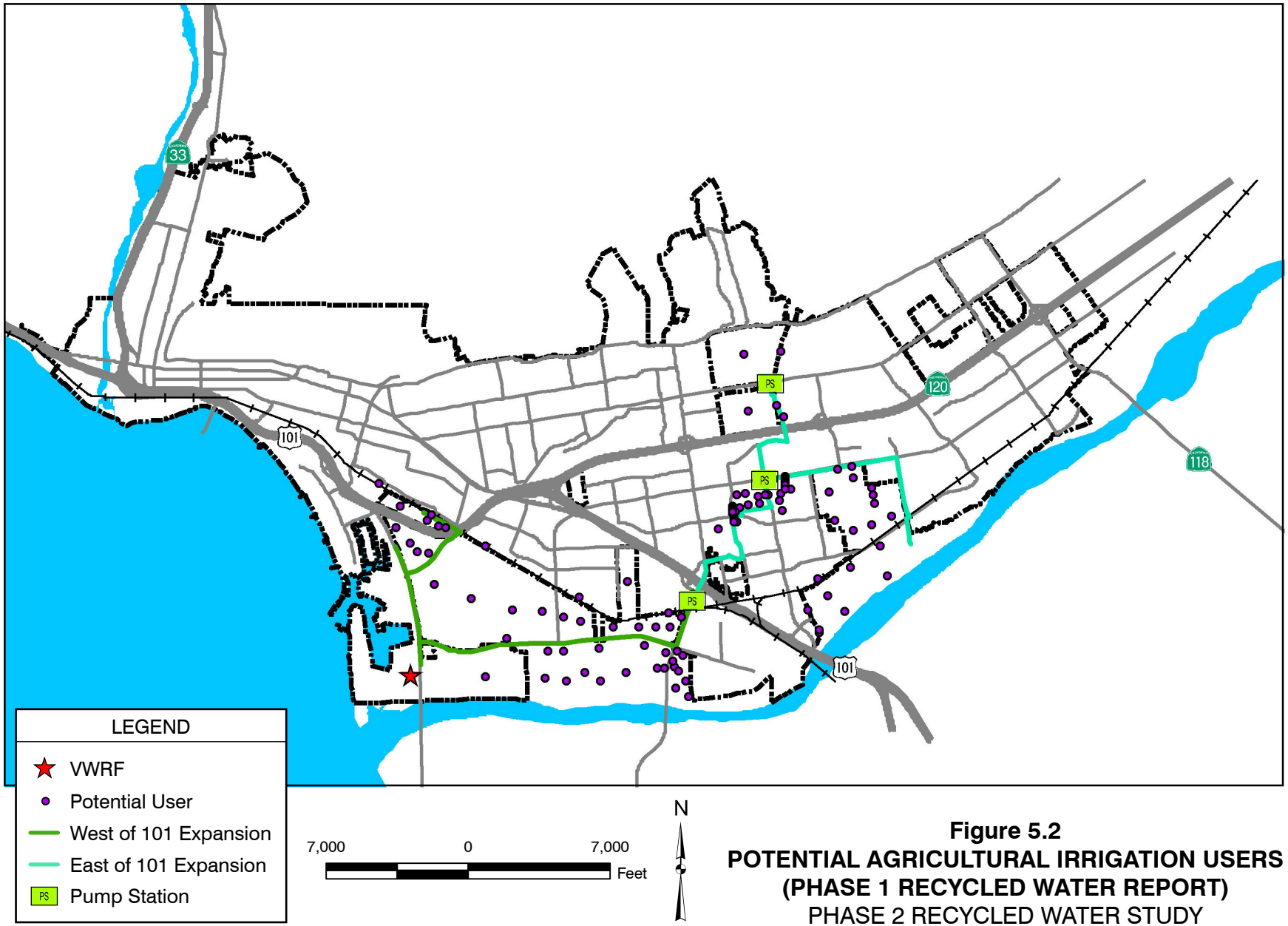

Figure 5.2
POTENTIAL AGRICULTURAL IRRIGATION USERS
(PHASE 1 RECYCLED WATER REPORT)
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

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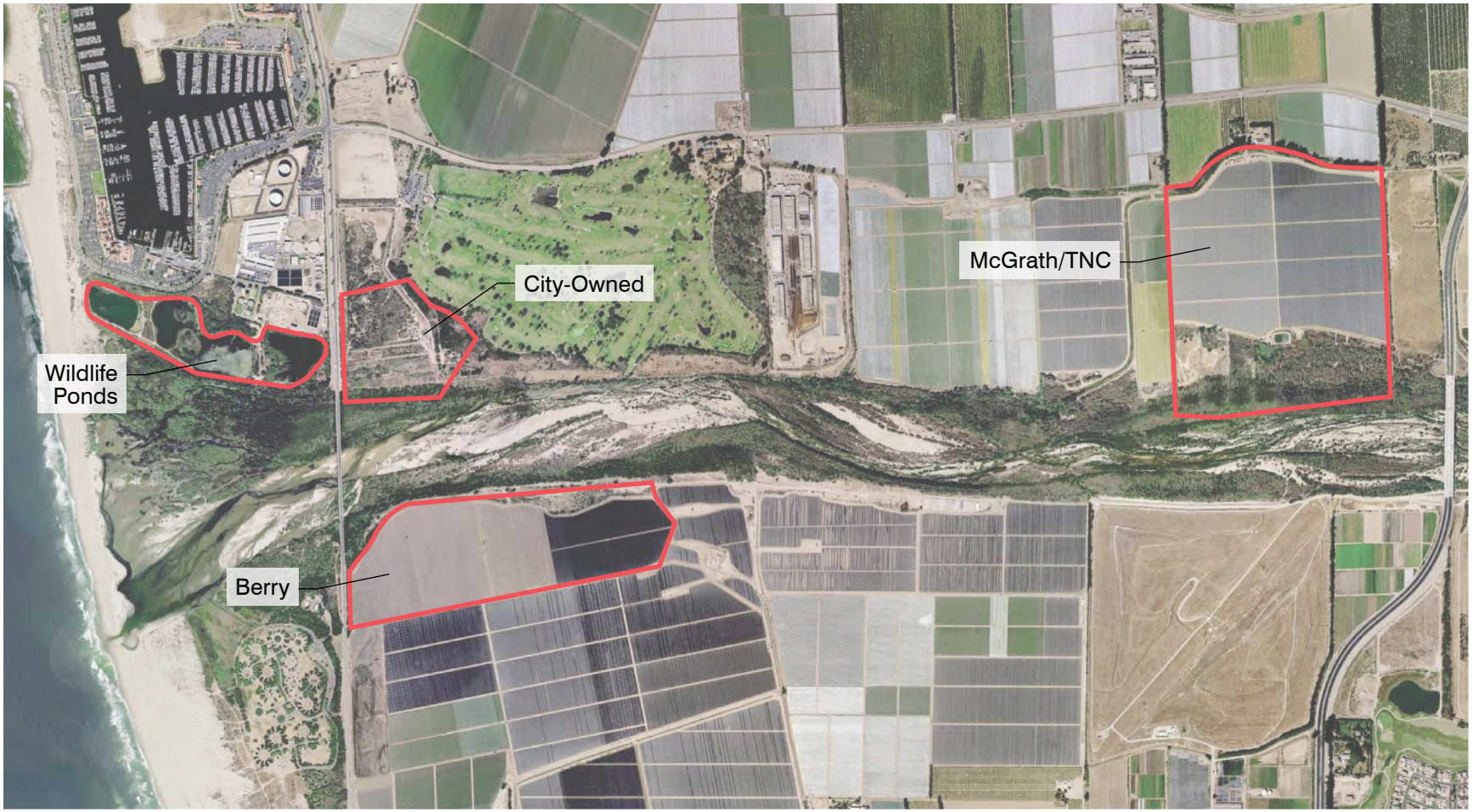

Figure 5.3
POTENTIAL SITES FOR TREATMENT WETLANDS
(PHASE 1 WETLAND FEASIBILITY REPORT)
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

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5.1.2 2010 Treatment Wetlands Study

In addition to using evaluating additional recycled water opportunities, the Treatment Wetlands Feasibility Study (2010) (Phase 1 Wetland Feasibility Report) study evaluated the potential benefits of using the recycled water to create wetlands adjacent to the Santa Clara River.

The results of the Phase 1 Wetlands Study are shown in Table 5.2.

Table 5.2 Summary of Treatment Wetland Alternatives (as presented in Phase 1 Wetland Feasibility Report)
Phase 2 Recycled Water Study
City of Ventura

Alternatives	Wetland Size, acres	Estimated Project Costs	Issues/Benefits
1 Retrofit existing wildlife ponds 1&2	12	$2,800,000	Existing utilities (e.g., sewer trunk line) limit the useable area Closest to the VWRF (shortest pipeline, lowest cost)
2 City-Owned Land adjacent to VWRF	29	$11,350,000	Existing utilities (e.g., sewer trunk line) limit the useable area Closest to the VWRF (shortest pipeline, lowest cost)
3 Berry	92	$30,250,000	Large area Pipeline needs to cross the Santa Clara River Unwilling seller(1)
4 McGrath/TNC	120	$44,550,000	Largest area (some planned for restoration) Disturbance of existing habitat at the southern end and discharge to the Santa Clara River may make permitting difficult Furthest from the VWRF (longest pipeline, highest cost)

Note:
(1) While there is an unwilling seller, stakeholders (specifically, representatives from State Parks and Fish and Wildlife Services) requested this site be kept for further examination.

5.1.3 Phase 2 Study

This current study builds on the Phase 1 studies and Draft Ventura Oxnard Recycled Water Interconnect Study (K/J, 2012). The potential uses/market for recycled water were expanded through discussion with City staff and through stakeholder input provided in the form of comments on the Phase 1 studies, and in workshops held throughout the development of the Phase 2 studies. In particular, the July 18, 2012 workshop introduced several additional recycled water market concepts, and small group sessions were convened to allow stakeholders to comment and provide additional ideas for expanding the potential uses/market for recycled water.

The potential recycled water uses for this study included:

- Urban and agricultural reuse of reclaimed water from the VWRF
- Urban and agricultural reuse of reclaimed water from new facilities in within the City's wastewater service area, i.e. the concept of decentralized treatment
- Groundwater recharge using the UWCD facilities
- Groundwater recharge, for the purpose of indirect potable reuse (IPR), in the Mound Basin or in the Oxnard Plain Basin.
- Direct potable reuse (DPR) of reclaimed wastewater from the VWRF as well as other new facilities (i.e. decentralized treatment plants)
- Conveyance of wastewater to the Oxnard Advanced Water Purification Facility.
- Treatment Wetlands/Habitat Creation using reclaimed wastewater from the VWRF
- The combination of treatment wetlands/habitat creation combine with groundwater recharge of the perched zone.

The alternatives that were developed to target these potential recycled water markets are described in more detail in Chapters 6 and 7.

5.2 OUTREACH WITH POTENTIAL CUSTOMERS

In addition to the many stakeholder meetings during the Phase 1 and Phase 2 studies, there were also individual meetings held with several of the potential user groups. In June 2012, separate meetings were held with UWCD, The Nature Conservancy, and the Ventura County Farm Bureau to discuss potential reuse opportunities for recharge, wetlands creation and agricultural reuse, respectively. In addition, there were numerous calls with City staff that included discussion of the City as a user of recycled water generated by IPR and DPR projects.

5.2.1 Project Website

The City set up a website for the Santa Clara River Special Studies.

http://www.cityofventura.net/rivers

This website includes study documents, reports, workshop agendas, workshop presentations, and workshop minutes. The website provides potential recycled water users with information on the types of reuse being considered in the studies, the development of reuse alternatives/projects, and the evaluation of reuse alternatives.

5.2.2 Stakeholder Informational Meeting

Many stakeholder meetings have been held to discuss the potential options for using the VWRF effluent for additional reuse options and the resulting impact to the estuary:

- July 15, 2009
- Nov 10, 2009
- Feb 2, 2010
- Sept 28, 2010
- Feb 10, 2011
- Aug 18, 2011
- July 18, 2012
- Oct 31, 2012
- Feb 21, 2013

Attendees to these workshops have included RWQCB staff, fishery resource agencies' staff (California Fish and Game, NOAA and USFWS), UWCD, TNC, California State Parks, City of Oxnard, Army Corps of Engineers, Ventura County Watershed Protection District, local NGOs (Ventura Coast Keeper, Heal the Bay, Audubon and Friends of the River) and local residents. The presentation materials and attendee lists for each of these meetings is available on the City's website.

5.3 CUSTOMER INCENTIVES

Recycled water projects can be costly and burdensome to residents and customers, so in many instances incentives are used to help attract the customer to convert to the use of recycled water. Since most water and wastewater systems already exist, and were developed with federal clean water funds years ago, the cost for a new reuse system can be overwhelming when placed entirely on a community or worse yet, on one large customer. Below summarizes some common incentive concepts that are seen when

recycled water projects are constructed, retrofit, and/or operated. The following list summarizes some of the incentives that can be put into place.

- Significantly lower unit cost than the next best water supply alternatives. This can be seen when recycled water is compared to current and future City water rates.
- Loan programs to pay for customer retrofit costs. This could be built into the rate structure or be provided through another department that benefits from water offsets. Retrofit payback programs should also be considered and are usually proposed for many customers who need help in funding the on-site upgrades needed to accept recycled water. This is a common approach for schools and public facilities with extremely limited funds.
- Grants or other programs to help customers with retrofit costs. Some grants are available to communities when combined with other programs such as water conservation, energy savings/conversion to solar, low-income areas of a City, City greening programs, etc.
- Waiving connection fees. For customers that eliminate irrigation meters or eliminate their water meters, there could perhaps be a return of part of their original connection fee (assuming they paid one and proof of payment exists).
- Recycled Water Use Ordinances. These are more along the line of a requirement, but can be used to promote and enforce more use.

The City intends to implement a mandatory Recycled Water Use Ordinance in the future instead of individual customer agreements. The intention of the use ordinance will be to define the user site requirements and those needing to connect to the recycled water system.

IDENTIFICATION AND PRELIMINARY SCREENING OF ALTERNATIVES

6.1 OVERVIEW OF ALTERNATIVES

As discussed in Chapter 5, the recycled water market was expanded beyond the potential uses described on the Phase 1 Recycled Water Report. With input from City staff and stakeholders, numerous alternatives were developed. The alternatives were identified based on fulfilling one or more of the following primary objectives:

- Reducing the discharge volume
- Improving discharge quality
- Providing habitat

The alternatives can be generally grouped into three categories that are discussed in subsequent sections of this chapter:

- Urban and Agricultural Reuse
- Groundwater Recharge Reuse
- Treatment/Habitat Wetlands Creation

Sections 6.2 through 6.4 include brief descriptions of the alternatives, and a preliminary screening analysis of the alternatives. The preliminary screening analysis focuses on major issues related to feasibility of each alternative, and in this sense is a “fatal flaws” type analysis. In addition, the screening analysis includes a comparison of the alternatives in each category based on several key evaluation criteria, including the effects on:

- The VWRF discharge volume to the SCRE
- The quality of the final discharge of VWRF effluent to the SCRE
- Creation of new wetland habitat
- Benefits to available water supply and quality
- The need for advanced wastewater treatment processes
- The need to purchase additional land for recycled water infrastructure

At the July 18th, 2012 stakeholder workshop, various initial concepts for alternatives were presented and discussed, and stakeholders had the opportunity to provide input in small group sessions. Some of the discussion focused on the major issues related to the feasibility of some of these alternatives, and stakeholder input informed the preliminary screening analysis and the decisions associated with developing a list of alternatives for further development and consideration.

6.2 URBAN AND AGRICULTURAL REUSE

This category of alternatives includes several approaches to reduce the discharge volume implementing urban irrigation, agricultural irrigation, and direct potable reuse (i.e. municipal water supply). The alternatives use different sources of reclaimed water and approaches to convey/use the water for urban and agricultural reuse. These alternatives include:

- Expanding the existing recycled water system to provide more urban irrigation
- Agricultural irrigation in the vicinity of the VWRF without blending
- Agricultural in the vicinity of the VWRF with blending
- A decentralized treatment plant on the north side of the City for urban and agricultural irrigation
- A decentralized treatment plant on the east side of the City for urban and agricultural irrigation
- DPR
- Conveyance to the Oxnard WWTP and Advanced Water Purification Facility (AWPF)

6.2.1 Expand Urban Reuse

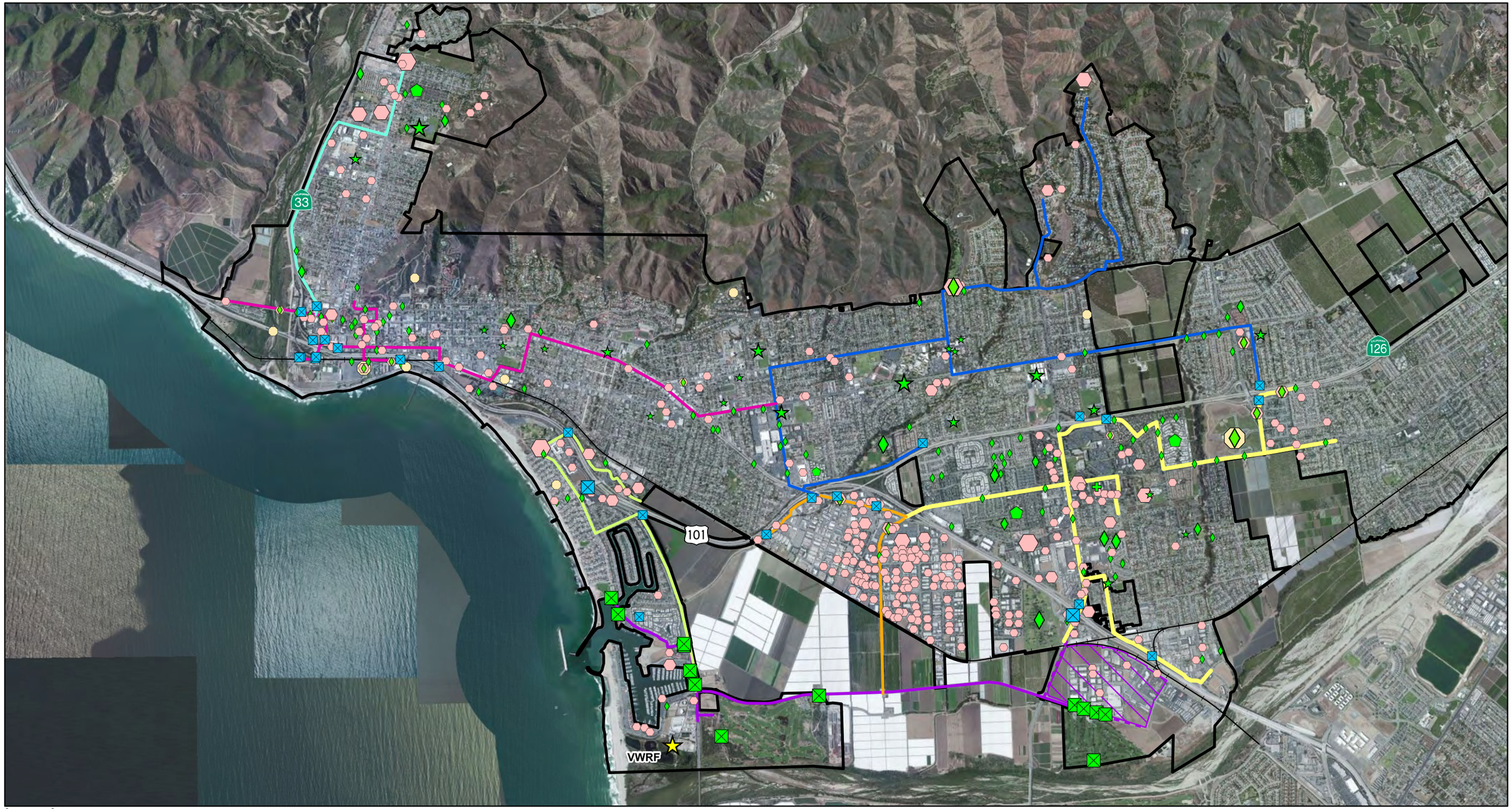
The Phase 1 Recycled Water Report describes opportunities for expanding the existing urban reuse system within a five mile radius of the VWRF. Estimates of potential demands were revisited based on information available since the completion of the Final Phase 1 Recycled Water Report. The most significant adjustment to potential demands was removing the estimated demand for the River Ridge Golf Course, as the City of Oxnard has plans to serve this customer with recycled water. The average demand and maximum month demands of the remaining identified urban irrigation reuse customers are 1.3 mgd and 1.8 mgd, respectively. However, serving these customers would involve construction of an extensive pipe network to deliver recycled water to users located throughout the city. Figure 6.1 shows the pipe network that would be required to deliver recycled water to potential customers. Additional treatment not be required because the VWRF currently treats wastewater to meet Title 22 standards for unrestricted reuse.

Major components of this alternative include:

- Recycled water pipelines, pump stations and reservoirs.

6.2.2 Agricultural Reuse without Blending

The Phase 1 Recycled Water Report describes opportunities for implementing water reuse for the purpose of agricultural irrigation. Estimates of potential demands were revisited



Legend

Urban Users
- Caltrans Meter
- Exing RW Meter
- Church
- Commercial
- Municipal
- Park
- School
- Irrigation

Potential RW Pipeline
- 2
- 3
- 4
- 5
- 6
- 7
- 8

- Existing RW Pipeline
- Existing Pipe Extension
- RW Focus Area
- City of Ventura

N

0 2,500 5,000 Feet

Figure 6.1
POTENTIAL URBAN IRRIGATION USERS
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

based on information available since the completion of the Final Phase 1 Report. The most significant adjustments to the demands include:

- Excluding the agricultural areas immediately adjacent to the north side of the Santa Clara River. It is anticipated that The Nature Conservancy (TNC) will be successful at purchasing these parcels as part of their Santa Clara River Parkway Project and that in the future these parcels will not be used for agriculture.
- Using crop specific, rather than an average, water demands to estimate the total demand of the agricultural parcels.
- Focusing the market on the agricultural areas that are along either side of Olivas Park Drive and either side of the railroad, as these areas present a potential demand in close vicinity to the VWRF.

The potential agricultural users are presented in Figure 6.2. The potential average and maximum month demands for these agricultural areas are 2.8 mgd and 4.6 mgd, respectively.

As discussed in the Phase 1 Recycled Water Report, advanced treatment for TDS and chloride would be required to meet crop specific water quality thresholds. Strawberries are the most sensitive crop (grown in the study area) to chloride concentrations in irrigation water. The Upper Santa Clara River Chloride TMDL, established a maximum chloride concentration of 117 mg/L to be protective of agricultural beneficial uses (irrigation of salt sensitive crops) (LARWQCB Final Basin Plan Amendment (TMDL), 2008). The advanced treatment train would include ultra or microfiltration (UF/MF) and reverse osmosis (RO) to meet this water quality goal. The brine waste from the RO process would require treatment and/or disposal.

In addition to the pipelines and pump stations required to deliver recycled water to potential agricultural irrigation customers, this alternative requires infrastructure that would allow growers the ability to control their source water through infrastructure that allows access to either the reclaimed water or the groundwater. (Personal communication with John Krist (Ventura County Farm Bureau), 2012).

Major components of this alternative include:

- Microfiltration and reverse osmosis treatment facilities at the VWRF
- Brine treatment/disposal facilities
- Recycled water pipelines, pump stations and reservoirs

6.2.3 Agricultural Reuse with Blending

This alternative would serve the same demands as described in Section 6.1.1.2. However, this alternative involves using existing groundwater blended with VWRF effluent (no additional treatment) to meet the crop specific water quality thresholds. The VWRF effluent

Legend

Proposed Irrigation Pipeline West of 101

Potential Agricultural Irrigation Users

N

Feet

0 1,000 2,000

Figure 6.2
POTENTIAL AGRICULTURAL IRRIGATION USERS
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

TDS and chloride concentrations are approximately 1489 mg/L and 290 mg/L. Groundwater quality data (UWCD, 2012) from wells located in the agricultural area west of 101, indicate ranges of TDS and chloride concentrations of 1100 mg/L to 1800 mg/L and 60 mg/L to 80 mg/L, respectively. The VWRF average TDS effluent concentration is within the range of the groundwater TDS concentrations, suggesting that there is not significant opportunity to reduce the effluent TDS by blending it with groundwater. However, the chloride concentrations in the groundwater are much less than in the VWRF effluent and therefore present an opportunity for improving effluent water by blending it with groundwater.

To protect the strawberry crops, the appropriate target chloride concentration for the blended water is 117 mg/L. To meet this limit, a blend of approximately 85 percent groundwater and 15 percent VWRF effluent would be required. At this blend ratio, to meet the average and maximum month demands, the VWRF effluent contribution would be limited to 0.4 mgd and 0.7 mgd respectively.

In addition to the pipelines and pump stations required to deliver recycled water to potential agricultural irrigation customers, this alternative requires infrastructure that would allow blending of reclaimed water and groundwater. Growers in the area would want a system that would allow them to access both the blended water sources, and the unblended groundwater source (Personal communication with John Krist, 2012).

Major components of this alternative include:

- Recycled water pipelines, pump stations and reservoirs
- Point of use blending systems

6.2.4 North Side Decentralized Treatment Plant for Agricultural and Urban Reuse

As described in the previous sections, there are opportunities for urban and agricultural irrigation throughout the City. This alternative includes the construction of a small wastewater treatment plant (decentralized treatment plant) for the purpose of providing an upstream supply of recycled water at a location in the vicinity of potential reuse opportunities.

The north side of the City presents opportunity for implementing a decentralized treatment plant. There are potential recycled water customers for urban and agricultural irrigation in the north side of the City. The wastewater in this area has low concentrations of TDS and chloride because the potable water supply in this area has low TDS and chloride concentrations, and therefore provides the potential for agricultural irrigation without advanced treatment. Also, the site of a former wastewater treatment plant, located near the Seaside Pump Station, could be use for the site of a new decentralized treatment facility.

Raw wastewater would be diverted from the collection system for treatment at a new treatment plant, located near the Seaside Pump station. The diverted flow would be

approximately 2.6 mgd. The potential average and maximum month urban irrigation demands in the vicinity of the potential site for a new decentralized treatment plant are 0.17 and 0.24 mgd, respectively. The potential average and maximum month agricultural irrigation demands are approximately 1.1 mgd and 1.8 mgd, respectively. The combined agricultural and urban average and maximum month demands are 1.3 and 2.0 mgd, respectively. Figure 6.3 shows the potential location for a north side treatment plant and the customers that could be served.

The treatment plant would be designed to meet Title 22 regulations for unrestricted reuse, and sized to achieve 100 percent reuse. The solids from the treatment plant would be routed to the VWRF collection system for treatment.

The acceptance of recycled water for agricultural irrigation would depend on the effluent water quality. In August 2012, the City of Ventura collected samples from 2 locations in the collection system located near the Seaside Pump Station. Measured TDS and chloride concentrations were 676 mg/L and 68 mg/L, respectively. These TDS and chloride concentrations are acceptable for sensitive crops and no additional treatment beyond treatment required to meet Title 22 would be required.

Major components of this alternative include:

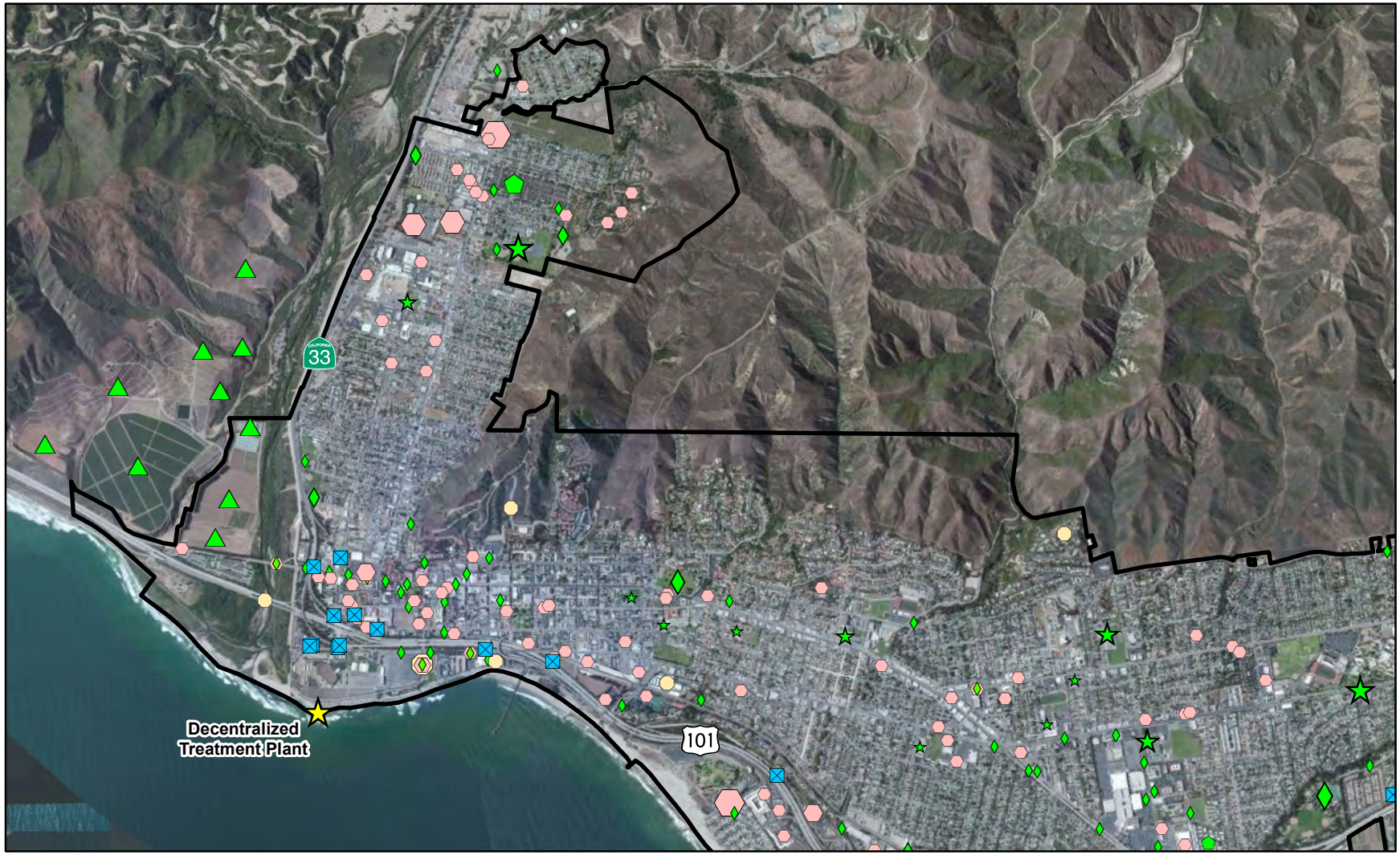
- New wastewater treatment plant designed to meet Title 22 requirements
- Diversion structure from the wastewater collection system
- Infrastructure to convey solids back to the VWRF collection system
- Recycled water pipelines, pump stations and reservoirs

6.2.5 East Side Decentralized Treatment Plant for Agricultural and Urban Reuse

Similar to the decentralized treatment plant alternative described in Section 6.2.4, this alternative would include construction of a small wastewater treatment plant for the purpose of providing an upstream supply of recycled water at a location in the vicinity of potential reuse opportunities.

On the east side of the City, there are potential recycled water customers for urban and agricultural irrigation, and there is a potential site of the decentralized treatment plant at the Saticoy Sanitary District WWTP. In the future, it is possible that the City will annex the Saticoy Sanitary District WWTP, and would therefore provide a source of wastewater and a site for a decentralized treatment facility. In addition, wastewater from the City's collection system would be diverted to the decentralized treatment plant.

Depending on the diversion location (from the VWRF collection system to the decentralized treatment plant), the average amount of flow available ranges from 0.3 mgd to 1.4 mgd. An additional 0.5 mgd would potentially be available form the Saticoy Sanitary District. The potential average and maximum month urban irrigation demands are approximately



Legend

- Ag Users
- **Urban Users**
- Caltrans Meter
- Exing RW Meter
- Church
- Commercial
- Municipal
- Park
- School
- Irrigation
- City of Ventura

N

0 1,500 3,000 Feet

Figure 6.3
POTENTIAL URBAN AND AGRICULTURAL USERS NEAR THE NORTH SIDE TREATMENT PLANT
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

0.24 mgd and 0.44 mgd, respectively. The potential average and maximum month agricultural irrigation demands are approximately 2.0 mgd and 3.3 mgd, respectively. The combined agricultural and urban average and maximum month demands are 2.2 and 3.7 mgd, respectively. Figure 6.4 shows the potential location for a east side treatment plant and the customers that could be served.

Similar to the north side decentralized treatment plant alternative, the treatment plant would be designed to meet Title 22 regulations for unrestricted reuse, and sized to achieve 100% reuse. The solids from the treatment plant would be routed to the VWRF collection system for treatment. The acceptance of recycled water for agricultural irrigation would depend on the effluent water quality.

In July 2012, the City collected water quality data from two sites near the Saticoy Sanitary District. Measured TDS and chloride concentrations were 1095 mg/L, and 319 mg/L, respectively. These concentrations exceed crop specific requirements for agricultural irrigation. Therefore, to serve the potential agricultural users, the scalping plant would need to include RO, and brine treatment/disposal.

Major components of this alternative include:

- New wastewater treatment plant designed to meet Title 22 requirements
- Reverse osmosis for TDS and chloride removal.
- Brine treatment and disposal
- Diversion structure from the wastewater collection system
- Infrastructure to convey solids back to the VWRF collection system
- Recycled water pipelines, pump stations and reservoirs

6.2.6 Direct Potable Reuse

DPR involves using recycled water directly as a water supply without an environmental buffer such as a large reservoir or the groundwater basin. There are currently no established regulations for DPR in California. However, the State has directed the Department of Public Health develop regulations for DPR by 2016. There is a significant amount of research and discussion currently underway regarding the levels of treatment and controls required to safely apply DPR. Based on these ongoing discussions and the current regulations for indirect potable reuse, it is expected that VWRF effluent would need to be treated by MF/UF, RO, and UV with advanced oxidation (UV/AOP). Between the RO and UV/AOP processes, the permeate from the RO process would be stored in a tank for a set period of time to allow monitoring to ensure quality standards are met. The use of two tanks and an equalization tank would allow a continuous supply of water. Water from the tanks would be treated by UV/AOP and then be conveyed to a location within the City's potable water distribution system.

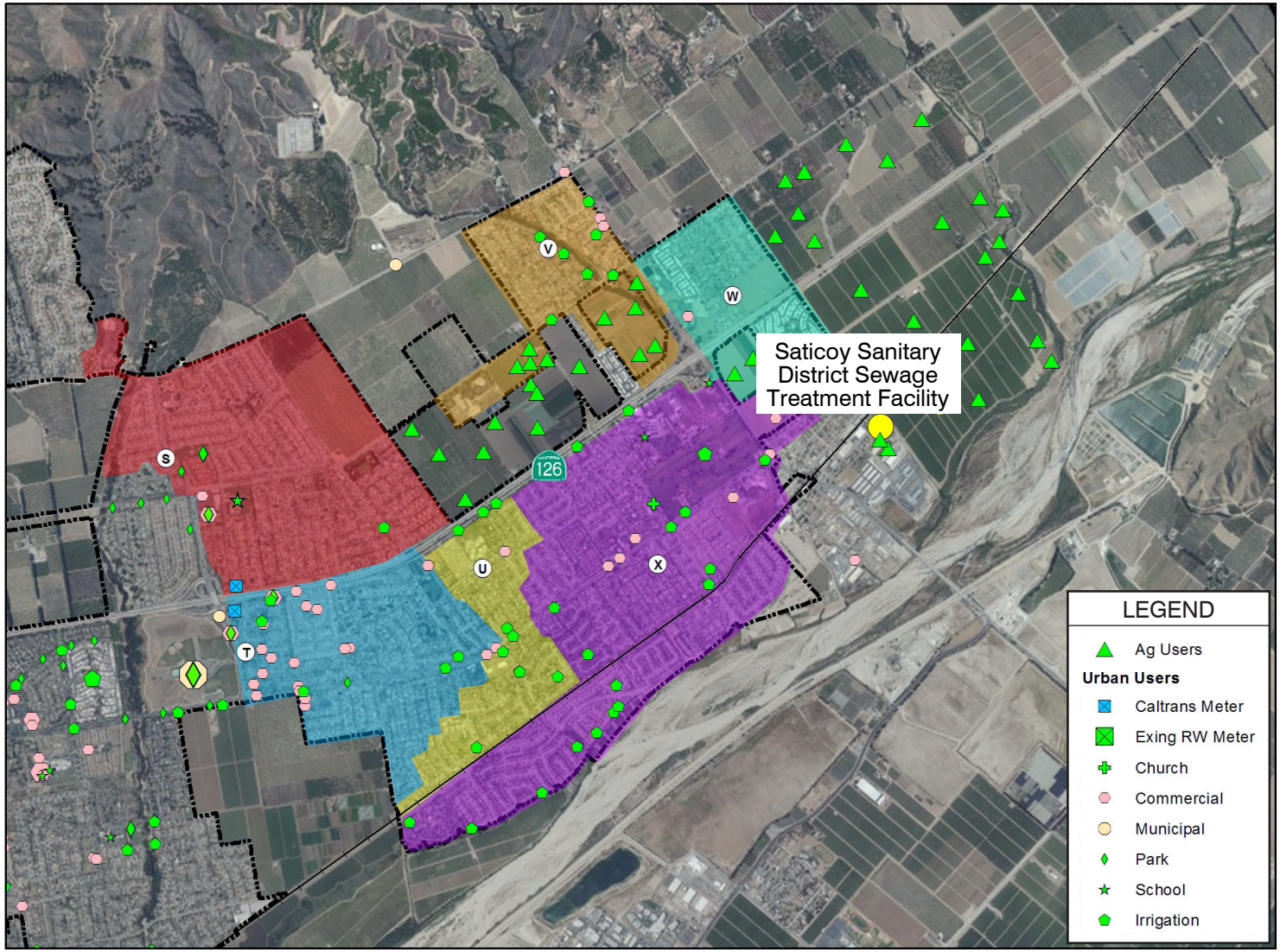


Figure 6.4
POTENTIAL URBAN AND AGRICULTURAL USERS
NEAR THE EAST SIDE TREATMENT PLANT
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

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The City water and wastewater system provide opportunities for DPR projects. One alternative would be to provide advanced treatment at the VWRF and convey the treated water to the Bailey conditioning facility where it would be mixed in the distribution system with water treated at Bailey and water that bypasses treatment at the Bailey WTP.

Another alternative is to provide advanced treatment at a new wastewater treatment facility. Section 6.2.4 presents the concept of a north side decentralized treatment plant. DPR could be implemented in a phased approach, where initially a new decentralized treatment facility would be designed to meet Title 22 standards for unrestricted reuse. In the future, this facility could be expanded to include advanced treatment processes for DPR. In this scenario, approximately 2.6 mgd would be available for a DPR project. The treated water would be conveyed to the potable water distribution system, at the location of Casitas Turnout No. 2. Figure 6.5 shows these two alternative locations for DPR projects.

In addition to the advanced wastewater treatment processes, the brine treatment and/or disposal would be required.

Major components of this alternative include:

- Advanced wastewater treatment processes including MF/UF, RO and UV/AOP.
- Brine treatment and disposal
- Storage basins and an equalization tank to provide adequate time for monitoring.
- If a decentralized treatment plant provides the supply then additional pretreatment, upstream of the MF/UF, would need to be constructed.
- Pipelines, reservoirs and pump stations required to convey the product water to the water distribution system.

6.2.7 Oxnard WWTP

The City of Oxnard’s Advanced Water Purification Facility (AWPF) is a part of their Groundwater Recovery Enhancement and Treatment (GREAT) program. Initial uses of the reclaimed water may include irrigation of parks, medians, golf courses and athletic fields; agricultural irrigation; and industrial process water. In addition, the recycled water may be used to provide a seawater barrier and to recharge groundwater aquifers (GREAT Program, Recycled Water Fact Sheet).

The Draft Ventura-Oxnard Recycled Water Interconnect Feasibility Study (Kennedy Jenks, 2012) investigates the feasibility of conveying VWRF effluent to the City of Oxnard's Advanced Water Purification Facility (AWPF), and, if treatment capacity is not available or if there is not enough demand, discharging the effluent to either the City of Oxnard's ocean outfall or Calleguas Municipal Water District's (Calleguas) Salinity Management Pipeline.

The proposed alternative includes conveyance of VWRF effluent to the AWPF for treatment and eventual utilization as high-quality recycled water. In the temporary event that the

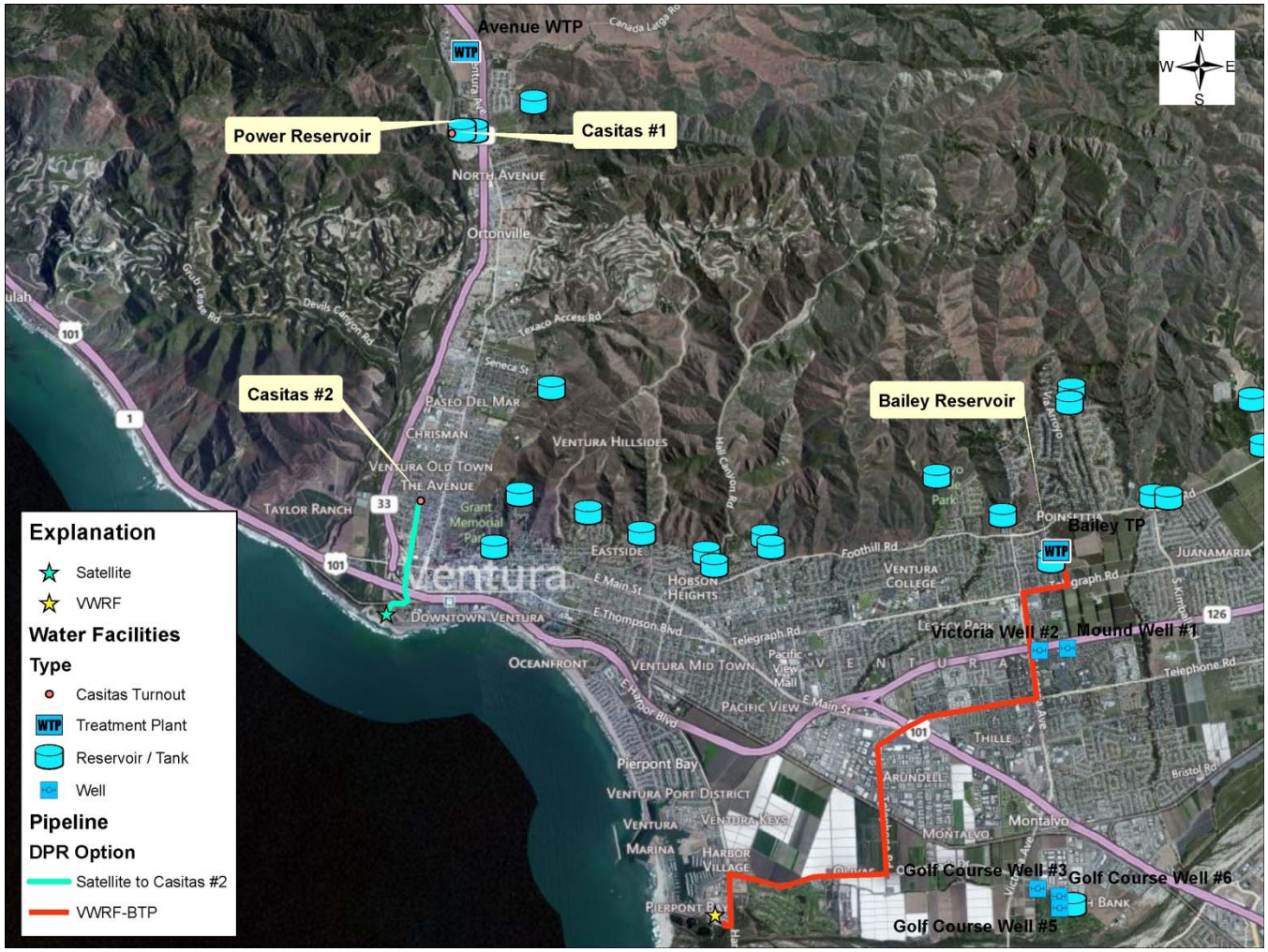


Figure 6.5
POTENTIAL LOCATIONS FOR DPR
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

AWPF could not receive the effluent, it could either be disposed of through the Salinity Management Pipeline or Oxnard's ocean outfall (Kennedy Jenks 2012). Figure 6.6 shows the potential pipe line routing for the Oxnard alternative.

Major components of this alternative include:

- Pipelines, reservoirs and pump stations required to convey VWRF effluent to Oxnard's AWPF.
- VWRF disinfection improvements
- Expansion of the AWPF
- Connection to the Oxnard Outfall
- Connection to the Salinity Management Pipeline

6.2.8 Preliminary Screening of Urban and Agricultural Alternatives

The preliminary screening analysis is summarized in Table 6.1 and in the discussion that follows. In the table, each of the alternatives is compared using the evaluation criteria discussed in Section 6.1. Where appropriate a relative rating of 1 to 3 (1 highest and 3 lowest) was assigned to provide a relative scaling of attainment of the criteria.

The preliminary evaluation of these alternatives and the rationale for including or excluding the alternatives for more detailed development and evaluation is described below. Note that none of the alternatives improve the water quality of the final discharge to the SCRE and none of the alternatives provide habitat, therefore these criteria are not discussed.

6.2.8.1 Expand Existing Urban Reuse System

Expanding the existing urban reuse system has the following benefits/disadvantages:

- Results in a lower discharge volume, but the potential reuse demand is small (average and maximum month demands of 1.3 mgd and 1.8 mgd, respectively) and requires and extensive pipe network to convey tertiary treated water to potential customers
- Provides a small water supply benefit through offsetting potable demands.
- No additional investment in treatment processes is required since Title 22 standards for unrestricted reuse are currently being attained.

The urban irrigation market is small and is characterized by numerous very small users dispersed throughout the City. Conveying recycled water from the VWRF to these numerous customers via an extensive pipe network is not the most efficient approach to reducing the discharge volume and offsetting potable demands. Therefore, this alternative is not selected for further evaluation as a stand alone alternative. However, urban irrigation

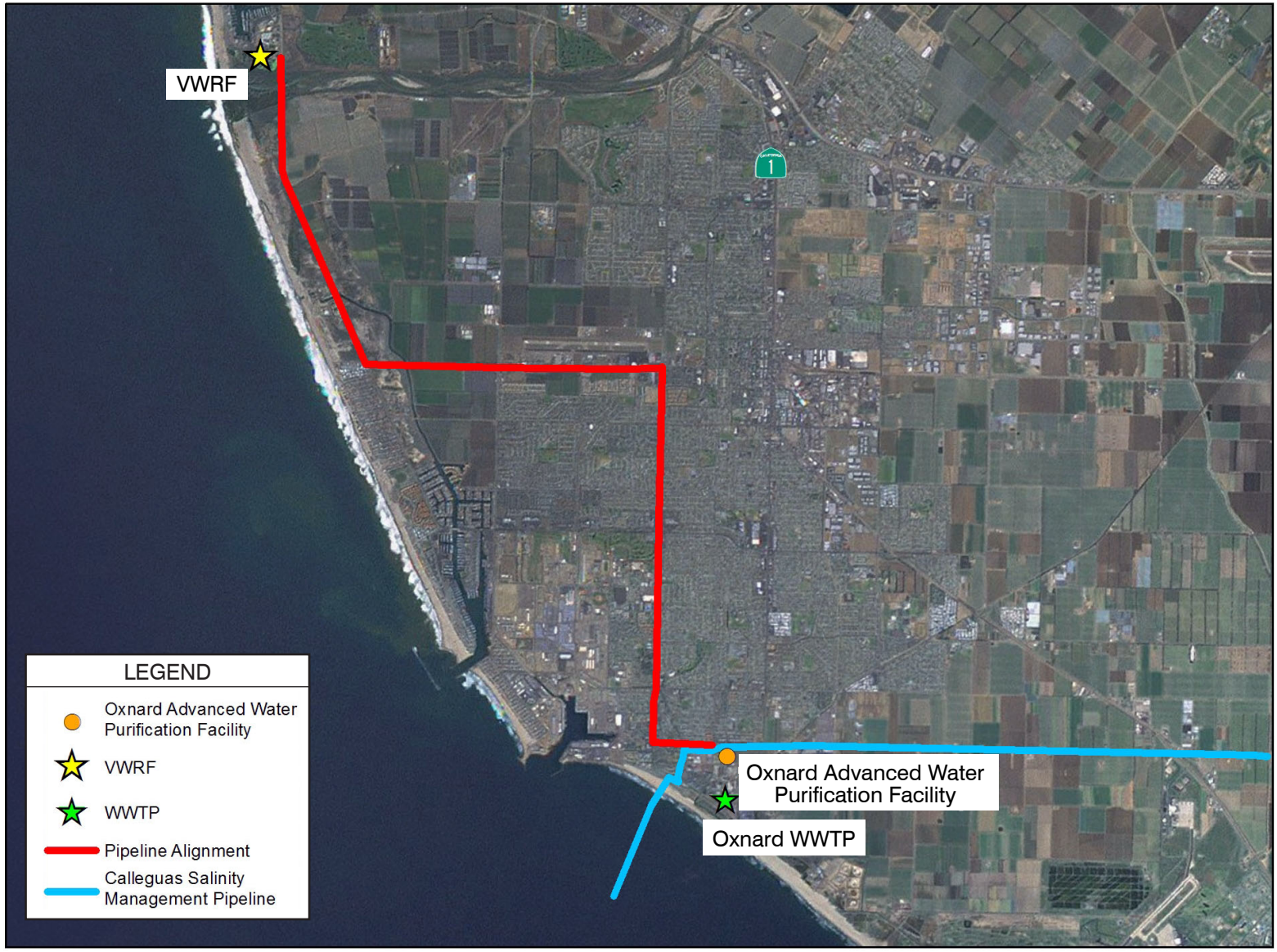


Figure 6.6
VWRF TO OXNARD AWPF PIPELINE ALIGNMENT
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

ven113f12-8144.ai

Table 6.1 Preliminary Screening of Reuse Alternatives
Phase 2 Recycled Water Study
City of Ventura

Alternatives	Criteria					
	Lowers Discharge Volume	Improves the Quality of Final Discharge to the SCRE	Provides Habitat	Provides a Water Supply Benefit	Relies on Existing Treatment	Selected for Further Evaluation
Expand Existing Urban Reuse System	3	N	N	3	Y	Only as part of other alts
Agricultural Irrigation without Blending	1	N	N	3	N	Only as part of other alts
Agricultural Irrigation with Blending	3	N	N	3	Y	N
North Side Decentralized Treatment Plant	3	N	N	3	N	Y
East Side Decentralized Treatment Plant	3	N	N	3	N	N
Direct Potable Reuse	1	N	N	1	N	Y
Reuse at Oxnard WWTP	1	N	N	N	Y	Y

Note:
Where appropriate a relative rating of 1 to 3 (1 highest and 3 lowest) was assigned in lieu of a Y to provide a relative scaling of attainment of the criteria.

can be combined with many other alternatives, especially given that the VWRF effluent quality currently meets Title 22 standards. For example, if VWRF effluent is being conveyed past potential users on the way to an end point defined by other alternatives, then connection to the users on the way should be considered. The urban irrigation market analysis in Phase 1 and the additional information provided in this report provide sufficient information for evaluating the potential benefits of combining urban irrigation with other alternatives.

In addition, it is important to note that the City is committed to expanding its existing urban reuse system. As opportunities arise, the City will implement recycled water projects in the Recycled Water Focus Area and elsewhere in the City.

6.2.8.2 Agricultural Irrigation without Blending

Agricultural irrigation without blending has the following benefits/disadvantages:

- Results in a relatively large reduction in discharge volume through diverting water for agricultural irrigation in an area that is relatively close to the VWRF.
- Provides a water supply benefit in reducing groundwater withdrawals from the Mound Basin, which is used for the City's potable supply.
- The existing treatment processes do not produce water quality that meets crop specific requirements and therefore blending with groundwater would be required in lieu of treatment, groundwater some fraction of the flow diverted for irrigation would need to be routed through MF/UF and RO. Brine treatment and disposal would also be required.

The relatively large, and close proximity, of the agricultural irrigation market provides an opportunity for a significant reduction in discharge volume. This potential benefit is offset by the need for MF/UF, RO, and brine treatment/disposal. If advanced treatment processes were implemented, the resulting water quality would be similar to the quality required for many types of end uses, including uses such as groundwater recharge and augmentation of potable water supplies. In comparison to other end uses that require similar advanced treatment processes and brine treatment/disposal, agricultural irrigation offers less of a direct benefit on the City's water supply. For these reasons, agricultural irrigation is not is not selected for further evaluation as a stand alone alternative. However, agricultural irrigation could be implemented in combination with other alternatives that require MF/UF and RO. In this scenario, agricultural irrigation could provide a means of further reducing the VWRF discharge to the SCRE especially in the summer months when there are increased agricultural demands.

6.2.8.3 Agricultural Irrigation with Blending

Agricultural irrigation with blending has the following benefits/disadvantages:

- Results in a relatively low reduction in discharge volume (average and maximum month demands of 0.4 mgd and 0.7 mgd, respectively) through diverting water for agricultural irrigation in an area that is relatively close to the VWRF.
- Provides a water supply benefit in reducing groundwater withdrawals from the Mound Basin, which is used for the City's potable supply.
- The existing treatment processes do not produce water quality that meets crop specific requirements, and to avoid the need for advanced treatment, the VWRF effluent would be blended with groundwater.

The close proximity of the agricultural irrigation market provides an opportunity for reducing the discharge volume without extensive conveyance and pumping. However, to meet crop specific criteria, approximately 85 percent of the total flow would be groundwater, which

limits the amount of VWRF effluent that would be diverted for agricultural irrigation. In addition, a criterion for the acceptance of recycled water by growers in the region is that any alternative water supply must be provided through a simple, low maintenance system that does not require additional effort by the growers. Growers would not be willing to do onsite blending of the VWRF effluent and extracted groundwater. Therefore, the City would need to take on the responsibility of blending, which is complicated by the need for a supply of blending water with low TDS and chloride. This alternative is not considered for further evaluation based on the low demand for VWRF effluent (15% of the total demand) and the complications with providing a blended water supply to growers.

6.2.8.4 North Side Decentralized Treatment Plant

- The north side decentralized treatment plant has the following benefits/disadvantages: Results in relatively low reduction in discharge to the SCRE. The combined agricultural and urban average and maximum month demands are 1.3 and 2.0 mgd, respectively.
- Provides a small water supply benefit through offsetting potable demands for the urban irrigation customers.
- The use of recycled water for agricultural irrigation provides a water supply benefit in the sense the groundwater extractions from the Ventura Basin would be reduced.
- Does not rely on the existing VWRF and requires construction of a new tertiary treatment plant located near the Seaside Pump Station.

While the supply and potential demand is relatively small, there are some advantages to this alternative, including the availability of City owned property at the Seaside Pump Station for new treatment facilities, the low chloride and TDS concentrations in the wastewater, and the similarity between the available supply of recycled water and the demand in the vicinity of the Seaside Pump Station. Therefore, this alternative is selected for further evaluation.

6.2.8.5 East Side Decentralized Treatment Plant

The east side decentralized treatment plant has the following benefits/disadvantages:

- Results in a moderate reduction discharge volume. The combined agricultural and urban average and maximum month demands are 2.2 and 3.7 mgd, respectively.
- Provides a small water supply benefit through offsetting potable demands for the urban irrigation customers.
- The use of recycled water for agricultural irrigation provides a water supply benefit in the sense the groundwater extractions would be reduced.
- Does not rely on the existing VWRF and requires construction of a new tertiary treatment plant, with the most feasible site being the Saticoy Sanitary District. If the

recycled water is to be use for agricultural irrigation then RO, and brine treatment and disposal is required.

There is potential for a moderate reduction in discharge volume, however, the majority of the potential demand is agricultural irrigation that would require advanced treatment to remove TDS and chloride. The location of this scalping plant limits the brine treatment and disposal options to evaporation ponds or physical/chemical treatment processes, which are the most land intensive and costly brine treatment/disposal alternatives. It is possible that if advanced treatment were considered for this scalping plant then the recycled water could be used for groundwater recharge. However, regardless of the recycled water use, any alternative that required brine treatment/disposal is going to be limited by the land based or physical /chemical brine treatment /disposal alternatives at this location. For these reasons, this alternative was not selected for further evaluation.

6.2.8.6 Direct Potable Reuse

Direct potable reuse has the following benefits/disadvantages:

- Has the potential to result in a relatively large reduction in the discharge volume to the SCRE
- Provides a water supply benefit
- Does not rely solely on the VWRF treatment processes and would require advanced treatment facilities at either the VWRF or a decentralized treatment plant near the Seaside Pump Station, consisting of UF/MF, RO, and UV/AOP. Brine treatment and/or disposal would be required.

This alternative has the potential to result in a large reduction in the discharge volume to the SCRE and provide a direct water supply benefit to the City. While there are challenges with this alternative including brine treatment and/or disposal, regulatory uncertainty and public perception, these challenges are offset by the potential reduction in discharge volume and benefit to the City's water supply. Therefore, this alternative is selected for further evaluation.

6.2.8.7 Reuse at the Oxnard WWTP/AWPF

- Reuse at the Oxnard WWTP has the following benefits/disadvantages: Has the potential to result in a in a relatively large reduction in the discharge volume to the SCRE (can take all of the effluent)
- Provides a regional water supply benefit by offsetting the use of other sources in the Oxnard Plain, but does not provide a water supply benefit to the City.
- Relies on the existing VWRF, and has the potential to eliminate tertiary treatment for a portion of the VWRF flow.

While this alternative does not provide a direct benefit to City's water supply system, is does present the opportunity for a relatively large reduction in the discharge to the SCRE without the need for new advanced treatment processes. For these reasons, this alternative is selected for further evaluation.

6.3 GROUNDWATER RECHARGE

This category of alternatives includes several approaches to reduce the discharge volume through various options for groundwater recharge, including:

- Recharge the Mound Basin
- Recharge the Oxnard Plain Basin
- Recharge the Oxnard Forebay
- Recharge at the UWCD Facilities
- Recharge at the UWCD Facilities with Oxnard Plain Blending Water

Figure 6.7 shows the location of the groundwater basins the City's water supply wells, water treatment facilities, and United Water Conservation District facilities in the region.

For all groundwater recharge alternatives, reclaimed water from the VWRF would be used to recharge a groundwater basin for the purpose of augmenting the potable groundwater supply, i.e. indirect potable reuse (IPR). As discussed in Chapter 4, the California Department of Public Health has released Draft Groundwater Reuse Regulations governing recharge projects, including requirements for treatment. The draft regulations also provide for two major types of groundwater recharge: subsurface injection and surface spreading. For subsurface injection, full advanced treatment (FAT) is required and consists of reverse osmosis and advanced oxidation. The brine from the reverse osmosis process requires treatment and/or disposal. Figure 6.8 shows the required treatment train for subsurface injection.

In this study area, the Oxnard Forebay is the only basin that does not have a confining clay layer where that surface spreading could be possible. The other basins would require subsurface injection. Surface spreading can be accomplished with tertiary treated water and does not require advanced treatment, provided the effluent meets quality requirements.

6.3.1 Recharge the Mound Basin

There are potential opportunities to use the VWRF effluent to augment the City's water supply. The Mound Basin is one of the water sources that the City relies on for potable supply. The City owns and operates groundwater wells in the Mound Basin and the Bailey Conditioning facility. Water extracted from the Mound Basin is treated for iron and manganese, and then blended with water extracted from City's wells located in the Oxnard Plain Basin.

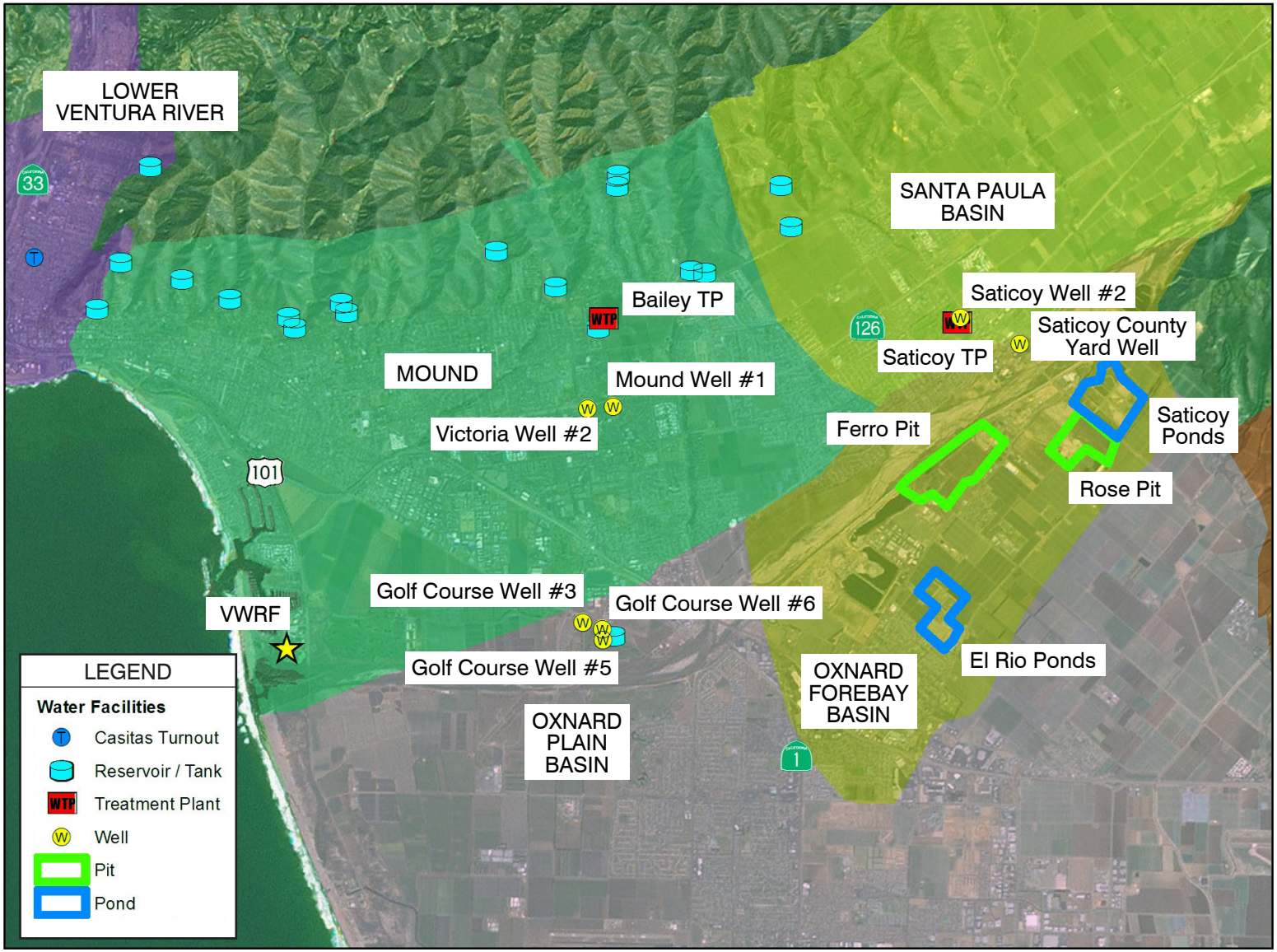
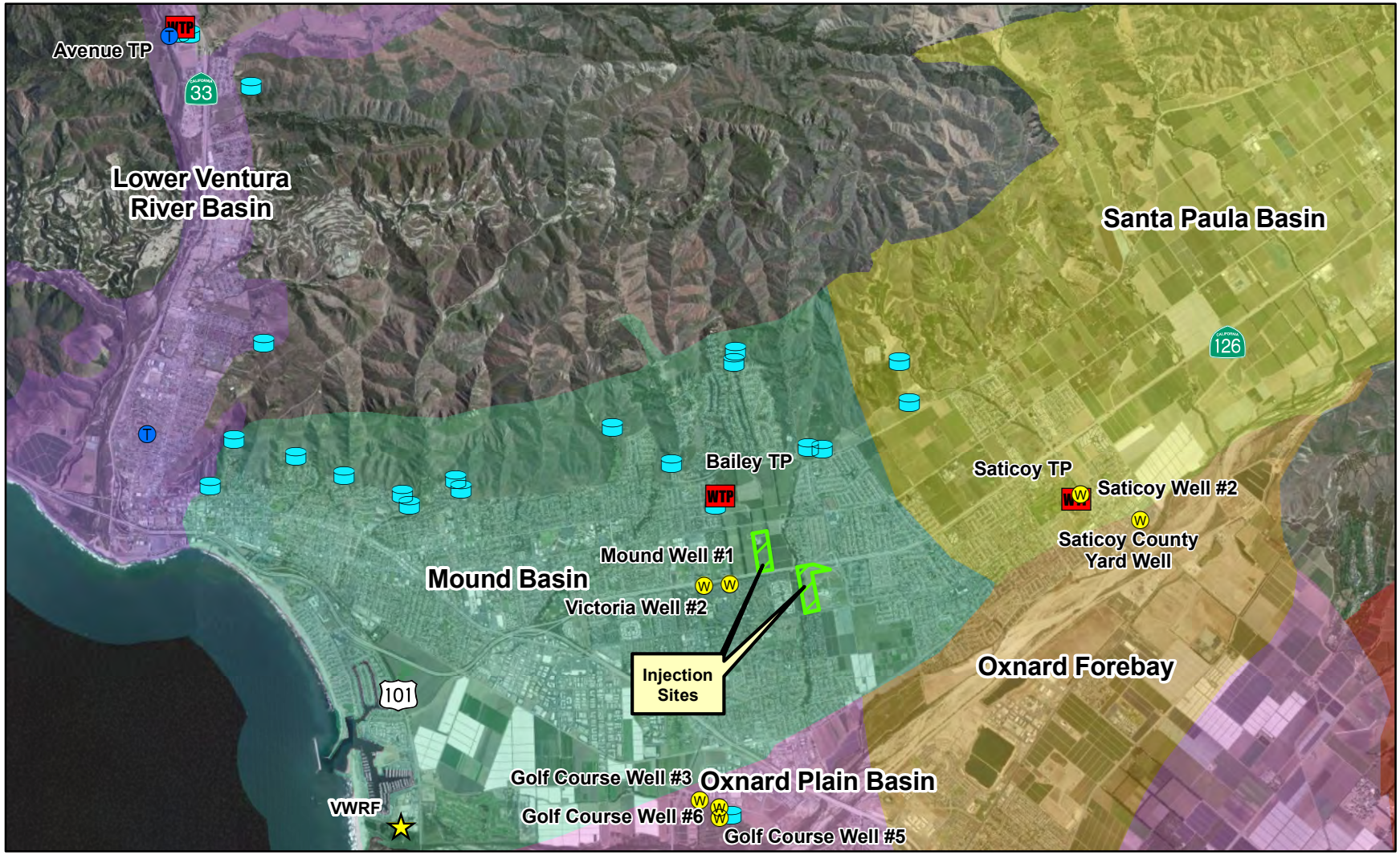


Figure 6.7
VENTURA WATER AND UWCD FACILITIES
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

ven113f14-8144.ai



Legend

Water Facilities
- Casitas Turnout
- Reservoir / Tank
- Treatment Plant
- Well
- Injection Site

Groundwater Basins
- Lower Ventura River
- Mound
- Oxnard Forebay
- Oxnard Plain
- Pleasant Valley
- Santa Paula
- West Las Posa

Feet
0 4,000 8,000

Figure 6.8
POTENTIAL GROUNDWATER RECHARGE SITES IN THE MOUND BASIN
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

In this alternative, reclaimed water from the VWRF would be used to recharge the Mound Groundwater Basin for the purpose of augmenting the potable groundwater supply, i.e. indirect potable reuse (IPR). The confining clay layers in the Upper Aquifer System of the Mound Basin limit the feasibility of surface ponds/spreading and recharge via percolation. The only option for groundwater recharge is subsurface injection and full advanced treatment (FAT) is required and consists of reverse osmosis and advanced oxidation. The brine from the reverse osmosis process requires treatment and/or disposal.

There are a couple of factors that contribute to assessing the capacity (or demand) for IPR. Ideally, all of the reclaimed water that is injected should be used, as opposed to allowing this water to migrate across the basin and eventually discharge to the ocean. Therefore, it would be prudent to limit the injection of recycled water to match demands. Average extraction from the Mound basin over the last 10 years by the City is approximately 3.6 mgd (4000 AFY) (RBF, 2011). An alternative approach would be to provide enough recycled water to match the extractions of the entire Mound Basin. Current extractions of the Mound Basin (including the City's extraction volume and agricultural pumper) are approximately 6.3 mgd (7000 AFY) (Personal communication with Curtis Hopkins, 2012).

There are a number of key issues in assessing feasibility of a 3.6 mgd or 6.3 mgd IPR project, including:

- Adequate travel time - The Draft Groundwater Recharge Reuse Regulation requires a two month minimum retention time between injection and any potable water supply well.
- Extraction well capacity – The current and future operational capacities of the existing extraction wells are 4.4 mgd and 7.2 mgd, respectively (reference).
- Land availability – Availability of land for construction of injection wells and extraction wells (if new wells are needed).

A preliminary planning level analysis was conducted to assess the feasibility of an IPR project in the Mound Basin (Hopkins, 2012). The study suggested that recycled water, at both flows) could be injected in a location northeast of the City's existing wells in the Mound Basin (Victoria Well #2), and that there would be greater than 2 months travel time. Figure 6.8 shows the potential locations evaluated for a groundwater recharge project in the Mound basin.

Major components of this alternative include:

- Microfiltration, reverse osmosis and advanced oxidation treatment facilities
- Brine treatment/disposal facilities
- Recycled water pipelines and pump stations to convey recycled water from the VWRF to the groundwater injection wells
- Groundwater injection wells

6.3.2 Recharge the Oxnard Plain Basin

There are potential opportunities to use the VWRF effluent to augment the City's water supply. The Oxnard Plain Basin is one of the water sources that the City relies on for potable supply.

The City owns and operates groundwater wells (the Golf Course Wells) in the Oxnard Plain Basin. Water extracted from the Oxnard Plain Basin is blended with water, post-treatment, from the Bailey Conditioning Facility. The reclaimed wastewater would be injected at new injection wells, and be extracted at the Golf Course Wells or at other wells that would be constructed for this purpose.

The key issues associated with feasibility discussed for the Mound Basin apply to the feasibility of an IPR projects in the Oxnard Plain. One additional issue in the Oxnard Plain is that this groundwater basin falls under the management of the Fox Canyon Groundwater Management Agency (FCGMA) The FCGMA has responsibility for groundwater management planning, managing pumping allocations and credits, and developing policies related to groundwater extractions and recharge (FCGMA, 2007).

The City is limited by the Fox Canyon GMA allocation of 4104 AFY (3.7 mgd) (RBF 2011). However, it is possible that this could change as a result of IPR since additional water would be recharging the basin. The operational capacity of the existing Golf Course Wells is currently at 6.0 mgd but with a planned increase to 8.9 mgd.

Major components of this alternative include:

- Microfiltration, reverse osmosis and advanced oxidation treatment facilities
- Brine treatment/disposal facilities
- Recycled water pipelines and pump stations to convey recycled water from the VWRF to the groundwater injection wells
- Groundwater injection wells
- Possibly new groundwater extraction wells
- Coordination and approval from the FCGMA

6.3.3 Recharge the Oxnard Forebay

Recharge of the Oxnard Forebay Subbasin is a potential opportunity to use reclaimed water from the VWRF to augment the City's water supplies. The Oxnard Forebay is recognized as the primary recharge area for aquifers in the Oxnard Plain (UWCD 2012a). The confining layers present in other aquifers are either absent or discontinuous in the Oxnard Forebay, and therefore recharge to downgradient aquifers occurs (UWCD 2012a). UWCD (2012b) report that the Mound Basin receives recharge from both the Oxnard Forebay and Oxnard

Plain. However, other scientists believe that this is not the case and differences of opinion have yet to be resolved.

In this alternative, VWRF effluent would be conveyed to new groundwater recharge facilities in the Oxnard Forebay. Because of the absence/discontinuities of confining layers in the Oxnard Forebay, surface recharge would be feasible. The Draft Groundwater Reuse Regulation includes requirements for surface recharge of reclaimed water. For surface application, FAT is not required, and this alternative could be implemented without the need for RO and AOP.

However, there are water quality requirements in the Draft Groundwater Reuse Regulation and the Basin Plan that apply to an IPR project in the Oxnard Forebay. The water quality objectives for the Oxnard Forebay include TDS and chloride concentrations of 1200 mg/L and 150 mg/L , respectively. In addition, there is a requirement that the initial recycled water contribution is less than 20 percent and that with demonstration of attainment of other requirements this could be increased to a maximum of 75%. Diluent water would be required for the purposes of meeting groundwater quality objectives and meeting the recycled water contribution limitations.

The Santa Clara River (SCR) and groundwater are potential sources of diluent water. Water rights to a surface water diversion or groundwater extractions would need to be obtained. In addition, the quality of the diluent water impacts the amount of recycled water that could be recharged. For example, based on an analysis of SCR water quality, the blend water fraction would need to be a minimum of approximately 40% SCR water to meet the chloride limitation of 150 mg/L in the Basin Plan. Under this scenario, where the SCR water is used as the diluent water, the VWRF effluent chloride concentrations would need to be reduced through RO to increase the recycled water contribution beyond 60%.

Similar to injection of reclaimed water, the Draft Groundwater Reuse Regulation requires that there is a minimum 2-month travel time between the site of surface recharge and any potable water supplies. Groundwater travel time from potential recharge sites in the Oxnard Forebay to potable supply wells would need to be determined to assess feasibility of this alternative. If the City wanted to extract the recharged groundwater for use, then new extraction facilities would need to be sited and constructed.

For this alternative, the capacity for recycled water depends on the availability of land for siting recharge facilities, the ability to site recharge facilities in a location where travel time to potable wells is at a minimum of 2 months, the availability of diluent water, and the quality of the diluent water to provide dilution of chloride in the VWRF effluent.

Major components of this alternative include:

- Construction of new groundwater recharge facilities (surface ponds, spreading basins, recharge pits)
- Land acquisition for the surface recharge facilities

- A source of diluent water and facilities to extract/divert water for use
- Recycled water pipelines and pump stations to convey recycled water from the VWRF to the groundwater recharge facilities.

6.3.4 Recharge the Oxnard Forebay using UWCD Facilities

UWCD owns and operates groundwater recharge facilities located on the south side of the Santa Clara River. The Phase 1 Report includes discussion of the potential opportunity to route reclaimed water from the VWRF to the UWCD facilities for groundwater recharge. The objective of this alternative is to take advantage of the existing facilities at UWCD, and their potential interest in augmenting their supply of recharge water through accepting VWRF effluent.

In this alternative, VWRF effluent would be conveyed to UWCD recharge facilities. Based on discussion with UWCD staff, the most likely location for recharge of VWRF effluent would be the Saticoy Spreading Grounds or the Noble Basins. In this scenario, UWCD would be introducing recycled water into their surface spreading operations, and would be required to meet the requirements of the Draft Groundwater Reuse Regulation.

As discussed previously, the Draft Groundwater Reuse Regulation requires that the initial recycled water contribution is less than 20% and that with demonstration of attainment of other requirements this could be increased to a maximum of 75%. UWCD extracts SCR water for recharge of their groundwater basins and for direct conveyance (via pipeline) to growers. Agricultural demands peak in the summer months, and during this time period, the first priority for diverted SCR water is to meet these agricultural demands. This alternative would rely on the SCR water extracted/recharged by UWCD as the source of diluent water for recharge of recycled water. UWCD diversion/recharge of SCR water depends on hydrologic conditions and agricultural demands.

UWCD does not want to introduce water quality issues as a result of recharging reclaimed water from the VWRF (personal communication with UWCD, 2012). Groundwater downgradient of UWCD facilities is used for potable supply and agricultural irrigation. The Upper Santa Clara River Chloride TMDL, established a maximum chloride concentration of 117 mg/L to be protective of agricultural beneficial uses (irrigation of salt sensitive crops) (LARWQCB Final Basin Plan Amendment (TMDL), 2008). UWCD has indicated that water (combination of recycled water and surface water) recharged in their spreading basins should not exceed a chloride concentration of 117 mg/L (note that this is lower than the Basin Plan Objective of 150 mg/L chloride).

The amount and quality of SCR water that UWCD uses for recharge impacts the amount of VWRF effluent that could be recharged as the SCR river water is needed to meet the recycled water contribution percentage and to achieve the target chloride concentration of 117 mg/L. While the initial concept of this alternative was to use VWRF tertiary effluent for groundwater recharge (without additional advanced treatment), the current operations of

UWCD combined with the chloride water quality target, led to the development of several sub-alternatives, including:

- Partial RO of VWRF effluent to increase the amount of effluent that could be recharged year round at UWCD.
- Conveying VWRF effluent to UWCD for blending with SCR water and conveyance to growers, in the summer months. Recharge of VWRF effluent blended with the SCR water diverted by UWCD in the winter months.
- Partial RO of the VWRF effluent to increase the amount of VWRF effluent that could be used for agricultural irrigation in the summer, combined with groundwater recharge in the winter.

Under the Draft Groundwater Reuse Regulation, a recharge project using the UWCD facilities would need to meet the minimum 2 month travel time between recharge sites and potable water supply wells. Groundwater travel time from the Saticoy Spreading Grounds or the Noble Basins to potable supply wells would need to be determined to assess feasibility of this alternative.

Major components of this alternative/sub-alternatives include:

- Recycled water pipelines and pump stations to convey recycled water from the VWRF to UWCD's facilities
- Possible advanced treatment processes, UF/MF and RO, to increase the amount of VWRF effluent that could be used by UWCD for recharge or agricultural irrigation.
- Brine treatment/disposal would be required if RO was implemented.

6.3.5 Recharge the Oxnard Forebay using UWCD Facilities with Blending Water from the Oxnard Plain

Similar to the alternative describe previously, this alternative would involve groundwater recharge using the UWCD facilities. However, in this case, water extracted from the Oxnard Plain would be used for diluent water. UWCD has suggested that there is groundwater in the Oxnard Plain that migrates to the Ocean and this alternative is designed to take advantage of that groundwater and use it as diluent water to meet the recycled water contribution requirements and water quality targets .

The feasibility of this alternative depends on the quantity and quality of groundwater available for extraction and use as diluent water. Chloride concentrations in the Oxnard Plain are low, with concentrations generally less than 60 mg/L. To meet a target of 117 mg/L with the blend of VWRF effluent and diluent water, the required diluent water fraction is approximately 55 percent. The quantity of water available for extraction and use as diluent water depends on hydrogeologic conditions in the area.

Similar to the UWCD alternatives presented in Section 6.1.2.4, this alternative would need to comply with the minimum 2 month travel time required by the Draft Groundwater Reuse Regulation.

Major components of this alternative include:

- Recycled water pipelines and pump stations to convey recycled water from the VWRF to UWCD's facilities
- Extraction wells, pipelines and pump stations to convey Oxnard Plain Groundwater to the UWCD facilities

6.3.6 Preliminary Screening of Groundwater Recharge Alternatives

The preliminary screening analysis is summarized in Table 6.2 and in the discussion that follows. Where appropriate, a relative rating of 1 to 3 (1 highest and 3 lowest) was assigned to provide a relative scaling of attainment of the criteria.

Table 6.2 Preliminary Screening of Groundwater Recharge Alternatives
Phase 2 Recycled Water Study
City of Ventura

Alternatives	Criteria					Selected for Further Evaluation
	Lowers Discharge Volume	Improves the Quality of Final Discharge to the SCRE	Provides Habitat	Provides a Water Supply Benefit	Relies on Existing Treatment	
Recharge the Mound Basin	1	N	N	1	N	Y
Recharge the Oxnard Plain Basin	1	N	N	2	N	N
Recharge the Oxnard Forebay	2	N	N	2	N	N
Recharge/Irrigation at the UWCD Facilities	1	N	N	-	N	Y
Recharge at the UWCD Facilities with Oxnard Plain Blending Water	1	N	N	-	Y	N

Notes:
Where appropriate a relative rating of 1 to 3 (1 highest and 3 lowest) was assigned in lieu of a Y to provide a relative scaling of attainment of the criteria.
The "-" indicates that it is not known at this time, whether the alternative would meet the criterion, and an explanation is provided in the discussion.

The preliminary evaluation of these alternatives and the rationale for including or excluding the alternatives for more detailed development and evaluation is described below. Note that none of the alternatives improve the water quality of the final discharge to the SCRE and none of the alternatives provide habitat, therefore these criteria are not discussed.

6.3.6.1 Recharge the Mound Basin

Recharging the Mound Basin has the following benefits/disadvantages:

- Potential for a moderate to large reduction in the VWRF discharge volume to the SCRE.
- Provides a potentially significant water supply benefit through augmenting one of the City's existing groundwater supplies. In addition, recharging the Mound Basin may also lead to improving the quality of the groundwater extracted for potable supply.
- Does not rely exclusively on the existing VWRF treatment processes and requires advanced treatment, including MF.RO, UV/AOP, and brine treatment/disposal to meet the Draft Groundwater Reuse Regulation.

The potential for a relatively large reduction of the VWRF discharge volume and the potential direct benefits to the City's potable source waters (quality and supply of groundwater), are significant advantages of this alternative. Therefore, this alternative is considered for further evaluation.

6.3.6.2 Recharge the Oxnard Plain Basin

Recharging the Oxnard Plain Basin has the following benefits/disadvantages:

- Potential for a relatively large reduction in the VWRF discharge volume to the SCRE
- Potentially provides a water supply benefit through recharge to the Oxnard Plain, which is a source of groundwater for the City. However, the amount of groundwater credits that the City would receive as a result of an IPR project in the Oxnard Plain would require coordination and approval from the FCGMA
- Does not rely exclusively on the existing VWRF treatment processes and requires advanced treatment, including MF.RO, UV/AOP, and brine treatment/disposal to meet the Draft Groundwater Reuse Regulation.

This alternative is similar to recharge of the Mound Basin, with respect to the potential for a relatively large reduction in the VWRF discharge, and the need for advanced treatment, including brine treatment/disposal. However, compared to the alternative for recharging the Mound Basin, the potential for water supply benefit may be less, as groundwater credits resulting from an IPR project in the Oxnard Plain would fall under the jurisdiction of the FCGMA. In addition, this alternative requires siting new injection and possibly new extraction wells. There is less City owned land in the Oxnard Plain than in the Mound Basin, potential making the siting of injection/extraction facilities more complicated. For these

reasons, implementing an IPR project in the Oxnard Plain Basin will likely be more challenging than in the Mound Basin, and therefore this alternative is not selected for further evaluation.

6.3.6.3 Recharge the Oxnard Forebay

Recharging the Oxnard Forebay has the following benefits/disadvantages:

- Potential for a moderate reduction in the VWRF discharge volume to the SCRE since this alternative would require diluent water to meet the recycled water contribution limits in the Draft Groundwater Recharge Regulation and to meet the water quality objective of 150 mg/L chlorine in the Basin Plan.
- Potentially provides a water supply benefit through recharge to the Oxnard Forebay, which is a source of groundwater to surrounding basins. However, the FCGMA would allocate groundwater credits to the City.
- Potentially relies on existing VWRF processes to produce water for groundwater recharge via surface spreading provide that there is sufficient diluent water available.

There is potential for a moderate reduction of the VWRF discharge volume and potential for some water supply benefit through recharge a groundwater source in the region. To meet basin plan objectives, this system would be recharging a maximum of 60% percent VWRF effluent, unless advanced treatment (UF/MF/ and RO) was implemented. However, there are a number of complicating factors with this alternative, including, it requires construction of new recharge facilities, there is limited land available for recharge facilities in the Oxnard Forebay, the amount of recharge that could be implemented would depend on the availability of diluent water from the SCR, and the feasibility of using the SCR for diluent water is limited, as the City does not currently have any water rights for the SCR. For these reasons, this alternative is not considered for further evaluation.

6.3.6.4 Recharge at UWCD Facilities

Recharging at UWCD Facilities has the following benefits/disadvantages:

- Potential for a relatively large reduction in the VWRF discharge volume to the SCRE. The flow that could be diverted to UWCD depends on the amount of flow that undergoes advanced treatment and/or the amount of diluent or blending water from SCR.
- Potentially provides a water supply benefit through agreement/coordination with FCGMA and UWCD.
- Does not rely exclusively on the existing VWRF, and requires advanced treatment, including MF.RO, and brine treatment/disposal.

There is potential for a relatively large reduction of the VWRF discharge volume by taking advantage of UWCD's existing recharge facilities and agricultural water supply distribution

system. While preliminary analysis suggests that there is limited opportunity for recharge or agricultural irrigation without partial advanced treatment, there is opportunity for a moderate to large reduction in discharge volume with partial advanced treatment. Additional investigation into the possibility of groundwater credits from the FCGMA and possible other water supply benefits through agreement with UWCD is needed to determine if there is a potential City water supply benefit associated with this alternative. The ability to take advantage of existing recharge and distribution facilities and the potential for a moderate to large reduction in discharge volume with only partial advanced treatment, are benefits of this alternative. For these reasons, this alternative is considered for further evaluation.

6.3.6.5 Recharge at UWCD Facilities with Oxnard Plain Blending Water

Recharging at UWCD Facilities with Oxnard Plain Blending Water has the following benefits/disadvantages:

- Potential for a moderate reduction in the VWRF discharge volume to the SCRE depending on the availability of diluent water from the Oxnard Plain.
- Potentially provides a water supply benefit through agreement/coordination with FCGMA and UWCD.
- Relies on the existing VWRF treatment processes

There is potential for a moderate reduction of the VWRF discharge volume, but the amount of recharge depends on the availability of diluent water to meet the 117 mg/L chloride target. Based on groundwater quality of the Oxnard Plain, the required diluent water fraction is at a minimum of 55 percent. This large fraction of diluent water means that piping and pumping facilities would need to be very large from the VWRF all the way to the UWCD facilities to carry both the effluent and the diluent water. A significant unknown with this alternative is the amount of groundwater in the Oxnard Plain that would be available for extraction and use as diluent water. UWCD has started to develop a more refined groundwater model that will provide a better to for predicting groundwater elevations and transport in the Oxnard Plain and other basins. At present time, since the availability of diluent water is still a major unknown, this alternative is not considered for further evaluation. However, the City should track the development of this model and upon completion should revisit this question of the availability of diluent water in the Oxnard Plain.

6.4 TREATMENT WETLANDS ALTERNATIVES

The treatment wetlands alternatives include several options for further polishing treatment of the VWRF effluent. In addition, there are a number of other reuse and recharge alternatives that may require reverse osmosis and therefore will require brine treatment. The potential use of wetlands for brine treatment is included in this grouping of alternatives. The wetlands alternatives include:

- Wetlands at Wildlife Ponds
- Wetlands on City Owned property
- Wetlands on TNC property
- Wetland on uplands
- Wetlands combined with perched recharge located East of 101
- Wetlands combined with perched recharge located West of 101
- Brine Wetlands

With the exception of the brine wetlands, the primary objective of the treatment wetlands is to further reduce nitrate concentrations in the VWRF effluent. In general, the greater the wetland area, the greater the amount of flow can be routed to the treatment wetland, while maintaining the residence time required to achieve the targeted effluent nitrate concentration. An overview of the areas considered for wetlands is shown in Figure 6.9.

6.4.1 Wetlands at Wildlife Ponds

The Phase 1 Report includes discussion modifying the existing Wildlife Ponds to function as treatment wetlands. Two of the existing ponds, Pond 1 (Bone) and Pond 2 (Snoopy), would be filled to create a depth less than three feet, and vegetated benches would be constructed. The Phase 1 Report indicates that approximately 12.4 acres of treatment wetlands could be created by modifying Ponds 1 and 2. The existing interties between the ponds would be preserved as would the existing discharge channel that conveys flow into the Santa Clara River Estuary.

The amount of additional nitrate removal that could be achieved in the 12.4 acres of treatment wetland area would depend on the amount of flow that would be routed to the treatment wetlands. Assuming a total inorganic nitrogen concentration of 8 mg/L as N, and a flow into the wetland of 3 mgd, the resulting effluent nitrate concentrations would range from 2 to 6 mg/L as N.

The major components of this alternative include:

- Approximately 12.4 acres of treatment wetlands (replacing existing Wildlife Ponds 1 and 2)
- Existing interties between wetland cells
- Existing discharge channel into the SCRE

Figure 6.10 shows the potential modifications of the Wildlife Ponds.

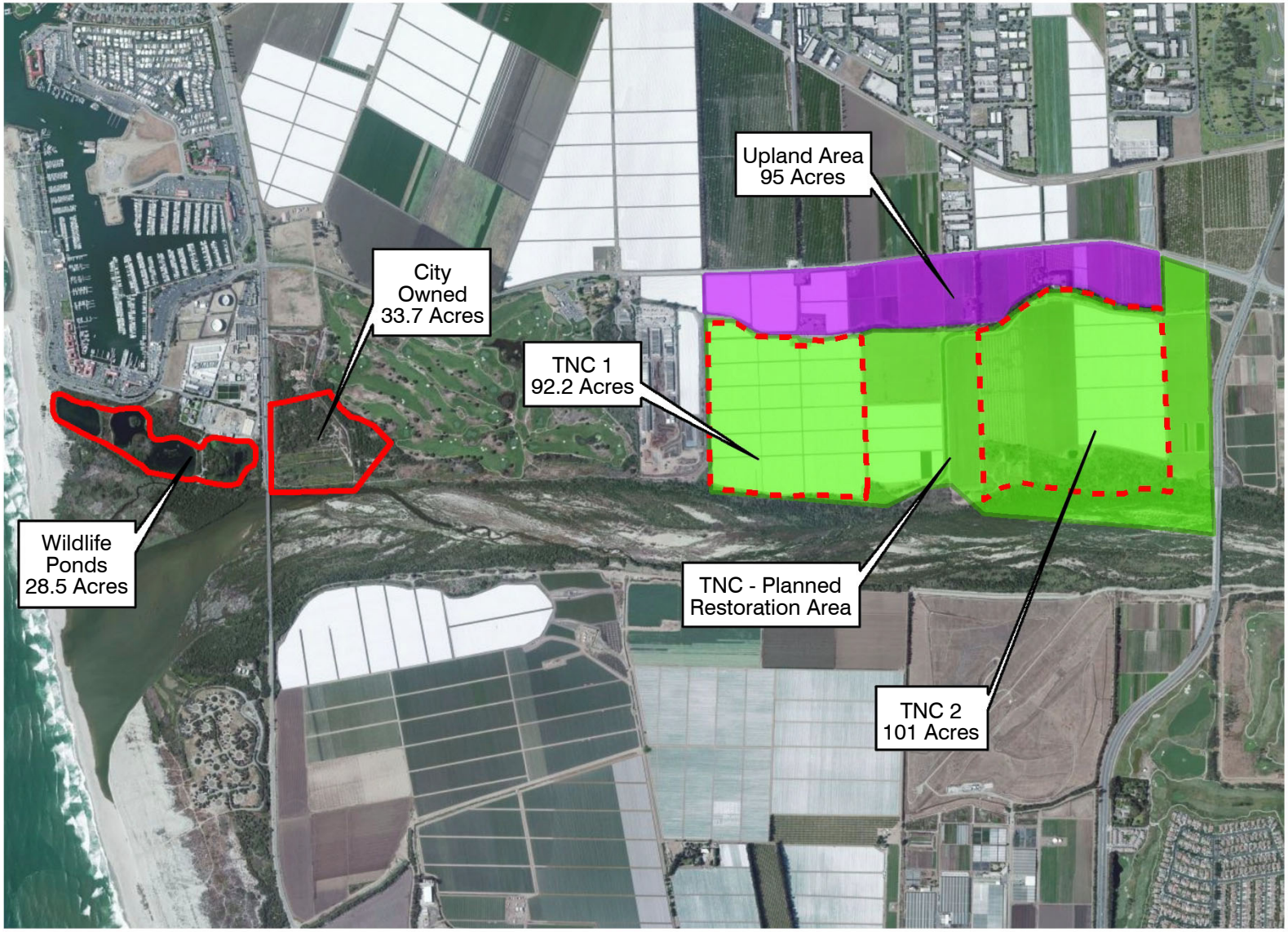


Figure 6.9
POTENTIAL SITES FOR TREATMENT WETLANDS
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

ven113f15-8144.ai

Legend

Wildlife Ponds

N

Feet
0 125 250

Figure 6.10
LOCATIONS OF THE BONE AND SNOOPY WILDLIFE PONDS
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

6.4.2 Wetlands on City Property

The Phase 1 Report includes discussion of the possibility of using the City owned property, located adjacent to the VWRF, for treatment wetlands. Approximately 29 acres would be available for construction of new treatment wetlands (85 percent of the total available area). In addition, associated infrastructure would need to be constructed. This infrastructure would include pipelines and pump stations required to convey the VWRF effluent to the wetland, and the infrastructure required for discharge of the wetland outflow to the SCRE. There are two alternatives for discharge from new wetlands at the City owned property, including routing the outflow to the existing VWRF effluent discharge channel, or construction a new outfall structure/channel into the SCRE.

The amount of additional nitrate removal that could be achieved in the 29 acres of treatment wetland area would depend on the amount of flow that would be routed to the treatment wetlands. By combining the City owned property and the existing wildlife ponds (modified to be vegetated wetlands), the influent flow can be increased while maintaining the same effluent nitrate concentration target. Assuming an influent total inorganic nitrogen concentration of 8 mg/L as N, and a flow into the wetland (combined city owned property and existing wildlife ponds) of 7 mgd, the resulting effluent nitrate concentrations would range from 3 to 5 mg/L as N.

The major components of this alternative include:

- Approximately 29 acres of treatment wetlands
- Pipelines and pump stations to route VWRF effluent to the treatment wetlands
- Infrastructure associated with discharge via the existing effluent channel or an new discharge structure
- A new point of compliance, if the existing VWRF effluent channel is not used.

6.4.3 Wetlands on TNC Property

The Phase 1 Report describes the potential for using a TNC owned property as the site for new treatment wetlands. Since the completion of the report, the TNC has purchased a parcel located closer to the VWRF. This alternative would involve constructing new treatment wetlands on the TNC parcel closest to the VWRF, as shown in Figure 6.12. If the site were to be used exclusively for treatment wetlands, then approximately 78 acres 85 percent or the total parcel area) would be available. In addition, new pipelines and pump stations would need to be constructed to convey effluent from the VWRF to the treatment wetlands. New infrastructure associated with the discharge of the wetland outflow to the SCR would need to be constructed.

The amount of additional nitrate removal that could be achieved in the 78 acres of treatment wetland area would depend on the amount of flow that would be routed to the

treatment wetlands. The proposed wetlands is estimate to reduce the TIN of 8 mg/L as N to between 3 to 6 mg/L nitrate at a flow of 13 mgd, or better for flows less than 13 mgd.

The use of this parcel would require coordination and agreement with the TNC. The TNC's Santa Clara River Parkway Project involves purchasing parcels along the SCR that are within the 100-year floodplain for the purpose of floodplain restoration. This involves removing the levees, ceasing agricultural activities, and re-establishing riparian vegetation. The removal of the levees would allow more frequent flooding of the parcel. The differences between the objectives of using the parcel for treatment wetlands versus for floodplain restoration would need to be resolved.

The major components of this alternative include:

- Approximately 78 acres of treatment wetlands within the 100-year floodplain, if the site can be used exclusively for treatment wetlands.
- Pipelines and pump stations to route VWRF effluent to the treatment wetlands
- Infrastructure associated with discharge via the existing VWRF effluent channel or a new discharge structure.
- A new point of compliance for discharge to the SCR, if the existing VWRF effluent channel is not used.

6.4.4 Wetlands on Uplands

This alternative involves construction of new treatment wetlands on upland area on the north side of the SCR, as shown in Figure 6.10. This area is outside of the 100-year floodplain and is currently used for agriculture. The City would need to purchase this upland area. Depending on how many parcels were purchased, up to 95 acres could be available for construction of new treatment wetlands, for 80 acres of wetlands (if 85% of acreage is used). In addition, new pipelines and pump stations would need to be constructed to convey effluent from the VWRF to the treatment wetlands. New infrastructure associated with the discharge of the wetland outflow to the SCR would need to be constructed. Since the parcel is not adjacent to the SCR, the discharge of the wetland outflow would need to be conveyed across an adjacent parcel to reach the SCR. Conveyance of the wetland outflow could be achieved by a pipeline. If the outflow were conveyed across TNC owned parcel(s) then it may be possible for the wetland outflow to be routed via overland flow to the SCR.

The amount of additional nitrate removal that could be achieved in the 80 acres of treatment wetland area would depend on the amount of flow that would be routed to the treatment wetlands. The proposed wetlands is estimate to reduce the TIN of 8 mg/L as N to between 3 to 6 mg/L nitrate at a flow of 13 mgd, or better for flows less than 13 mgd.

The major components of this alternative include:

- Approximately 80 acres of new treatment wetlands.

- Pipelines and pump stations to route VWRF effluent to the treatment wetlands.
- Infrastructure associated with a new discharge structure, including the infrastructure to convey the wetland outflow across the parcel(s) between the upland site and the SCR.
- A new point of compliance for discharge to the SCR.

6.4.5 Wetlands with Perched Recharge East of 101

One possibility with treatment wetlands is to site and design it to promote recharge to shallow groundwater, as opposed to a surface water discharge. The crossing of Route 101 and the SCR roughly aligns with the boundary between the Oxnard Forebay Basin and the Oxnard Plain Basin. This alternative involves construction of treatment wetlands combined with perched zone recharge located east of 101. The construction of treatment wetlands combined with perched zone recharge located west of 101 is described in the next section.

This alternative involves routing the VWRF effluent to a treatment wetlands located east of 101. The wetlands would be configured to promote groundwater recharge. As previously described, the Oxnard Forebay Basin readily percolates into the shallow aquifer as well as deeper aquifers. The recharge of the wetlands outflow would be subject to attainment of groundwater quality objectives in the Basin Plan. Oxnard Forebay water quality objectives include TDS of 1200 mg/L and chloride of 150 mg/L. This alternative may also be subject to the Draft Groundwater Recharge Regulations. The wetlands would be recharging a groundwater basin that is designated for municipal supply and is currently used for municipal supply.

The boundary of the Oxnard Forebay Basin, is located north of the SCR, and there is land adjacent to the SCR that could be used to site treatment wetlands with recharge. However, much of the area adjacent to the SCR and within the Oxnard Forebay Basin is currently owned and used for other purposes. In addition, land adjacent to the north side of the SCR is within the 100 year floodplain.

The major components of this alternative include:

- Purchase of land to site a treatment wetlands
- Pipelines and pump stations to route VWRF effluent to the treatment wetlands
- Surface water treatment wetlands, that are configured to promote groundwater recharge.

6.4.6 Wetlands with Perched Recharge West of 101

This alternative involves construction of treatment wetlands combined with perched zone recharge located west of 101. VWRF effluent would be routed to treatment wetlands that would be designed to promote the recharge of the wetland outflow to shallow groundwater.

In this case, the recharge would occur by surface recharge to the shallow groundwater of the Oxnard Plain Basin, and would ultimately contribute to the baseflow in the SCR.

The potential area for wetlands within the Oxnard Plain Basin, roughly coincides with the area west of Route 101. Much of the area adjacent to the SCR within the Oxnard Plain Basin are currently owned and used for other purposes. In addition, land are adjacent to the SCR is within the 100 year floodplain.

The recharge of the wetlands outflow would be subject to attainment of groundwater quality objectives in the Basin Plan. The water quality objectives of the shallow groundwater aquifer in the Oxnard Plain Basin include TDS of 3000 mg/L and chloride of 500 mg/L. This alternative may also be subject to the Draft Groundwater Recharge Regulations. The wetlands would be recharging a groundwater basin that is designated for municipal supply. However, while the shallow groundwater is designated as municipal supply, there are no known municipal wells that rely on the shallow groundwater.

- The major components of this alternative include:
- Purchase of land to site a treatment wetlands
- Pipelines and pump stations to route VWRF effluent to the treatment wetlands
- Surface water treatment wetlands, that are configured to promote groundwater recharge.

6.4.7 Wetlands for Brine Treatment Disposal

There are a number of alternatives for recharge and irrigation that require reverse osmosis to meet water quality requirements. The RO process generates a brine waste that requires treatment and/or disposal. This alternative involves the construction of a wetlands for brine treatment and final surface water disposal.

Brine wetlands can provide removal of nutrients, metals and other contaminants. In addition, brine wetlands provide brackish water vegetation and habitat. The brine generated from the RO process would be conveyed to the inflow of a brine wetland, where it would be subject to treatment by natural physical and biochemical processes. The outflow of the brine wetland would be combined with VWRF effluent to provide dilution prior to discharge into the SCRE.

The feasibility of using a brine wetlands is dependent on the ability of the wetlands to reduce metals, nutrients and other pollutants to concentrations, that when combined with the VWRF effluent, would not water quality discharge limitations or cause adverse effects on the SCRE. There has been limited research on the efficacy of brine treatment wetlands. Pilot studies would be required to assess the feasibility of a brine treatment wetlands.

The major components of this alternative include:

- Construction of a new brine treatment wetlands

- Pipelines and pump stations to route the brine to the treatment wetlands and to convey the treated brine back to the VWRF effluent channel for blending and discharge.
- Infrastructure to blend brine with VWRF effluent

Figure 6.11 shows the concept of how a brine wetland could be configured.

6.4.8 Preliminary Screening of Wetlands Alternatives

The preliminary screening results are presented in Table 6.3 and discussed in the bullets that follow. Where appropriate a relative rating of 1 to 3 (1 highest and 3 lowest) was assigned to provide a relative scaling of attainment of the criteria.

Table 6.3 Preliminary Screening of Wetlands Alternatives
Phase 2 Recycled Water Study
City of Ventura

Alternatives	Criteria					Selected for Further Evaluation
	Lowers Discharge Volume	Improves the Quality of Final Discharge to the SCRE	Provides Habitat	Provides a Water Supply Benefit	Relies on Existing Treatment	
Wetlands at Wildlife Ponds	3	Y	3	N	Y	Y
Wetlands on City Owned property	3	Y	3	N	Y	Y
Wetlands on TNC property	1	Y	1	N	Y	N
Wetland on uplands	1	Y	1	N	Y	N
Wetlands combined with perched recharge located East of 101	1	Y	3	N	Y	N
Wetlands combined with perched recharge located West of 101	1	Y	3	N	Y	N
Brine Wetlands	NA	NA	Y	NA	NA	Y

Notes:
Where appropriate a relative rating of 1 to 3 (1 highest and 3 lowest) was assigned in lieu of a Y to provide a relative scaling of attainment of the criteria.
NA = Not applicable

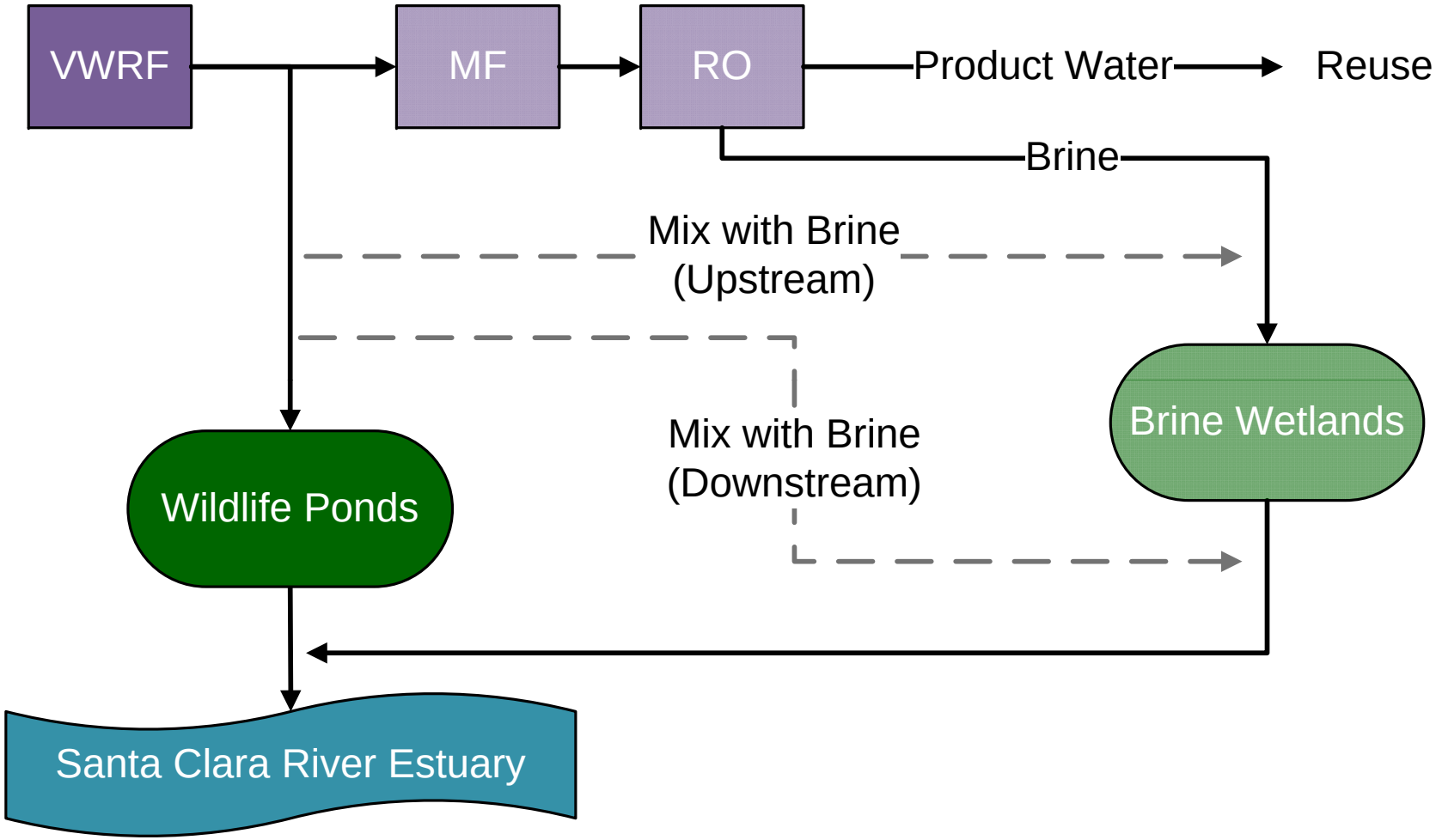


Figure 6.11
SCHEMATIC OF BRINE WETLANDS
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

The preliminary evaluation of these alternatives and the rationale for including or excluding the alternatives for more detailed development and evaluation is described below. Note that none of the alternatives provide a benefit to the City's water supply, and all of the alternatives rely on the existing VWRF treatment processes, therefore, these criteria are not discussed.

6.4.8.1 Wetlands at Wildlife Ponds

Wetlands at the Wildlife Ponds have the following benefits/disadvantages:

- There is a low potential for reducing the volume of the discharge through increased evapotranspiration of a wetlands system as compared to the existing Wildlife Ponds.
- There is relatively low potential for improving water quality of the discharge because the land available for treatment wetlands is relatively small. A flow of 3 mgd could be treated to a nitrate concentration of 2 to 6 mg/L as N. Higher flows would achieve less reduction.
- There is relatively low potential for providing habitat because of the limitations on area available for wetlands.

While the relatively small area of the Wildlife Ponds provides capacity for only 3 mgd, there may be combinations of alternatives that would result in an VWRF effluent discharge of 3 mgd or less. In this case, the Wildlife Ponds could be used to provide additional nutrient removal and polishing of the WVRF effluent prior to discharge to the SCRE. In addition, the wetlands would provide some wildlife habitat. For these reason, this alternative is considered for further evaluation.

6.4.8.2 Wetlands at City Owned Property

Wetlands at City Owned Property have the following benefits/disadvantages:

- There is a low potential for reducing the volume of the discharge through evapotranspiration of a wetlands system.
- There is relatively moderate potential for improving water quality of the discharge.
- There is relatively moderate potential for providing habitat.

The City owned property provides the potential for increasing the capacity of a treatment wetland and increasing habitat. For alternatives that result in a discharge of flow to the SCRE greater than 3 mgd, the treatment wetland area could be expanded to include the Wildlife Ponds and the City-owned parcel. Complicating factors include the infrastructure to convey water to and from the City-owned parcel. However, these challenges are offset by the potential financial benefit of using an existing City owned parcel and the potential to provide additional nitrate removal for a larger flow volume. For these reasons, this alternative is considered for further evaluation.

6.4.8.3 Wetlands at TNC Property

- Wetlands at TNC Property have the following benefits/disadvantages: The volume of the discharge to the SCRE would be reduced because the discharge location would be upstream of the Estuary into the river.
- There is relatively high potential for improving water quality of the discharge.
- There is relatively high potential for providing habitat.

The TNC owned property provides a relatively high the potential for treatment and habitat because it is a relatively large parcel. However, there are a number of challenges with siting treatment wetlands on the TNC parcel. The TNC plans to pull back the levees, allow more frequent flooding, and promote re-establishment of riparian vegetation These objectives are not aligned with a treatment wetlands, consisting of wetland vegetation and would put any investment in wetland infrastructure and vegetation at risk during flood events. In addition, the TNC parcels were purchased with grant funding from several agencies including, the State Coastal Conservancy, the Wildlife Conservation Board, Department of Water Resources and US Fish and Game. The funding agreements include requirements that the land be used for conservation and flood plain restoration. Ultimately, the TNC plans to sell back their parcel to an owner with conditions for maintaining the floodplain and riparian vegetation function of the parcels.

The lack of consistency between TNC objectives for the parcel and the objectives of a treatment wetlands, the risk to the investment in the construction of the treatment wetlands, and the expectation of future land purchase, limits the feasibility of siting treatment wetlands on the TNC property. For these reasons, this alternative is not considered for further evaluation.

6.4.8.4 Wetlands on Uplands

Wetlands on Uplands have the following benefits/disadvantages:

- The volume of the discharge to the SCRE would be reduced because the discharge location would be upstream of the Estuary.
- There is relatively high potential for improving water quality of the discharge.
- There is relatively high potential for providing habitat.

The upland area, outside of the 100 year floodplain, provides a relatively high the potential for treatment and habitat because there is a significant amount of land that could be converted to treatment wetlands. However, there are a number of challenges with siting treatment wetlands on the upland area. The most significant challenges include, that this area is prime agricultural land, changing the land use would be in conflict with local land use policies, the land area is owned by several different entities, there is already an entity interested in purchasing this land, it would require coordination with adjacent land owners to

route the wetland outflow to the SCRE or SCR, and the City would need to purchase the land. For these reasons, this alternative is not considered for further evaluation.

6.4.8.5 Wetlands combined with perched recharge located east of 101

Wetlands combined with perched recharge located East of 101 has the following benefits/disadvantages:

- While the discharge would be outside of the SCRE, the amount of available land limits the potential for reducing the discharge volume.
- Due to land constraints there is low potential for improving water quality of the discharge and for providing habitat.

The area on the north side of the river that is within the Oxnard Forebay (East of 101) is either being used for other purposes or is a parcel targeted by the TNC for acquisition and restoration to floodplain, and therefore, space for a treatment wetlands is limited. In addition, the concept of a treatment wetlands would be to improve the VWRF water quality through natural treatment. However, the water quality objectives of the Oxnard Forebay could not be met without RO. For these reasons, this alternative is not considered for further evaluation.

6.4.8.6 Wetlands combined with perched recharge located West of 101

Wetlands combined with perched recharge located West of 101 has the following benefits/disadvantages:

- While the discharge would be outside of the SCRE, the amount of available land limits the potential for reducing the discharge volume.
- Due to land constraints there is low potential for improving water quality of the discharge and for providing habitat.

The area on the north side of the river that is within the Oxnard Plain (West of 101) is either being used for other purposes or is a parcel targeted by the TNC for acquisition and restoration to floodplain, and therefore, space for a treatment wetlands is limited. For these reasons, this alternative is not considered for further evaluation.

6.4.8.7 Brine Wetlands

Brine wetlands has the following benefits/disadvantages:

- Not designed to reduce the VWRF discharge volume or to improve the VWRF effluent quality.
- Moderate potential to provide habitat.

There a number of alternatives that require some portion of the VWRF effluent to be treated by RO, Among the number of alternatives for brine treatment/disposal is a brine treatment

wetlands. The analysis of the wetlands alternatives has led to the City-owned property as the most viable site for construction of a wetlands. A brine wetlands on the city-owned property is considered in the context of brine treatment/disposal option. However, as discussed, the feasibility of a brine wetlands would require more investigation and pilot testing to determine the ability of the wetlands to removal nutrient, metals and other pollutants in the concentrated brine stream.

6.5 SUMMARY OF SCREENING ANALYSIS

The preliminary screening analysis led to a number of alternatives that were identified for further consideration, including:

- Northern decentralized Treatment Plant with Urban and Agricultural Irrigation
- Direct Potable Reuse
- Conveyance to the Oxnard WWTP/AWPF
- Groundwater Recharge of the Mound Basin (IPR)
- Groundwater Recharge/Irrigation at UWCD Facilities
- Treatment Wetlands Onsite and at City Owned Property

In addition, urban irrigation and agricultural irrigation are selected as alternatives that could be combined implemented along with other alternatives. Chapter 7 provides additional information, analysis and evaluation of these alternatives.

VIABLE ALTERNATIVES DEVELOPMENT AND COMPARISON

The preliminary screening of alternatives (presented in Chapter 6) led to a number of alternatives that were selected for further evaluation. This chapter provides additional detail on these alternatives, including cost estimates. This chapter also includes a discussion of environmental considerations associated with these alternatives that focuses on the amount of flow that remains in the discharge and the resulting effects on the SCRE stage and water quality.

7.1 NORTH SIDE DECENTRALIZED TREATMENT PLANT WITH URBAN AND AGRICULTURAL IRRIGATION

7.1.1 Planning and Design Assumptions

This alternative includes the construction of a decentralized treatment plant for the purpose of providing an upstream supply of recycled water located near the Seaside Pump Station. Raw wastewater would be diverted from the collection system for treatment. Figure 7.1 presents the location of the decentralized treatment plant and recycled water distribution system. Year 2050 estimates of sea level rise suggest inundation in this area. If selected as a preferred alternative then addition investigation of alternative sites in the vicinity would be needed.

Based on analysis of collection system flows (Kennedy Jenks, 2010) as well as flow information from the Seaside Pump Station, there is approximately 2.6 million gallons per day (mgd) raw wastewater available at this location in the VWRF collection system.

Potential urban and agricultural demands were estimated using land use/crop information, and City records of potable water demands. The average and maximum month demands in the vicinity of this new distributed treatment plant are presented in Table 7.1.

Table 7.1 Summary of Urban and Agricultural Irrigation Demands near the Proposed Distributed Treatment Plant
Phase 2 Recycled Water Study
City of Ventura

Demand Type	Average (mgd)	Maximum Month (mgd)
Urban Irrigation	0.17	0.24
Agricultural Irrigation	1.1	1.8
Total	1.3	2.0

On a maximum month basis, these demands are similar to the available supply of approximately 2.6 mgd. Agricultural irrigation demands represent the majority of the total demands. The potable average and maximum month demands that would be offset with recycled water are 0.17 mgd and 0.24 mgd, respectively.

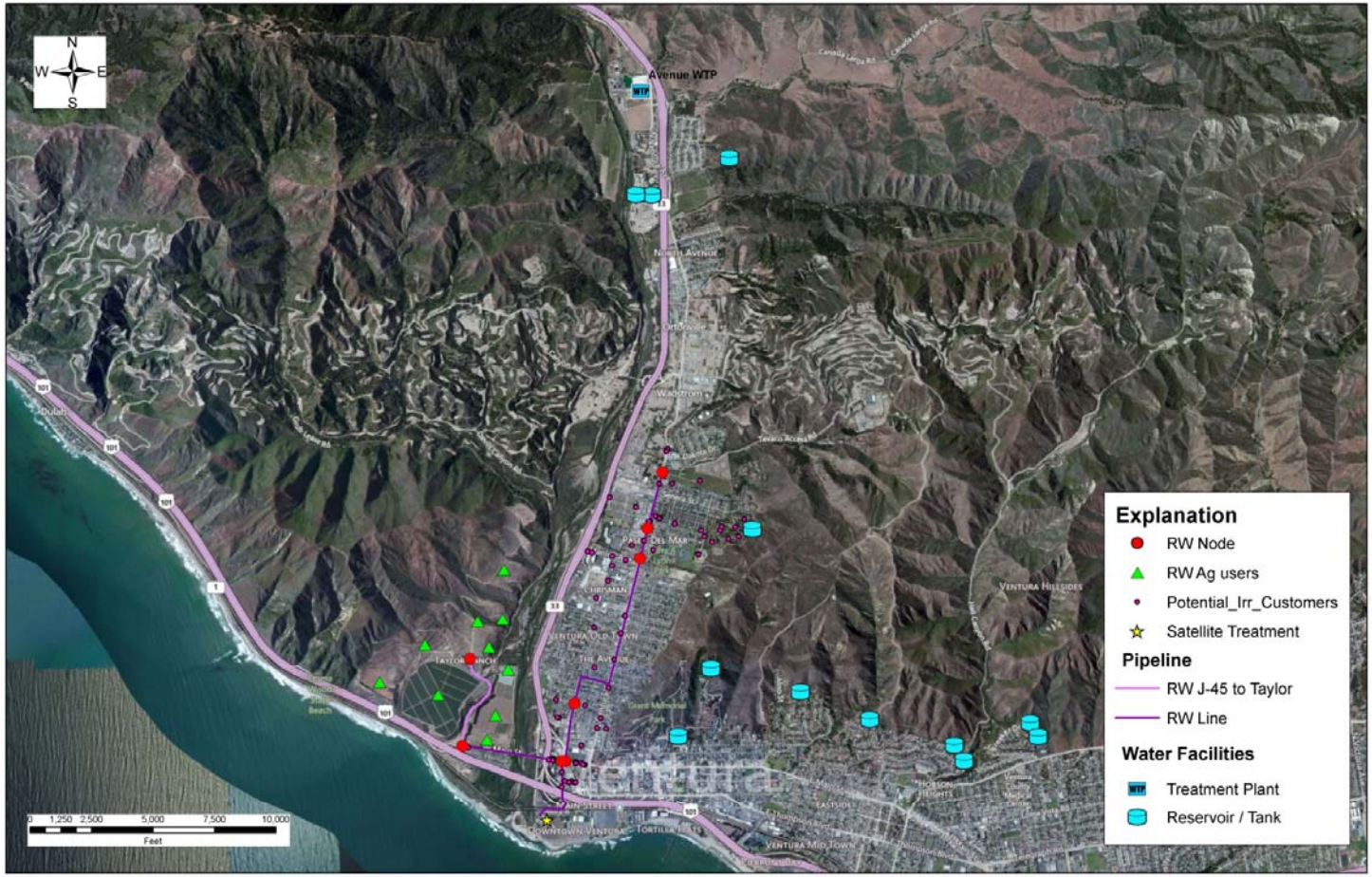


Figure 7.1
NORTH SIDE DECENTRALIZED TREATMENT PLANT AND DISTRIBUTION SYSTEM
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

7.1.2 Treatment

To serve local urban and agricultural demands, the treatment plant would be sized for a maximum month flow of 2 mgd. The treatment plant would be designed to meet Title 22 standards for unrestricted reuse. In addition, the recycled water would need to meet a chloride target of 117 milligrams per liter (mg/L) for the irrigation of crops sensitive to chloride. Raw wastewater samples from this area of the VWRF collection system suggests that this chloride target could be met. Measured TDS and chloride concentrations were 676 mg/L and 68 mg/L, respectively. These TDS and chloride concentrations are acceptable for sensitive crops and no additional treatment beyond treatment required to meet Title 22 would be required.

Small distributed treatment plants can either be package treatment plants or customized plants. While there are several different approaches to wastewater treatment that could be employed, this analysis considers two treatment approaches, conventional activated sludge and a membrane bioreactor (MBR). Figure 7.2 presents the treatment alternatives. One advantage of a membrane bioreactor is that if there was need or interest in implementing advanced treatment, such as reverse osmosis (RO), at this treatment plant, then the ultra or microfiltration (UF/MF) pretreatment process would not be needed due to the membrane bioreactor process. Upgrading a conventional activated sludge treatment plant to include RO would require the addition of UF/MF. Section 7.2 presents a direct potable reuse alternative that would include implementing advanced treatment (RO) at the distributed treatment plant and conveyance to Casitas Turnout No.2.

For the conventional and MBR treatment plants, the solids would be conveyed back to the collection system and would be conveyed in the influent wastewater to the VWRF.

7.1.3 Distribution System

As shown in Figure 7.1, the distribution system was designed to convey recycled water to potential urban and agricultural users. The recycled water distribution systems consist of 4-inch and 8-inch PVC pipes.

7.1.4 Summary

The components of this alternative are summarized in the Table 7.2.

Table 7.2 Summary of the North Decentralized Treatment Plant Alternative Phase 2 Recycled Water Study City of Ventura

Recycled Water Demand (average)	1.3 mgd
Recycled Water Demand (max month)	2.0 mgd
Decentralized Treatment Plant Capacity	2 mgd
Volume Diverted from SCRE	2 mgd
Treatment Processes	Conventional or MBR, designed to meet Title 22 requirements, no solids treatment
Location	Near the Seaside Pump Station
Infrastructure	Recycled water distribution system

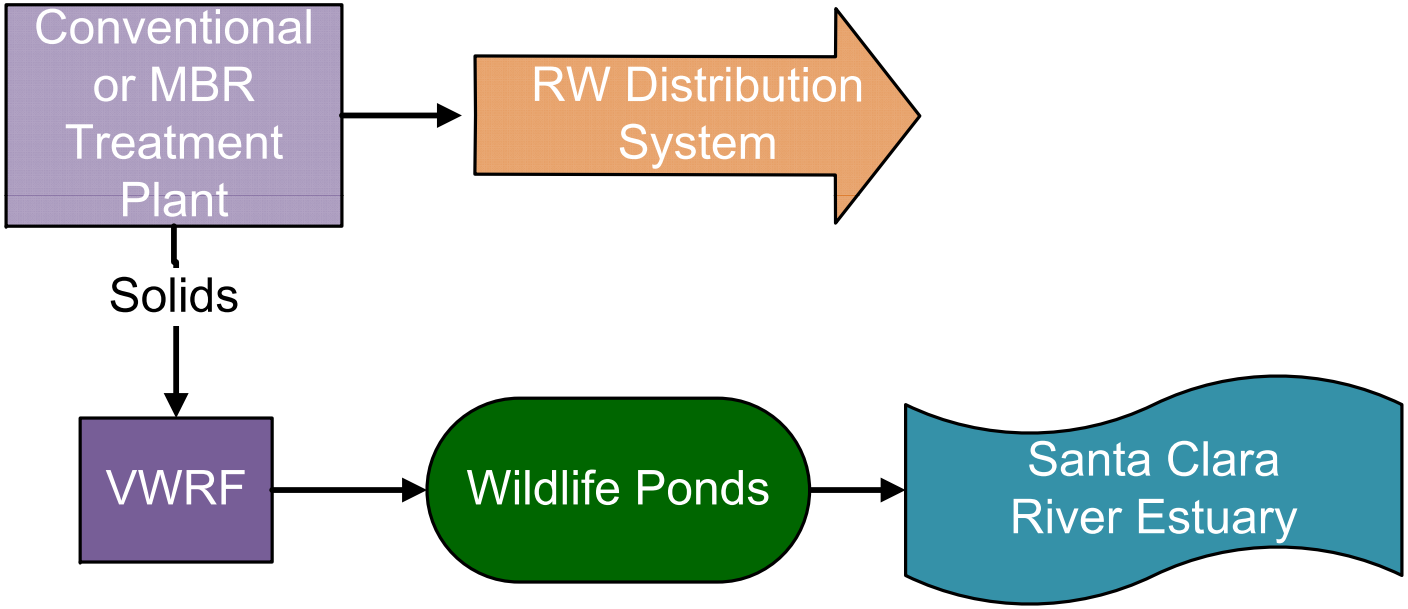


Figure 7.2
DECENTRALIZED TREATMENT PLANT SCHEMATIC
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

7.2 DIRECT POTABLE REUSE

7.2.1 Planning and Design Assumptions

This alternative involves advanced treatment of wastewater and direct reuse in the potable water distribution system. There are two sub-alternatives for direct potable reuse (DPR) that utilize different sources of wastewater for DPR.

The first sub-alternative involves advanced treatment at the VWRF and conveyance to the distribution system that originate from the Bailey Water Conditioning Facility. This alternative would provide approximately 3.6 mgd of reclaimed wastewater to replace the City's current extractions from the Mound Basin.

The second sub-alternative involves advanced treatment at a new north side decentralized treatment facilities. Advanced treatment processes would be located at the north side decentralized treatment plant. The treated water would be conveyed to Casitas Turnout No 2, for use in the potable water distribution system. This alternative would provide approximately 2 mgd of reclaimed wastewater to be used in the City's potable water system.

7.2.2 Treatment

While regulations have not been developed, it is anticipated that the DPR will require RO and advanced oxidation. The treatment train is similar to the indirect potable reuse (IPR) treatment train without the environmental buffer (minimum 2 month groundwater travel time). Additional treatment and monitoring is substituted for the environmental buffer. After RO treatment, the water would be stored for a set period of time, 12 hours, to allow for additional monitoring. The influent to the storage tank would be dosed with free chlorine to provide for an additional measure of disinfection. Storage would be such that treated "potable" water would be diverted for 12 hours at a time to two tanks, "Tank 1" and "Tank 2." After 12 hours of flow to Tank 1, the tank would be sealed and water would be diverted to start filling "Tank 2." Water samples would be taken at constant intervals during the filling process and tested. Upon successful completion of the advanced monitoring, water would be released from the full tank, undergo UV and advanced oxidation, and be delivered into the distribution system. The tank would subsequently be refilled while Tank 2 undergoes advanced monitoring. An equalization basin would be needed to regulate flow into the two tanks. Figure 7.3 presents the DPR treatment train.

The recovery of the RO process is dependent on the influent (to the RO process) water quality. In particular, silica is an important water quality parameter that can adversely affect the RO process. Preliminary analysis of silica concentrations in the VWRF effluent suggests that the silica content could affect the operation of an RO process. However, additional data would need to be collected to confirm the silica concentrations. Additional treatment or operation at a lower recovery are two approaches for addressing issues related to high silica concentrations.

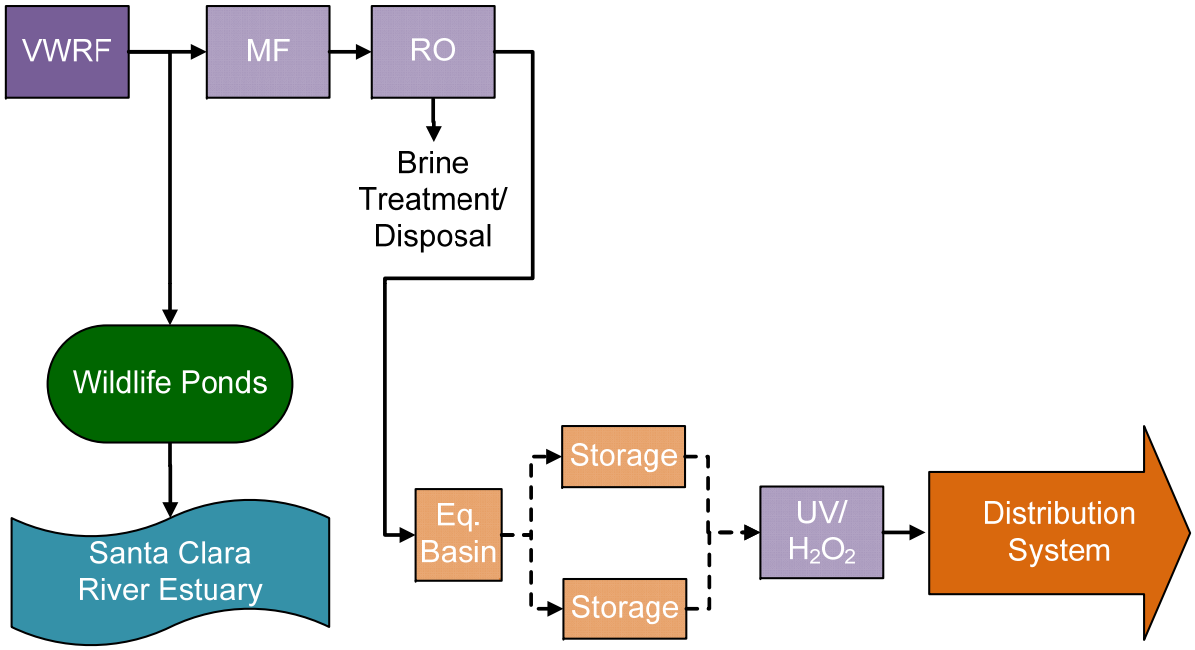


Figure 7.3
DPR TREATMENT PLANT SCHEMATIC
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

Brine will be generated from the DPR treatment process. For the DPR treatment processes at the VWRF, the brine generated will require treatment and disposal. For the DPR treatment processes at the north side decentralized treatment plant, it is assumed that the small volume of brine (0.5 mgd) would be conveyed back into the VWRF collection system. The impacts of this brine flow on treatment and effluent quality at the VWRF would require further study to assess feasibility of this brine disposal option.

7.2.3 Distribution System

The first sub-alternative requires new infrastructure to convey the water from the DPR treatment train to the Bailey Water Conditioning Facility. This alternative relies on the existing potable water distribution system to convey the water to the City's potable water supply customers.

Similarly, the second sub-alternative requires new infrastructure from the potential new decentralized treatment plant to Casitas Turnout No. 2. This alternative relies on the existing potable water distribution system between Casitas Turnout No. 2. and the City's potable water customers.

Figure 7.4 shows the potential pipeline alignments to convey the treated wastewater to the potable water distribution system.

7.2.4 Summary

Table 7.3 summarizes the DPR alternatives. The City participated in a research project on DPR (Evaluation of Risk Reduction Principles for Direct Potable Reuse, WateReuse Research Foundation Project 11-10). This study evaluated the treatment performance of current IPR practices and considers what additional treatment and monitoring and operational issues may be necessary to implement DPR. The City of Ventura Case Study section of the draft report is included in Appendix C.

7.3 CONVEYANCE TO THE OXNARD WWTP/AWPF

7.3.1 Planning and Design Assumptions

The Final Draft Ventura-Oxnard Recycled Water Interconnect Feasibility Study (Kennedy Jenks, 2013) investigates the feasibility of conveying VWRF effluent to the City of Oxnard's Advanced Water Purification Facility (AWPF), and, if treatment capacity is not available or if there is not enough demand, discharging the effluent to either the City of Oxnard's ocean outfall or Calleguas Municipal Water District's (Calleguas) Salinity Management Pipeline. Figure 7.5 shows the potential pipeline routing for conveying VWRF effluent to the AWPF.

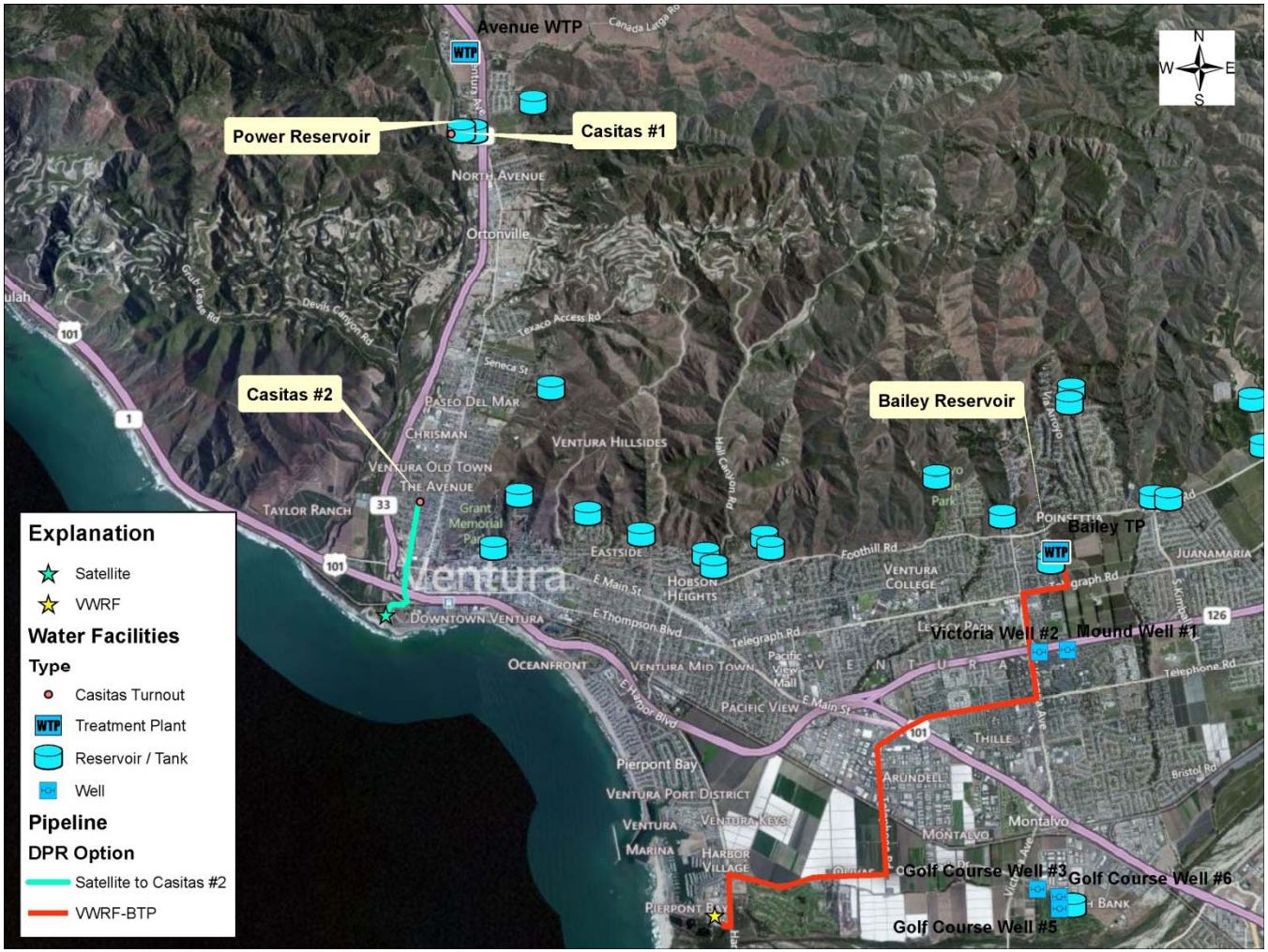


Figure 7.4
POTENTIAL DPR PIPELINE ALIGNMENTS
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

Source: Adapted from Kennedy Jenks (2012)

Figure 7.5
POTENTIAL VWRF-AWPF PIPELINE ALIGNMENT
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

Table 7.3 Summary of the DPR Alternatives Phase 2 Recycled Water Study City of Ventura	
Bailey/Mound Alternative	
Product Water Flow	3.6 mgd
Advanced Treatment Plant Capacity	5 mgd
Volume Diverted from SCRE	4.5 mgd
Brine Flow	0.9 mgd
Advanced Treatment Processes	MF/UF, RO, advanced oxidation
Brine Treatment/Disposal	Required
Siting	Advanced treatment processes located at the VWRF.
Infrastructure	Pipelines and pump stations to convey water from the VWRF to the Bailey Conditioning Facility.
Casitas Turnout No. 2 Alternative	
Product Water Flow	1.8 mgd
Advanced Treatment Plant Capacity	2.5 mgd
Volume Diverted from SCRE	2.5 mgd
Brine Flow	0.5 mgd
Advanced Treatment Processes	MF/UF, RO, advanced oxidation
Brine Treatment/Disposal	Required
Siting	Advanced treatment processes located at the North Decentralized Treatment Plant.
Infrastructure	Pipelines and pump stations to convey water from the North Decentralized Treatment Plant to Casitas No 2.

In the proposed alternative, VWRF effluent is supplied to the AWPF for treatment and utilization as high quality recycled water. The alternative involves using secondary effluent that is disinfected through modified disinfection facilities. At the AWPF the secondary effluent will undergo MF/UF and RO treatment. The AWPF capacity will need to be increased to accommodate flow from the VWRF. The City and the City of Oxnard would need to develop an agreement on the financing approach and parties responsible for both capital and O&M costs. There are numerous possible arrangements that could be made between the City and the City of Oxnard. Section 7.9.3 includes additional information on two possible financial arrangements between the City and the City of Oxnard. In this study, two possibilities are considered:

- City pays for AWPF expansion – In this scenario the City would be responsible for the capital investment in the AWPF expansion. In addition, the City would pay the City of Oxnard for O&M associated with treatment of VWRF effluent at the AWPF.
- City of Oxnard pays for AWPF Expansion – In this scenario, the City of Oxnard would be responsible for the capital investment in the AWPF expansion. The City would pay annual fees to the City of Oxnard to cover both treatment costs at the AWPF and an annualized capital costs that would allow the City of Oxnard to recover their capital investment.

As discussed, the silica concentration in the VWRF effluent may present operational problems with the RO process, The acceptability of the VWRF effluent at the AWPF may depend on attainment of water quality limits. If the silica concentrations in the VWRF present a problem for the AWPF, then additional treatment may be required.

7.3.2 Distribution System

This alternative requires a new pipeline to convey VWRF effluent to the AWPF. Once treated at the AWPF, the recycled water will conveyed to users to offset potable demands, irrigate agriculture and recharge local groundwater. (Kennedy Jenks, 2012). The City of Oxnard has constructed a delivery system and is working with existing customers to retrofit sites to accept recycled water (Kennedy Jenks, 2012). If treatment capacity at the AWPF is not available or if there is not enough demand, then the water from the VWRF would not be reused, and would be conveyed to the City of Oxnard's ocean outfall or the Calleguas Salinity Management Pipeline.

7.3.3 Summary

A summary of this alternative is provided in Table 7.4.

Table 7.4 Summary - Conveyance to Oxnard WWTP/AWPF Alternative
Phase 2 Recycled Water Study
City of Ventura

Volume Diverted from SCRE	Up to 13 mgd
Treatment	Disinfection Improvements
Infrastructure	Pipelines and pump stations to convey water from the VWRF to the AWPF Oxnard WWTP outfall connection Calleguas SMP discharge station/piping

7.4 GROUNDWATER RECHARGE OF THE MOUND BASIN

7.4.1 Planning and Design Assumptions

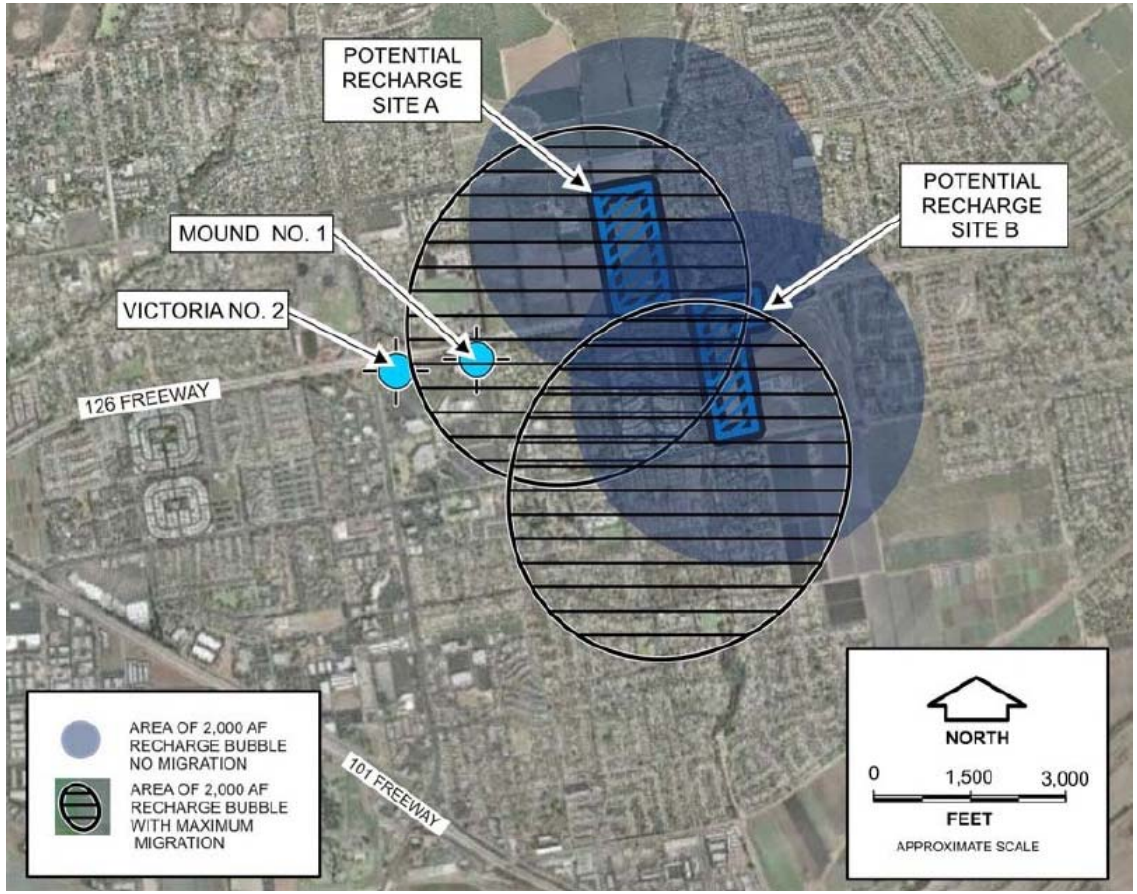
In this alternative, reclaimed water from the VWRF would be used to recharge the Mound Groundwater Basin for the purpose of augmenting the potable groundwater supply, i.e., indirect potable reuse (IPR).

Currently, two wells withdraw water from the Mound Subbasin; Victoria Well No. 2, and Mound Well No. 1. Water from these wells is treated at the Bailey Water Conditioning Facility for iron and manganese. The treated water is then blended with groundwater extracted from the Oxnard Plain basin and conveyed to users through the City's potable water distribution system.

Subsurface characteristics limit the feasibility of groundwater recharge through surface spreading. The only option for groundwater recharge is subsurface injection. IPR projects with capacities of 3.6 mgd and 6.3 mgd are considered in this alternative. A 3.6 mgd flow is consistent with the City's current extractions from the Mound Basin, and a 6.3 mgd flow is consistent with the total extractions from the Mound Basin.

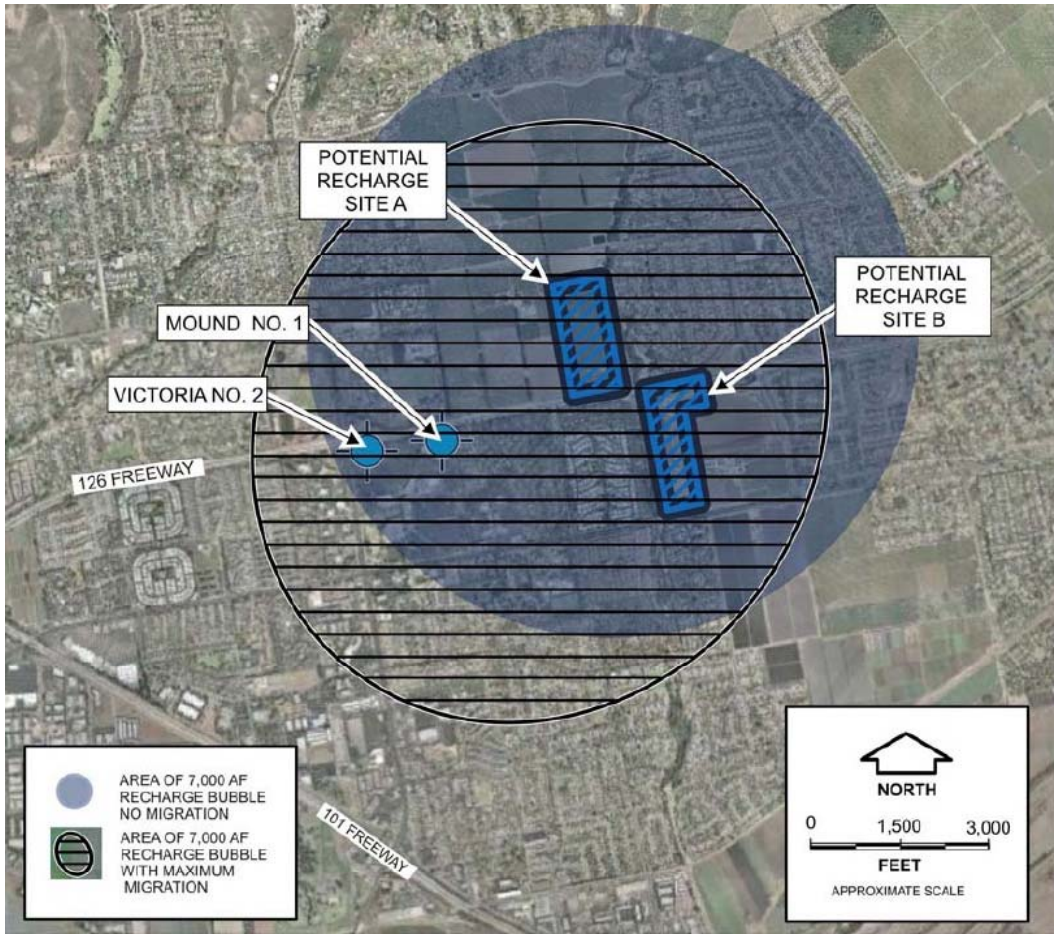
Hopkins (2013) describes the approach to IPR through injection of the Lower Aquifer System (LAS) of the Mound Basin. One of the key requirements in the Draft Groundwater Recharge Reuse Regulation is a minimum 2 month subsurface travel time. A preliminary analysis of groundwater travel time in the LAS was conducted (Hopkins 2013) and is included in Appendix A. The study evaluated the feasibility of a 3.6 and 6.3 mgd IPR project that would use the City's Victoria Well No. 2. Figures 7.6 and 7.7 show the area of recharge without migration and with maximum migration for the 3.6 and 6.3 mgd alternatives, respectively. Well Site A is located on a parcel that is currently used for agriculture. Well Site B is located adjacent to the Ventura Community Park.

Preliminary analysis suggested that the location of Recharge Site A had a higher likelihood of being recaptured at the location of Victoria Well No. 2 and that groundwater travel time



Source: Hopkins Groundwater Consultants (2013)

Figure 7.6
RECHARGE AREAS WITHOUT MIGRATION AND WITH MAXIMUM MIGRATION FOR A 3.6 MGD IPR PROJECT
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA



Source: Hopkins Groundwater Consultants (2013)

Figure 7.7
RECHARGE AREAS WITHOUT MIGRATION AND WITH MAXIMUM MIGRATION FOR A 6.3 MGD IPR PROJECT
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

would be greater than the 2 month minimum under the 3.6 and 6.3 mgd recharge scenarios (Hopkins 2013). Therefore, is assumed that this alternative involves injection at Well Site A, and extraction at the location of Victoria Well No. 2.

Injection of the recycled water at Recharge Site A, may require multiple wells capable of injection rates of between 1,000 gallons per minute (gpm) (1.4 mgd) to 2,000 gpm (2.9 gpm). Depending on the injection rate of the wells, a 3.6 mgd IPR project would require 2 to 3 wells, and a 6.3 mgd IPR project would require 3 to 5 wells.

7.4.2 Treatment

The Draft Groundwater Recharge Reuse Regulation requires FAT for injection of recycled wastewater. Figure 7.8 shows the conceptual treatment train to achieve FAT. The existing VWRF effluent undergoes tertiary media filtration. Additional filtration with MF/UF is required as pretreatment for the RO process.

All of the water that would be injected into the Mound Basin would undergo FAT. Assuming an 80 percent recovery of the RO process, the 3.6 and 6.3 mgd IPR alternatives would require treatment of approximately 5 mgd and 9 mgd, respectively. The brine produced by the RO process would require treatment and disposal, which is further described in Section 7.7.

As discussed earlier, the recovery of the RO process is dependent on the influent (to the RO process) water quality. While preliminary analysis of silica concentrations in the VWRF effluent suggests that the silica content could affect the operation of an RO process, additional data would need to be collected. Additional treatment or operation at a lower recovery are two approaches for addressing issues related to high silica concentrations.

While groundwater that is currently extracted from the Mound Basin is treated for iron and manganese at the Bailey Conditioning Facility, it is possible that these treatment processes would not be needed if IPR was implemented. It may be feasible that the IPR project would lead to recover of groundwater that is better quality than is currently extracted from the Mound Basin's lower aquifer system (Hopkins 2013).

7.4.3 Distribution System

The water produced from the advanced treatment processes, located at the VWRF, would be conveyed to injection Recharge Site A. The proposed pipeline alignment is shown in Figure 7.9. This pipe sizing and alignment is the same for the 3.6 mgd and 6.3 mgd alternatives, to allow for a potentially phased approach where the lower capacity IPR project is implemented initially and then expanded in the future.

As discussed, the injected water would be extracted at a location near Victoria Well No. 2. Hopkins (2013) concluded that recharge of the Mound Basin would require construction of additional downgradient production wells. Additional investigation into the feasibility of using Victoria Well No. 2 and/or additional new extraction wells near Victoria Well No. 2 or other

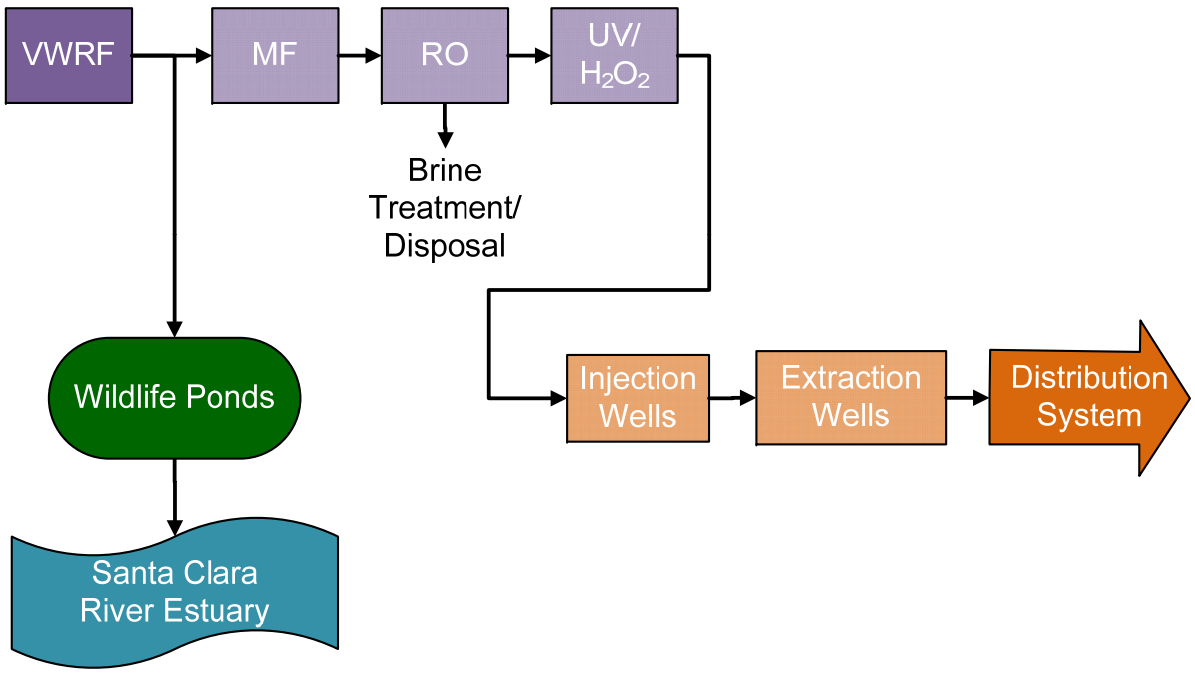


Figure 7.8
IPR TREATMENT PLANT SCHEMATIC
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

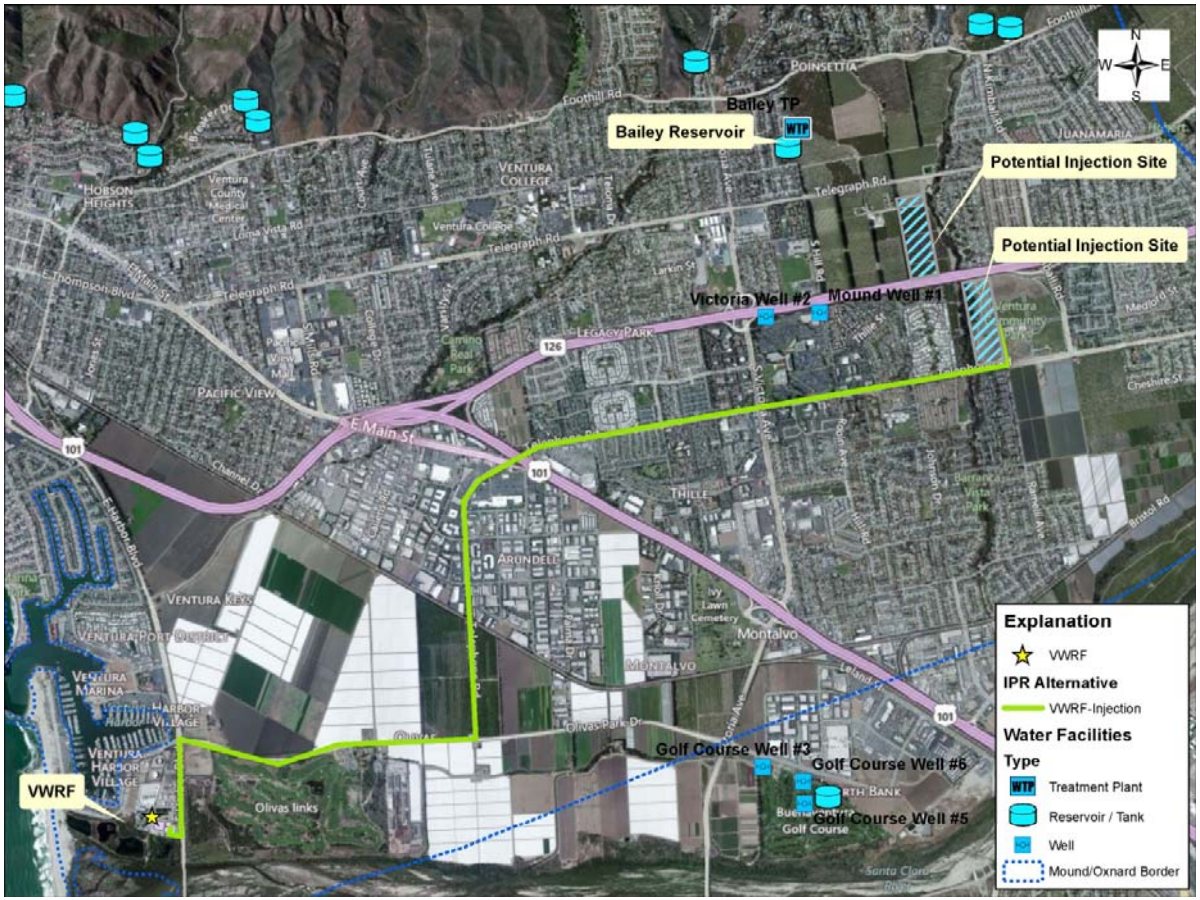


Figure 7.9
POTENTIAL IPR PIPELINE ALIGNMENT
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

locations, would need to be conducted. Distribution of the extracted water would be achieved through the existing potable water distribution system that originates from the Bailey Water Conditioning Facility.

7.4.4 Summary

The components of this alternative are summarized in Table 7.5.

Table 7.5 Summary of the Mound Basin Groundwater Recharge Alternatives Phase 2 Recycled Water Study City of Ventura	
3.6 mgd IPR Alternative	
Product Water Flow	3.6 mgd
Advanced Treatment Plant Capacity	5 mgd
Volume Diverted from SCRE	4.5 mgd
Brine Flow	1 mgd
Advanced Treatment Processes	MF/UF, RO, advanced oxidation
Brine Treatment/Disposal	Required
Siting	Advanced treatment processes located at the VWRF. Injection wells at Recharge Site A. Extraction at Victoria No 2/additional nearby wells/ other wells.
Land Requirements	Recharge Site A, and possibly for new extraction wells if needed.
Infrastructure	Pipelines and pump stations to convey water from the VWRF to Recharge Site A. 2-3 Injection Wells. New Extraction Wells
6.3 mgd IPR Alternative	
Product Water Flow	6.3 mgd
Advanced Treatment Plant Capacity	9 mgd
Volume Diverted from SCRE	7.9 mgd
Brine Flow	1.6 mgd
Advanced Treatment Processes	MF/UF, RO, advanced oxidation
Brine Treatment/Disposal	Required
Siting	Advanced treatment processes located at the VWRF. Recharge Site A. Extraction at Victoria No 2/additional nearby wells/ other wells.
Land Requirements	Recharge Site A, and possibly for new extraction wells if needed.
Infrastructure	Pipelines and pump stations to convey water from the VWRF to Recharge Site A. 3-5 Injection Wells. New Extraction Wells

7.5 GROUNDWATER RECHARGE/IRRIGATION AT UWCD FACILITIES

7.5.1 Planning and Design Assumptions

The groundwater recharge/agricultural irrigation alternatives are designed to take advantage of UWCD's existing facilities and their existing practices of diverting SCR water for groundwater recharge and irrigation.

The availability of diluent water is the key factor in assessing the feasibility of groundwater recharge or agricultural irrigation. In both cases, the limiting criterion is target chloride concentration of 117 mg/L. The variability of SCR water depends on hydrologic conditions and is highly variable. However, in general, in average to dry years, all of the water diverted by UWCD is conveyed directly to growers for agricultural irrigation and therefore, SCR water is not available for dilution of recycled wastewater for the purposes of groundwater recharge. Given these constraints, several sub-alternatives were investigated, including:

- Summer agricultural irrigation and winter recharge without advanced treatment
- Summer agricultural irrigation and winter recharge with partial advanced treatment
- Year round maximum recharge with partial advanced treatment

The additional investigation of these alternatives is discussed, as the results form the basis of the planning and design assumptions, specifically the end use, total flow, and advanced treatment flow required to meet regulatory and water quality limitations.

The first sub-alternative, summer agricultural irrigation and winter recharge, relies on the SCR water to provide sufficient dilution to meet a 117 mg/L chloride target. The VWRF effluent chloride concentration is about 290 mg/L. The SCR chloride concentration varies with hydrologic condition, and is inversely proportional to SCR flow. Therefore, during the summer low flow conditions, the SCR chloride concentrations are the greatest. Based on data collected every 1 to 2 weeks since 2010, the 95th percentile chloride concentrations in May through September, range from 68 mg/L to 85 mg/L. Based on UWCD agricultural diversion flows from 1997 through 2011, and assuming a summer SCR chloride concentration of 85 mg/L, the VWRF flow that could be blended with SCR water for irrigation was estimated. The estimated median VWRF flow that could be diverted for agricultural irrigation via UWCD is 2.5 mgd. By definition, 50 percent of the monthly VWRF flow that could be diverted for agricultural irrigation would be less than 2.5 mgd. The median SCR flow diverted for agricultural irrigation (1997 to 2011 data) is approximately 17 mgd. The 2.5 mgd from the VWRF would represent less than 15 percent of this diversion. If UWCD were to use reclaimed wastewater from VWRF, then they would be required to meet title 22 requirements, and would need to overcome potential opposition from their irrigation customers. A median flow of 2.5 mgd does not present enough of a benefit to UWCD to overcome the increased regulatory oversight and potential public perception issues associated with using reclaimed wastewater in their system (personal

communication with UWCD staff). The additional analysis of using VWRF effluent at UWCD without advanced treatment showed that there were limitations with this approach, and therefore this sub-alternative was not considered further.

The second sub alternative involves summer agricultural irrigation and winter recharge, with partial advanced treatment of the VWRF effluent. Figure 7.10 presents a schematic of this scenario. This alternative relies on the combination of dilution of the effluent using SCR water and partial advanced treatment to reduce the chloride concentration in the reclaimed water that is conveyed to UWCD. Using this approach, the amount of VWRF effluent that could be used for UWCD for agricultural irrigation can be increased, while still meeting the chloride target. A VWRF flow of 7.7 mgd with 33 percent treated by RO will result in a blended VWRF effluent (partial RO) of approximately 7.3 mgd. Assuming 33 percent of the effluent is treated by RO, then the median VWRF flow that could be used at UWCD for conveyance to agricultural users is approximately 7.3 mgd. There is a significant amount of variability in the amount of VWRF effluent (with partial RO) that could be used due the variability in the amount of water that UWCD can divert from the SCR in the summer months. For example, 25 percent of the months, the VWRF effluent (with partial RO) that could be used by UWCD would be less than 5 mgd. In the non-summer months, the VWRF effluent with partial RO. could be used for groundwater recharge, although the volume that VWRF that could be recharged is dependent on the volume of SCR water diverted for recharge.

The third sub-alternative involves maximizing the use of VWRF effluent for recharge at UWCD facilities. Approximately 62 percent of the VWRF effluent needs to be treated by RO to meet the chloride concentration of 117 mg/l in the blended water (combination of the water treated by RO and bypassed effluent) . Following the Draft Groundwater Reuse Regulations, if we assume the maximum recycled water contribution for surface spreading is 75 percent, a 25 percent contribution of diluent water from the SCR would be needed. A VWRF flow of 12 mgd with 62 percent treated by RO will result in a blended VWRF effluent (partial RO) of approximately 10.7 mgd. To achieve a recycled water contribution of 75 percent, approximately 3.3 mgd of SCR water is needed. The SCR water diverted for recharge was greater than 3.3 mgd in approximately 35 percent of the summer months, and 80 percent of winter months. When the SCR flow diverted for recharge is less than 3.3 mgd in the summer months, then the VWRF effluent (with partial RO) could be conveyed by UWCD to meet irrigation demands. Because the VWRF effluent (with partial RO) meets the 117 mg/L chloride standard, no dilution from SCR water would be needed. This scenario results in year-round use of 10.7 mgd of VWRF effluent that has undergone partial (62 percent) RO treatment.

Any alternative that involves groundwater recharge of recycled water at the UWCD facilities would be subject to the minimum travel time of 2 months between recharge sites and potable water supply wells. Groundwater travel time from the Saticoy Spreading Grounds or

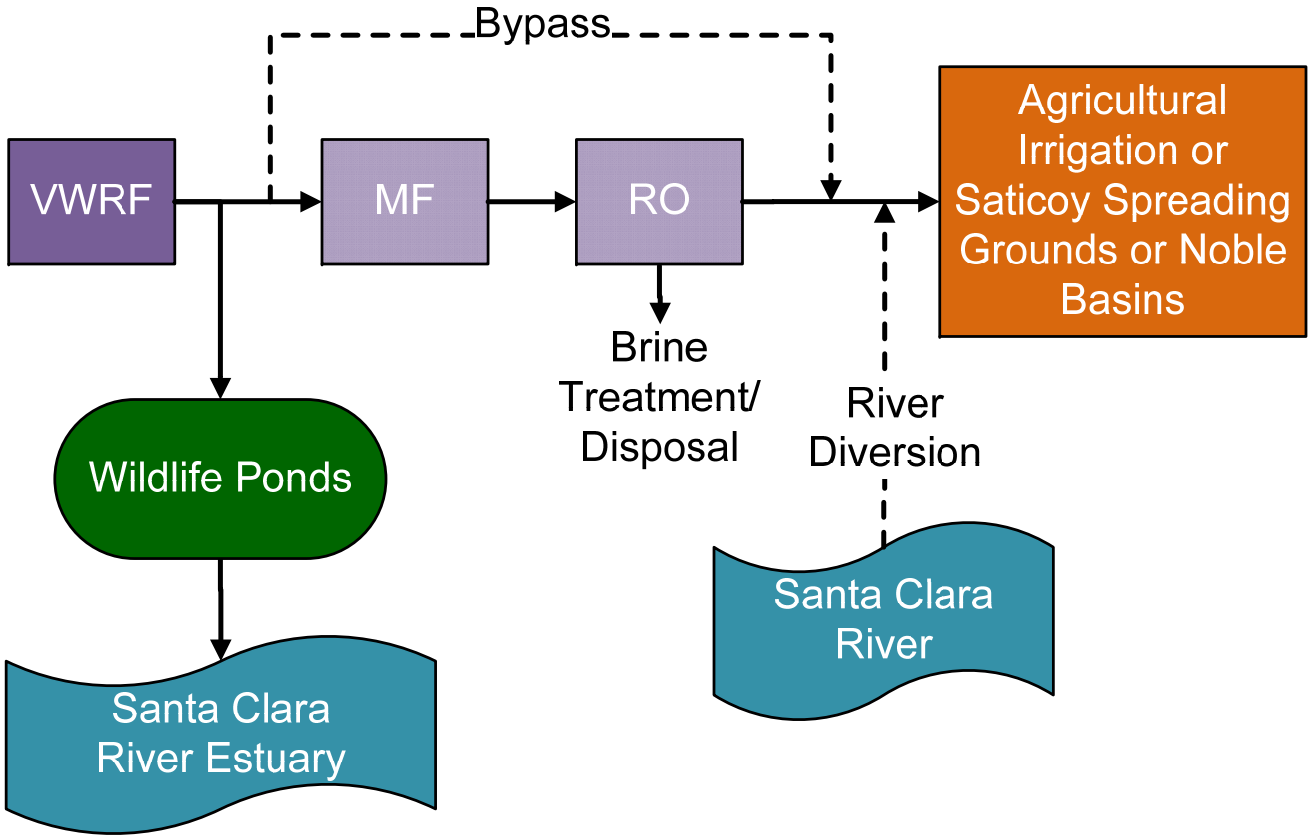


Figure 7.10
PARTIAL RO TREATMENT APPROACH FOR UWCD ALTERNATIVES
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

the Noble Basins to potable supply wells would need to be determined to assess feasibility of this alternative.

7.5.2 Treatment

As discussed previously, the alternative requires a portion of the VWRF effluent to be treated by RO to reduce the chloride concentrations in the VWRF effluent. The additional treatment processes include MF, RO, and brine treatment/disposal (see Section 7.7). Approximately 95 percent of the chloride concentration can be removed through the RO process. As shown in Figure 7.10, a portion of the VWRF effluent would bypass MF and RO, and the bypass flow depends on the alternative.

As discussed earlier, the recovery of the RO process is dependent on the influent (to the RO process) water quality. While preliminary analysis of silica concentrations in the VWRF effluent suggests that the silica content could affect the operation of an RO process, additional data would need to be collected. Additional treatment or operation at a lower recovery are two approaches for addressing issues related to high silica concentrations.

7.5.3 Distribution System

The recycled water from the VWRF would be conveyed to UWCD facilities. Figure 7.11 shows the proposed pipeline alignment. The UWCD's existing distribution systems would provide recycled wastewater to growers for agricultural irrigation. When conditions allow groundwater recharge, the recycled wastewater would be recharged via UWCD’s existing facilities (Saticoy Spreading Grounds or Noble Basins).

7.5.4 Summary

The components of this alternative are summarized in Table 7.6.

7.6 TREATMENT WETLANDS

The treatment wetlands alternative being considered for further evaluation is a hybrid alternative combining both the Wildlife Ponds and City-Owned Property alternatives. In general, the greater the wetland area, the greater the amount of flow that can be routed through the treatment wetlands while maintaining the residence time required to achieve the targeted effluent nitrate concentration (i.e., 3 to 5 mg/L during the critical summer months).

7.6.1 Planning and Design Assumptions

This alternative requires modification of the existing Wildlife Ponds (Pond 1 (Bone) and Pond 2 (Snoopy)), as well as modifying the City-Owned Property located east of and adjacent to the VWRF, to function as treatment wetlands. Ponds 1 and 2 must be filled to

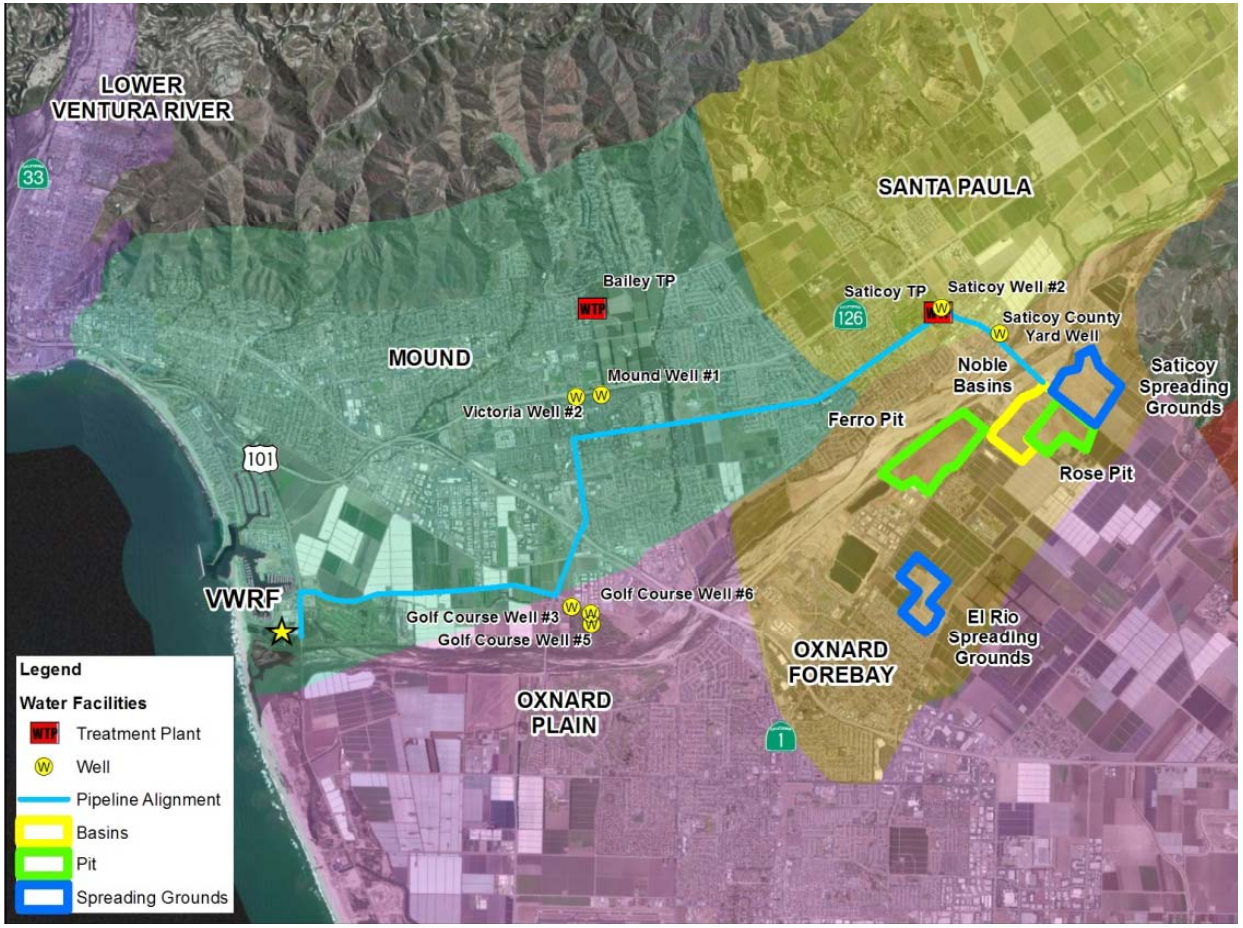


Figure 7.11
POTENTIAL IPR PIPELINE ALIGNMENT
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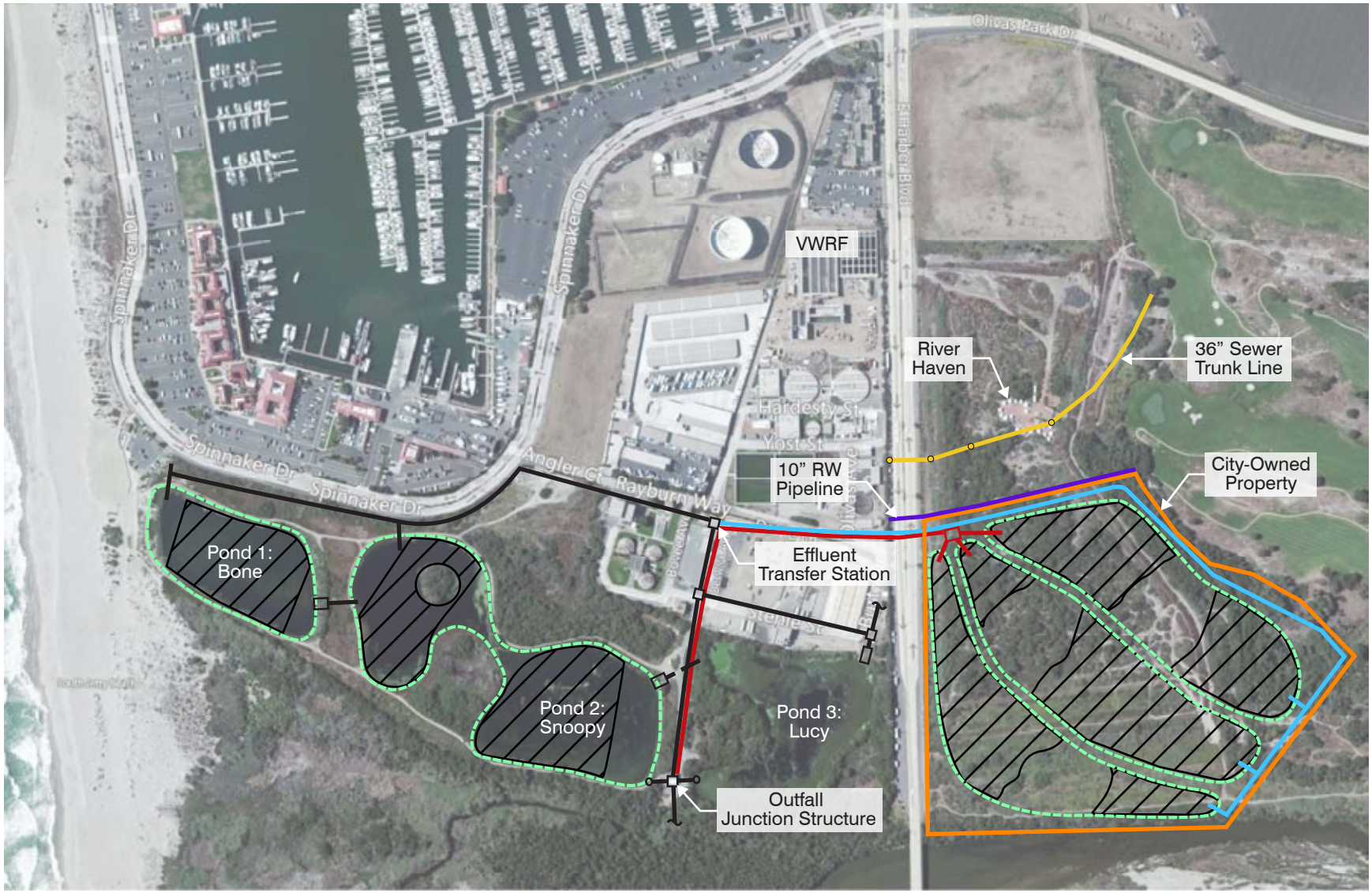
CITY OF VENTURA

Table 7.6	Summary of the UWCD Groundwater Recharge and Agricultural Irrigation Alternatives Phase 2 Recycled Water Study City of Ventura
8 mgd Alternative	
Volume Diverted from SCRE	7.7 mgd
Advanced Treatment Processes	MF/UF, RO
RO Flow Percentage	33%
Blended Water (RO and bypass) flow	7.3 mgd
MF/UF and RO Process Capacity	3 mgd
Brine Flow	0.5 mgd
Brine Treatment/Disposal	Required
Siting	Advanced treatment processes located at the VWRF.
Infrastructure	Pipelines and pump stations to convey water from the VWRF to UWCD facilities
12 mgd Alternative	
Volume Diverted from SCRE	12 mgd
Advanced Treatment Processes	MF/UF, RO
RO Flow Percentage	62%
Blended Water (RO and bypass) flow	10.7 mgd
MF/UF and RO Process Capacity	8 mgd
Brine Flow	1.5 mgd
Brine Treatment/Disposal	Required
Siting	Advanced treatment processes located at the VWRF.
Infrastructure	Pipelines and pump stations to convey water from the VWRF to UWCD facilities

reduce the depth to approximately 2.5 feet and vegetated benches need to be constructed creating a total area of approximately 12.4 acres of treatment wetlands. In addition, approximately 29 acres (i.e., 85 percent of the total area) are available for construction of new treatment wetlands on the City-Owned Property. The combined area available for treatment wetlands is approximately 41.4 acres for nitrate reduction and wildlife habitat.

While infrastructure is already in place for the Wildlife Ponds, for the additional wetlands at the City-Owned Property new infrastructure is required to convey the VWRF effluent from the effluent transfer station (ETS) to the wetland, including pump stations and pipelines. New infrastructure is also required to convey the wetland effluent to the SCRE. Discharge from the new wetlands at the City-Owned Property will be routed to the existing VWRF effluent discharge channel via the outfall junction structure (OJS) to eliminate the need for considering a new point of compliance. Figure 7.12 shows an aerial view of the potential layout of the alternative.



LEGEND
- Existing
- Planned Wetland Influent
- Planned Wetland Effluent
- Polishing Wetland
- Vegetated Zone

Figure 7.12
AERIAL VIEW OF THE TREATMENT WETLANDS ALTERNATIVE
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

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7.6.2 Treatment

The primary objective of the treatment wetlands is to further reduce nitrate concentrations in the VWRF effluent to improve water quality in the estuary. The VWRF effluent is currently meeting levels of total inorganic nitrogen of 8 mg/L. Modifying the area of the Wildlife Ponds to be vegetated wetlands provides capacity for up to 3 mgd to be able to meet summer nitrate levels of 3 to 5 mg/L. Combining the existing Wildlife Ponds and the City-Owned Property effluent nitrate concentration levels can be reduced to 3 to 5 mg/L up to the projected future VWRF summer effluent flow of 11.2 mgd. The removal of nitrate in a wetland is variable, and is dependent on detention time (which is a function of area, depth and flow) temperature and vegetation conditions. A range of effluent nitrate concentrations is shown to reflect the variability that can be expected in a natural system and due to the flow variability that may occur. Distribution

An advantage of this alternative is that the existing interties between the Wildlife Ponds can be preserved, as can the existing discharge channel that conveys effluent into the SCRE. A challenge of this alternative includes the infrastructure (pump stations and pipelines) required to route VWRF effluent from the ETS to the City-owned treatment wetlands and back to the existing OJS. However, this challenge is offset by the potential financial benefit of using an existing City-owned parcel and the potential to provide additional nitrate removal for a larger flow volume. Figure 7.13 shows a process flow schematic for the potential routing required for the treatment wetlands.

7.7 BRINE TREATMENT AND DISPOSAL

Several of the alternatives discussed in sections 7.1 through 7.1 require partial or full RO treatment. These alternatives include:

- Mound Basin IPR
- DPR
- Groundwater Recharge/Agricultural Irrigation at UWCD

The brine generated from these alternatives requires treatment and/or disposal. Brine flows from these alternatives range from 0.5 mgd to 1.6 mgd.

AECOM (2011) conducted a groundwater treatment study that evaluated treatment options for the City's potable supply. The study includes an evaluation of RO for groundwater treated at the Bailey Conditioning Facility and the Saticoy Conditioning Facility. Approximately 1.4 mgd of brine would be generated from RO of these two water supplies.

The AECOM (2011) study evaluated a number of brine disposal alternatives, including discharge to the SCRE, evaporation ponds, deep well injection, ocean outfalls, and a wetland discharge. The evaluation of discharge to an ocean outfall included investigation of a number of discharge points, including (1) Calleguas SMP; (2) Reliant Power Plant,

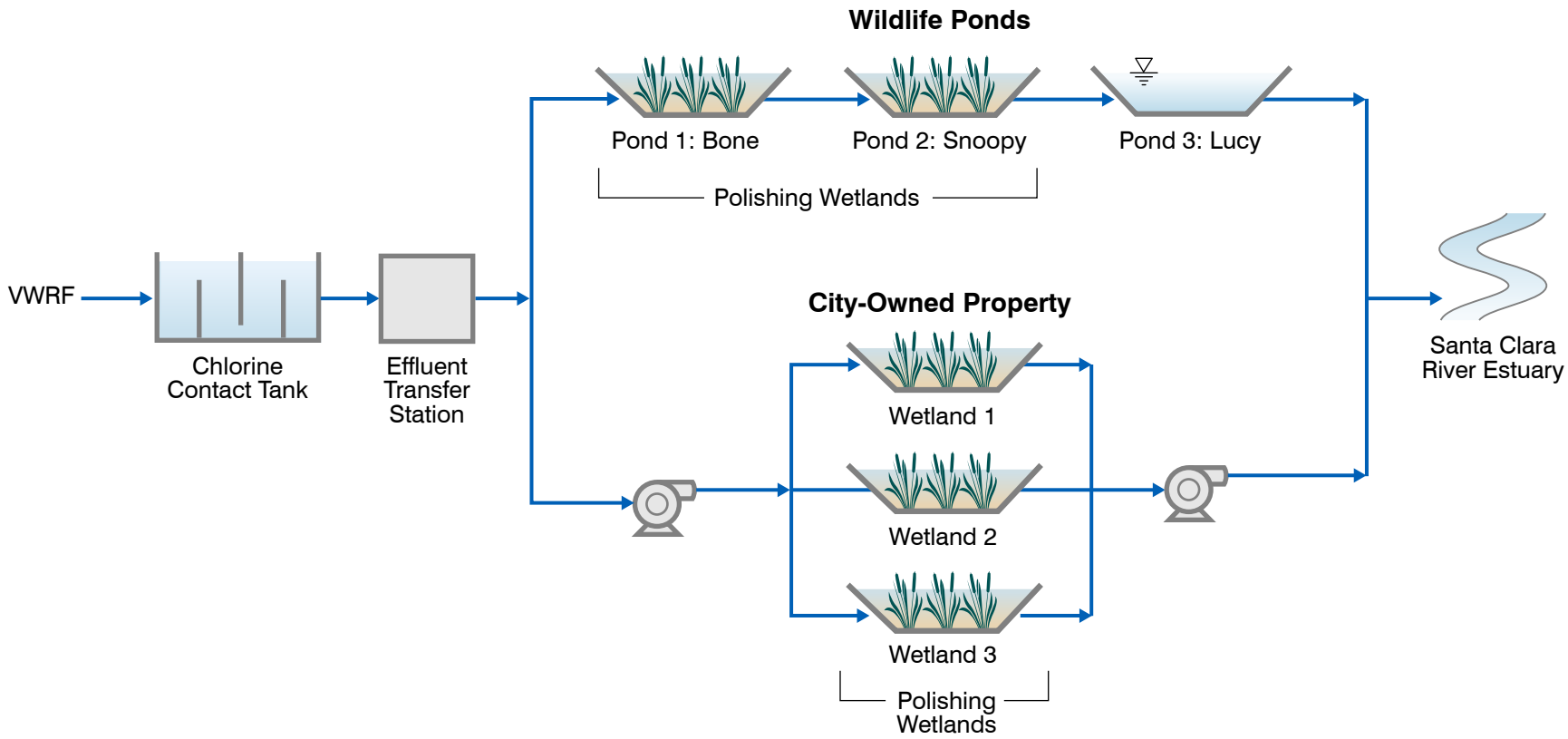

Figure 7.13
PROCESS FLOW SCHEMATIC OF THE TREATMENT WETLANDS ALTERNATIVE
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

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Ormond (3) Reliant Power Plant, Mandalay (4) City of Port Hueneme WWTP; (5) Oxnard WWTP (6) Ventura WRP ; (7) Fairgrounds outfall; (8) Crimson Pipeline; (9) beach wells or reverse Ranney collectors. The results of this analysis are summarized in Table 7.7.

Table 7.7 Summary of Brine Disposal Alternatives Presented in AECOM (2011) Phase 2 Recycled Water Study City of Ventura

Alternative	Further Investigation (Y/N)	Comments (per AECOM, 2012)
Discharge to the SCRE	N	Permit challenges. Opposition from organizations and stakeholders.
Evaporation Ponds	N	Limited by climate and land availability. Thousands of acres would be required for evaporation ponds.
Deep Well Injection	Y	The logistics of deep well injection in the Ventura Oil Field would require additional study
Santa Clara Valley Regional Brine Line	Y	Potential new regional brine line. Requires interest and agreement between participating municipalities
Ocean Outfalls		
Calleguas SMP	Y	Existing brine line with capacity for brine from the VWRF
Reliant Power Plant Ormond	Y	Permitting challenges. Technical issues related to the “dilution ratio”, due to the intermittent operation of the power plant. Additional study is needed to determine whether this outfall could be used.
Reliant Power Plant Mandalay	N	Existing permitting challenges and issues similar to the Ormond alternative limit feasibility.
City of Port Hueneme WWTP	N	Abandoned outfall removed as a condition of the permit process of the Calleguas SMP
Fairgrounds outfall	Y	Condition of pipeline requires additional study
Beach wells or reverse Ranney collectors	N	Coastline is not well suited for production of seawater or disposal of brine because of the poor transmissivity of the soil.

As shown in Table 7.7 there are a number of alternative brine disposal alternatives that may be possible, pending further investigation of technical, regulatory, and inter-agency issues. The Calleguas SMP is an existing brine line and is therefore one of the more promising alternatives. Section 7.7.1 presents additional information on conveying brine generated at the VWRF to the Calleguas SMP.

With the exception of evaporation ponds, the AECOM (2011) report did not evaluate zero liquid discharge alternatives. Section 7.7.2 includes a discussion of a zero liquid discharge (ZLD) alternative.

7.7.1 Brine Pipeline to Calleguas SMP

The brine pipeline to the Calleguas SMP would follow the same alignment as discussed in the alternative where VWRF effluent would be conveyed to the Oxnard AWPF. Figure 7.5 presents this alignment. The brine pipeline consists of approximately 10 miles of 8-inch PVC pipe. The size of the pipeline was designed to convey approximately 1.6 mgd, the greatest brine flow that would be generated from the various alternatives.

7.7.2 Zero Liquid Discharge

For a ZLD process, RO recovery should be maximized prior to downstream brine minimization processes to minimize capital and operating costs. In order to maximize recovery of the primary RO process, soluble salts are removed from the wastewater effluent through a softening process.

Using the wastewater effluent water quality and RO performance projections, brine quality was established. The brine quality is the basis for developing the ZLD system. The brine quality is presented in Table 7.8. Based on this analysis, a treatment process that utilizes chemical softening (upstream of the MF), filtration, reverse osmosis, was developed to achieve a zero liquid discharge brine management system. The proposed process is presented in Figure 7.14.

In this system, the recovery rate of the RO is approximately 99.3 percent. The resulting brine flows range from 0.4 to 0.8 mgd. The brine flow is further reduced (via a thermal process) and the conveyed to evaporation ponds. The required evaporation pond areas range from 17 to 37 acres.

7.8 ENVIRONMENTAL CONSIDERATIONS

There are both short and long-term environmental considerations associated with implementing any of the alternatives discussed in this report. The primary long-term environmental considerations include:

- Creation of new wetland habitat
- Impacts on SCRE habitat and ecosystem functions

The short term environmental impact and primarily associated with construction activities, and will be described in subsequent studies when the proposed project is defined.

7.8.1 Creation of New Wetland Habitat

Throughout the stakeholder involvement process, many stakeholders have expressed interest in implementing alternatives that will lead to creation of new wetland habitat. This study evaluated a number of wetland treatment alternatives that would provide polishing treatment for the VWRF effluent prior to discharge into the SCRE, and would create

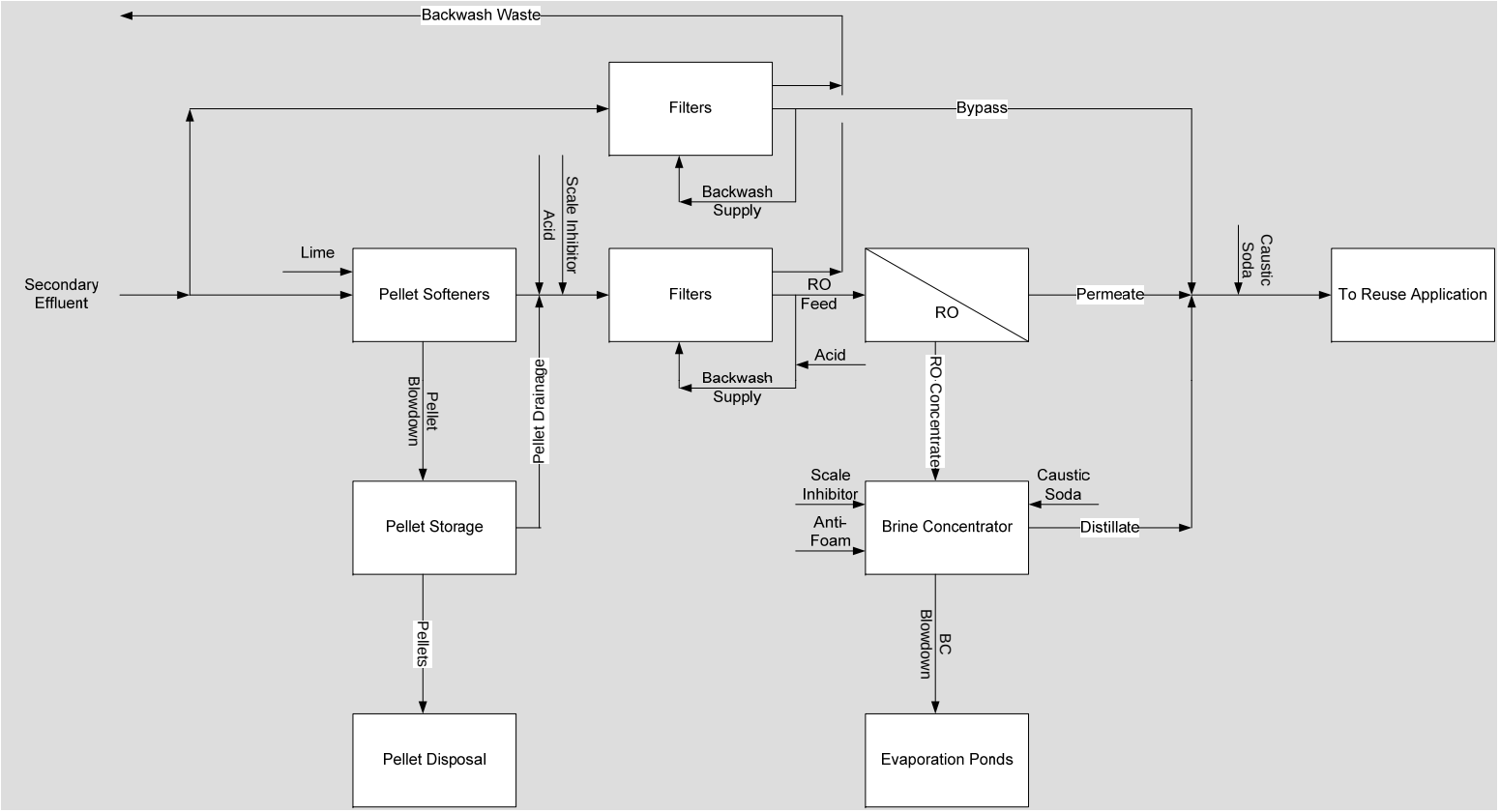


Figure 7.14
ZLD TREATMENT PROCESS
PHASE 2 RECYCLED WATER STUDY
CITY OF VENTURA

Table 7.8 Projected Primary RO Brine Quality Phase 2 Recycled Water Study City of Ventura		
Parameter	**Units**	**Value**
pH	units	9.7
Total Dissolved Solids	mg/L	15,800
Total Hardness	mg/L as $CaCO_3$	4,570
Total Organic Carbon	mg/L	
Total Alkalinity	mg/L as $CaCO_3$	10
Ammonia	mg/L as N	9.6
Barium	mg/L	0.11
Bicarbonate	mg/L as $CaCO_3$	12
Calcium	mg/L	632
Chloride	mg/L	3,080
Fluoride	mg/L	1.4
Magnesium	mg/L	727
Nitrate	mg/L	225
Phosphate	mg/L	44
Potassium	mg/L	284
Silica (Total)	mg/L as SiO_2	336
Sodium	mg/L	3,280
Strontium	mg/L	11.9
Sulfate	mg/L	7,262

Notes:
(1) Design water based on softened wastewater effluent treated with RO at a recovery of 92%. Quality projected using Hydranautics IMSDesign (R) software, ESPA 2 membranes, and a 3-yr membrane age.

additional wetland habitat adjacent to the SCRE. The preliminary screening analysis (Chapter 6) of the wetland treatment alternatives led to the conclusion that the most feasible treatment wetland alternative involved reconfiguration of the existing Wildlife Ponds, in combination with the new treatment wetlands on the City-owned property. The Phase 1 Treatment Wetlands Feasibility Study describes the habitat that would be created as a result of implementing treatment wetlands at the Wildlife Ponds and adjacent city-owned property.

While treatment wetlands provide additional habitat, they do not achieve the objective of reducing the VWRF effluent discharge volume to the Estuary. All of the other alternatives discussed in this chapter provide some degree of reduction in the VWRF discharge flow to the SCRE. To achieve both effluent reduction and habitat creation, the alternatives have

been combined. It is assumed that for each alternative (described in sections 7.1 through 7.5), the remaining effluent flow to the SCRE would be routed to a treatment wetlands. The benefits of this approach include additional polishing treatment of the VWRF effluent prior to discharge to the SCRE, and the creation of wetland habitat.

As discussed in Section 7.6, the area of the Wildlife Ponds (modified to be vegetated wetlands) provides capacity for up to 3 mgd. The combined area of the Wildlife Ponds (modified to be vegetated wetlands) and the City-Owned Property would be needed to meet nitrate concentration levels of 3 to 5 mg/L for higher flows.

7.8.2 Impacts on SCRE Habitat and Ecosystem Function

The Phase 1 Estuary Study assessed habitat/ecosystem function affected by each alternative during the dry season (June through September) by using the SCRE water balance, nutrient balance, and SCRE stage modeling tools. These tools developed during Phase 1 predicted future SCRE focal species habitat conditions while accounting for climate change and various alternatives for modifications to VWRF effluent discharges. Habitat conditions were assessed as a function of modeled SCRE stage, water depth, and associated mouth breaching timing, modeled average nitrogen levels, and habitat areas (as a function of SCRE stage) and habitat needs of for each listed focal species (Steelhead, Tidewater goby, California least tern, and Western snowy plover) associated with each VWRF discharge alternative. Stillwater Sciences (2011) includes a comprehensive analysis of the habitat/area relationship and water quality conditions to support the focal species. In the Phase 2 studies, these established conditions were used as the basis for evaluating the impacts of alternatives on SCRE beneficial uses related to habitat and ecosystem function.

Based on Stakeholder feedback received following the Phase 1 alternatives assessment, additional data was collected for Phase 2 and used to update both the water balance and nutrient balance tools. The additional data collected for Phase 2 led to several modifications to the water and nutrient balances, as described in Stillwater Sciences (2013) (provided in Appendix B) Key changes to the water and nutrient balances include:

- A SCRE berm breaching elevation of 12.5 feet.
- Total inorganic nitrogen (TIN) concentration of 8 mg-N/L in the VWRF effluent.
- Groundwater data from new wells on the north side of the SCRE provided groundwater quality information (TIN concentrations as high as 15 mg-N-L).

The Phase 2 alternatives assessment included developing SCRE stage/depth estimates for both dry and wet water year types as a means of elucidating the anticipated minimum and maximum values associated with each alternative. The Stillwater Sciences (2013) technical memo (Appendix B) describes the analysis of the effects of the alternatives on SCRE beneficial uses based upon impacts to the focal species' habitat and ecosystem function. In the Phase 1 study, the recreational camping opportunities at McGrath State Park, were considered in the evaluation of alternatives. In recognition that McGrath State Park is in the

100 year floodplain and there is potential for future closure and/or relocation, this recreation opportunity was considered to be less important in the Phase 2 studies. However, the bird watching recreational benefit of the SCRE remains an important evaluation criterion and is incorporated into the analysis through evaluation of the foraging and nesting habitat of the focal species.

The effects of the remaining discharge on the SCRE were evaluated for each alternative for both the existing and future VWRF flow conditions. The discharge to the SCRE under current and future conditions was calculated based on a water balance for the treatment plant and existing Wildlife Ponds. Figure 3.2 presented a treatment plant schematic. The effluent flow meter is located at the ETS. Flow is diverted for the existing recycled water system upstream of the ETS. There are internal plant recycled water streams that are also diverted upstream of the ETS. The influent flow meter measures the raw influent wastewater to the treatment plant and the internal plant recycled water streams. The Wastewater Master Plan projected the influent ADWF to be 13 mgd, for the buildout condition. The calculations of existing and future VWRF effluent flow into the proposed treatment wetland are summarized in Table 7.9.

Table 7.9 Historic and Projected Flows
Phase 2 Recycled Water Study
City of Ventura

Development Condition	Existing (mgd)(1)	Projected at Build-out(2) (mgd)
Influent Treatment Plant Flow (June through September)	-	13.0 (3)
Existing Recycled Water System Diversion (Summer)	-	1.0
Internal Treatment Plant Recycle Flow	-	0.8
VWRF Effluent Flow (June through September)	7.3	11.2

Notes:
(1) Effluent flow data from the ETS was used to estimate the average June through September flows.
(2) The projected VWRF (June through September) effluent flow was calculated using the projected ADWF for the influent and the approximate flows diverted for recycled water use and for internal plant recycled streams.
(3) The projected ADWF of 13.0 mgd from the Master Plan is a good estimate of the average June through September influent flow, based on analysis of historical data.

The amount of flow that would be routed to the treatment wetlands and subsequently discharge to the SCRE was calculated for each alternative under existing and future conditions. The loss of water through evaporation and percolation through the wetlands was estimated based on the observed losses from the existing Wildlife Ponds. Based on the

influent flow to the treatment wetlands, the effluent nitrate concentrations were estimated based on estimates of hydraulic residence time, water temperature, and denitrification rate constants, as well as other inputs and parameters. A range of nitrate concentrations was estimated for each of the alternatives and the upper end of this range was used as input to the nutrient balance for the SCRE. The flow and water quality conditions for the alternatives are summarized in Table 7.10. In addition, Table 7.10 also includes the results of a “no action” alternative, which represents the existing VWRF discharge flow and quality to the SCRE.

In each of these alternatives where there is flow into the treatment wetlands, the outflow of the wetlands results in a discharge to the SCRE. The discharge flows from the treatment wetlands to the SCRE range from 0 to 8 mgd, and the nitrate concentrations of the discharges range from 4 mg-N/L to 5 mg-N/L. For each of the alternatives with remaining VWRF effluent flow, the effluent would be conveyed to a treatment wetland to further improve water quality, Depending on the remaining VWRF effluent flow, the wetlands would be the “onsite” Wildlife Ponds with modifications and/or the modified Wildlife Ponds in combination with the offsite City-owned property. The “no action” alternative represents the discharge from the Wildlife Ponds and existing flows. Each of the existing and future conditions for the alternatives, dry and wet year hydrologic conditions were evaluated. The analysis is limited to the critical summer period, June through September, when the SCRE mouth is typically closed. Alternatives with the same discharge conditions have be grouped to simplify Table 7.10.

The analysis included an assessment of SCRE hydrology and stage, water quality, and SCRE habitat. The results are summarized as follows.

Estuary hydrology and stage

- For 0 mgd effluent discharge alternatives, the maximum modeled equilibrium stage range for dry and wet water year conditions was the lowest of all the alternatives considered (8.0 – 8.5 feet NAVD88) and the average unmeasured groundwater inflow range (which is driven by SCRE stage) for the modeled period was the highest (2.3 to 3.4 mgd).
- Increasing the effluent discharge rate resulted in a progressive increase in SCRE equilibrium stage and associated decrease in unmeasured groundwater flow rate.
- The maximum equilibrium stage for the 8 mgd effluent discharge alternative was 11.5 feet NAVD88, which is considered to be below the current breaching threshold indicated by summer/fall 2012 SCRE stage data (12.5 feet NAVD88) but is above the breaching threshold during the Phase 1 alternatives assessment (11.0 feet NAVD88). For this alternative, the 8 mgd flow will result in stage conditions with greater likelihood of leading to unseasonal breaching, relative to the other alternatives.

Table 7.10 Estimated average dry season (June - September) flows and nitrate concentration for each alternative
Phase 2 Recycled Water Study
City of Ventura

Alternative	Treatment Wetland	Flow Components (mgd)					Discharge to SCRE (from Treatment Wetlands) Nitrate Concentration (mg-N/L)
		VWRF Effluent	Diverted Effluent Capacity	Influent to Treatment Wetland	Evaporation/ Percolation Estimate (2)	Approximate Discharge to SCRE from the Treatment Wetlands	
Existing Flows							
No Action	None	7.3	-	-	1	6.3 (5)	8
North decentralized plant (Irrigation or DPR)	Onsite + City-Owned	7.3	2.0(4)	5.3	1.3	4	4
Conveyance to Oxnard or Recharge/Ag supply for UWCD	Onsite	7.3	>7.3 (1)	0	-	0	0
Ag supply for UWCD	Onsite	7.3	>7.3 (1)(3)	0	-	0	0
Mound Basin IPR & DPR (3.6 mgd)[3]	Onsite	7.3	4.5	2.8	1	2	4
Mound Basin (6.3 mgd)	Onsite	7.3	>7.3 (1)	0	-	0	0
Future Flows							
North decentralized plant (Irrigation or DPR)	Onsite + City-Owned	11.2	2.0(4)	9.2	1.3	8	5
Conveyance to Oxnard or Recharge/Ag supply for UWCD	Onsite	11.2	>11.2	0	-	0	0
Ag supply for UWCD	Onsite + City-Owned	11.2	7.7(3)	3.2	1.3	2	4
Mound Basin IPR & DPR (3.6 mgd)[3]	Onsite + City-Owned	11.2	4.5	6.7	1.3	5	4
Mound Basin IPR (6.3 mgd)	Onsite + City-Owned	11.2	7.9	3.3	1.3	2	4

Notes:
(1) Capacity for the diverted flow is greater than the VWRF effluent flow. The VWRF effluent flow was used for the calculations.
(2) Estimated as 1 mgd for the onsite wetlands (modified Wildlife Ponds) and 1.3 mgd for the combination of the Modified Wildlife Ponds and the City-Owned Property Wetlands.
(3) There is significant variability in the diverted capacity since the diverted flow depends on the diverted SCR flow.
(4) The effluent flow diverted for Irrigation and DPR are 2 mgd and 2.5 mgd respectively. The lower value of 2 mgd was used.
(5) In this alternative treatment wetlands would not be constructed and therefore approximately 6.3 mgd would discharge from the Wildlife Ponds to the SCRE.

Estuary water quality

- Because recent water quality monitoring results show relatively high TIN levels in shallow groundwater along the north side of the SCRE that were previously un-identified, the current results show that in the absence of VWRF discharge, TIN levels of the SCRE will approach levels in the groundwater. Alternatives with no discharge to the SCRE result in the greatest SCRE nitrate concentrations.
- The lowest TIN levels in the SCRE were achieved for alternatives that resulted in discharges to the SCRE of 4 to 8 mgd with nitrate concentrations ranging from 4 mg-N/L to 5 mg-N/L.

Assessment of Impacts to Estuary Habitat Conditions

- The highest VWRF discharge (8 mgd) resulted in the highest average depth and wetted area.
- Steelhead habitat area increased with increasing VWRF discharge, reaching the maximum value of approximately 157 acres for all alternatives under the 8 mgd discharge scenario.
- The California least tern foraging habitat area remained fairly static at approximately 130 acres for all alternatives.
- Tidewater goby and habitat was essentially static at approximately 110 acres for the zero through 5 mgd alternatives then dropped considerably to approximately 85 acres for alternatives with a discharge of 8 mgd to the SCRE.
- California least tern/western snowy plover nesting habitat was essentially static at approximately 180 acres for the zero through 5 mgd alternatives then dropped considerably to approximately 160 acres for alternatives with a discharge of 8 mgd to the SCRE.
- A discharge of about 4 mgd to 5 mgd provides the most habitat benefit considering the key factors that impacts habitat conditions, including SCRE nitrate concentrations and estuary stage/habitat area.

The alternatives results in 5 different combinations of SCRE discharge flow and nitrate concentration. Table 7.11 presents the results of the analysis for these conditions, as well as the no action alternative, and therefore brackets the range of results that would occur as a result of implementing the alternatives. The color gradations in Table 7.11 represent a relative comparison of the results with the lightest shades representing the lowest water quality/habitat and the darkest shades representing the highest quality and habitat. California least tern foraging habitat is not included in Table 7.11 because the results were constant across the discharge flow and nitrate concentrations. Table 7.11 suggests that a discharge flow into the SCRE of 4 to 5 mgd, and a nitrate concentration of 4 mg-N/L (or less) would result in the lowest concentrations of nitrate in the SCRE and would provide a the greatest (or near greatest) habitat for the four focal species.

Table 7.11 Estimated average dry season (June through September) flows and nitrate concentration for each alternative
Phase 2 Recycled Water Study
City of Ventura

Discharge to SCRE – Flow and Water Quality			Predicted Habitat, acres		
Flow (mgd)	**Nitrate Concentration from treatment wetlands (mg-N/L)**	**Predicted SCRE Nitrate Concentration Range (mg-N/L) (1)(3)**	**Steelhead**	**Tidewater Goby**	**CLT and WSP nesting (2)(3)**
No Action (6.3)	8	6.2 – 7.7	148	101	167
0	0	9.6 – 12.5	58	107	183
2	4	4.5 - 8	78	110	183
4	4	3 – 5.2	115	111	182
5	4	2.8 – 4.7	132	110	177
8	5	3.5 – 4.9	157	85	160

Notes
(1) Concentration range is based on range of denitrification rates and wet and dry hydrologic conditions.
(2) CLT = California least tern; WSP = Western snowy plover
(3) Color gradations for SCRE nitrate concentrations and habitat area show lowest quality/habitat in the light shades and the highest quality/habitat in the darkest shades. For similar numbers the same color shading was applied.

As stated in the Phase 1 Estuary Subwatershed Study (Stillwater Sciences 2011), because significant levels of TIN are present in local groundwater and the Santa Clara River, it should be noted that reductions in nitrate levels under one or more alternatives may not result in substantially reduced algal levels and continued algal bloom episodes are likely to occur under all alternatives. Nevertheless, it is expected that the frequency and duration of algal blooms should decrease with reduced inorganic nitrogen levels in the SCRE approaching the 1.5–4.5 mg-N/L range identified for algal growth limitation (see Stillwater Sciences 2011 for more detail).

As discussed in Stillwater Sciences (2011), unseasonal breaching of the SCRE mouth has potential adverse impacts on tidewater goby and steelhead. Estimated stages for a discharge into the SCRE of 4 mgd and 5 mgd are 9.5 feet NAVD88 and 10.5 feet NAVD88 respectively. Both of these stage estimates are below both the Phase 1 and Phase 2 estimates of breaching stage (11.0 feet NAVD88 and 12.5 feet NAVD88, respectively). The alternatives with discharges into the SCRE of 4 mgd to 5 mgd will result in increased breaching potential relative to alternatives with lower discharges in to the SCRE, but reduced breaching potential relative to alternatives with greater discharge into the SCRE.

It is important to understand that the alternatives do not need to be implemented at their full diversion capacity shown in this study. Several alternatives could be implemented at a capacity for diversion that would lead to increased water recycling, and local supply benefits, while continuing a discharge to the SCRE of between 4 to 5 mgd. At these flow levels, the combination of the modified Wildlife Ponds and the City-Owned Property would be used for treatment wetlands to achieve a nitrate concentration of approximately 4 mg-N/L (outflow from the treatment wetlands to the SCRE).

7.9 COST ESTIMATES

7.9.1 Basis of Costs

Capital costs are Class 5 estimates as outlined by the Association for the Advancement of Cost Engineering International. Class 5 estimates are typically used for conceptual and screening purposes and are based on a project definition of 0 to 2 percent. A contingency is often used to compensate for lack of detailed engineering data and oversights (–20 percent to -50 percent on the low side, and +30 percent to +100 percent on the high side) depending on the technological complexity of the project, availability and accuracy of appropriate reference information, and the inclusion of an appropriate contingency determination.

The costs presented are based on preliminary layouts, preliminary unit process sizes, and conceptual alternative configurations. Construction costs are estimated from unit costs developed from estimating guides, equipment manufacturers' information, unit prices, and construction costs of similar facilities and configurations at other locations.

The total installed equipment costs are inclusive of the equipment, and associated installation costs and ancillary equipment. The total construction costs include the total installed equipment costs, and additional costs to account for sales tax, general conditions, contractor overhead and profit margin, and a construction estimating contingency. The project costs include an additional cost to account for engineering, legal, administration, and project contingencies (ELAC). Table 7.12 presents a summary of the percentages applied to account for these costs.

7.9.2 Costs Common to Alternatives

7.9.2.1 <u>Treatment Wetlands</u>

Common to all of the alternatives, is the additional cost of treatment wetlands, as the approach is to combine each of the alternatives with treatment wetland for any remaining flow that the alternative does not provide the capacity to divert for reuse. Considering the additional cost of treatment wetlands as common to all alternatives also assures that additional water quality treatment and habitat benefits associated with the treatment wetlands are provided should it be determined appropriate to implement one or more alternatives at less than full diversion capacity for purposes of assuring some continued

Table 7.12 Summary of the Total Project Cost Components Phase 2 Recycled Water Study City of Ventura			
Description	**Row**	**Percentage**	**Subtotal Calculation**
Installed Equipment Cost	1	-	A
Construction and Estimating Contingency	2	30%	B=A*30%
Contractor Overhead and Profit Margin	4	10%	D=C*10%+C
Sales Tax Rate	5	7.5%	E=7.5%*B*0.5+D
Total Construction Cost	6		E
ELAC	7	30%	F=E*30%+E
Total Project Cost	8		F

discharge to the SCRE to control TIN values. Costs are included to construct vegetated zones in the existing Wildlife Ponds as well as constructing new treatment wetlands at the City-Owned Property adjacent to the VWRF.

The planning level estimates of total project costs and annual O&M costs are provided in Table 7.13. The total project cost estimates include treatment wetland construction as well as pumping and pipeline costs as separate line items. The Wildlife Ponds treatment wetland construction cost estimate includes only fill, earthwork, plants, and planting, since the remaining items were already performed or were in place. The City-Owned Property treatment wetland construction cost estimate includes clearing and grubbing the site, earthwork, plants and planting, control structures, and plumbing. The pump cost estimates are based on the average annual flow and the distance the pump will convey the treated effluent from the Wildlife Ponds to the City-Owned property (accounting for the total dynamic head). The pipeline cost estimates are based on the total length, diameter, and material of the pipe determined to be appropriate for conveying the treated effluent. The annual O&M costs are based on *Constructed Wetlands Treatment of Municipal Wastewater Manual* range of costs ($2,000 to $4000 per hectare) of treatment wetlands (U.S. EPA, 2000). Costs from this manual were adjusted to November 2012 dollars using the ENR index for Los Angeles.

7.9.2.2 Brine Treatment/Disposal

As discussed in Section 7.7, there are a number of brine treatment and disposal alternatives that could be considered. Constructing pipeline to the Calleguas SMP is one of the more promising alternatives since the Calleguas SMP is an existing pipeline. The estimated cost for the pipeline between the VWRF and the Calleguas SMP is approximately $22 million.

Table 7.13 Summary of Treatment Wetland Planning Level Estimates of Total Project Costs in 2013 Phase 2 Recycled Water Study City of Ventura		
	Wildlife Ponds 1 & 2	**City-Owned Property**
Approximate Area (acres)(1)	12.4	29
Pipe Length from VWRF (feet)	N/A	5,200
Wetland Construction ($)	$670,000	$3,000,000
Pump and Pipeline Costs ($)	N/A	$3,100,000
Total Project Costs ($)	$670,000	$6,100,000
Annual O&M Costs ($)(2)	$30,000	$120,000

Notes:
(1) Area provided in table is 85 percent of the total area available for the constructed treatment wetland.
(2) Based on *Constructed Wetlands Treatment of Municipal Wastewater Manual* range of costs for operations and maintenance ($2,000 to $4000 per hectare) of treatment wetlands (U.S. EPA, 2000). Costs from this manual were adjusted to November 2012 dollars using the ENR index for Los Angeles.

Additional investigation of brine treatment alternatives for this study included an analysis of ZLD systems. The resulting project cost estimates for the range of flows that require brine treatment range from $59 million to $120 million.

These costs far exceed the estimated cost of $22 million to construct a pipeline to convey brine from the VWRF to the Calleguas SMP. Therefore, the costs for the alternatives that require brine disposal include the cost ($22 million) of the pipeline to convey the brine from the VWRF to the Calleguas SMP.

7.9.3 Alternatives Cost Estimates

The project cost estimates for the alternatives are presented in Table 7.14. The table shows a breakdown of the treatment costs and infrastructure associated with each alternative.

For the alternative where VWRF effluent is conveyed to the City of Oxnard for treatment and reuse, two cost options are presented. The City and the City of Oxnard do not have an agreement as to the financial approach and parties responsible for the both capital and O&M costs. While there are numerous possible arrangements that could be made between the City and the City of Oxnard, the following two possibilities are considered in this study:

- City pays for AWPF expansion – In this scenario the City would be responsible for the capital investment in the AWPF expansion. In addition, the City would pay the City of Oxnard for O&M associated with treatment of VWRF effluent at the AWPF.

Table 7.14 Alternatives Comparison Summary
Phase 2 Recycled Water Study
City of Ventura

Alternative	Effluent Diversion Capacity	Treatment Processes	Project Cost Components ($M)					CEQA and Permitting	Total Project Cost ($M)	Total Project Unit Cost ($/gal) – Diverted Flow Basis (1)	Total Project Unit Cost ($/gal) – Water Supply Flow Benefit(2)	Total O&M Cost ($ thousands/year)(3)
			Wastewater Treatment	Brine Disposal	Conveyance/Storage/Injection	Recycled Water Distribution System	Wetlands					
North decentralized plant - Irrigation	2	MBR Plant	21			3.5	6.8	1.5	33	13	107	900
Conveyance to Oxnard(4)	13	Disinfection Improvements	5		41		6.8	2.0	54	4	None	16,200
Conveyance to Oxnard(5)	13	AWPF Expansion and Disinfection Improvements	45		41		6.8	2.0	95	7	None	5,200
Recharge/Ag supply for UWCD	11	MF/UF and RO	41	22	27		6.8	2.5	100	9	None	5,600
Ag supply for UWCD	7	MF/UF and RO	16	22	27		6.8	2.5	74	9	None	2,100
Mound Basin IPR (3.6 mgd)	4.5	MF/UF, RO, advanced oxidation	32	22	30		6.8	2.5	94	19	24	3,200
Mound Basin IPR (6.3 mgd)	7.9	MF/UF, RO, advanced oxidation	52	22	39		6.8	2.5	122	15	18	5,300
North decentralized plant - DPR	2.3	MBR, RO, advanced oxidation	38		4		6.8	3.0	52	20	25	2100
DPR (3.6 mgd)	4.5	MF/UF, RO, advanced oxidation	32	22	16		6.8	3.0	80	16	20	3,000

Notes:
(1) Project unit costs based on the effluent diversion capacity of the alternative, and does not include the wetland costs.
(2) Project unit costs based on the product water that would benefit the City's water supply, and does not include the wetland costs.
(3) For alternatives with brine treatment, the cost of disposal at the SMP is included.
(4) City of Oxnard pays for the AWPF expansion. Treatment and conveyance capital costs, and O&M costs are from Kennedy Jenks (2013).
(5) City of Ventura pays for the AWPF expansion. Treatment and conveyance capital costs, are from Kennedy Jenks (2013). O&M costs estimated as part of this study.

- City of Oxnard pays for AWPF Expansion – In this scenario, the City of Oxnard would be responsible for the capital investment in the AWPF expansion, The City would pay annual fees to the City of Oxnard to cover both treatment costs at the AWPF and an annualized capital costs that would allow the City of Oxnard to recover their capital investment.

Table 7.14 includes two cost estimates the conveyance to Oxnard alternative to reflect these different potential financial arrangements between the City and the City of Oxnard.

The capital and O&M costs in Table 7.14 do not reflect any potential financial offsets associated with existing water and wastewater system operating costs or future capital investments that may be avoided through implementation of the alternatives. Potential financial offsets are listed in Table 7.15.

7.10 COMPARISON OF ALTERNATIVES

The alternatives were compared based on criteria established throughout the stakeholder process. In particular, in the October 31, 2012 stakeholder meeting, the stakeholders provided input on the criteria that should be used to evaluate the alternatives. These criteria included several that were used as the basis for the preliminary screening of the alternatives, as well as other criteria. The list of suggested criteria includes:

- Improves discharge quality
- Reduces discharge flow
- Provides a potable source water benefit to the City
- Provides a reliable effluent diversion
- Creates wetland habitat (some stakeholders recognized this criteria was less important that others)
- Capital and operating costs, including rate payer impacts
- Provides multiple benefits (appealing to various stakeholders), in particular, habitat creation and water supply benefit

Since the development of this list of criteria, the alternatives have been further developed and the analysis of impacts of SCRE habitat and ecosystem function has been conducted. There are a number of key developments and findings that frame the criteria and basis for comparing the alternatives.

Table 7.15 Potential Financial Offsets of the Alternatives
Phase 2 Recycled Water Study
City of Ventura

Alternative	Potential Offset	Description
North decentralized plant - Irrigation	Not quantified	A small offset of potable water and potentially resale value of recycled water for agricultural use.
Conveyance to Oxnard	$14.7 M per year	For the scenario where the AWPF expansion is paid for by the City of Oxnard, there may be reductions in the annual fee to receive, treat and dispose of the secondary effluent, These offsets include the resale, incentive and allocation value of the VWRF effluent. These offsets would potentially reduce the annual fees. In addition, depending on the point of diversion from the VWRF, some wastewater treatment costs may be avoided (upgrading the existing VWRF tertiary filters and associated operating costs). Note that these costs associated with the VWRF filtration process were not quantified
Recharge/Ag supply for UWCD	None	Based on conversation with UWCD, there is not interest from the UWCD to pay for VWRF effluent
Ag supply for UWCD	None	Based on conversation with UWCD, there is not interest from the UWCD to pay for VWRF effluent
Mound Basin IPR (3.6 mgd and 6.3 mgd)	$16.8 M capital, and $860,000 per year O&M(1)	Future investment in advanced treatment (RO) of water extracted from the Mound Basin for potable supply may be offset. However, the potential to eliminate the need for RO of the Mound basin groundwater depends on the quality of the groundwater that is realized after implementation of the IPR project. Depending on whether secondary or tertiary effluent is used as the feed to the MF/UF the need for upgrading the existing VWRF tertiary filters and associated operating costs, may be eliminated. Note that these costs associated with the VWRF filtration process were not quantified
North decentralized plant - DPR	Not quantified	Provides an additional source of potable water and therefore potentially eliminates the need for investing in new water supplies. Note that this alternative provides approximately 1.8 mgd of treated water.

Table 7.15 Potential Financial Offsets of the Alternatives Phase 2 Recycled Water Study City of Ventura		
Alternative	**Potential Offset**	**Description**
DPR (3.6 mgd)	$16.8 M capital, and $860,000 per year O&M(1)	Provides an additional source of potable water and therefore potentially eliminates the need for investing in new water supplies. Treated water could be used directly as an additional water supply to the system (i.e. groundwater from the Mound Basin would continue to be extracted and treated). However, given the water quality issues with the Mound Basin potable supply, the reclaimed wastewater could be blended with groundwater to achieve water quality targets. The capital investment associated with RO of Mound Basin potable groundwater supply could potentially be offset. In addition, depending on whether secondary or tertiary effluent is used as the feed to the MF/UF the need for upgrading the existing VWRF tertiary filters and associated operating costs, may be eliminated. Note that these costs associated with the VWRF filtration process were not quantified

Note:
(1) If the City implemented RO for the Mound Basin groundwater supply, it is anticipated that it would not be acceptable to convey the brine to the VWRF. Any alternative that involved RO, of either water or wastewater, would require capital investment in brine disposal. Note that the recycled water alternatives presented in this study include the cost of conveying brine from the VWRF to the Calleguas SMP.

The criteria of reducing the discharge flow and improving the quality were developed based on the Phase 1 estuary study analysis that suggested that there may be an optimized condition for the SCRE that would result from a lower discharge flow and improve discharge quality. The results of the Phase 2 SCRE habitat and ecosystem function analysis suggests that a discharge flow of 4 to 5 mgd to the SCRE, with a nitrate concentration of 4 mg-N/L (or less) would result in the lowest concentrations of nitrate in the SCRE and would provide a the greatest (or near greatest) habitat for the four focal species. Therefore, the discharge flow criteria are related to whether the alternative can be designed to achieve the target flow range of 4 to 5 mgd.

By adopting the approach that any remaining discharge to the SCRE would be routed through treatment wetlands, all of the alternatives result in improved discharge quality. The creation of new wetland habitat is also achieved by all alternatives. For any alternative that provides a water supply benefit, the criteria of providing multiple (habitat creation and water supply) benefits is achieved.

These key developments and findings, discussed above, lead to a list of criteria that are inclusive of the stakeholder criteria, but are structured to highlight the differentiating features of the alternatives. These criteria include:

- Can the alternative be operated to result in a remaining discharge flow of 4 to 5 mgd to the SCRE, with a nitrate concentration of 4 mg-N/L (or less)?
- Does the alternative provide a potable source water benefit to the City?
- Does the alternative provide a reliable diversion of VWRF effluent?
- What is the relative cost compared to other alternatives?

The attainment of these criteria, with exception of costs, is presented in Table 7.16. A summary of the alternatives comparison is included in Table 7.17. The costs for these alternatives are presented in Table 7.14.

The alternatives that attain the most criteria are the Mound Basin IPR project (3.6 mgd) and the DPR project (3.6). In both cases, the IPR or DPR project would be coupled with treatment wetlands that would provide additional nutrient removal and provide wetland habitat.

7.11 REPORT CONTENT SUMMARY

The development of this report was financially supported by grants from the State Water Resources Control Board Water Recycling Funding Program and the U.S. Bureau of Reclamation Title XVI Water Reclamation and Reuse Program. Each of these grant funding agreements comes with stipulations for what shall be included in the development of a facilities plan. The current Draft version of this report has included the following chapters.

- Chapter 1 – Background, Study Area Characteristics
- Chapter 2 - Water Supply Characteristics and Facilities
- Chapter 3 - Wastewater Characteristics and Facilities
- Chapter 4 - Treatment Requirements for Discharge and Reuse
- Chapter 5 - Potential Recycled Water Market
- Chapter 6 - Preliminary Alternative Analysis and Screening
- Chapter 7 - Viable Alternative Development and Comparison

Table 7.16 Alternatives Comparison Discussion
Phase 2 Recycled Water Study
City of Ventura

Alternative	Evaluation Criteria		
	Operated to Meet Target Discharge Flow and Quality?	**Provides a Potable Source Water Benefit for the City?**	**Provides a Reliable Diversion of VWRF Effluent?**
North Decentralized Plant - Irrigation	This alternative is limited by the available raw wastewater and the local irrigation demands. The estimated diversion capacity is approximately 2 mgd. Under existing conditions the remaining discharge to the SCRE would be 4 mgd, but in the future buildout conditions the remaining discharge would be 8 mgd.	This alternative provides a potable source water benefit to the City by offsetting the potable water demand used for irrigation through conversion to recycled water. However, the potable water demand that would be offset by this alternative is very low (0.17 mgd average, and 0.24 mgd maximum month).	This alternative provides a reliable diversion of VWRF effluent in the summer months. For non-summer months the irrigation demands would be very low.
Conveyance to Oxnard	This alternative would be designed for 13 mgd, but could be operated at flows that would result in the target discharge flow of 4 to 5 mgd.	This alternative does not provide a potable source water benefit to the City.	The pipeline to Oxnard provides a reliable means of diverting the VWRF effluent.
Recharge/Ag Supply for UWCD	This alternative would be designed for a diversion of 12 mgd but the treatment processes could be constructed in phases and the system could operate at flows that would result in the target discharge of 4 to 5 mgd.	In this alternative, the City could potentially benefit from credits that would be granted from the FCGMA in return from recharging the groundwater basin and offsetting agricultural extractions. However, based on ongoing conflict over water rights credits for other cities with similar project benefits, there is low potential that the City would be able to negotiate a favorable agreement on water credits.	In this alternative, all of the water that would be conveyed to UWCD would meet the water quality targets, and would not rely on the dilution capacity of SCR water. Therefore, this alternative provides a reliable means for diverting the VWRF effluent.

Table 7.16 Alternatives Comparison Discussion
Phase 2 Recycled Water Study
City of Ventura

Alternative	Evaluation Criteria		
	Operated to Meet Target Discharge Flow and Quality?	**Provides a Potable Source Water Benefit for the City?**	**Provides a Reliable Diversion of VWRF Effluent?**
Ag Supply for UWCD	This alternative would be designed for a diversion of 8 mgd but the treatment processes could be constructed in phases and the system could operate at flows that would result in the target discharge of 4 to 5 mgd.	In this alternative, the City could potentially benefit from credits that would be granted from the FCGMA in return from recharging the groundwater basin and offsetting agricultural extractions. However, based on ongoing conflict over water rights credits for other cities with similar project benefits, there is low potential that the City would be able to negotiate a favorable agreement on water credits.	This alternative relies on the availability of SCR water to provide dilution of chloride levels.
Mound Basin IPR (3.6 mgd)	This alternative results in about a 5 mgd discharge of effluent to the SCRE.	This alternative directly benefits the Mound Basin. It is anticipated that the IPR project would lead to improved groundwater quality.	An IPR project is a reliable means of diverting VWRF effluent
Mound Basin IPR (6.3 mgd AFY)	This alternative does not result in the target discharge to the SCRE for existing and future conditions	This alternative directly benefits the Mound Basin. It is anticipated that the IPR project would lead to improved groundwater quality.	An IPR project is a reliable means of diverting VWRF effluent
North Decentralized Plant - DPR	This alternative is limited by the available raw wastewater and the local irrigation demands. The estimated diversion capacity is approximately 2 mgd. Under existing conditions the remaining discharge to the SCRE would be 4 mgd, but in the future buildout conditions the remaining discharge would be 8 mgd.	In this alternative, the recycled water is conveyed directly into the City potable system and would therefore provide a benefit.	A DPR project is a reliable means of diverting VWRF effluent
DPR (3.6 mgd)	This alternative results in about a 5 mgd discharge of effluent to the SCRE.	In this alternative, the recycled water is conveyed directly into the City potable system and would therefore provide a benefit.	A DPR project is a reliable means of diverting VWRF effluent

Table 7.17 Alternatives Comparison Summary
Phase 2 Recycled Water Study
City of Ventura

Alternative	Evaluation Criteria		
	Operated to Meet Target Discharge Flow and Quality?	**Provides a Potable Source Water Benefit for the City?**	**Provides a Reliable Diversion of VWRF Effluent?**
North decentralized plant - Irrigation	N	Y (low)	Y
Conveyance to Oxnard	Y	None	Y
Recharge/Ag supply for UWCD	Y	Not Likely	Y
Ag supply for UWCD	Y	Not Likely	N
Mound Basin IPR (3.6 mgd)	Y	Y	Y
Mound Basin IPR (6.3 mgd)	N	Y	Y
North decentralized plant - DPR	N	Y	Y
DPR (3.6 mgd)	Y	Y	Y

Note:
(1) Project unit costs based on the effluent diversion capacity of the alternative, and do not include the wetland costs

Because this version of the report is a draft for stakeholder review and input, Chapters 8 thru 10 are not developed yet as there has not been a decision as to the recommended project. The final version of this report will include the following additional chapters:

- Chapter 8 – Stakeholder Input and Recommendations
- Chapter 9 – Financial Plan/Capabilities and Next Steps
- Chapter 10 – Research Needs

Table 7.18 presents an outline of Chapters 8 through 10 to provide readers with information on the eventual content of these chapters.

Table 7.18 Final Report Content
Phase 2 Recycled Water Study
City of Ventura

Section	Description
Chapter 8 - Stakeholder Input and Recommendations	
8.1	Recommended Alternative
8.2	Institutional Requirements and Permitting
8.3	Implementation Plan
Chapter 9 – Financial Plan/Capabilities and Next Steps	
9.1	Funding Sources and Considerations
9.2	Funding Source Identification
9.3	Recycled Water Pricing Policy
9.4	Annual Cost Projections
Chapter 10 – Research Needs	

APPENDIX A – HOPKINS PRELIMINARY HYDROGEOLOGICAL STUDY

HOPKINS GROUNDWATER CONSULTANTS, INC.

PRELIMINARY HYDROGEOLOGICAL STUDY

RECYCLED WATER MASTER PLAN GROUNDWATER REPLENISHMENT AND REUSE PROJECT VENTURA, CALIFORNIA

Prepared for:
City of San Buenaventura

January 2013

HOPKINS
GROUNDWATER
CONSULTANTS, INC.
THE WATER RESOURCE SPECIALISTS

January 21, 2013
Project No. 01-009-07B

City of San Buenaventura
Ventura Water
Post Office Box 99
Ventura, California 93002-0099

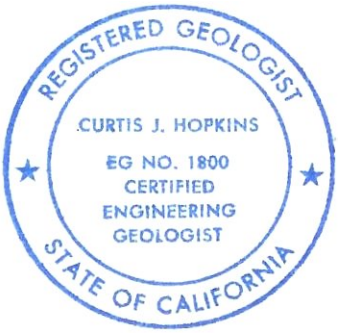
Attention: Mr. Dan Pfeifer
Wastewater Utility Manager, Ventura Water

Subject: Preliminary Hydrogeological Study, Recycled Water Master Plan, Groundwater Replenishment and Reuse Project, Ventura, California, January 2013.

Dear Mr. Pfeifer:

Hopkins Groundwater Consultants, Inc. (Hopkins) is pleased to submit this final report summarizing the findings, conclusions, and recommendations developed from a preliminary study to assist the City of San Buenaventura (City) in understanding the potential feasibility for a Groundwater Replenishment and Reuse Project using highly treated recycled water. The study concludes that it is likely feasible to operate a 4,000 or 7,000 acre-feet per year recharge and recovery operation in the Mound Groundwater Basin. Groundwater replenishment can likely be accomplished at sites located upgradient of the existing City Mound Basin Wellfield and result in improving the native groundwater quality.

As always, Hopkins is pleased to be of service. If you have questions or need any additional information, please give us a call.



Sincerely,

HOPKINS GROUNDWATER CONSULTANTS, INC.

Curtis J. Hopkins
Principal Hydrogeologist
Certified Hydrogeologist HG 114
Certified Engineering Geologist EG 1800

Report Copies Submitted: Three (3) Bound Copies, One (1) Electronic Copy

C: Ms. Susan Rungren, Principal Engineer, Ventura Water

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P.O. Box 3596, Ventura, California 93006 Phone: (805) 653-5306 e-mail: chop4@earthlink.net

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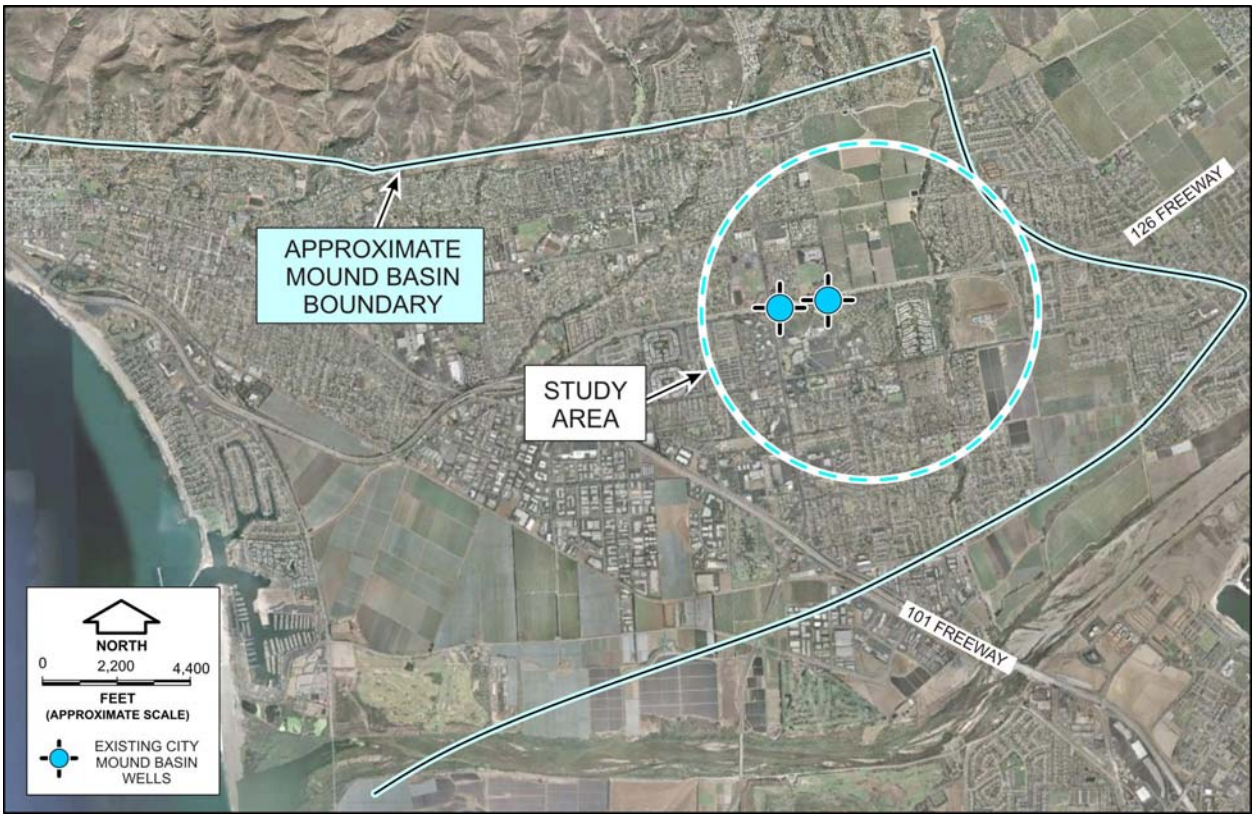
INTRODUCTION

GENERAL STATEMENT

Presented in this report are the findings, conclusions, and recommendations that were developed from a preliminary hydrogeological study conducted by Hopkins Groundwater Consultants, Inc. (Hopkins) to assist the City of San Buenaventura (City) in evaluating the preliminary feasibility of a potential Groundwater Replenishment and Reuse Project (GRRP) using its recycled water. This supplemental study was conducted in support of the City's Recycled Water Master Plan (RWMP) that is presently in draft form. The City is interested in the potential of developing a sustainable program for replenishment and reuse of highly treated recycled water using aquifer units in the Mound Groundwater Basin (Mound Basin). The proposed GRRP could provide the ability for Indirect Potable Reuse (IPR) of this high quality supply that could augment the City's potable water system and improve the delivered water quality. The study area is shown on Figure 1 – Study Area Location Map.

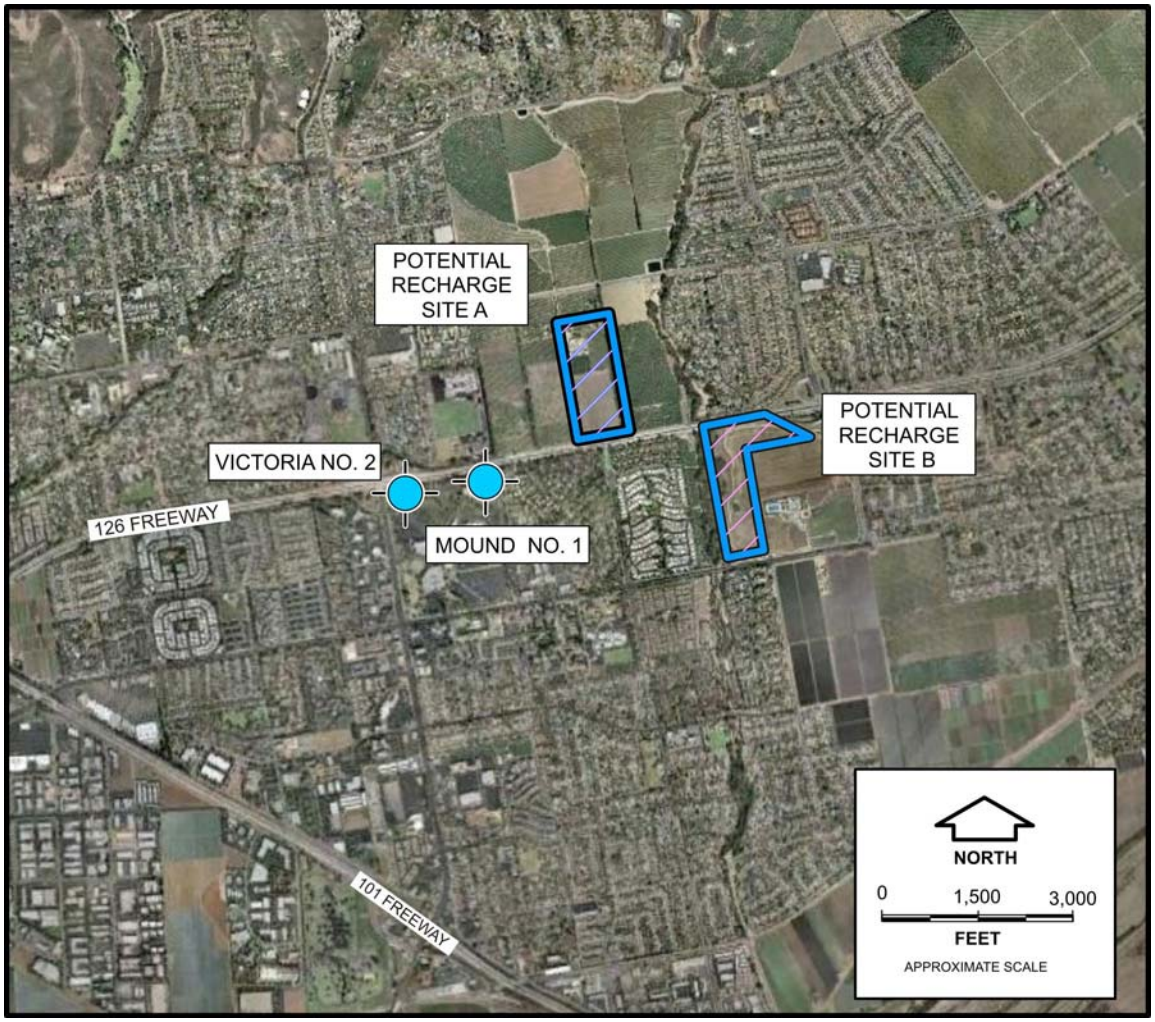
Figure 1 – Study Area Location Map



The two (2) proposed groundwater replenishment alternatives being considered by the City would provide the ability to store and reuse; 1) up to 4,000 acre-feet per year (AFY), or 2) up to 7,000 AFY of recycled water. The full advanced treatment water (FATW) proposed for use will be treated by desalination through a membrane process, advanced oxidation, and ultraviolet exposure. This study assumes that the FATW would be; a) produced at a constant rate on a daily basis, b) would be injected at a rate of 2,500 gallons per minute (gpm) (for the 4,000 AFY alternative), and c) injected at a rate of 4,340 gpm (for the 7,000 AFY alternative).

The supplemental planning study was requested to focus on the hydrogeology of the Mound Basin along the east side of the City where groundwater flows westward toward the City's existing Mound Wellfield. The preliminary locations identified for this study for groundwater recharge wells are designated as Recharge Sites A and B and are shown on Figure 2 – Potential Recycled Water Recharge Well Site Location Map.

Figure 2 – Potential Recycled Water Recharge Well Site Location Map



While the proposed use for the wells considered in this study is to strictly inject recycled water for the purpose of groundwater replenishment and downgradient withdrawal from the City's municipal supply wells, the wells will require routine recovery of groundwater by pumping in order to remove accumulated well plugging material and maintain a reasonable service-life. Future considerations for groundwater produced from the injection wells will need to include discharge to waste or onsite reuse alternatives.

PURPOSE AND SCOPE

The purpose of the study is to develop an understanding of the potential feasibility of the GRRP based on existing data and the present understanding of the Mound Basin. The study is also intended to preliminarily identify future facilities and studies that may be required to further assess project feasibility. The scope of work for the supplemental study was developed through discussions with Ms. Elisa Garvey and Ms. Lydia Holms, with Carollo Engineers, and Mr. Dan Pfeifer and Ms. Susan Rungren, with the City. As developed, the work scope included performance of the following tasks:

- Conduct a preliminary hydrogeological analysis based on the best available information to support the evaluation of the GRRP alternatives in the Mound Basin,
- Provide a rough estimate of travel time from possible injection locations east of the City Mound Wellfield,
- Provide a brief description of the method used to estimate travel time for the GRRP scenarios,
- Preliminarily identify potential investigations and studies that may be required to further assess project feasibility for IPR,
- Identify the potential injection and production capacities of aquifer zones that comprise the lower aquifer systems in the eastern portion of the Mound Basin,
- Prepare this supplemental report summarizing the findings, conclusions, and recommendations for use in the City's RWMP document.

Sources of available data and published information that were used for the study include; a) City data and reports, b) United Water Conservation District (UWCD) data and reports, and c) Ventura County Watershed Protection District databases.

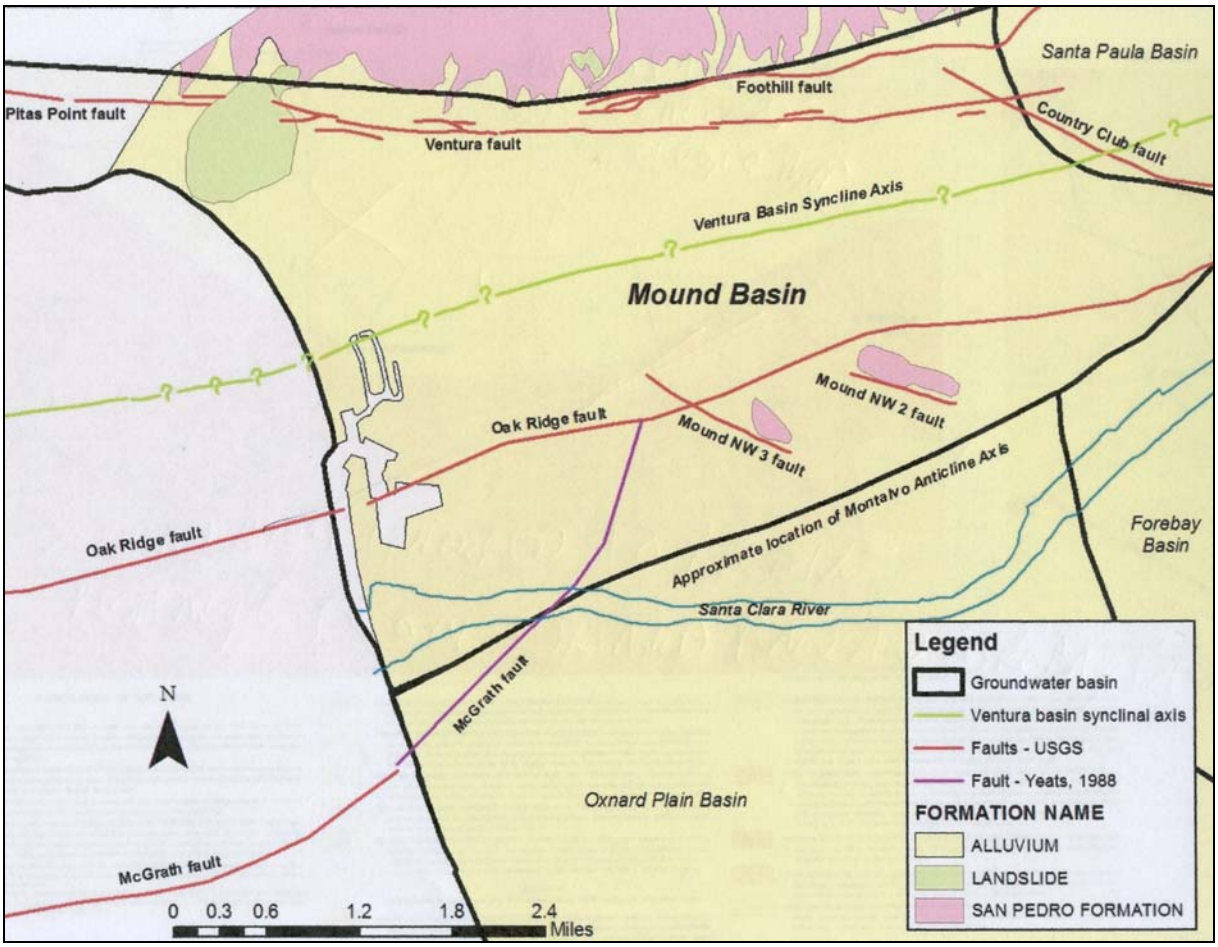
FINDINGS

HYDROGEOLOGY AND AQUIFER DELINEATION

Geology

The proposed City project is located in the Mound Basin which is part of the Transverse Ranges geologic/geomorphic province and is defined by a number of geologic structures and features that separate it from the adjacent groundwater basins. The geology of the Mound Basin has been described in detail by several authors including the California State Water Resources Control Board (SWRCB, 1953), Turner (1975), GTC (1982, draft), and UWCD (2012). Figure 3 – Generalized Geologic Map and Mound Basin Boundary shows the mapped boundaries of the Mound Basin along with the location of geological structures that influence groundwater flow within the basin and between adjacent basins.

Figure 3 – Generalized Geologic Map and Mound Basin Boundary



FROM UWCD, 2012b

The subsurface geology that controls groundwater flow in the study area has recently been differentiated into two geologic units (UWCD, OFR 2012-01). The units include; 1) the Holocene and late Pleistocene alluvium, and 2) the San Pedro Formation. The first unit is comprised of largely unconsolidated sedimentary deposits and includes all older and recent alluvium deposits. These shallower units are coarser grained in the vicinity of the Santa Clara River and form the Oxnard and Mugu Aquifers to the south in the Oxnard Plain Basin. The shallow alluvial deposits in the Mound Basin range in thickness and are dominated by fanglomerate deposits derived from the Ventura Foothills. These deposits lie unconformably on top of the San Pedro Formation. The San Pedro Formation is typically comprised of semiconsolidated Plio-Pleistocene sedimentary deposits and is up to 1,500 feet thick near the center of the Mound Basin along the axis of the Ventura Basin Syncline. The San Pedro Formation consists of consolidated marine and nonmarine clay, silt, sand, and gravel deposits that comprise the aquifer zones designated as the lower aquifer system. The low permeability materials underlying the San Pedro Formation are generally considered as non-water-bearing and effectively define the base of fresh water.

Groundwater Basin and Aquifer Zone Delineation

Within the Mound Basin, the aquifer system has recently been delineated (UWCD, OFR 2012-01) and divided into an upper aquifer system (UAS) and lower aquifer system (LAS) to facilitate understanding and management of the groundwater resources. These classifications define the UAS as the younger and older alluvium and the LAS as aquifers in the San Pedro Formation that are separated by an unconformable contact.

The Mound Basin groundwater is semi-protected from overlying land uses by the extensive silt and clay layers that are on the order of 200 to 500 feet thick. The Montalvo Anticline effectively defines the southern edge of the Mound Basin and separates it from the Oxnard Plain and Oxnard Forebay Basins (see Figure 3). The Country Club Fault zone defines the eastern edge of the basin and separates the Mound Basin from the Santa Paula Basin. The western boundary of the Mound Basin is defined by the offshore outcrop area of each separate aquifer zone which is largely undetermined. The RWMP recharge sites are located within the Mound Basin downgradient (west) of the Santa Paula Basin boundary.

The Mound Basin is further dissected by the Oak Ridge and McGrath Fault zones (see Figure 3). The effects of these structures on groundwater flow have not been evaluated through the use of field investigation methods. For the purpose of the study, we recognize that the Oak Ridge Fault likely creates an effective flow barrier to the south, and it is assumed that the City's Mound Wellfield will be in hydraulic communication with the proposed recharge sites because they are both located on the north side of this structure (see Figure 2).

Historically, many wells completed in the Mound Basin produced water from the shallower aquifers and have since been replaced by deeper wells in an attempt to produce better

quality groundwater. The City wells produce from both the shallow (UAS) and deeper (LAS) aquifer zones and yield on the order of 2,500 gpm. The water quality is fair to poor, and generally of poorer quality in the UAS zones.

In the study area, the LAS is comprised of permeable strata contained in the San Pedro Formation and is a confined aquifer system. Although there are a number of coarse grained strata in the LAS, historical data indicate that there is an abundance of lower permeability materials that separate the aquifer zones and may create laterally discontinuous layers (lenticular layers) that may increase the difficulty of predicting cross-basin flow.

Historical groundwater production from the Mound Basin has annually been in the range of 3,000 to 10,000 AFY. Figure 4 – Mound Basin Annual Extractions shows the groundwater production historically reported to UWCD between 1980 and 2011.

Figure 4 – Mound Basin Annual Extractions

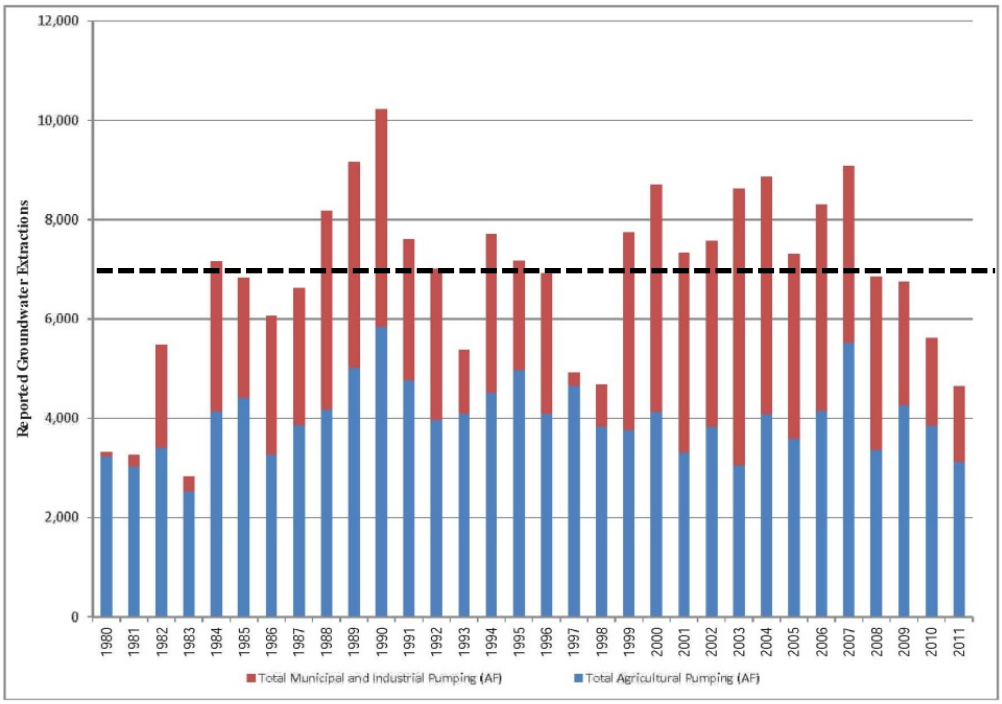


Figure 4.3-19. Historical reported groundwater extractions for the Mound Basin

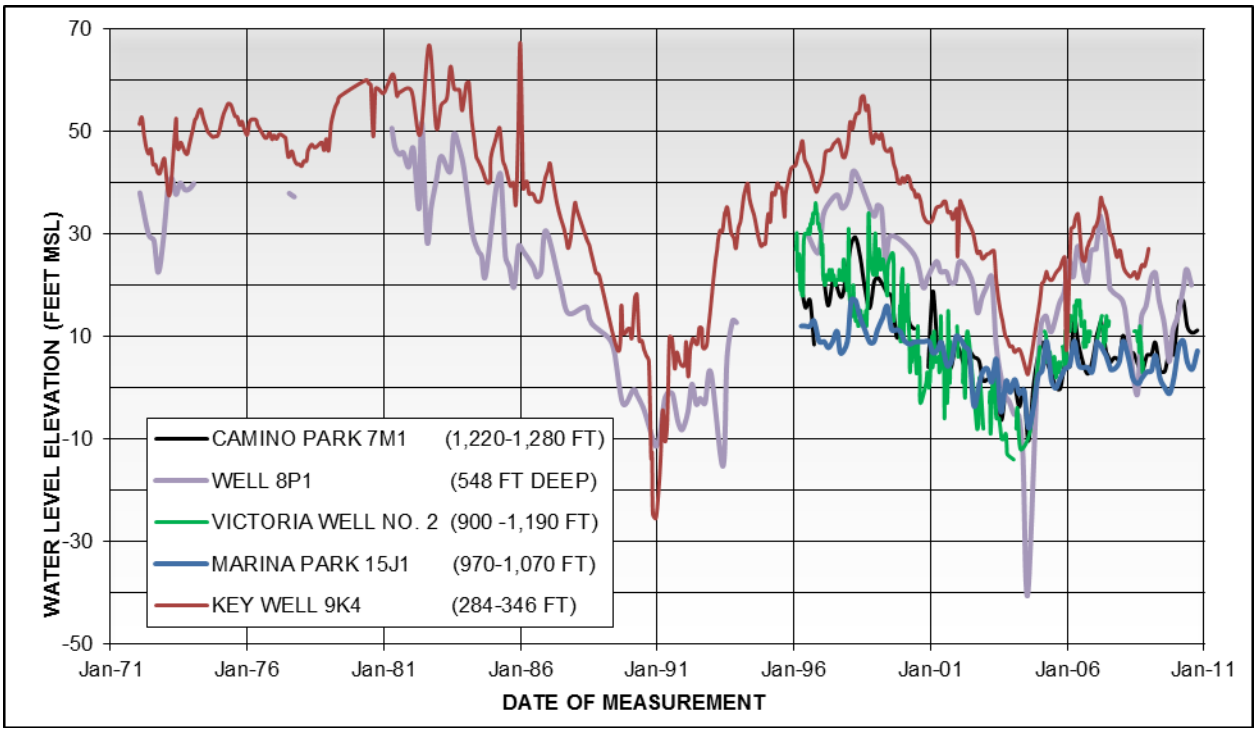
FROM UWCD, 2012a

As shown, the average annual production from the basin is on the order of 7,000 AFY. However, the safe yield, or sustainable perennial yield has not yet been determined.

Groundwater Levels

Groundwater elevations in the Mound Basin have varied significantly over time. Figure 5 – Groundwater Elevation Hydrograph shows the fluctuations in water levels in the basin that have occurred since 1972. The groundwater elevation within the Mound Basin in proximity to the study area dropped to approximately 20 feet below mean sea level (msl) during the 1986 to 1990 drought and has risen as high as 40 to 50 feet above msl in recent years. These available data indicate that seasonal fluctuations in the Mound Basin groundwater levels typically range between 10 and 15 feet. Dry climatic conditions result in consecutive annual declines in the regional water levels (see Figure 5).

Figure 5 – Groundwater Elevation Hydrograph

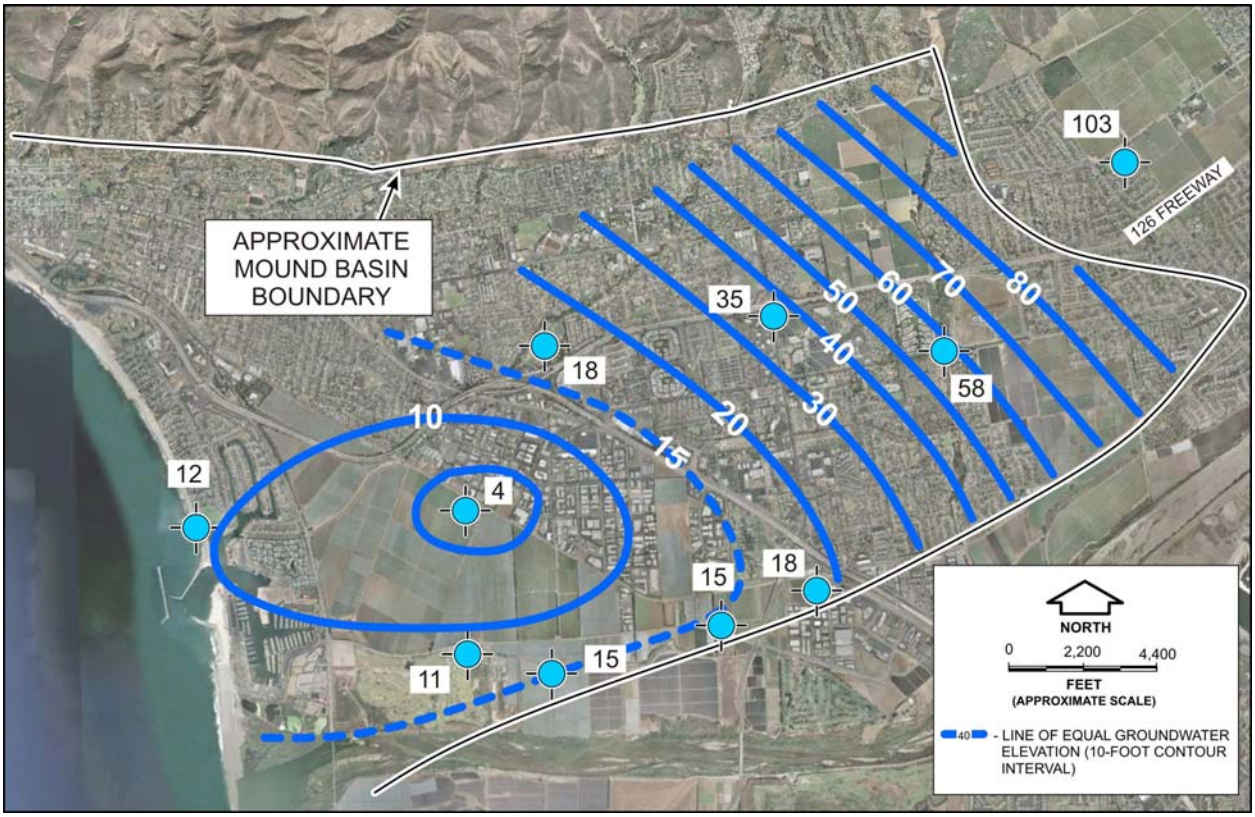


Groundwater Gradient and Flow Velocity

Information available from the UWCD was used to construct the groundwater elevation contour maps for the Fall of 2011 (UWCD, 2012b). Figure 6 – Lower Aquifer System Groundwater Elevation Contour Map shows the groundwater elevations indicated by the

available data and the approximate direction of flow in the LAS. The number of data points in the basin is very small and lends to the potential for error in trying to estimate the precise direction and gradient of groundwater flow. For the purpose of the preliminary study, the use of the groundwater gradient provided by these available data is believed sufficient for planning purposes to understand the approximate flow direction.

Figure 6 – Lower Aquifer System Groundwater Elevation Contour Map



Utilizing the water level contours from the 2011 data, the groundwater gradient was calculated at 0.0075 (dimensionless) in the southwesterly direction for the LAS which is believed to approximate typical eastern basin conditions in the vicinity of the recharge well sites and the City's Mound Basin Wellfield. To determine the area potentially influenced by recycled water recharge, the rate of flow away from the proposed recharge well sites was estimated using; a) a discrete cumulative aquifer thickness of 160 feet to estimate the hydraulic conductivity of the aquifer zones, b) the 2011 east basin gradient previously estimated, c) an average aquifer porosity of 15 percent, and d) the following equation:

$$V = K\ I/\eta$$

V	=	GROUNDWATER FLOW VELOCITY
K	=	AQUIFER HYDRAULIC CONDUCTIVITY
I	=	GROUNDWATER GRADIENT
η	=	AQUIFER POROSITY

The hydraulic conductivity of the cumulative aquifer zones was estimated from Victoria Well No. 2 production test data at approximately 100 feet per day (ft/d). The resulting groundwater flow velocities for the LAS in the eastern Mound Basin were estimated to be approximately 5 ft/d [1,840 feet per year (ft/yr)].

Using 15 percent as an aquifer porosity value and an cumulative aquifer thickness of 160 feet (combined thickness of the LAS zones produced by Victoria Well No. 2), the injected volume of FATW (4,000 AFY) would fill a storage area having a radius of over 3,900 feet. Figure 7 – Area of Lower Aquifer System Filled by Recycled Water shows the approximate areal extent of the displaced volume of native groundwater that is replenished by recycled water over a one-year-period. The estimated aquifer storage area shown in Figure 7 that is occupied by the recycled water (recharge bubble) is calculated assuming the entire volume of 4,000 AFY is injected in a single well or closely spaced wells solely completed in the LAS at any one of the recharge sites. Should the annual injection volume be distributed between sites or between aquifer systems, the displaced volume of native groundwater (areal extent) would be proportionally smaller. The use of a limited aquifer thickness (160 feet) and only 15 percent porosity is believed to be conservative and contribute to a larger affected area. If either of these parameters is increased (which is highly likely), the aquifer area required to contain the recharge bubble would be reduced.

As shown in Figure 7, the recycled water recharge bubble migrates in the downgradient direction at a rate of 5 ft/d. While the estimated area of recycled water influence does not account for advective or dispersive mixing, it is believed to provide a sufficient level of detail for the intended planning purposes. The result of this exercise indicates that water injected at potential Recharge Well Site A (at a steady rate of 2,500 gpm) would reach Victoria Well No. 2 within an 8 to 9-month period of time. Because of the above stated assumptions, this estimate is believed to be conservative and the travel time between the point of replenishment and the point of reuse is likely longer.

Figure 7 – Area of Lower Aquifer System Filled By Recycled Water

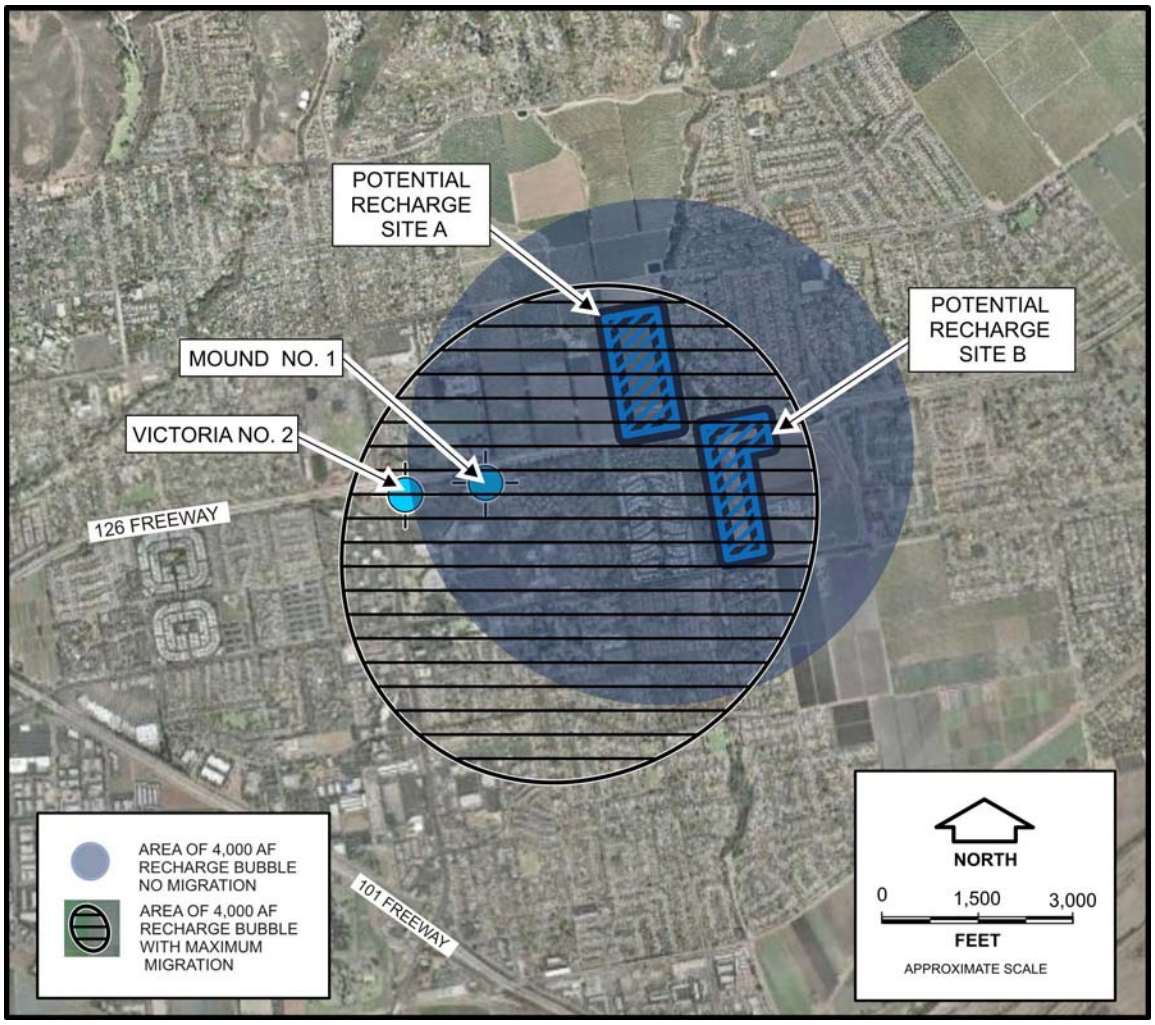
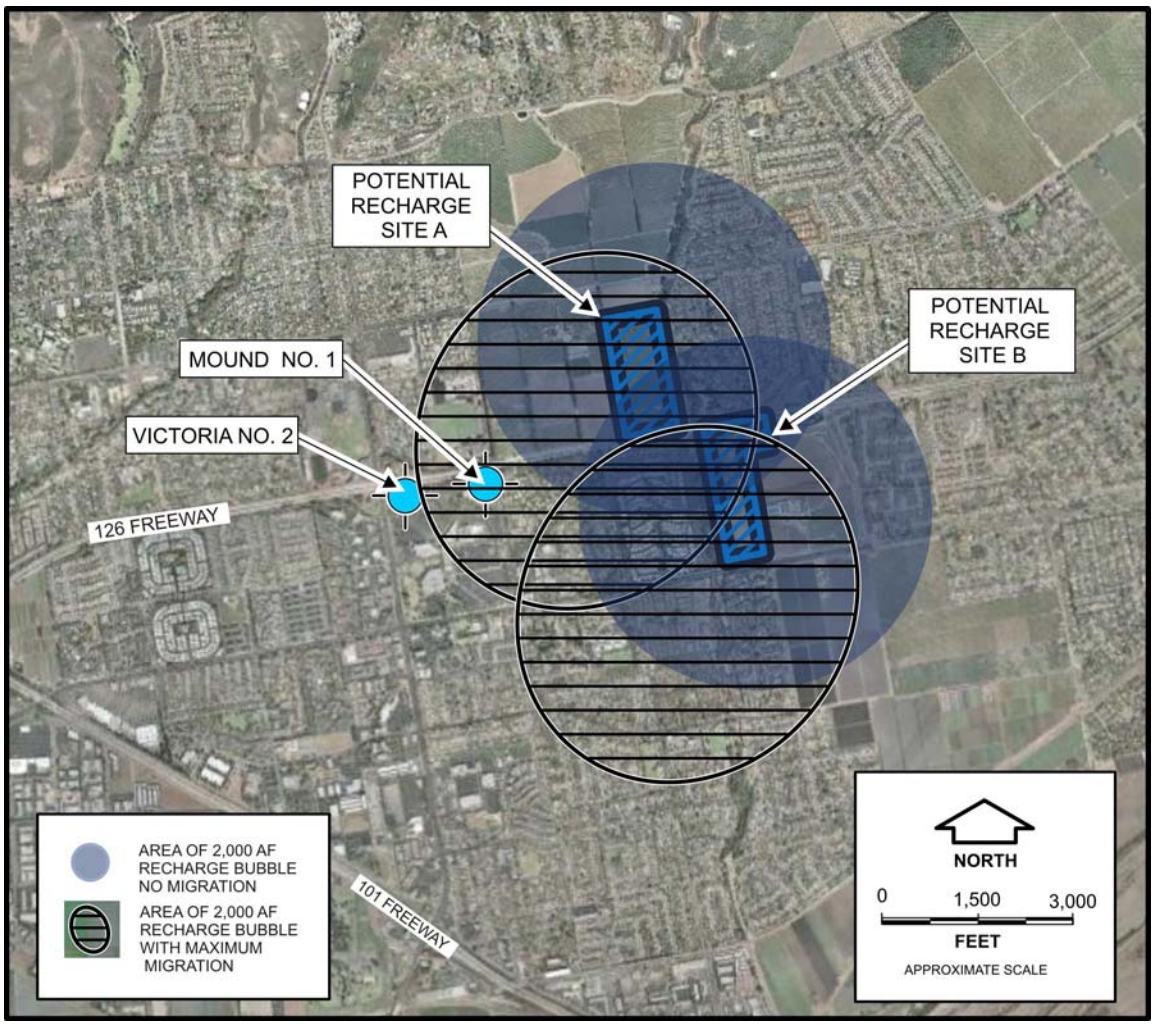


Figure 8 – Annual Recharge of 4,000 Acre-Feet Per Year Using Separate Well Sites shows the approximate corresponding areal extent of the aquifer that would be filled if the 4,000 AFY is injected using 2 separate well sites at a constant rate of 1,250 gpm. The results indicate that the injected recycled water would take approximately 1 year to travel to the site of Victoria Well No. 2.

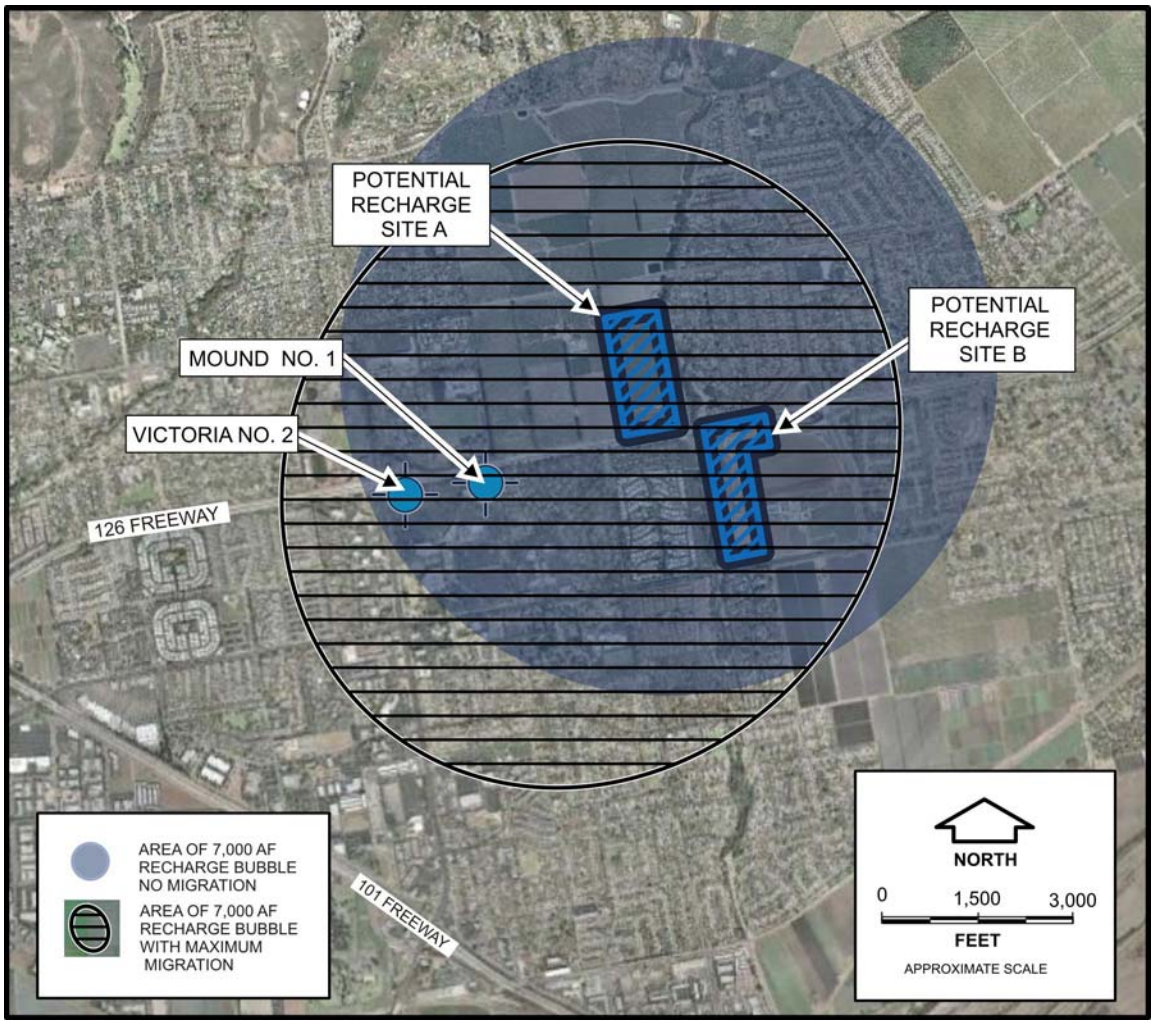
Figure 8 – Annual Recharge of 4,000 Acre-Feet Per Year Using Separate Well Sites



The injected volume of 7,000 AFY of recycled water would fill a storage area within the aquifer zones having a radius of approximately 5,200 feet. Figure 9 – Area of Lower Aquifer System Filled by 7,000 Acre-Feet of Recycled Water shows the approximate areal extent of the displaced volume of native groundwater that would be filled by recycled water over a one-year-period. The estimated aquifer storage area (recharge bubble) occupied by recycled water is calculated assuming the entire volume of 7,000 AFY is injected in at a single well site in closely spaced wells solely completed in the LAS at either of the recharge sites. The travel time for injected water on the east side of Potential Recharge Well Site A to reach Victoria Well No. 2 is 6 to 7 months. Should the annual injection volume be distributed between sites or if the effective

aquifer thickness is greater, the displaced volume (areal extent) of native groundwater would be proportionally smaller and the travel time to the downgradient wellfield would increase.

Figure 9 – Area of Lower Aquifer System Filled By 7,000 Acre-Feet of Recycled Water



Water Quality

Review of historical water quality data indicate that groundwater in the LAS is generally of fair to poor quality with total dissolved solids (TDS) concentrations in the range of 900 to 1,500 milligrams per liter (mg/l) and sulfate concentrations that range from 400 to 650 mg/l. The LAS groundwater is generally a calcium sulfate chemical character. Historical data indicate that the storage of the proposed recycled water will improve the quality of groundwater in LAS

and that injection water chemistry can likely be controlled (buffered) to be compatible with native groundwater.

Future Site Specific Investigations

Should the City decide to pursue the groundwater replenishment project at either of the proposed sites, it will need to develop a comprehensive plan for investigation that will determine site specific subsurface conditions and develop facilities that can be used to conduct demonstration testing that is required for application of the permits required for the GRRP. Site specific groundwater studies will be required to further define the aquifer replenishment potential at either recharge site. Field investigation will include exploratory drilling and construction of pilot test wells and monitoring wells to test the aquifer properties and confirm groundwater travel time estimates at each site. Ultimately, groundwater tracer testing using an intrinsic tracer will be required to satisfy California Department of Public Health (CDPH) and obtain a permit for the GRRP. Additional analyses to be conducted during the site investigation will include evaluating the geochemical compatibility of the FATW with the native groundwater and the lithology of aquifer materials through the use of sample analysis, bench tests, and geochemical modeling.

It is anticipated that the relative cost of exploration will reflect the difficulty and expense of drilling and constructing facilities to the depths on the order of 1,500 bgs. Based on our recent experience with these types of well construction projects we estimate that a nested monitoring well with 2 casing and screen assemblies installed to 1,500 and 1,000 feet will cost approximately $250,000. We estimate that an aquifer test well constructed to 1,500 feet bgs will cost approximately $600,000 and that the facilities design, construction management, subsequent demonstration testing and reporting may cost approximately $500,000. The total anticipated cost for each site to explore, test, and prepare the reporting necessary to determine site suitability and generate information for project permitting will likely range up to $2,000,000 and require an approximate 2- to 3-year-study period.

CONCLUSIONS AND RECOMMENDATIONS

In November 2011, the CDPH Drinking Water Program released a draft regulation that reflects its current thinking on the regulation for replenishing groundwater with recycled municipal wastewater. Based on the findings of this study, we conclude that available data indicate the proposed GRRP is feasible and that replenishment and recovery of groundwater with an improved quality could be effectuated in this portion of the Mound Basin that is consistent with the current draft regulation. It is anticipated that properly designed and constructed recharge wells located at or in the vicinity of the proposed recharge well sites will provide operational well capacities beneficial for the proposed recycled water replenishment program. Injection into the LAS in the Mound Basin will require multiple wells that will likely be capable of sustained injection rates of between 1,000 to 1,500 gpm.

We conclude that aquifer replenishment at Potential Recharge Well Site A or at the northern end of Potential Recharge Well Site B has a higher likelihood of being recaptured at the location of the existing City wells. The CDPH draft regulations require that the retention time of the FATW in the aquifer be no less than 2 months prior to reuse. We conclude that it is feasible for both the 4,000 and 7,000 AFY GRRP alternatives being considered to be designed at the two replenishment sites to meet the minimum aquifer retention time prior to being produced at the existing City Mound Wellfield.

We conclude that the sparse water level data available in the Mound Basin preclude the ability to confidently determine of the direction and rate of groundwater flow and that the effectiveness of capture and reuse of higher quality recharge water from the existing Mound Wellfield cannot be assessed with any accuracy from the available data. We conclude that the GRRP will require the construction of additional downgradient production wells and that new well site locations may need to be considered to maximize the capture of a greater percentage of the higher quality FATW.

For planning purposes we recommend the City use; a) a total of 3 wells for the 4,000 AFY alternative, b) a total of 5 wells for the 7,000 AFY alternative, and c) a cost of approximately $2,000,000 per well to construct the recharge well facilities and equip with pump and motor assemblies, and wellhead piping for injection operations. This cost does not include electrical power or automated controls, conveyance piping, site security, well housing, or purge water discharge disposal considerations. The well construction cost estimate does not include land acquisition or project environmental documentation.

We recommend that upon completion of field investigations that the City evaluate well location alternatives for both future recharge wells and downgradient production wells using groundwater modeling software. Groundwater modeling should include particle tracking to simulate well capture zones and optimize the placement of new well facilities.

CLOSURE

This report has been prepared for the exclusive use of the City of San Buenaventura and its agents for specific application to the City of Ventura Recycled Water Master Plan. The findings, conclusions, and recommendations presented herein were prepared in accordance with generally accepted hydrogeological planning and engineering practices. No other warranty, express or implied is made.

□

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APPENDIX B – CITY OF VENTURA SPECIAL STUDIES PHASE 2 – VWRF DISCHARGE ALTERNATIVES ASSESSMENT

Stillwater Sciences
2855 Telegraph Ave, Suite 400, Berkeley, CA 94705
phone 510.848.8098 fax 510.848.8398

TECHNICAL MEMORANDUM

DATE: January 24, 2013

TO: Lydia Holmes, Carollo Engineers

FROM: Scott Dusterhoff and Noah Hume

SUBJECT: City of Ventura Special Studies Phase 2 – VWRF Discharge Alternatives Assessment

1 PURPOSE

The purpose of this memorandum is to provide the results for the assessment of Ventura Water Reclamation Facility (VWRF) discharge alternatives' impacts on Santa Clara Estuary (SCRE) habitat conditions and ecosystem functions. The findings presented herein provide an update to assessments developed in the Phase 1 Estuary Subwatershed Study (Stillwater Sciences 2011) and are intended to be used in combination with the Phase 2 Recycled Water Market Study (Carollo Engineers 2013) and subsequent Phase 3 cost/benefit and permitting assessments to support selection of a preferred VWRF discharge alternative for review by the Los Angeles Regional Water Quality Control Board (RWQCB) and other Stakeholders that is sustainable, cost-effective, and further optimizes beneficial uses of the SCRE.

2 BACKGROUND

In 2008, the City of San Buenaventura (City) was required by the RWQCB to conduct interrelated "Special Studies for the Santa Clara River Estuary" as a condition of the City's NPDES discharge permit (CA0053651) for the VWRF. The special studies that were required by the RWQCB include an Estuary Subwatershed Study, a Treatment Wetlands Feasibility Study, and a Recycled Water Market Study. Collectively, these studies are intended to provide information necessary to determine: (1) whether the VWRF tertiary treated flow discharged in the existing condition to the Wildlife/Polishing Ponds and then to the SCRE creates fuller realization of beneficial uses as necessary to confirm "enhancement" under the California Enclosed Bays and Estuaries Policy; and (2) if alternative VWRF discharge scenarios might improve water quality and habitat conditions supporting existing beneficial uses in the SCRE and its watershed.

Phase 1 of the special studies began in the summer of 2009 and was completed in the fall of 2011. The work conducted for the three studies included the following:

- **Estuary Subwatershed Study** – A synthesis of information regarding the SCRE ecosystem functioning under existing conditions (characterized by tertiary treated VWRF flows discharged to the Wildlife/Polishing Ponds and then to the SCRE) to determine if the current discharge results in fuller realization of beneficial uses within the SCRE. In addition, this study included an assessment of a range of representative potential future

VWRF effluent discharge alternatives (including zero VWRF discharge) and other management measures that could be implemented to achieve further improvement in water quality and/or beneficial uses using water balance and water quality predictive tools developed with existing and newly-collected data.

- **Treatment Wetlands Feasibility Study** – Evaluation at a planning concept level the feasibility of implementing a constructed treatment wetland to achieve additional reductions in nutrients, copper and other metals in the VWRF tertiary treated discharge to further promote improvements in receiving water for beneficial uses. Depending upon flow volume requirements of one or more of the VWRF discharge alternatives developed under the Phase 1 Estuary Subwatershed Study, additional nutrient reductions were identified through a combination of process upgrades at the VWRF plant and a wetland design accommodating a hydraulic residence time of 4–12 days, or some combination of upgrades and multi-day residence time within treatment wetlands.
- **Recycled Water Market Study** – Evaluation and quantification at a conceptual planning level the feasibility of expanding the City's existing reclaimed water system through evaluation of potential users within a five-mile radius of the VWRF for purposes of providing an alternative to discharging VWRF effluent flow to the SCRE. Depending on the flow diversion requirements, this study determined that recycled water projects could be implemented for the purpose of diverting the VWRF discharge on a seasonal basis, provided that diversion requirements take into account technical constraints on diversion, such as public health and safety, design and capacity, and/or operational constraints that may make diversions at certain times infeasible or inappropriate to implement.

The results from the discharge alternative assessment conducted in the Phase 1 Estuary Subwatershed Study concluded that fuller realization of receiving water beneficial uses occurs under current levels of VWRF discharge as compared to the complete absence of discharge due to increased habitat area for listed species (RARE) including tidewater goby (*Eucyclogobius newberryi*), steelhead (*Oncorhynchus mykiss*), Western snowy plover (*Charadrius nivosus nivosus*), and California least tern (*Sterna antillarum browni*). In addition, the VWRF Wildlife/ Polishing Ponds provide habitat for bird and wildlife beneficial uses (RARE, WET, WILD) as well as recreational opportunities (REC-2). The results also suggested that a modification to VWRF effluent flow to reduce nutrient input to the SCRE during dry season, closed-mouth conditions (Alternative 5 in the Phase 1 study) would improve water quality by reducing periods of low DO in localized areas of the SCRE, as well as the frequency and duration of algal blooms, which together may benefit resident fish and bird species and thereby improve fish and wildlife-related beneficial uses. In addition, modeled reductions in discharge volumes during dry season, closed-mouth conditions were found to result in decreasing flooding potential within the McGrath State Beach campground (REC-2) and to benefit tidewater goby and steelhead habitat conditions by reducing the potential for unseasonal breaching. Consequently, the Phase 1 Estuary Subwatershed Study concluded that, on balance, discharge alternatives that reduce discharge volumes and nutrient levels would likely improve habitat conditions and further improve fish and wildlife-related beneficial uses in the SCRE (see Stillwater Sciences 2011 for more detail).

In 2012, Phase 2 of the special studies was initiated to develop additional information for improving the understanding of SCRE ecosystem functioning, and to integrate the conclusions of all three of the Phase 1 Studies into a process for selection, environmental review, and design of a preferred VWRF discharge/diversion alternative that creates a discharge regime that further improves beneficial uses of the SCRE. Per the recommendations provided to the City and RWQCB at the end of Phase 1 in a Recommendations Memorandum (Carollo Engineers and Stillwater Sciences 2011), the Phase 2 studies included: (1) additional data collection at existing

and new locations within and adjacent to the SCRE based on RWQCB and project Stakeholder input; (2) development of feasible VWRF effluent discharge reduction and/or improvement alternatives that utilize treatment wetland and recycled water approaches (i.e., variations of the Phase 1 Alternative 5); and (3) a refined assessment of the impact of potential discharge alternatives on SCRE habitat conditions using developed predictive tools to increase confidence that adoption of any new VWRF discharge and/or diversion regime further improves beneficial uses. Phase 2 data collection occurred from mid-September 2010 to early December 2012 following the methodology laid out in a detailed Monitoring Plan (Stillwater Sciences 2012, which can be found along with the Phase 2 monitoring data at http://www.cityofventura.net/rivers). Through collaboration with the City, project Stakeholders, and other local entities, Carollo Engineers developed a set of viable VWRF discharge alternatives that include additional treatment to meet reuse requirements, decreased effluent outflow to the SCRE through diversion to agricultural water and groundwater recharge facilities, and increased reuse activities and improved water quality treatment for the effluent discharged to the SCRE (see Table 1-1). The alternatives developed include consideration of the existing dry season effluent flow volume to the VWRF Wildlife/Polishing Ponds (7.3 millions of gallons per day [MGD] on average) and the corresponding projected future effluent flow volumes (11.2 MGD on average).

Table 2-1. Estimated average dry season (June through September) flows and VWRF effluent outflow nitrate concentration by VWRF discharge alternative.

VWRF discharge alternative		Alternative description	VWRF Effluent treatment approach	Flow rate (MGD)				Outflow nitrate concentration (mg-N/L)
				Dry Season VWRF effluent flow[1]	Diverted effluent flow	Influent to treatment wetland	Outflow to the SCRE	
Current conditions	No Action	Current effluent treatment	Onsite wetland	7.3	1.0	0	6.3	8.0
	Alternative 5.1	North decentralized plant[2]	Onsite + additional wetland[5]	7.3	2.0	5.3	4.0	4.0
	Alternative 5.2	Recharge supply to Oxnard or UWCD[3]	Onsite wetland	7.3	7.3	0	0	0
	Alternative 5.3	Agricultural water supply to UWCD	Onsite wetland	7.3	7.3	0	0	0
	Alternative 5.4	IPR & DPR (4,000 AFY)[4]	Onsite wetland	7.3	4.5	2.8	2.0	4.0
	Alternative 5.5	IPR (7,000 AFY)	Onsite wetland	7.3	7.3	0	0	0
Future conditions	Alternative 5.6	North decentralized plant	Onsite + additional wetland	11.2	2.0	9.2	8.0	5.0
	Alternative 5.7	Recharge supply to Oxnard or UWCD	Onsite wetland	11.2	11.2	0	0	0
	Alternative 5.8	Agricultural water supply to UWCD	Onsite + additional wetland	11.2	8.0	3.2	2.0	4.0
	Alternative 5.9	IPR & DPR (4,000 AFY)	Onsite + additional wetland	11.2	4.5	6.7	5.0	4.0
	Alternative 5.10	IPR (7,000 AFY)	Onsite + additional wetland	11.2	7.9	3.3	2.0	4.0

[1] Refers to the volume of flow into the VWRF Wildlife/Polishing Ponds from the Effluent Transfer Station (ETS).
[2] North decentralized plant refers to construction of an additional treatment plant for reuse in the northern sector of the VWRF service area.
[3] Oxnard refers to the City of Oxnard Groundwater Recovery Enhancement and Treatment (GREAT) program; UWCD refers to the spreading ponds operated by United Water Conservation District (UWCD) northeast of the SCRE.
[4] IPR is indirect potable reuse; DPR is direct potable reuse, AFY is acre-feet per year.
[5] Onsite refers to treatment using Wildlife/Polishing Ponds modified for improved treatment; additional wetland refers to treatment at a new off-site treatment wetland adjacent to the VWRF.

3 APPROACH

The approach used for assessing ecosystem functions affected by each VWRF discharge alternative during the dry season (June through September) included using the SCRE water balance and nutrient balance modeling tools developed during Phase 1 to predict effects of discharge alternatives on SCRE water quality conditions, particularly with respect to nutrients and focal species habitat conditions, while accounting for climate change and the modifications to VWRF effluent discharge (as summarized in Table 1-1). Within the Phase 1 VWRF discharge alternatives analysis, the flooding potential within the SCRE southern floodplain and subsequent impacts to McGrath State Beach recreational camping opportunities (REC-2) were considered in the evaluation of each alternative. Due to recent Stakeholder input suggesting that there is the potential for the campground to be moved out the floodplain in the near future, flooding impacts are not explicitly accounted for in the Phase 2 VWRF discharge alternatives assessment presented herein.

Based on Stakeholder feedback received following the Phase 1 alternatives assessment, the Phase 2 alternatives assessment included developing SCRE stage/depth estimates for both dry and wet water year types as a means of elucidating the anticipated minimum and maximum values associated with each alternative. The impact of climate change within this analysis was reflected in values of future sea level elevation (approximate 1.3 ft increase in MSL) and air temperatures (approximately 2°C [3.6°F]) increase in average temperatures) projected to 2050. The data presented in the Phase 1 Climate Change Assessment (Carollo Engineers 2011) indicate that the projected increase in average annual precipitation is minimal, which suggests that the average annual groundwater elevation adjacent to the SCRE and the average annual river flow into the SCRE will likely be similar to current conditions. Although increased evaporation of the SCRE has been included in this assessment, increased air temperatures could also result in increased evapotranspiration and a decrease in local groundwater elevation and thus base flows to the river and SCRE during the drier months. We have not attempted to model these impacts and have also not included temperature related effects upon bacterial and algal respiration in the water column.

3.1 Water balance modeling

The SCRE water balance modeling tool developed in Phase 1 was updated with additional data and used to provide a hypothesized time series of SCRE stage for each alternative as a function of inflows and outflows for representative dry and wet water year conditions. The modeling assessment assumed a 2009/2010 lagoon morphology and a mouth berm that had just closed at the beginning of each model simulation (June 1). The SCRE stage data collected during spring/summer 2012 show that the mouth currently remaines closed for a stage up to 12.5 ft NAVD88. Based on the newly-collected data, the SCRE mouth was presumed to breach when the stage reached 12.5 ft NAVD88, which is approximately 2 ft higher than equilibrium SCRE stage previously observed during dry season, low-flow conditions and approximately 1.5 ft higher than estimated for the Phase 1 alternatives assessment. Although the cause for the higher breaching elevation is not fully understood, it is known that that the SCRE was mechanically breached in the past when the stage was 10–11 ft NAVD88 where no mechanical breaching occurred at this stage range from fall 2011 to summer 2012 (possibly due to increased patrols by California State Park employees). Therefore, 12.5 ft NAVD88 appears to be an appropriate current dry season, low-flow breaching stage.

Assumptions used to develop the flow rates and the average flow rate for each inflow and outflow component used in the alternatives assessment are given below.

VWRF effluent flow
The VWRF effluent outflow rates to the SCRE ranged from 0 to 8 MGD and were derived from the VWRF discharge alternative estimated average effluent outflow rates to the SCRE from June through September (see Table 1-1). As the average daily VWRF effluent discharge rate is fairly constant during the summer months for all years, we assumed that the VWRF effluent flow rates did not vary as a function of water year type.

Santa Clara River flow
The rate of Santa Clara River flow into the SCRE was derived from the monthly mean flow rates at two gages just upstream of the SCRE (USGS gage 11114000 and VCWPD Station 723) for a representative dry water year (water year [WY] 1957, no river discharge from June through September) and a representative wet water year (WY 1973, monthly mean river flow <1 cubic feet per second [cfs] in June and no river discharge from July through September). These flows were presumed to be representative of future conditions primarily due to an anticipated minimal increase in future mean annual precipitation over the next several decades.

Evaporation
Evaporation used in the modeling analysis was determined from combining present-day evaporation estimate with a multiplier to account for climate change. Present-day values were determined by first using evaporation data from El Rio to calculate median monthly SCRE evaporation rates for June through September (per the methodology used to determine SCRE evaporation in Phase 1) and then reducing that evaporation rate by 50% (the ratio of measured SCRE evaporation and calculated SCRE evaporation using El Rio data during summer 2012). Similar to the Phase 1 alternatives assessment, the present-day median monthly evaporation estimates were then increased by 4% to account for the anticipated increase in future dry season air temperatures (see Stillwater Sciences 2011 for the detailed methodology). Because summertime conditions are fairly similar for all years, evaporation estimates did not vary as a function of water year type.

Subsurface flow through the mouth berm
Similar to the Phase 1 alternatives assessment, the flow through the closed-mouth berm during the model simulation period was derived from the hydraulic variables determined as part of the water balance analysis and the gradient between the SCRE stage and the adjacent tidal elevation. A future tidal elevation time series was compiled using current normal tidal elevations combined with the anticipated increase in mean sea level. The current normal tidal elevations for each month were determined using the tidal time series for June through September 2010 and adjusting the elevations according to how much the mean monthly elevation differed from the long-term value. The current normal tidal elevations were then increased by 1.35 ft, or the average of the range of values for anticipated sea level rise (see Stillwater Sciences 2011).

Groundwater flows
Similar to the subsurface flow through the mouth berm, the groundwater inflows and outflows were derived from calculated hydraulic variables combined with local hydraulic gradients. For groundwater flow across the south bank at McGrath State Beach, the hydraulic gradient was derived from the modeled SCRE stage and an assumption that the water table elevation remained fixed at an elevation of 6.5 ft NAVD88 and that flow would be directed out of the SCRE when the SCRE stage was above this elevation. This assumption regarding the change in gradient direction was based on the data collected during both 2009–2010 (Phase 1) and 2010–2012 (Phase 2) monitoring periods. For the groundwater flow from the VWRF Wildlife/Polishing Ponds, the hydraulic gradient was derived from the modeled SCRE stage and an assumed

constant VWRF Wildlife/Polishing Pond surface elevation that is the same as current conditions (19 ft NAVD88). The variables and relationships used to determine the groundwater flow across the south bank and from the VWRF Wildlife/Polishing Ponds did not vary as a function of water year type.

For the unmeasured groundwater flow component, groundwater inflow rate varied between water year types based on the results from WY 2011 and WY 2012 SCRE water balance development. Between June and September, the unmeasured groundwater discharge to the SCRE in WY 2011 (a relatively wet water year) was calculated using the following relationship:

$$\textit{Unmeasured groundwater discharge} = -9{,}500(\textit{SCRE stage}) + 80{,}500 \qquad (1)$$

During that same period in WY 2012 (a relatively dry water year), the unmeasured discharge to the SCRE was calculated using the following relationship:

$$\textit{Unmeasured groundwater discharge} = -8{,}000(\textit{SCRE stage}) + 76{,}000 \qquad (2)$$

For the purposes of this analysis, these two relationships were considered to be representative of long-term dry and wet water year conditions and were used in the determination of dry and wet water year groundwater contributions for each discharge alternative.

3.2 Nutrient balance modeling

As a means of understanding the relative contributions of nutrients from the local watershed (VWRF and upstream sources) under alternative VWRF effluent discharge scenarios, a simplified nutrient balance for the SCRE was developed as part of the Phase 1 Estuary Subwatershed Study (Stillwater Sciences 2011). This nutrient balance model was updated and used to assess nutrient concentrations in the SCRE associated with the Phase 2 alternatives. Using updated flow estimates (Section 2.1), primary flows from the water balance (e.g., Santa Clara River, VWRF, groundwater sources/sinks, ocean outflow) were assigned nutrient concentrations as total inorganic nitrogen (TIN = NH_4 + NO_3 + NO_2), of which nitrate-nitrogen (NO_3-N) is the dominant component. Similar to the approach from Phase 1, this mass balance was modeled assuming a balance of material inflows and outflows over the course of a day (i.e., mass in equals mass out), and the modeling further assumed that the lagoon is well mixed due to the shallow SCRE lagoon depth and consistent onshore winds. Although the mixing model assumptions were not met during periods with ocean exchanges, the approach was useful in assessing the relative magnitude of nutrient loadings to the SCRE from contributing sources with an equilibrium (steady-state) concentration in the water column. Representative flows by source were paired with up-to-date estimates of nitrate based upon both historical (2001–2010) as well as more recent estimates from data collected during 2012.

The TIN concentrations associated with each SCRE inflow component used in the modeling were updated to take into account Phase 2 monitoring data and are described below.

Santa Clara River Inflows

TIN levels arriving to the SCRE from the Santa Clara River were primarily comprised of NO_3 and have historically ranged from 5.5–6.4 mg-N/L (Stillwater Sciences 2011). More recent data collected in 2012 upstream of the SCRE have averaged 5 mg/L and we have assumed that TIN arriving from riverine sources will average 5 mg-N/L during the spring/summer months for all

alternatives. However, because the Santa Clara River flow is frequently zero during summer months, contributions to the SCRE nutrient levels are expected to be minor.

VWRF Inflows
Recent upgrades to the VWRF denitrification processes have reduced NO_3 and TIN levels in the VWRF Effluent Transfer Station (ETS) discharge below the 10 mg-N/L water quality objective established under the Basin Plan. Recent data collected in 2012 has consistently shown 8 mg/L at the ETS. Therefore, we have assumed that TIN arriving to the SCRE from the VWRF will average 8 mg-N/L at most for the No Action alternative (i.e., 2012 nutrient conditions) (Table 1-1). Based upon updated sizing calculations from Carollo Engineers (2010), TIN levels following additional treatment at onsite and offsite wetlands will likely average 4 mg-N/L (Table 1-1) depending on estimated flows discussed in the Phase 2 Recycled Water Market Study (See Carollo Engineers 2013 for additional details).

Groundwater sources
TIN levels in groundwater were found to be low in the SCRE floodplain adjacent to McGrath State Beach based on monitoring well sampling conducted in 2009–2010 (Stillwater Sciences 2011). However, based upon groundwater sampling conducted in 2012 along the north side of the SCRE, TIN levels may be as high as 15 mg-N/L (See Section 4.2 for additional discussion). Because water balance modeling indicates significant groundwater inflows from the north bank from where these samples were collected, 15 mg-N/L is used as the estimate of groundwater TIN arriving in the SCRE year-round for all alternatives,

TIN uptake and removal within the SCRE Inflows
Based upon summertime observations of lower NO_3 and TIN concentrations under closed-mouth conditions at levels below the major sources to the SCRE (e.g., VWRF and Santa Clara River inflows), it is apparent that some combination of algal uptake and denitrification effectively reduces TIN levels in the SCRE during summer months. Based upon higher removal estimates of 79–359 mg-N/m^2-d due to denitrification in deeper estuaries with the reducing conditions (i.e., low oxygen) at the sediment-water interface (Seitzinger 1988, Horne 1995), we assumed conservatively low rates of TIN removal rates of 50–100 mg-N/m^2-d on an aerial basis by biological uptake and denitrification processes within the SCRE.

3.3 Estuary Habitat Conditions

Available habitat was assessed as a function of modeled SCRE stage and associated mouth breaching timing, modeled average nitrogen levels, and focal species habitat area (as a function of SCRE stage) associated with each VWRF discharge alternative (SCRE stage-focal species habitat area relationships can be found in Stillwater Sciences 2011).

4 RESULTS & DISCUSSION

4.1 Assessment of Impacts to Estuary Hydrology & Stage

Table 4-1 summarizes the calculated average dry and wet year flow rates used to assess each alternative, with SCRE stage and average depth during a hypothetical 4-month filling period beginning June 1 shown in Figures 4-1 to 4-6. Overall, these modeling results clearly illustrate the impact that varying VWRF effluent outflow rate has on SCRE stage and groundwater inflow rate. For zero effluent discharge alternatives (i.e., those alternatives with zero VWRF discharge

into the SCRE), the maximum modeled equilibrium stage range for dry and wet water year conditions was the lowest of all the alternatives considered (~2.5–3 ft lower than the No Action alternative) and the average unmeasured groundwater inflow range (which is driven by SCRE stage) was the highest (~1.9–2.6 MGD lower than the No Action alternative). Increasing the effluent discharge rate within the modeling analysis resulted in a progressive increase in SCRE equilibrium stage and associated decrease in unmeasured groundwater flow rate. In addition, increasing the effluent discharge resulted in a decreasing difference in dry and wet water year stage and unmeasured groundwater inflow for individual discharge alternatives, suggesting that SCRE stage/depth and subsequent habitat area is more sensitive to water year type at lower VWRF discharge rates than higher rates. The maximum equilibrium stage for the 8 MGD discharge alternative was 11.5 ft NAVD88 (~0.5 ft higher than the No Action alternative), which, as previously mentioned, is considered to be below the current breaching threshold indicated by summer/fall 2012 SCRE stage data but is above the breaching threshold during the Phase 1 alternatives assessment. Although the SCRE mouth berm can currently remain closed at a stage up to approximately 12.5 ft NAVD88 during dry season, low-flow conditions, it should be noted that there is the possibility that this is a temporary condition and the breaching stage may be lower in the near future.

Table 4-1. Estimated average dry season SCRE inflows and outflows by VWRF effluent discharge alternative and water year type.

VWRF discharge alternative	Surface water inflow/outflow (MGD)				Subsurface water inflow/outflow (MGD)			
	VWRF to SCRE	Santa Clara River	Precipitation	Evaporation	Closed Mouth Berm	South Bank	VWRF Ponds	North Bank and other sources
No Action (DRY)	6.3	0	0	-0.4	-5.0	-0.2	0.9	0.7
No Action (WET)	6.3	0.01	0	-0.4	-4.8	-0.2	0.9	0.4
Alternatives 5.2, 5.3, 5.5, and 5.7 (DRY)	0	0	0	-0.3	-2.6	-0.3	1.0	3.3
Alternatives 5.2, 5.3, 5.5, and 5.7 (WET)	0	0.01	0	-0.3	-2.1	-0.2	1.1	2.3
Alternatives 5.4, 5.8, and 5.10 (DRY)	2.0	0	0	-0.3	-3.1	-0.2	1.0	1.9
Alternatives 5.4, 5.8, and 5.10 (WET)	2.0	0.01	0	-0.3	-2.5	-0.3	1.0	1.0
Alternative 5.1 (DRY)	4.0	0	0	-0.3	-3.7	-0.2	0.9	0.9
Alternative 5.1 (WET)	4.0	0.01	0	-0.3	-3.4	-0.2	1.0	0.5
Alternative 5.9 (DRY)	5.0	0	0	-0.4	-4.3	-0.2	0.9	0.8
Alternative 5.9 (WET)	5.0	0.01	0	-0.4	-4.0	-0.2	0.9	0.5

VWRF discharge alternative	Surface water inflow/outflow (MGD)				Subsurface water inflow/outflow (MGD)			
	VWRF to SCRE	Santa Clara River	Precipitation	Evaporation	Closed Mouth Berm	South Bank	VWRF Ponds	North Bank and other sources
Alternative 5.6 (DRY)	8.0	0	0	-0.4	-6.1	-0.2	0.8	0.6
Alternative 5.6 (WET)	8.0	0.01	0	-0.4	-6.0	-0.2	0.8	0.3

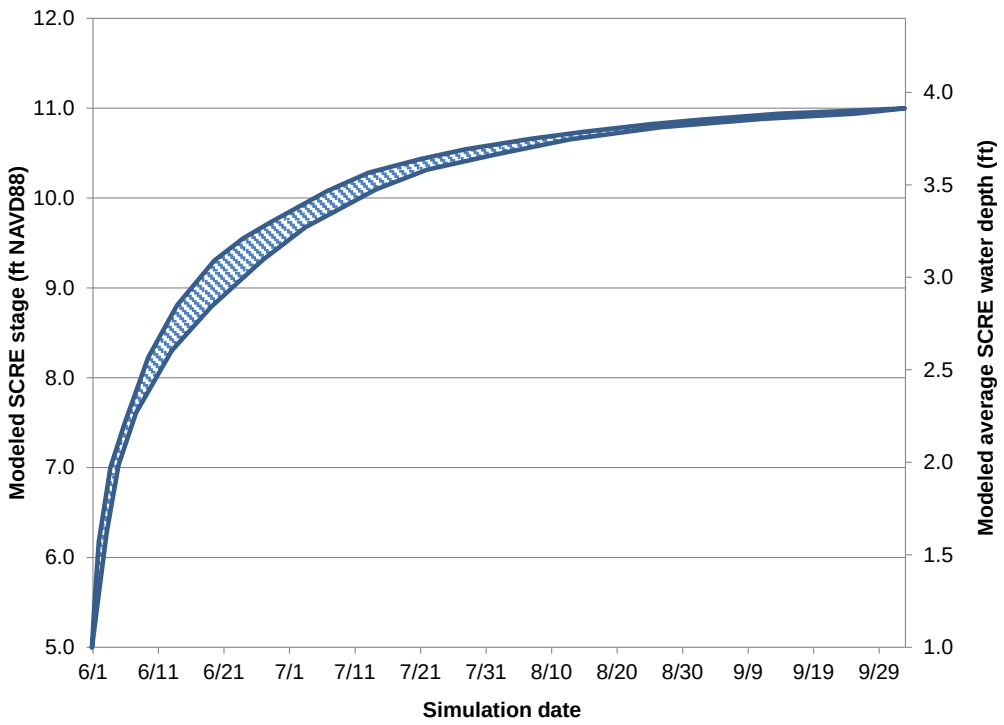

Figure 4-1. Modeled SCRE stage and average depth range for the No Action effluent discharge alternative (6.3 MGD average dry season discharge).

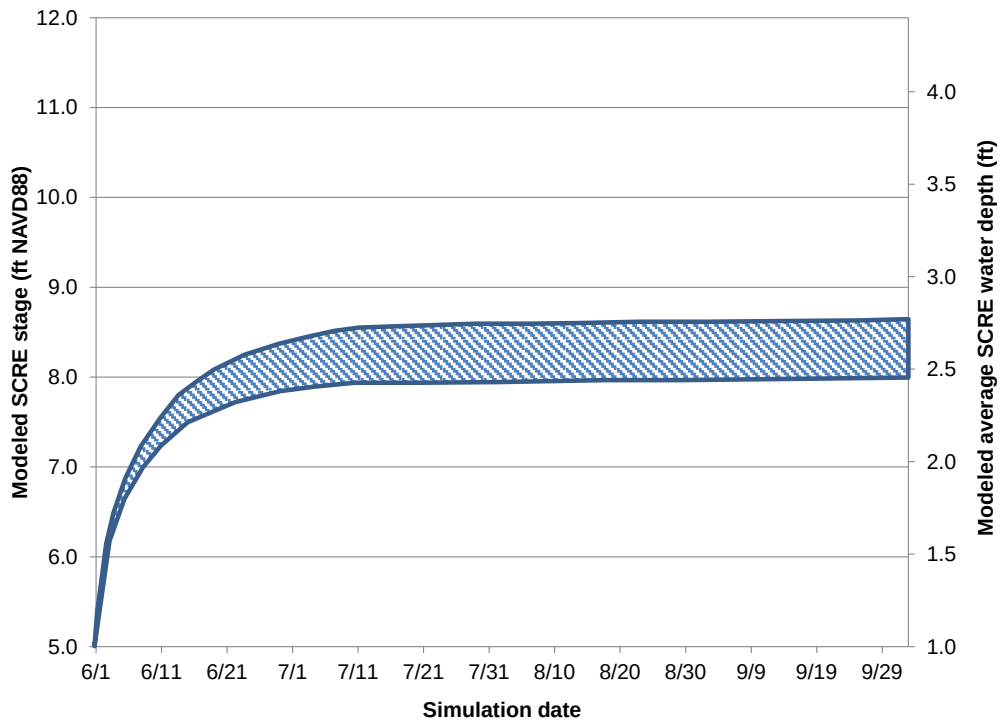

Figure 4-2. Modeled SCRE stage and average depth range for the 0 MGD dry season effluent discharge alternatives.

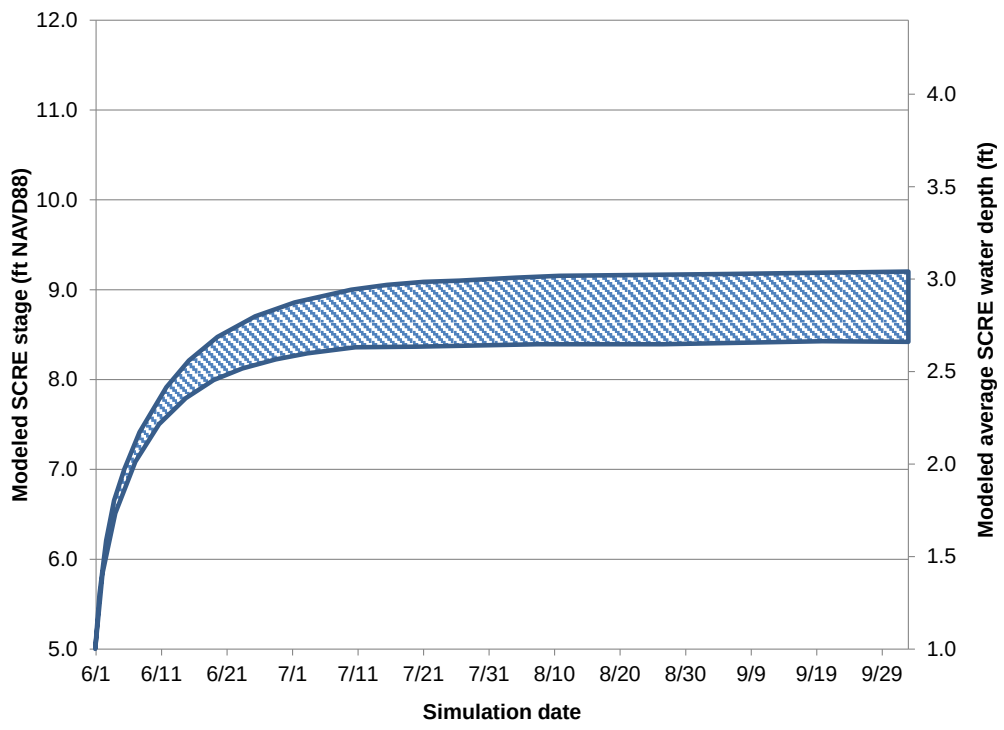

Figure 4-3. Modeled SCRE stage and average depth range for the 2 MGD dry season effluent discharge alternatives.

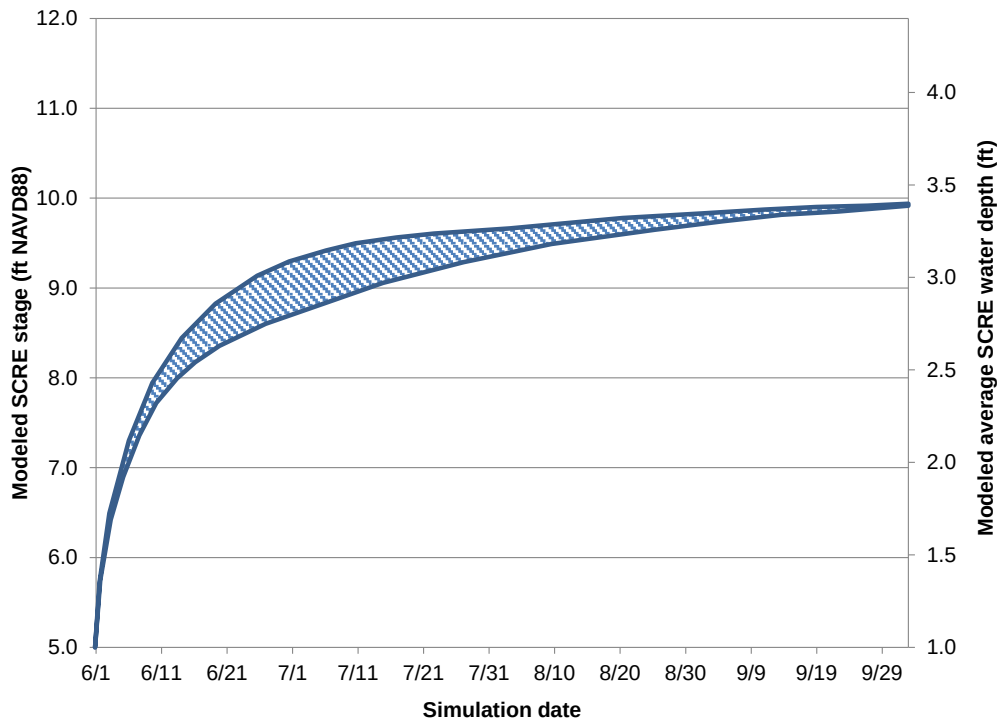

Figure 4-4. Modeled SCRE stage and average depth range for the 4 MGD dry season effluent discharge alternative.

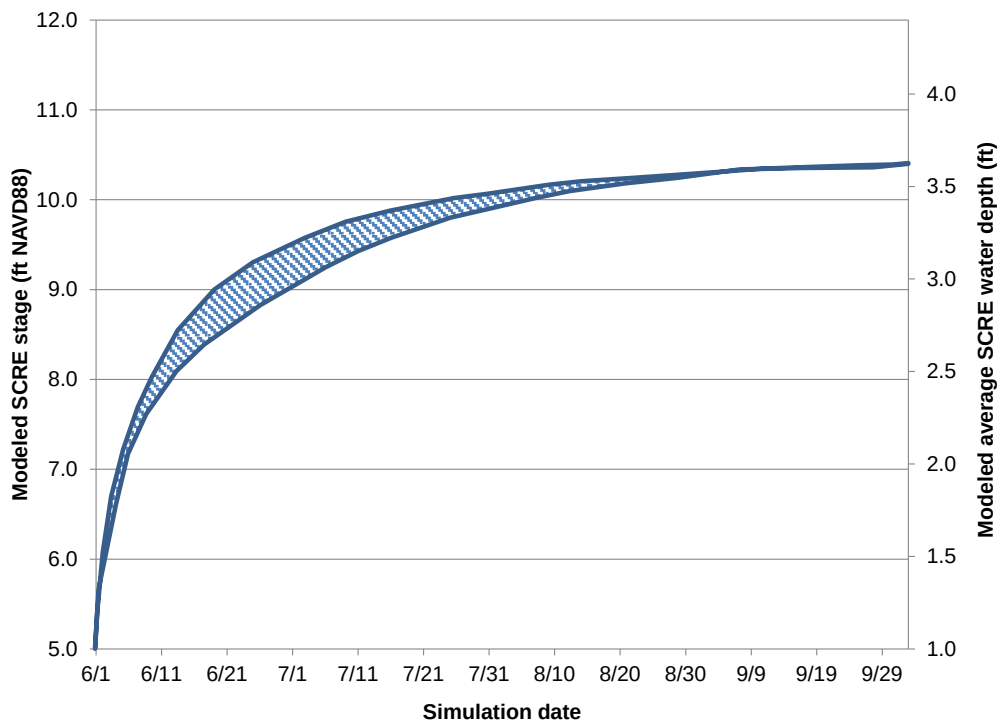

Figure 4-5. Modeled SCRE stage and average depth range for the 5 MGD dry season effluent discharge alternative.

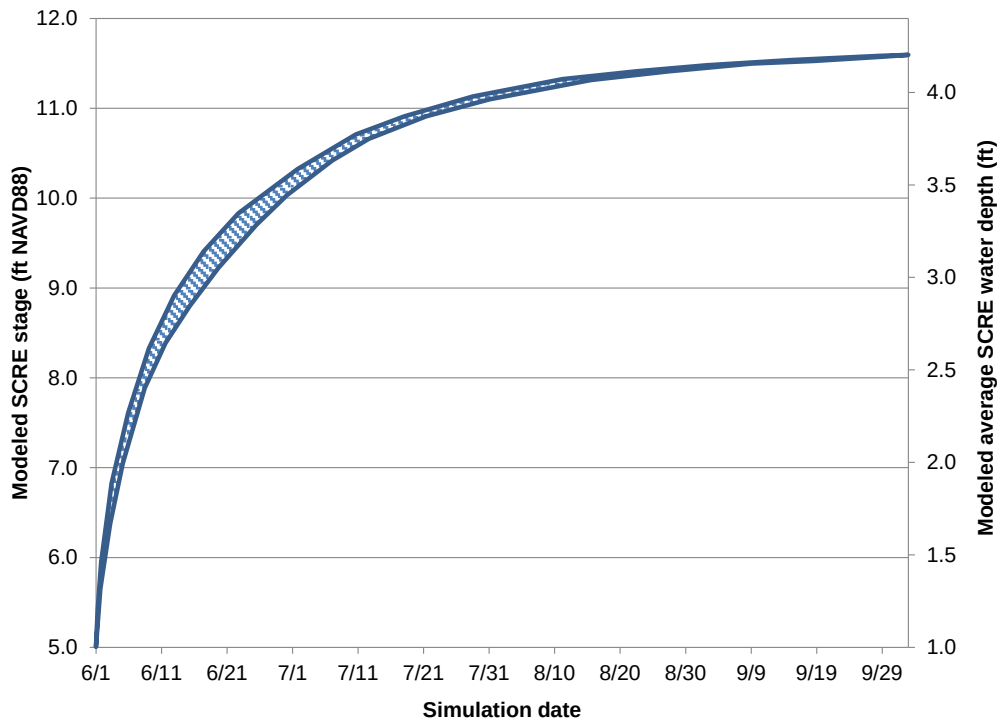

Figure 4-6. Modeled SCRE stage and average depth for the 8 MGD dry season effluent discharge alternative.

4.2 Assessment of Impacts to Estuary Water Quality

Using the nutrient balance developed in the Phase 1 study (Stillwater Sciences 2011), updated nutrient estimates from 2012, and average flows from the updated water balance modeling (Table 3-1), future nutrient loads to the SCRE were estimated for each of the Phase 2 VWRF discharge alternatives (Table 4-2). VWRF discharge nitrate concentrations used in the analysis represent current denitrification practices for the No Action alternative and additional denitrification occurring in on-site treatment wetlands for all other alternatives (see Table 1-1). The analysis below centers upon variations in the amount of NH_4 and NO_3 (i.e., TIN) arriving to the SCRE driven by flow reductions and various onsite and offsite treatment alternatives such as wetlands denitrification (Carollo Engineers 2013). Within the SCRE, TIN removal mechanisms included advective transport (i.e., lagoon berm and south bank of SCRE) as well as algal uptake and denitrification. Table 4-2 shows estimates of future TIN levels in the SCRE using the assumptions above along with future flow estimates (Section 2.1) and the nutrient balance approach discussed in Section 2.2.

For each alternative evaluated, future TIN levels were estimated by summation of the total of all loads arriving from each source and removed by algal uptake and denitrification (Table 4-2). The total SCRE TIN loading was then divided by the total water volume represented by the sum of SCRE outflows and storage terms from the water balance to arrive at an estimate of average TIN levels expected under the alternative.

As discussed for the development of the nutrient balance (Stillwater Sciences 2011), future TIN levels will rapidly approach the largest flow and thus load contribution to the SCRE under the

future discharge conditions. Because recent water quality monitoring results show relatively high TIN levels in shallow groundwater along the north side of the SCRE that were previously un-identified and also show low TIN levels in the VWRF discharge, the current modeling results suggest the lower TIN levels in VWRF discharges as compared to groundwater inflows may enhance conditions in the SCRE affected by excess nutrients such as biostimulation of nuisance algae. For alternatives including complete VWRF discharge removal from the SCRE (Alternatives 5.2, 5.3, 5.5, and 5.7), modeled TIN levels in the SCRE approached levels found during the 2012 groundwater monitoring (Table 4-2). In the absence of habitat area considerations, the lowest TIN levels were achieved under the highest SCRE discharge alternatives corresponding to the North Decentralized Plant alternative (Alternatives 5.1 and 5.6), followed by indirect or direct potable reuse in the Mound Basin at 4,000 acre-feet per year (AFY) (Alternatives 5.4 and 5.9), indirect potable reuse in the Mound Basin at 7,000 AFY (Alternative 5.5 and 5.10), agricultural water supply to United Water Conservation District (UWCD) (Alternative 5.3 and 5.8), and groundwater recharge supply to the City of Oxnard or UWCD (Alternative 5.2 and 5.7).

As stated in the Phase 1 Estuary Subwatershed Study (Stillwater Sciences 2011), because significant levels of TIN are present in local groundwater and the Santa Clara River, it should be noted that reductions in nitrate levels under one or more alternatives may not result in substantially reduced algal levels and continued algal bloom episodes are likely to occur under all alternatives. Nevertheless, it is expected that the frequency and duration of algal blooms should decrease with reduced TIN levels. As discussed in Stillwater Sciences (2011), measurable reductions of algal biomass in the SCRE may not occur until the TIN:PO_4 ratio approaches 4.5:1 by mass, with TIN approximately below 1.5–4.5 mg-N/L under current conditions.

Table 4-2. Estimated average future TIN loading and SCRE concentration by VWRF discharge alternative and water year type.

VWRF discharge alternative	Alternative description	Water year type	Santa Clara River (lb-N/day)	VWRF pond ground-water (lb-N/day)	Onsite/ Offsite wetland (lb-N/day)	Area (ac)	Denitrification/algal uptake (lb-N/day)		Equilibrium TIN (mg-N/L)	
							Low	High	Low	High
No Action	Current effluent treatment	Wet	0.0	58	420	183	-82	-163	6.4	7.7
		Dry	0.5	59	420	179	-80	-159	6.2	7.5
Alternative 5.1	North decentralized plant	Wet	0.0	62	133	156	-69	-139	3.7	5.2
		Dry	0.4	64	133	150	-67	-133	3.0	4.6
Alternative 5.2	Recharge supply to Oxnard or UWCD	Wet	0.0	68	0	136	-61	-122	10.7	12.5
		Dry	0.5	71	0	127	-57	-113	9.6	11.8
Alternative 5.3	Agricultural water supply to UWCD	Wet	0.0	68	0	136	-61	-122	10.7	12.5
		Dry	0.5	71	0	127	-57	-113	9.6	11.8
Alternative 5.4	IPR & DPR (4,000 AFY)	Wet	0.0	65	67	144	-64	-128	6.3	8.0
		Dry	0.5	69	67	134	-60	-120	4.5	6.4
Alternative 5.5	IPR (7,000 AFY)	Wet	0.0	68	0	136	-61	-122	10.7	12.5
		Dry	0.5	71	0	127	-57	-113	9.6	11.8
Alternative 5.6	North decentralized plant	Wet	0.0	55	334	201	-90	-180	3.7	4.9
		Dry	0.4	56	334	198	-88	-177	3.5	4.7
Alternative 5.7	Recharge supply to Oxnard or UWCD	Wet	0.0	68	0	136	-61	-122	10.7	12.5
		Dry	0.5	71	0	127	-57	-113	9.6	11.8
Alternative 5.8	Agricultural water supply to UWCD	Wet	0.0	65	67	144	-64	-128	6.3	8.0
		Dry	0.5	69	67	134	-60	-120	4.5	6.4
Alternative 5.9	IPR & DPR (4,000 AFY)	Wet	0.0	60	167	168	-75	-150	3.3	4.7
		Dry	0.4	62	167	162	-72	-145	2.8	4.2
Alternative 5.10	IPR (7,000 AFY)	Wet	0.0	65	67	144	-64	-128	6.3	8.0
		Dry	0.5	69	67	134	-60	-120	4.5	6.4

4.3 Assessment of Estuary Habitat Conditions

Table 4-3 shows average SCRE habitat parameters for the VWRF discharge alternatives developed directly from the water balance modeling results (average depth and wetted area) and by combining the modeled SCRE stage with stage-habitat area relationships for the four focal species pursuant to the methodology developed in the Phase 1 Estuary Subwatershed Study (Stillwater Sciences 2011). To provide a clear picture of anticipated average habitat conditions associated with each alternative, the dry year and wet year model results were combined. The data presented in Table 4-3 show that modifying the VWRF effluent during closed-mouth, dry season conditions has varying impacts on SCRE habitat conditions. As expected, the highest VWRF discharge into the SCRE (8 MGD) resulted in the highest average depth and wetted area (with values being ~10% higher than for the No Action alternative discharge average dry season flow of 6.3 MGD). Similarly, steelhead habitat area increased with increasing VWRF discharge, reaching the maximum value for all alternatives under the 8 MGD discharge scenario (which was ~6% higher than the No Action alternative stage). The California least tern foraging habitat area remained fairly static for all alternatives, varying very little between 125 and 129 acres. Conversely, tidewater goby and California least tern/Western snowy plover nesting habitat was essentially static for the zero through 5 MGD VWRF discharge alternatives then dropped considerably as stage increased going from a discharge of 5 to 8 MGD. The relatively high equilibrium SCRE stage and wetted area associated with the 8 MGD alternative is thought to result in unsuitable depths for tidewater goby spawning and rearing habitat as well as inundation of California least tern and western snowy plover habitat in the dunes to the south of the SCRE main lagoon (see Stillwater Sciences 2011 for more detail).

The assessment of the impacts of VWRF discharge volume on habitat area provided similar results to our Phase 1 VWRF discharge alternatives assessment. However, the results from the 2012 groundwater monitoring and the nutrient balance modeling suggest that in the absence of VWRF discharge, high groundwater nutrient concentrations may cause poor SCRE water quality. The implemented effluent treatment process improvements at the VWRF combined with the potential to gain further TIN reductions with wetland treatment would likely result in lower TIN levels from the VWRF discharge than groundwater from the northern floodplain. Therefore, under dry season, closed-mouth conditions when the VWRF discharge is the dominant inflow to the SCRE, the VWRF discharge may improve water quality conditions with respect to nutrient levels and may represent an enhancement relative to an alternative with zero VWRF discharge to the SCRE

Combining the habitat parameter results in Table 4-3 with the nutrient balance modeling results in Table 4-2 suggests there is no one VWRF effluent recharge/reuse approach currently being considered that would maximize habitat conditions for both existing and future flows. Under existing VWRF effluent flow conditions (7.3 MGD from June through September), Alternative 5.1 (North decentralized plant) appears to provide the most SCRE habitat benefit of all the alternatives due to the relatively large habitat area for all focal species and the relatively low range of TIN concentrations. However, under future effluent flow conditions (11.2 MGD, Alternative 5.6), the VWRF discharge to the SCRE during the dry season is anticipated to increase from 4 to 8 MGD, which would result in less tidewater goby and bird nesting habitat as well as an increased potential for unseasonal breaching (which could negatively impact both tidewater goby and steelhead habitat). Therefore, based solely on SCRE habitat impacts considerations and our understanding of likely future water quality conditions within the SCRE, an effluent recharge/reuse alternative that results in a VWRF discharge to the SCRE of 4 to 5 MGD for both existing and future conditions appears to maximize habitat conditions from both a

habitat area and water quality perspective. This VWRF discharge volume range would, however, cause the SCRE stage to rise above 9.5 ft NAVD88 during extended dry season, closed-mouth periods, thereby causing flooding at the McGrath State Beach campground (see Stillwater Sciences 2011 for more detail).

Table 4-3. Average habitat parameter values for each VWRF effluent discharge alternative for the June through September model simulation period.

VWRF discharge alternative	VWRF Discharge to SCRE (MGD)	Avg. Water Depth (ft)	Wetted Area (acres)	Habitat Area (acres)			
				Steelhead	Tidewater Goby	CLT & WSP nesting[1]	CLT foraging
No Action	6.3	3.4	181	148	101	167	129
Alternatives 5.2, 5.3, 5.5, and 5.7	0	2.5	132	58	107	183	125
Alternatives 5.4, 5.8, and 5.10	2.0	2.7	139	78	110	183	127
Alternative 5.1	4.0	3.1	153	115	111	182	125
Alternative 5.9	5.0	3.3	166	132	110	177	128
Alternative 5.6	8.0	3.7	200	157	85	160	129

[1] CLT = California least tern; WSP = Western snowy plover

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APPENDIX C – CITY OF VENTURA DPR CASE STUDY

WateReuse Research Foundation
Evaluation of Risk Reduction Principles for Direct Potable Reuse
WRRF-11-10

City of Ventura

Direct Potable Reuse Case Study

Carollo Engineers,INC. 2700 Ygnacio Valley Road, Suite 300 Walnut Creek, CA 94598

City of Ventura

Direct Potable Reuse Case Study

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1.1 Introduction

The WateReuse Research Foundation is conducting Project #WRRF-11-10: Evaluation of Risk Reduction Principles for Direct Potable Reuse. The primary goal of this project is to develop recommendations for best practices for direct potable reuse (DPR), considering cost and practicality issues without compromising public health protection. The City of Buenaventura (City or Ventura) contributed funds toward this project in an effort to develop a case study that would evaluate differing logistical and treatment challenges, providing a specific example of how different options might be implemented in different municipalities. This case study illustrates some of the inherent trade-offs in logistics, complexity, and cost associated with DPR and will provide an enhanced understanding of what engineering practices could be incorporated into the design and control of advanced treatment systems for DPR.

1.2 Background

The City of San Buenaventura is located 62 miles north of Los Angeles and 30 miles south of Santa Barbara along the California coastline. The City is located within the County of Ventura, and bound by the City of Oxnard to the south, by unincorporated Ventura County to the east and north, and by the Pacific Ocean to the west. The northwest portion of the City is bound by the Ventura River, while the southern portion is bound by the Santa Clara River. The Ventura Freeway (101) bisects the City in the north-south direction, while the Santa Paula Freeway (126) runs east to west through the center of the City. The Ojai Freeway (33) runs along the northwestern edge of the City. The City currently occupies an estimated 21 square miles and has an estimated population of 109,000 persons.

The City's domestic water supply is derived from local groundwater basins, Lake Casitas, surface water from the Ventura River, and sub-surface water from the Ventura River. The City also has a 10,000 acre-foot per year allocation from the California State Water Project. To date the City has not received any of this water because there are no facilities to get the water to the City. There are presently five water sources that provide water to the City water system (below and Table 1):

- Casitas Municipal Water District (Casitas)
- Ventura River Foster Park Area (Foster Park)
- Mound Groundwater Basin (Mound)
- Oxnard Plain Groundwater Basin (Fox Canyon Aquifer)
- Santa Paula Groundwater Basin (Santa Paula Basin)

Table 1 Ventura Water Supply

Water Supply Source	Historical Supply Projection[1] (AFY)	Average Annual Supply (2000-2009) (AFY)	Future Water Supply[2] (AFY)
Casitas	4,960-8,000	6,200	5,000
Foster Park	4,200-6,700	4,200	6,700
Groundwater from City Wells	9,600-11,100	9,440	11,100
Mound	2,500-4,000	4,000	4,000
Fox Canyon Aquifer	4,100	4,100	4,100
Santa Paula Basin	3,000	1,340	3,000
Recycled Water		700	700
Total	**18,760 - 25,800**	**20,540**	**23,500**

Source: (1) City of Buenaventura Water Master Plan, March 2011; (2) LAFCo Municipal Service Review, 2012.

1.2.1 Challenges Affecting Current Water Supply

Historical use of the Mound basin has been documented to temporarily exceed the yield of the basin and result in water levels that have fallen below sea level and created a threat of seawater intrusion (Water Master Plan, 2011). Water quality in the Mound is highly mineralized with high levels of total dissolved solids (TDS) and hardness. The City manages the water quality issues by blending groundwater from the Mound basin with lower TDS groundwater from the Fox Canyon Aquifer (via the Golf Course Wells). This operational strategy is required to meet drinking water standards established by the California Department of Public Health (CDPH). Thus, minimizing the amount of groundwater pumped from the Mound basin could potentially alleviate the water quality issues mentioned above.

The Ventura River water source is dependent upon local hydrology. The City is currently working with experts to ascertain a pumping regime that will balance production demands with environmental concerns and is presently studying the relationship between groundwater production and surface flows in the Ventura River.

Implementation of potable reuse could result in reduced reliance on groundwater supplies and/or surface water supplies (Ventura River) thus mitigating water quality issues and potential environmental concerns.

Flows from the City's wastewater collection system are treated at the City's Ventura Water Reclamation Facility (VWRF). Current average annual flows to the VWRF total about 9.3 MGD. The VWRF produces tertiary treated water suitable for unrestricted reuse. Recycled water from the VWRF is used to irrigate two golf courses, a park and several landscaping areas. The remaining effluent is discharged to the Santa Clara River Estuary. In the last several years there has been tremendous debate by regulators, resource agencies and environmental organizations on whether or not the discharge is a benefit to the estuary to support the endangered species that inhabit the estuary. The City recently settled a lawsuit and agreed to increase diversion of recycled water from the estuary. However, ongoing studies and regulatory discussions may require a portion of flow to remain in the estuary to provide flows and adequate habitat. While there clearly is a need to better understand the available amount of VWRF water for

future use, it is assumed that approximately 8 MGD of tertiary treated water will be available for DPR as part of this analysis.

1.2.2 Existing UF System at Avenue Treatment Plant

The Avenue Water Treatment Plant (AWTP) is a filtration plant designed to treat groundwater under the influence of surface water from the Ventura River. In some potable reuse schemes, advanced treated water could be sent to the Ventura River upstream of the AWTP. Thus, an understanding of the AWTP facilities could be relevant.

The AWTP is sized for 10 MGD and can be expanded to 15 MGD. The AWTP implements an in-line ultra filtration (UF) membrane and chlorine disinfection processes. Current configuration consists of 4 membrane basins with additional basins for future expansion. Each basin is designed for a 2.5 MGD capacity with 6 cassettes per basin. The removal credits for the existing Zenon UF system are 4-log Giardia, 4-log Crypotsporidium, and 3.5-log Virus. An additional 2 log and 6 log removal credits for Giardia and Virus respectively are attained by chlorine residual in the water coming from the Power Reservoir. This is based on 0.5 mg/l chlorine residual, 15°C, ph 8 and 1.7 hours of contact time. The Power Reservoir is a concrete lined covered reservoir used to store approximately 15 mgd of potable water from the Ventura River and Lake Casitas before entering the distribution system.

1.3 IPR versus DPR Potable Reuse Basic Comparisons

For IPR projects in the State of California (CDPH 2011), a minimum of 12-log enteric virus reduction, 10-log *Giardia* cyst reduction, and 10-log *Cryptosporidium* oocyst reduction, are needed through advanced treatment prior to consumption. While potable reuse is not a California only issue, the CDPH standards are used here as a starting point for DPR. Per CDPH (2011), the treatment train shall consist of at least three separate treatment processes, and can include a mixture of primary, secondary, and tertiary treatment. For each pathogen (i.e., virus, *Giardia* cyst, and *Cryptosporidium* oocyst), a separate treatment process may be credited with no more than 6-log reduction and shall achieve at least 1-log reduction.

For this case study, two levels of treatment were developed for comparison. The first alternative (Figure 1) is the conventional IPR treatment scheme. The VWRF would treat secondary effluent with ultra-filtration (UF), reverse osmosis (RO), and UV/H_2O_2, which CDPH would call the FAT (fully advanced treatment) treatment train. Note that tertiary effluent (filtered and disinfected to California's Title 22 "tertiary recycled water" standard) is available. However, for simplicity, we are assuming secondary effluent to the FAT process. The purified water from the FAT process would be:

- Pumped either North to the Ventura River; or
- Pumped East to the Bailey Treatment Plant; or
- Pumped East and injected into the Mound Basin.

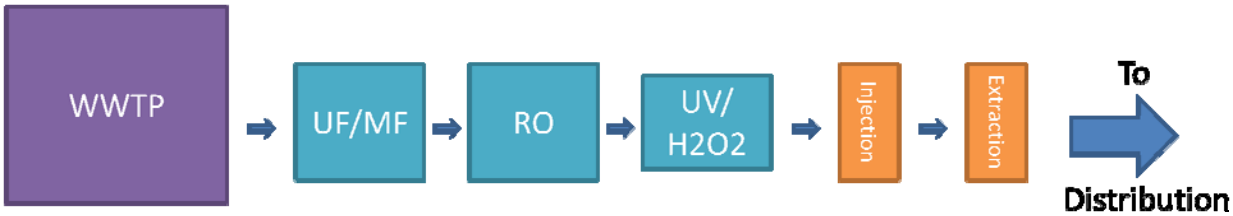
The first two options are more complex than the conventional IPR process. For this analysis, it is assumed that the third option (injection into the Mound) is selected. The associated log reductions for this IPR alternative are summarized in Table 2 below.

Table 2- IPR Log Reductions

	Cryptosporidium	Giardia	Virus
Secondary Treatment	0	2[a]	2[b]
UF	4.5[c]	4[d]	3[e]
RO	2[f]	2[g]	2[g]
UV/ H2O2	6[h,i]	6[i]	6[j]
Underground Travel Time	0[1]	6[k]	6[l]
Total	12	16	13

EPA, 1986 (see Table 2-1). (b) Francy et al, 2012 (see Table 2).(c) Reardon et al., 2005 and Lovins et al, 2002 . (d) Lovins et al., 2002 (The cited study shows 6-log removal is achievable, but project experience indicates that 6-log removal may not be achieved reliably; 4-log was chosen to remain conservative.) (e) Based on EPA (2008) and Reardon et al. (2005). Lovins et al, (2002) indicates 6-log may be achievable.(f) Schäfer et al., 2005; limited by online monitoring of conductivity (g) Reardon et al., 2005; limited by online monitoring of conductivity (h) Snyder et al., 2012 (i) Hijnen et al., 2006 (j) Rochelle et al., 2005 (k) EPA, 2008 (l) CDPH, 2011

Figure 1- IPR Treatment



The second alternative (Figure 2) is the DPR alternative in which additional treatment and monitoring is substituted for the environmental buffer. Similar to the IPR scheme, VWRF secondary effluent would be treated by UF and RO. At that point, the water would be stored for a set period of time, 12 hours is proposed here to allow for additional monitoring. The influent to the storage tank would be dosed with free chlorine to provide for an additional measure of disinfection and destruction of trace pollutants. Storage would be such that treated "potable" water would be diverted for 12 hours at a time to two tanks, "Tank 1" and "Tank 2." After 12 hours of flow to Tank 1, the tank would be sealed and water would be diverted to start filling "Tank 2." Water samples would be taken at constant intervals during the filling process and tested by one of the advanced monitoring methods described in Section 1.5 of this report. Upon successful completion of the advanced monitoring, water would be released from the full tank, undergo UV and advanced oxidation, and be delivered into the distribution system. The tank would subsequently be refilled while Tank 2 undergoes advanced monitoring. An equalization basin would be needed to regulate flow into the two tanks. As discussed in Section 1.5 of this report,

[1] Literature suggests that at least a similar inactivation compared to virus can be assumed (Hogg et al., 2012). No credit is currently provided by CDPH.

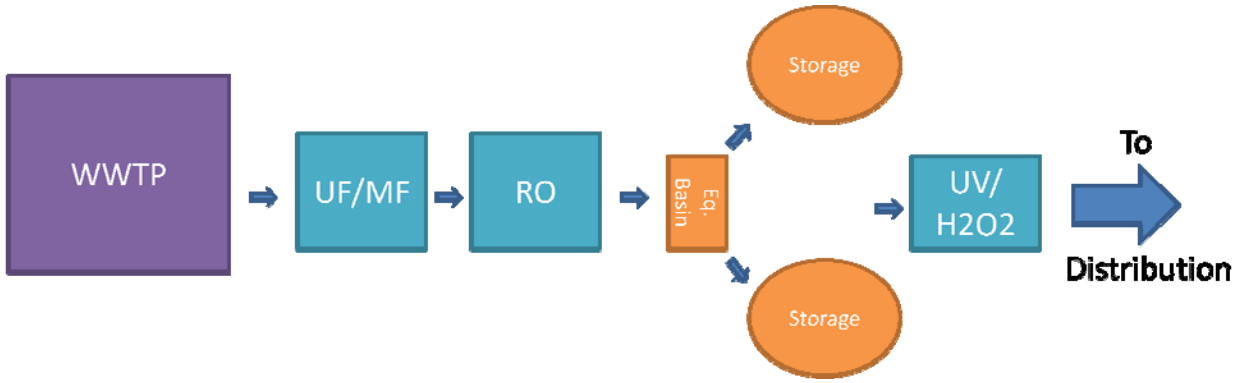
additional innovative monitoring techniques are proposed for the RO process to further bolster process confidence. The associated log reductions of the DPR alternative are summarized in Table 3 below.

Table 3 – DPR Log Reductions

	Cryptosporidium	Giardia	Virus
Secondary Treatment	0	2[a]	2[b]
UF	4.5[c]	4[d]	3[e]
RO	2[f]	2[g]	2[g]
Chlorine/Storage	3[h]	4[h]	4[h]
UV/ H2O2	6[i,j]	6[j]	6[k]
Total	15.5	18	17

EPA, 1986 (see Table 2-1). (b) Francy et al, 2012 (see Table 2).(c) Reardon et al., 2005 and Lovins et al, 2002 . (d) Lovins et al., 2002 (The cited study shows 6-log removal is achievable, but project experience indicates that 6-log removal may not be achieved reliably; 4-log was chosen to remain conservative.) (e) Based on EPA (2008) and Reardon et al. (2005). Lovins et al, (2002) indicates 6-log may be achievable.(f) Schäfer et al., 2005; limited by online monitoring of conductivity (g) Reardon et al., 2005; limited by online monitoring of conductivity (h) Bandy, 2009 (see Table 2.2), which is based on: Asano et al., 2007 and Meng, 1996 (i)Snyder et al., 2012 (j) Hijnen et al., 2006 (k) Rochelle et al., 2005

Figure 2 - DPR Treatment Train



1.4 Approach and Layout

The distribution system and facility layouts required for each of the IPR and DPR alternatives are important in consideration of these options and thus, are presented in this section.

Conventional Indirect Potable Reuse

Under this alternative, 8 MGD of tertiary treated water would undergo FAT at the VWRF producing 5.8 MGD of finished water. The water would then be pumped approximately 8 miles near the vicinity of the Bailey Treatment Plant (BTP) where it would be injected into the Mound basin and then extracted by the

existing wells Victoria No. 1 and Mound No. 2 after a travel time of 6-8 months. This option would provide an alternative supply, replacing the approximately 5 MGD currently pumped from the Mound basin and provide an additional 0.8 MGD, assuming 90% recovery following MF/UF and 80% recovery following RO, that could serve new users or potentially offset diverted/pumped water from one of the City's other water supplies. The additional 0.8 MGD could also potentially help supply the storage deficiency of 5.69 MG as described in the 2011 Water Master Plan (WMP). A summary of maximum extraction rates is provided in the table below:

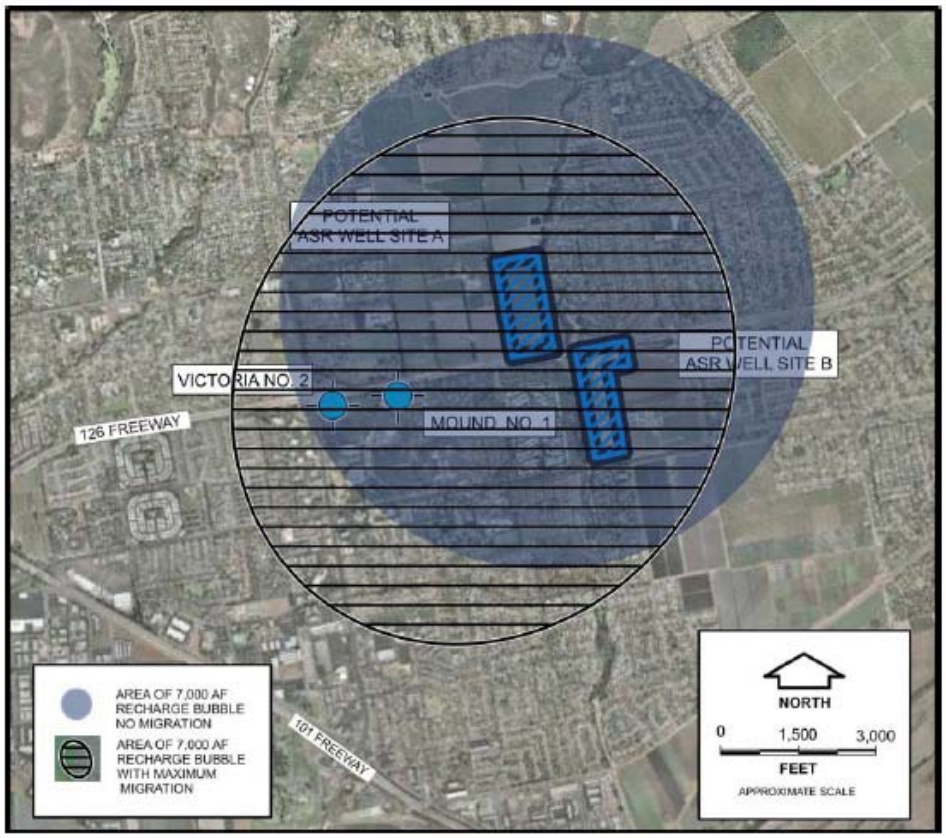
Mound Aquifer Extractions	Maximum Capacity (gpm)	Maximum Capacity (mgd)
Victoria 2	3,000	4.3
Mound 1	2,500	3.6
Total Supply	**5,500**	**7.9**
Total Current Use	3,455	5
Potential Supply from FAT	4,027	5.8

A pump station would need to be constructed in order to pump the water from the VWRF to the injection site. The following is a list of components that would be needed for a proposed IPR project injecting and extracting water from the Mound:

- FAT treatment train at VWRF including RO, UV and AOP
- 8 miles of 16" pipeline to injection well site
- Pump station sized at approximately 600 hp (4 pumps @ 1200 gpm including standby capacity)
- Monitoring Wells
- Injection Wells
- 1 additional extraction well

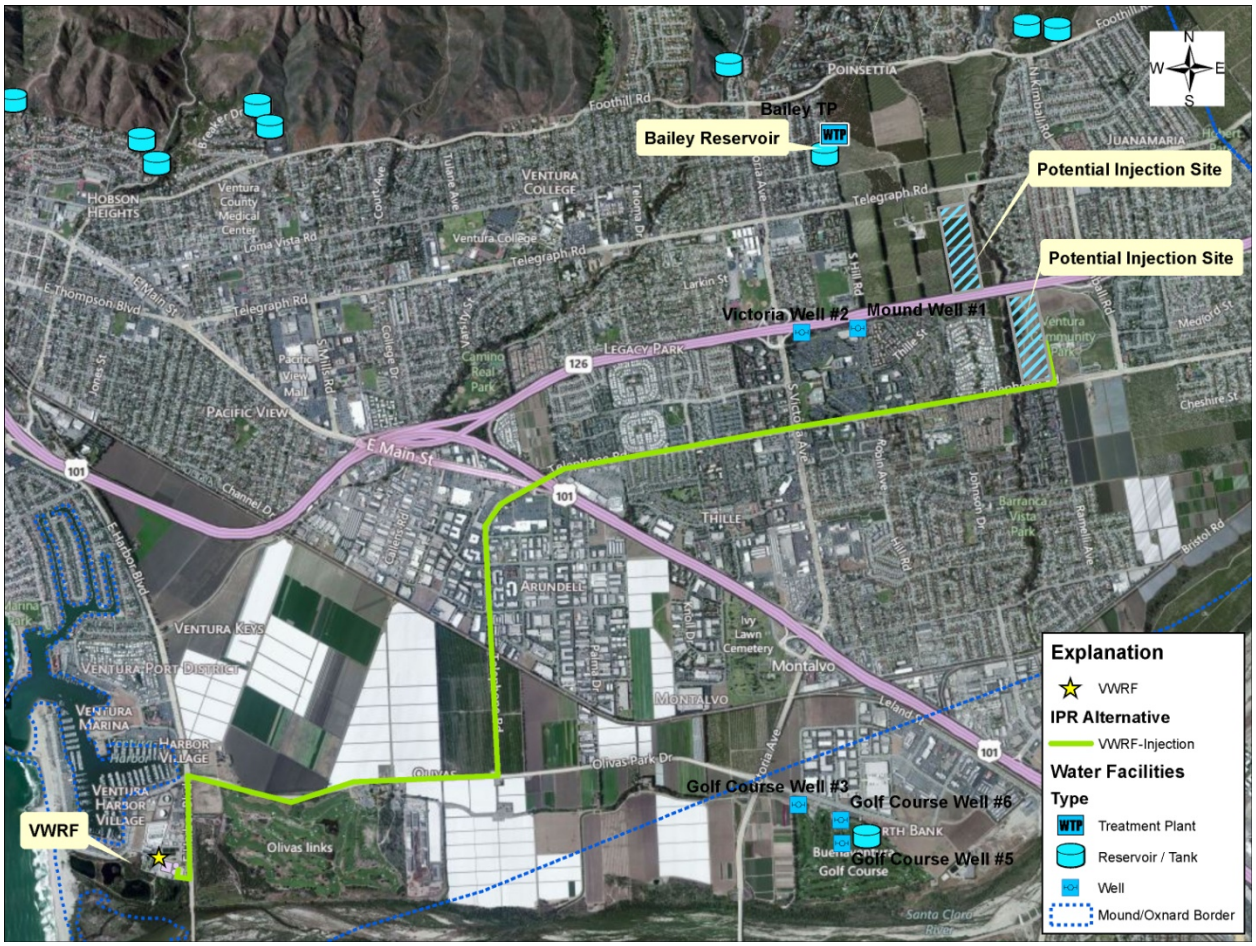
Indirect potable reuse is dependent upon the aquifer characteristics of the Mound basin. A preliminary hydrogeological study (Hopkins, 2013) of the Mound was conducted to assist the City of Buenaventura in evaluating the feasibility of IPR alternatives. It was estimated that approximately 7000 afy, or 6.25 MGD, could be injected into the Mound in the vicinity of the existing extraction wells (Victoria No.2 and Mound No. 1). This volume is based on the total water currently being extracted from the Mound by the City of Ventura as well as agricultural users. Assuming existing infrastructure limitations, the 5.8 mgd of high quality FAT treated water would provide a replacement supply to the poor quality water currently pumped from the Mound and supply both agricultural and potable use needs. Assuming that the entire volume of 7,000 afy is injected in a single well or closely spaced wells, the estimated travel time to reach Vitoria Well No. 2 is 6 to 8 months (Hopkins, 2013).

Figure 3 - Area of Lower Aquifer Filled by IPR Water



(Hopkins, 2013)

Figure 4 - IPR Alternatives in Vicinity of Bailey Treatment Plant



<u>Direct Potable Reuse</u>

Under this alternative 8 MGD of tertiary treated water would undergo treatment at the VWRF producing 5.8 MGD of finished water. The RO treated water would then be stored for a set period of time, with 12 hours proposed to allow for additional advanced monitoring. Upon successful completion of the advanced monitoring, water would undergo UV and advanced oxidation before being pumped to three possible locations for connection to the existing distribution system:

- *Alternative 1:* 5.3 miles to the North of the VWRF to Casitas Turnout #2
- *Alternative 2:* 8 miles to directly connect to the produced water side of the BTP (or to the 7.2 MG Bailey Reservoir)
- *Alternative 3:* 9.4 miles to the Power Reservoir or produced water side of the AWTP

Alternative 1

The Casitas Turnout #2 is one of the largest supply lines to the city. The 24" transmission main has a capacity for approximately 12 MGD with current use at approximately 6.6 MGD. The City currently

purchases water from the Casitas Municipal Water District (CMWD). Storm water runoff from local watersheds is stored in Lake Casitas, located approximately 10 miles northwest of the City, then treated and delivered to customers by CMWD. The City's minimum annual purchase is 5.4 MGD (6000 AFY) which is subject to an allocation program put into effect during drought conditions. During extreme drought conditions, approximately 4.4 MGD would be available.

This alternative would enable the City to maintain its water purchase agreement with CMWD and provide a number of options to decrease water pumped from the Ventura River as well as reduce or eliminate the amount of water pumped from the Mound, in addition to providing supplemental supply during extreme drought. If the City were to maintain its minimum annual purchase agreement, approximately 11.2 MGD would run through the system, which is just under the stated capacity of the distribution infrastructure in place.

Casitas Turnout #2 is located in the 210-pressure zone, which is the lowest pressure zone in the distribution system. Water from the 210 zone is distributed throughout the system by a series of pump stations. The 330 and 430 pressure zones are currently supplied by water from the Victoria, Mound, and Golf Course wells. This alternative could potentially allow for discontinuation of Victoria Well No.2 and Mound Well No.1 by delivering water directly to the 330-pressure zone and 430 pressure zones by way of the 5 Points and 330 Pump Stations. The WMP recommended the construction of two wells, Mound Well No. 2 (CIP 97907) and Golf Course Well No. 7 (CIP 97908) in order to increase the capacity of the 330 Pressure zone by 5,000-6,000 gpm (7-8.5 MGD) eliminating a storage deficiency in the 330 pressure zone of 5.69 MG. This alternative would eliminate the need for these new wells. The existing wells could potentially remain operational to serve as additional storage capacity as well as an additional safety measure in the event of a malfunction in the FAT treatment train, or if a breach is detected by the advanced monitoring systems.

The following two figures, taken from the 2011 City of Buenaventura Water Master Plan, show a hydraulic schematic of the system depicting pressures zones, pump stations, storage reservoirs and the capacities of the separate components during typical operating conditions. Figure 5 provides a schematic of the distribution alternatives for finished water using the existing distribution infrastructure. Further hydraulic modeling would be needed to verify and optimize the new distribution of water depending on the City's desired adjustment of existing supply sources.

The following infrastructure components would be included in this scenario:

- 8 MGD FAT treatment train at VWRF including RO, UV and AOP (5.8 MGD finished water)
- Pump station sized at approximately 600 hp (including standby capacity)
- Engineered storage for detention during advanced monitoring at VWRF
- 5.3 mile 16" pipeline to deliver 5.8 MGD high quality DPR water to the Casitas Turnout #2
- Discontinued operation of Victoria Well No. 2 and Mound Well No. 1.
- Could possibly keep one or both of the Mound wells operational to account for part or all of the storage supply shortage identified in the 2011 WMP (4.11 MGD) .
- Continued use of existing infrastructure.

Figure 5 - Existing System with Distribution Alternatives

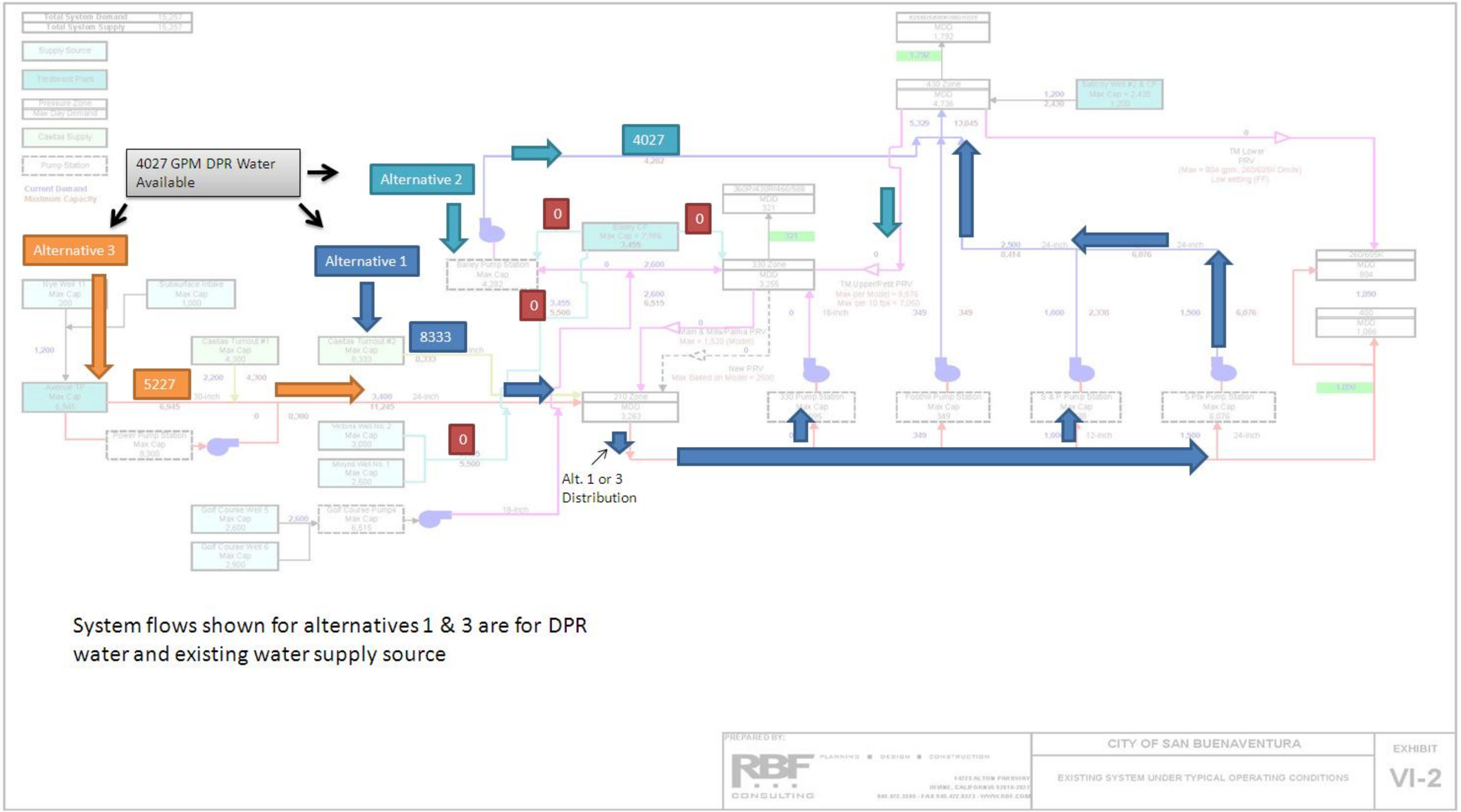
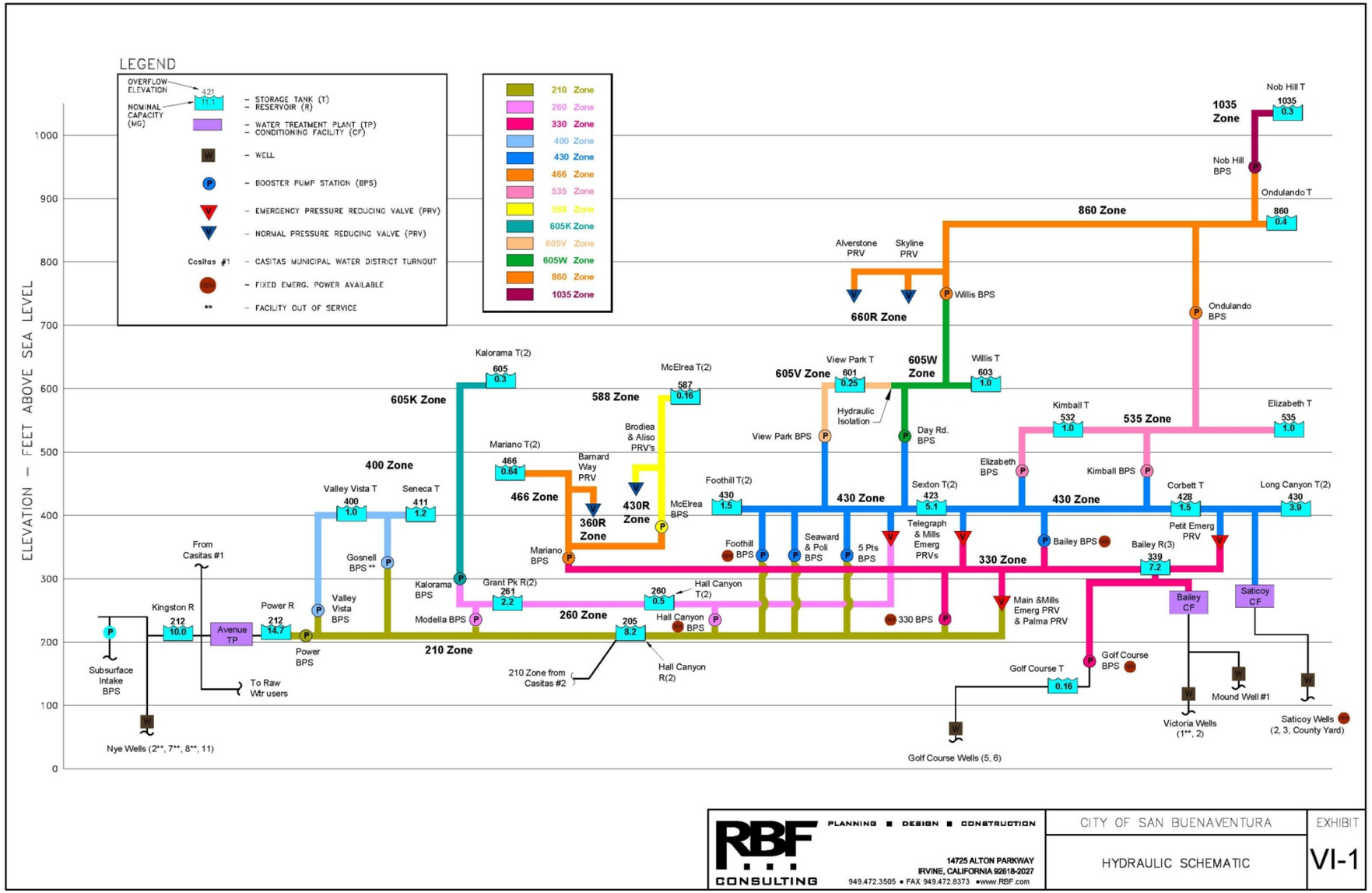


Figure 6 - Hydraulic Schematic



Alternative 2
This alternative would deliver FAT treated water to either one of the following locations: the finished water side of the BTP, directly to the Bailey Pump Station, or to the Bailey Reservoir. The Bailey Reservoir is a 7.2 MG storage tank providing storage for the 330-pressure zone. This approach would replace the current low quality water pumped from the Mound (5 MGD) supplying the 330-pressure zone and enable a decreased amount of water to be pumped from the Oxnard Groundwater Basin via the Golf Course wells or decreased extractions from the Ventura River. The water would continue to be distributed in the 330-pressure zone and throughout the distribution system as it is currently, via the Bailey Pump Station and the pressure reducing valve (PRV) at TM Upper/Petit would be used to convey water to the 330-pressure zone. The PRV at Main and Mills would be utilized to convey water to the 210-pressure zone if desired. This alternative would also provide the ability to mix DPR water with water pumped from Golf Course Well No. 5 at the Bailey Reservoir, allowing for an alternative water supply for short-term treatment shutdowns. Assuming that all of the existing infrastructure remain in place and operational, groundwater from the Mound Basin could still be utilized in the event of an emergency. Alternative 2 would include the following components:

- 8 MGD FAT treatment train at VWRF including RO, UV and AOP (5.8 MGD finished water)
- Pump station sized at approximately 600 hp (4 pumps @ 1200 gpm including standby capacity)
- Engineered storage for detention during advanced monitoring at VWRF
- 8 mile 16” pipeline to deliver 5.8 MGD high quality DPR water to the Bailey Reservoir.
- Discontinued operation of Victoria Well No. 2 and Mound Well No. 1.
- Continued use of existing distribution infrastructure.

Alternative 3
The third DPR alternative includes delivering finished water to the produced water side of the AWTP or into the Power Reservoir, which as mentioned, is a covered storage facility currently fed by Casitas Turnout #1 and finished water from the AWTP. This alternative is similar to Pumping DPR water to Casitas Turnout #2 with the key differences being:

1.) The pipeline would be longer (9.4 miles)
2.) Water would have to be pumped to a higher elevation (Approx. 200 ft) than Casitas #2 (30 ft)
3.) Would enable supply to pressure zones supplied by the Valley Vista Booster Pump Station and Modella Booster Pump Station.
4.) Would provide additional flexibility for distribution of finished water

The main benefit of this option is that it would provide additional capability to distribute finished water. According to the hydraulic model developed as part of the WMP, Alternative 1 would be limited by the capacity of Casitas Turnout #2 (8,333 gpm) which currently uses 4,602 gpm of that capacity (see Figure 5 above). This alternative would allow the City to continue to purchase the same amount of water that it currently buys from Casitas at Turnout #2, while allowing the full 5.8 MGD of DPR water to enter the system at Casitas Turnout #1.

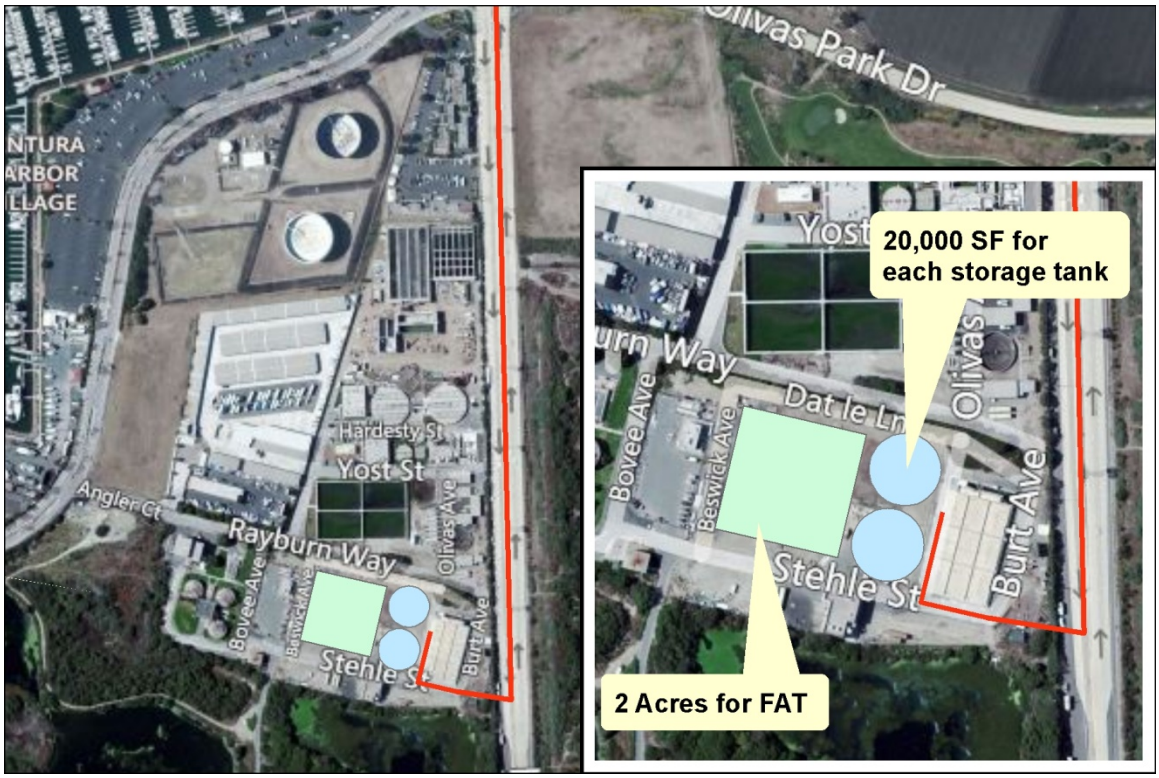
Similar to Alternative 1 the following infrastructure components would be included:

- 8 MGD FAT treatment train at VWRF including RO, UV and AOP
- Pump station sized at approximately 600 hp (including standby capacity)
- Engineered storage for detention during advanced monitoring at VWRF
- 9.4 mile 16” pipeline to deliver 5.8 MGD high quality DPR water to the AWTP or Power Reservoir
- Discontinued operation of Victoria Well No. 2 and Mound Well No. 1.
- Could possibly keep one or both of the Mound wells operational to account for part or all of the storage supply shortage identified in the 2011 WMP (4.11 MGD).
- Continued use of existing infrastructure.

Figure 7 - DPR Alternatives

The following Figure 8 illustrates an approximate footprint for the 8 MGD DPR scenario:

Figure 8 - DPR Footprint at VWRF



The FAT footprint includes 27,000 ft^2 for the membrane facilities (UF/RO), 11,000 ft^2, 50,000 ft^2 for engineered storage and additional space required for equipment access points, additional roads, and a pump station for the finished water. The total space available at the southern end of the VWRF is approximately 185,000 ft^2 (4.25 acres) which should be able to accommodate the required infrastructure. The Orange County Water District's advanced treatment facility, which is for 100 mgd of treatment, sits on 25 acres of land, and is well configured with wide roads and multiple equipment access points. A simple ratio for 8 mgd would consume about 2 acres of land.

1.5 Monitoring

Facilities that utilize advanced treatment for IPR have detailed water quality monitoring plans, including testing and analysis of the treatment process and of the water as it migrates from the point of application to the point of use. This discussion relates to the ***additional monitoring*** recommended for DPR projects. These proposed monitoring tools are intended to provide a higher degree of confidence in process performance.

1.5.1 Membrane Integrity

The membranes that are typically used in advanced treatment provide for a large amount of the total performance of the advanced treatment system. Accordingly, the ability to continuously and accurately track the membrane performance is desired.

In 2005, EPA published the Membrane Filtration Guidance Manual (MFGM) (EPA 2005) which put forth the following requirements to verify integrity for an RO and NF Membrane System (as per Section 1.3 of the MFGM):

1. Removal efficiency must be established through product-specific challenge test and direct integrity testing.

2. Continuous indirect integrity testing. The MFGM states that turbidity and particle counting are acceptable continuous integrity tests for MF/UF membranes (Sections 5.2 and 5.3) and conductivity is acceptable for RO/NF membranes (Section 5.4).

3. Daily direct integrity testing using a method sensitive to the log removal rating that the system is credited for.

Regarding MF/UF, methods for direct integrity testing include, air pressure decay or hold tests, diffusive airflow monitoring, sonic testing, and bubble point tests. The most commonly applied direct integrity test method is the pressure decay test, which is a variation of the diffusion test, in which the leakage of air from a closed volume at known pressure through a wetted membrane is measured and converted to an equivalent water leakage rate. The air leaks only through pathways representing large pore sizes, since the smaller pores remain wetted due to capillary forces. By selecting the appropriate test pressure, typically between 10–20 psig, it is possible to measure the leak rate through only those pathways large enough to cause transmission of pathogenic protozoa.

One disadvantage of the direct integrity monitoring, is the need to perform the tests offline and the consequent interruption of normal operation. Another limitation of the pressure-driven integrity monitoring tests is the minimal detectable pore size that can be detected within the operating range of the membranes being tested. Typical pressure for conducting pressure decay or diffusive airflow tests is in the range of 10-20 psi, which would be able to detect defects on the order of 2-3 µm, approximately the size of protozoan cysts (Lozier et al., 2003). The required test pressure for a virus-sized resolution of 0.01 µm is over 4,000 psi, a value far in excess of what any current, commercially available water treatment membrane could withstand without rupturing (USEPA, 2005).

Regarding RO and NF, there is currently no recognized “direct integrity test” that can be conducted on a daily basis which can demonstrate more than 2-log removal (electrical conductivity (EC) can detect a 99% removal of pathogens). Improved monitoring techniques are needed and should be sensitive enough to pick up small but significant changes and trends in treatment performance that could have a significant impact on the safety of the finished water. An ideal monitoring system would be able to continuously detect up to 6-log reduction of a trace particle that is equal or smaller than the approximate virus size of 0.01 µm. This method could be used to test RO and NF as well as MF/UF systems.

There are a number of products on the market that could provide useful assurances for membrane integrity. Two possible examples of technologies that could provide membrane integrity verification would be the 3D Trasar® Technology by Nalco and Mem Shield by MINT. Trasar is an inert molecular tracer that can be detected down to concentrations of parts per trillion by fluorescence. It is currently used as part of a continuous online monitoring method for antiscalant used in RO facilities. The Trasar molecule is approximately 610 Da which is approximately 4 orders of magnitude smaller than the average virus. The Trasar molecule alone (or blended in with Antiscalants) has NSF Std 60 approval for use in potable water in front of an RO system. Trasar was tested in 2007 as part of the City of Sand Diego Advanced Water Treatment Research Studies (MWH, 2007), where results showed a log removal value of greater than 6 log. Further testing would be required in the future. The figure below illustrates the potential value of the Trasar or similar type of product.

MEM-SHIELD (http://www.mintmembranes.com/the-technology/) is an indirect integrity testing method for low-pressure membrane systems such as MF/UF, which can then be used to trigger a direct integrity test. The direct integrity test is based on correlation to the MFGM log removal values (LRV) calculations. Direct integrity testing based on correlation has not been accepted yet by regulators in the US. The principle of operation is based on measuring the differential pressure across a membrane that intercepts a portion of the permeate from the MF/UF modules relative to the differential pressure across a valve. The system is able to detect breaches of up to 0.001% broken fibers with a resolution of 3 µm. MEM-SHIELD claims to be able to reliably differentiate between 3 log removal and 4 log removal of protozoa sized pathogens (> 3 µm) with further work being done to differentiate between log 4 removal and log 5 removal. The product is currently being tested at the Bedok Newater Factory in Singapore. Existing monitoring methods such as the pressure decay test, microbial challenge test and high-sensitivity (0.5 µm or 0.05 µm) particle counters have been found capable of detecting as low as 1 cut fiber in a full-scale rack. A 2-µm particle counter has been shown able to detect between 1 to 0.001% cut fibers in a full-scale UF rack, depending on the feed water turbidity (Sethi et al, 2004).

1.5.2 Pathogen Monitoring

Continuous and accurate online monitoring of membrane performance should be complimented with rapid response water quality analysis. Ideally, an online monitor would be able to continuously monitor for bacteria, protozoa, and virus. There are a number of products currently on the market that can continuously monitor for bacteria sized pathogens: ZAPS http://www.zapstechnologies.com/ is an optical, online instrument for real time multi-parameter water quality monitoring which can detect *E. coli* among other water quality parameters. Biosentry http://www.jmar.com/wordpress/ uses optical spectroscopy to identify pathogens between 0.5 µm to 15 µm. Biosentry is based on light scatter from specific pathogens. RMS---W™ from Instant Bioscan http://www.ibioscan.com/ utilizes auto-fluorescence from certain metabolites and other proteins in the microbial cells and uses this fluorescence as biological marker for differentiating microbes from inert particles., but can only detect presence/absence of bacteria sized pathogens greater than 0.3 µm.

Current online detection methods are unable to detect virus-sized pathogens at levels of less than 1 CFU/1 ml without DNA enrichment or concentration, which takes time. Furthermore, none of the current online methods are able to detect virus size pathogens. Other Presence/Absence tests could provide a "red flag" however, results could be skewed due non-pathogenic microbial growth on membranes. The Zaps Technologies product LiquID Station is currently being piloted in San Diego, CA and could possibly be sensitive enough to detect virus though this has not been demonstrated yet.

It is important to note that the time for testing and reporting of results is critical. Large engineered storage systems are costly and have a significant footprint. As methods are developed that can produce results in shorter amounts of time, costs will decrease accordingly. The currently proposed scheme is to utilize 12 hours of storage to allow for rapid response water quality monitoring. One method that could possibly achieve the sensitivities needed in under 12 hours is real time quantitative polymerase chain reaction (qPCR). This method has been widely used to detect viruses in environmental waters. A number of these uses are referenced in EPA Method 1615, 2010. This molecular procedure has the ability to obtain results in a very short time and is more rapid than cell culture but cannot distinguish between infectious and inactivated viruses. Research is ongoing on several promising approaches to detect infectious viruses (Reynolds, et al. 1996, Parshionikar, et al. 2010). However, qPCR is still a useful public health tool in spite of these problems. Because there is a strong relationship between indicator measurements by qPCR and health effects in recreational waters (Wade, et al. 2010), the EPA is considering using qPCR to set new criteria for monitoring recreational beaches (EPA Method 1615, 2010).

In theory, no virus would be able to penetrate the RO membrane. The advanced monitoring methods proposed above are proposed as an additional level of safety and would be employed before the UV and advanced oxidation process, which would provide an additional level of safety. As such, even in the event of a membrane malfunction anticipated virus concentrations would be extremely small on the order of 1 CFU/ 100 mL. Under these conditions, samples would have to be concentrated or enriched in order for there to be enough DNA to run a qPCR analysis. Concentration steps would possibly involve a bench scale RO system. Samples would be collected from the membranes at set time intervals and tested for virus and bacteria using qPCR. Additional research is needed to identify the current operational constraints of existing methods and to develop a protocol for a method using qPCR or other molecular techniques and perhaps combine these molecular techniques with one of the online monitoring techniques mentioned above.

With regard to trace organic contaminant monitoring, an accurate method has been developed for the trace analysis of 15 pharmaceuticals, four metabolites of pharmaceuticals, three potential endocrine disruptors, and one personal care product in various waters (Vanderford and Snyder, 2006). The method reporting limits for all compounds were between 0.25 and 1.0 ng/L, based on 500 mL of sample extracted and a final extract volume of 500 µL. The method is based on solidphase extraction (SPE) and liquid chromatography/tandem mass spectrometry (LC-MS/MS), using electrospray ionization (ESI) in both positive and negative modes. This method would be able to provide results in approximately 24 hours. Daily monitoring of trace pollutants (or surrogates) would provide further confidence in advanced treatment performance.

The following table summarizes a number of pathogen testing techniques currently available or under development:

Table 4- Pathogen Monitoring Methods

Product	Company/Research	Description	Sensitivity	Pathogens Detected	Analysis Time	Cost	Ease of Use
MassCode PCR	Widely used in research	Endpoint amplification of a suite of indicators or pathogens. This method is good if for high throughput applications or for more than 10 types of pathogens and high level of sampling.	100-500 DNA copies (would require an enrichment step)	Can be used for Bacteria, Protozoa, and Virus. Specific probe for each different pathogen.	Could potentially have results in under 6 hours	NA	Manual, but could possibly automate
QPCR	Widely used in research	Amplified DNA is detected as the reaction progresses in real time. Cannot distinguish between infectious and inactivated viruses QPCR is much more sensitive than PCR, and more affordable.	Can detect down to 1 copy of DNA but would need a concentration or enrichment step.	Can be used for Bacteria, Protozoa, and Virus. Specific probe for each different pathogen.	Could potentially have results in under 6 hours	NA	Manual, but could possibly automate
Biosentry	Jmar	Microbial activity detection using light scatter. The concept is that specific pathogens (or microorganisms) scatter light in repeatable ways. Key here is that the organisms must be dispersed and wastewater particulates do not interfere. Should be acceptable for RO permeate. 3 channels of size and shape to determine biologicals plus unknown channel.	All Microorganisms and Particles are Detected from 0.5 microns to 15 microns in size. Previous calibration of the BioSentry showed a sensitivity of 1 CPM per 1.2 CFU per mL	Rod shaped bacteria (*E.coli*), endospores, protozoan cysts	Measurement each minute	NA	Continuous real time monitoring.
Endetect -TECTA- B16	Tecta Automated Rapid Microbial Detection Systems	Based on enzymatic reaction of *E.coli* growth in water. Technology assesses growth through continuous monitoring using an enzyme detection algorithm. This increases the sensitivity of the instrument and it is now quicker to detect low enzyme concentrations over the general background noise. This is particularly helpful when there are low levels of bacteria concentrations or where the bacteria are stressed and slow at producing the required detection enzymes. Similar to IDEXX.	Dynamic range of <1 to >10 CFU in 100 ml without requirement for sample dilution. Needs an additional step for enrichment, makes it 18 hrs.	E.Coli and Coliform	18 hrs	$20,000 + $525/box of 48 tests	Grab sample. Don't need lab
Anti-Body Based Bio Sensor	Dr. Alocilja, University of Michigan	Antibody based bio-sensor. Can change the antibody to any specific target	1 CFU /1 ML. Would need an additional enrichment step to get down to 1 CFU /100 ML	Specific antibody can be developed for target pathogen	18 hrs w/enrichment. 50 min for concentrations of 5-10CFU/1ML	NA	Manual. Could be automated
DNA Based Bio Sensor	Dr. Alocilja, University of Michigan	DNA based biosensor. Targets pathogen specific DNA target. Detection achieved electrochemically by measuring the Redox potential of attached electrically active magnetic nanoparticles	Has been able to detect redox signal of the nanoparticles as low as 0.01 ng/ul	In development. So far for *Bacillus anthracis* and *Salmonella enteritidis*	Under development	NA	Manual. Could be automated
RMS-W™	Instant BioScan	Continuous presence/non-presence monitoring. Monitors for certain particle sizes. Cannot speciate for different microbes. Works on a Mie Scatter for particle sizing using photodiode and fluorescence emission for bio detection using PMT. Flow rate of 100 mL/min.	Can detect down to 0.3um. Min resolution needed is 1 bio count	Not pathogen specific	Online/instant	$39,900 or Lease $2,500/month	Constant Online monitoring
LiquID Station (Multi-Frequency optical measurement)	Zaps Technologies	An optical, online instrument for real time multi-parameter water quality monitoring. Can detect multiple parameters using "hyperspectral" detection methodology. Also uses a hybrid spectrometer, which allows the system to monitor absorbance, fluorescence, and reflectance on the same optical platform.	BOD, cBOD, COD 1 to 10,000 mg/l, *Ecoli* ~1 CFU/100ml TOX 10mg/l NO3 0.05 – 500 mg-N/l	*E.coli*, BOD, cBOD, COD, NO3, TOC, TSS, TOX (disinfection byproducts)	Online/instant	$65,000 + minimal O&M	Constant Online monitoring
Bactiquant	Mycometer	BactiQuant®water is based on detection of a hydrolytic enzyme activity by use of fluorescence technology. Presence/Non presence only.	Sensitivity can be adjusted. Can detect down to 1 CFU/100ml but would need large sample volume (2 L).	Multiple Bacteria: E.Coli, Athrobacter, Bacillus cereus, Pseudomonas, Rhodobacter. Both gram positive and gram negative	2 hours	$7500 + $18 per test	Manual. Minimal human intervention needed

* NA – Not Available. Costs were either not available or more information is needed costs of developing technology.

1.6 Costs

A summary of preliminary costs estimated for the 4 supply alternatives presented above is presented in Table 5 below. Costs include infrastructure costs associated with each alternative (FAT, pipelines, pump stations, storage) as well as operation and maintenance (O&M) costs for each as well as annual costs associated with advanced monitoring. The total implementation cost includes all capital costs, engineering costs, construction contingencies, and contractor overhead and escalation. However, costs for administration, legal, CEQA and permitting were not included. In addition, costs for brine disposal were not included. The annual cost is determined by calculating the annual amortization of the capital cost for the treatment plant, calculated at 4 percent interest over 30 years and adding it to the annual O&M cost to determine the total annual cost. The total annual cost is then divided by the annual production in acre-feet (6500 AF) to determine a cost per acre-foot. Depending on the final distribution of water, the total finished water production could decrease and costs would have to be adjusted accordingly.

Costs provided in Table 5 are given in U.S. dollars as of December 2012. General assumptions utilized are provided below:

- FAT assumes 90% recovery from UF/MF and 80% recovery from RO
- 95% UVT is assumed for the UV/AOP process
- Feed flow is assumed to be 8 MGD
- Assumed rate of 4% over 30 year life span
- Distribution pipeline is estimated to be 16” DIP
- Permitting and outreach efforts associated with DPR have <u>not</u> been included
- Brine disposal costs have <u>not</u> been included

All of the alternatives include a capital and O&M cost credit associated with the offset of future RO costs needed to treat water pumped from the Mound Basin as identified in a groundwater treatment study completed in March 2011 (AECOM, 2011). This credit assumes that water from the mound aquifer would no longer need to be used as a potable water supply and would thus not need to be treated. It also assumes that an equivalent amount of treatment will be needed in the future for VWRF effluent discharge reduction into the Santa Clara River Estuary. The DPR alternative would provide a solution to both issues of concern enabling a savings credit to be applied. An estimate of O&M costs that would be incurred by a future BTP RO system, approximately $860,000 annually, were deducted from the estimated O&M costs of each alternative presented above. An additional credit would be applied in the event that water was credited toward Ventura River extractions causing less water to be treated by the AWTP. In order to foster a conservative approach, this credit was not applied to this analysis. Additional cost savings for the DPR options will be achieved as advanced monitoring methods become more readily available and detection time decreases, thus reducing the large amount of storage currently needed and associated costs.

Table 5 - Cost Summary

	Total Construction Cost	Annual O&M	Annual Cost ($/AFY)	Annual Cost ($/1000 gal)
Casitas #2 DPR	$51.6M	$2.6M	$860	$2.80
Bailey DPR	$52.4M	$2.6M	$860	$2.80
Avenue DPR	$57.8M	$2.7M	$920	$2.80
Bailey IPR	$70.0M	$2.9M	$1000	$3.10

The costs presented above are for the general information of the City, for comparison of alternatives. Detailed cost estimates for the above options are presented in Appendix A of this report. Before developing a final budget and financing for the preferred alternative, it is recommended that a preliminary engineering report be prepared, investigating in greater detail site-specific conditions that may affect costs.

1.7 References

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Appendix A Detailed Cost Estimates

DPR Treatment Options Alternative #1 Casitas Turnout #2 City of Buenaventura		
Project Element		**Cost Estimate**
Pump Station		$870,000
Pipeline (Ventura to Casitas Turnout #2)		$4,222,500
FAT		$25,009,800
Storage (2 x 4 MGD) + Eq basin		$5,500,000
Bailey RO Credit		-$8,750,000
Total		**$26,860,000**
Construction Contingency	30.00%	$8,058,000
Subtotal		$34,918,000
General Contractor Overhead+Profit	10.00%	$3,491,800
Subtotal		$38,409,800
Sales Tax (7.25% of 50% of Total Cost)	7.25%	$1,265,778
Total Capital Cost + (30% Contingency)		**$39,680,000**
Engineering	30%	$11,904,000
Land Acquisition	0	$0
Total Estimated Project Implementation Cost		**$51,590,000**
Annualized Construction Cost		**$2,983,455**
O & M Pump Station + Pipeline	2.50%	$127,313
O & M Treatment (FAT)		$3,087,500
O&M Storage/Chlorination	2.00%	$110,000
Advanced Monitoring		$100,000
Bailey Treatment Credit		-$860,000
Total O&M		**$2,570,000**
Total Annualized Cost		**$5,560,000**
Annual Yield AF		**6500**
Unit Cost ($/1000gal)		**$2.60**
Unit Cost ($/AF)		**$860**

Notes:
FAT assumes 90% recovery from UF/MF 80% recovery
from RO
95% UVT assumed for UV/AOP process
Feed flow assumed 8 MGD
Assuming 4 pumps (1 standby) pumping 1200 GPM 24/7
Rate of 4% assumed over 30 year life
Pumping costs from equalization basin and other costs are assumed to be taken into account by contingency.

DPR Treatment Options Alternative #2 DPR to BTP City of Buenaventura		
Project Element		**Cost Estimate**
Pump Station		$870,000
Pipeline (Ventura to Bailey)		$4,637,100
FAT (Total Implementation Cost)		$25,009,800
Storage (2 x 4 MGD) + EQ Basin		$5,500,000
Bailey RO Credit		-$8,750,000
Total		**$27,270,000**
Construction Contingency	30.00%	$8,181,000
Subtotal		$35,451,000
General Contractor Overhead+Profit	10.00%	$3,545,100
Subtotal		$38,996,100
Sales Tax (7.25% of 50% of Total Cost)	7.25%	$1,285,099
Total Capital Cost + (30% Contingency)		**$40,290,000**
Engineering	30%	$12,087,000
Land Acquisition	0	$0
Total Estimated Project Implementation Cost		**$52,380,000**
Annualized Construction Cost		**$3,029,141**
O & M Pump Station + Pipeline	2.50%	$137,678
O & M Treatment (FAT)		$3,087,500
O&M Storage + Chlorine	2.00%	$110,000
Advanced Monitoring		$100,000
Bailey Treatment Credit		-$860,000
Total O&M		**$2,580,000**
Total Annualized Cost		**$5,610,000**
Annual Yield AF		**6500**
Unit Cost ($/1000gal)		**$2.60**
Unit Cost ($/AF)		**$860**

Notes:
FAT assumes 90% recovery from UF/MF 80% recovery
from RO
95% UVT assumed for UV/AOP process
Feed flow assumed 8 MGD
Assuming 4 pumps (1 standby) pumping 1200 GPM 24/7
Rate of 4% assumed over 30 year life
Pumping costs from equalization basin and other costs are assumed to be taken into account by contingency.

DPR Treatment Options Alternative #3 VWRF to Avenue Treatment Plant City of Buenaventura		
Project Element		**Cost Estimate**
Pump Station		$870,000
Pipeline (Ventura to Avenue Treatment Plant)		$7,441,350
FAT		$25,009,800
Storage (2 x 4 MGD) + Eq basin		$5,500,000
Bailey RO Credit		-$8,750,000
Total		**$30,080,000**
Construction Contingency	30.00%	$9,024,000
Subtotal		$39,104,000
General Contractor Overhead+Profit	10.00%	$3,910,400
Subtotal		$43,014,400
Sales Tax (7.25% of 50% of Total Cost)	7.25%	$1,417,520
Total Capital Cost + (30% Contingency)		**$44,440,000**
Engineering	30%	$13,332,000
Land Acquisition	0	$0
Total Estimated Project Implementation Cost		**$57,780,000**
Annualized Construction Cost		**$3,341,423**
O & M Pump Station + Pipeline	2.50%	$207,784
O & M Treatment (FAT)		$3,087,500
O&M Storage/Chlorination	2.00%	$110,000
Advanced Monitoring		$100,000
Bailey Treatment Credit		-$860,000
Total O&M		**$2,650,000**
Total Annualized Cost		**$6,000,000**
Annual Yield AF		**6500**
Unit Cost ($/1000gal)		**$2.80**
Unit Cost ($/AF)		**$920**

Notes:
FAT assumes 90% recovery from UF/MF 80% recovery
from RO
95% UVT assumed for UV/AOP process
Feed flow assumed 8 MGD
Assuming 4 pumps (1 standby) pumping 1200 GPM 24/7
Rate of 4% assumed over 30 year life
Pumping costs from equalization basin and other costs are assumed to be taken into account by contingency.

IPR Treatment Option City of Ventura		
Project Element		**Cost Estimate**
Pump Station		$870,000
Pipeline (Ventura to Bailey Treatment Plant)		$5,872,400
FAT (Total Implementation Cost)		$25,009,800
Injection Wells + Monitoring Wells		$10,000,000
Additional Extraction Well		$3,450,000
Bailey RO Credit		-$8,750,000
Total		**$36,460,000**
Construction Contingency	30.00%	$10,938,000
Subtotal		$47,398,000
General Contractor Overhead+Profit	10.00%	$4,739,800
Subtotal		$52,137,800
Sales Tax (7.25% of 50% of Total Cost)	7.25%	$1,718,178
Total Capital Cost + (30% Contingency)		**$53,860,000**
Engineering	30%	$16,158,000
Land Acquisition	0	$0
Total Estimated Project Capital Cost		**$70,020,000**
Annualized Capital Cost		**$4,049,264**
O & M Pump Station + Pipeline	2.00%	$134,848
O & M Wells	2.00%	$269,000
O & M Treatment (FAT)		$3,087,500
Bailey Treatment Credit		-$860,000
Total O&M		**$2,640,000**
Total Annualized Cost		**$6,690,000**
Annual Yield AF		**6500**
Unit Cost ($/1000gal)		**$3.10**
Unit Cost ($/AF)		**$1,000**

Notes:
FAT assumes 90% recovery from UF/MF 80% recovery
from RO
95% UVT assumed for UV/AOP process
Feed flow assumed 8 MGD
Assuming 4 pumps (1 standby) pumping 1200 GPM 24/7
Rate of 4% assumed over 30 year life
Pumping costs from equalization basin and other costs are assumed to be taken into account by contingency.