CITY OF VENTURA

RECYCLED WATER MARKET STUDY

PHASE 1 REPORT

DRAFT
January 2010

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CITY OF VENTURA

RECYCLED WATER MARKET STUDY

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1.0 INTRODUCTION

The City of Ventura owns and operates the Ventura Water Reclamation Facility (VWRF), which discharges tertiary treated municipal wastewater to the Santa Clara River Estuary (Estuary) just south of the City near the mouth of the Santa Clara River. 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 Regional Board 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). Work plans establishing the breadth and scopes for the special studies were submitted to the Regional Board in September 2008 and approved in December 2008.

The special studies include:

- Estuary Subwatershed Study – evaluating the physical and biological function of the Estuary affected by the discharge to determine whether the discharge to the Estuary provides an ecological enhancement now or under different conditions such as a decreased discharge to the Estuary.

- Treatment Wetlands Study – to evaluate the feasibility of implementing a constructed treatment wetland to further improve the water quality of the VWRF tertiary discharge by reducing copper, other metals, and nutrient concentrations to meet effluent limits and further promote receiving water quality improvements.

- Recycled Water Market Study – to evaluate and quantify the feasibility of expanding the City’s existing reclaimed water system through evaluation of potential users within a five-mile radius of the VWRF (study area).

The Estuary Subwatershed Study and the Treatment Wetlands Feasibility study are documented separately. This report focuses on the Recycled Water Market Study.

1.1 Purpose and Scope of Study

The purpose of the Recycled Water Market Study is to quantify and evaluate expansion of the City’s existing recycled water system within a 5 mile radius from the VWRF. The study includes identification of potential uses in the study area, review of regulations, evaluation of water quality for specific recycled water uses, evaluation of any necessary water quality improvements, development of preliminary alternatives, and planning level estimation of associated costs.

This study evaluates the potential recycled water market for urban irrigation, agricultural irrigation and groundwater recharge. There are many scenarios where these uses could be combined into integrated recycled water system alternatives. This analysis will be conducted after the Estuary Subwatershed Study is completed and will be the topic of subsequent reports.

The scope of this study does not include a regional water management analysis. This type of analysis would include evaluation of regional water supplies (potable supplies and gray water), water demands, wastewater flows, stormwater, water conservation, etc. The City is in the process of updating their Water Master Plan, Urban Water Management Plan, and Wastewater Master Plan, which include analysis of some of these issues.

1.2 Previous Recycled Water Reports and Studies

In 2007, Kennedy Jenks (K/J) prepared a study on the potential recycled water market within the City of Ventura (K/J, 2007). The K/J (2007) study focused on urban irrigation uses. In addition, irrigation of citrus crops was included, assuming a 1:1 dilution with potable water to meet water quality requirements for citrus crops. The total demand within the city limits (some locations greater than 7 miles from the VWRF) was estimated at 1.3 mgd.

K/J also prepared the first phase of a recycled water master plan for the City of Oxnard (K/J, 2009). The Oxnard master plan is relevant because the 5-mile radius study area for this study includes areas within the City of Oxnard. The master plan indicates that it is possible that the City of Oxnard may provide recycled water to the River Ridge Golf Course in the future. In addition, the master plan suggests that the use of recycled water from the City of Oxnard for groundwater recharge at United Water Conservation District's facilities is also possible, but that additional feasibility analysis needs to be conducted as part of Phase 2 of the master plan.

2.0 BACKGROUND

2.1 Study Area

San Buenaventura, commonly referred to as Ventura, is located 62 miles northwest of Los Angeles, CA. The city is located in Ventura County and encompasses an area of approximately 21 square miles. Ventura is bordered on the northwest by the Ventura River and on the south by the Santa Clara River.

Ventura is a coastal community with a population of approximately 109,000 people. Land use in the City has changed over time, from predominantly agricultural land use to a mix of land uses including residential, commercial, agricultural, industrial, and institutional areas. Table 1 summarizes the information on land use types and areas in the General Plan Boundary provided in the 2005 General Plan.

Table 1	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

The study area for this project is a 5 mile radius from the VWRF. Figure 1 presents a map of the City of Ventura, and includes the location of the VWRF and the 5 mile radius study area.

2.2 Water and Wastewater Systems

The City of Ventura provides water and sewer connections to over 109,000 people in the community. Details on the City's water system are included in the City of Buenaventura Water Master Plan - Draft (RBF, 2008). The City is in the process of updating the City of Buenaventura Wastewater System Master Plan.

2.2.1 Water Sources and Facilities

The City water service area includes all areas within the City limits, unincorporated areas within Ventura County, and the Saticoy Country Club area. The system includes treatment plants, pump stations, reservoirs and a distribution system. In 2008, the City produced approximately 18,400 acre-feet (AF) of potable water for its customers.

Potable water sources include sub-surface withdrawal from the Ventura River via a shallow collection system and groundwater wells, the Oxnard Plain, Santa Paula, and Mound groundwater basins, and potable water purchased from the Casitas Municipal Water

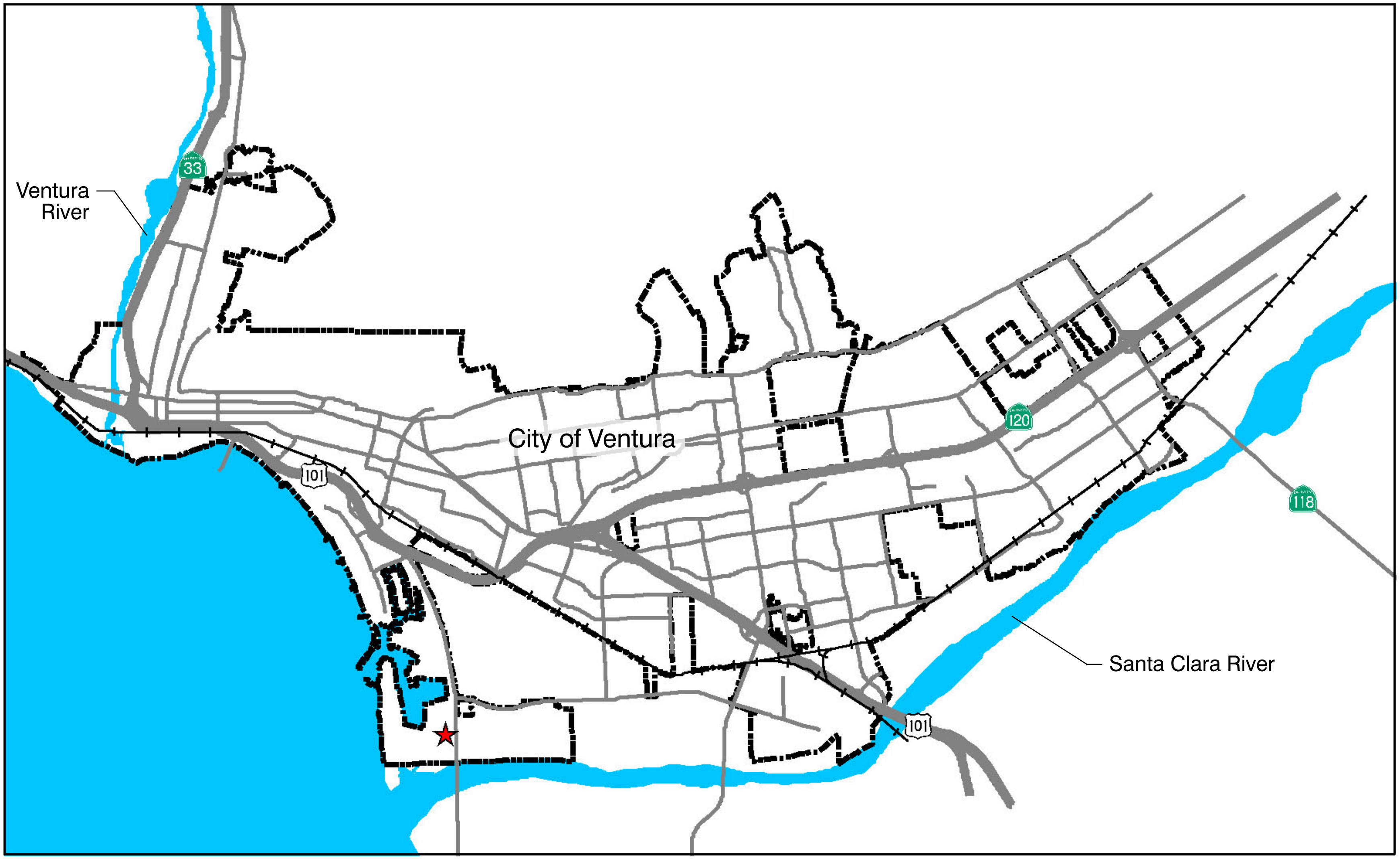

Figure 1
CITY OF VENTURA MAP
SPECIAL STUDIES FOR THE
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District (CMWD). Water from the Ventura River is treated at the Ventura Avenue Treatment Plant. Water from the Oxnard Plain and Santa Paula basins is treated at the Saticoy Conditioning Facility, while water from the Mound groundwater basin is treated at the Bailey Conditioning Facility. Potable water from the CMWD is delivered to the City via two turnouts.

In addition, potable demands are offset with the use of recycled water by several customers. The existing recycled water system is discussed in Section 3.5.

2.2.2 Wastewater Facilities

The City provides wastewater collection and treatment services to approximately 98 percent of City residences as well as for McGrath State Beach Park and the North Coast Communities (Ventura County Service Area 29). The wastewater system consists of the collection system, lift stations and a treatment facility.

The Ventura Water Reclamation Facility (VWRF) is a tertiary treatment plant that consists of screenings and grit removal, primary sedimentation, flow equalization, activated sludge nitrification and partial denitrification, tertiary filters, ammonia addition, and chlorination. In addition, solids processing consists of a primary sludge thickener, dissolved air flotation (DAF) secondary sludge thickener, anaerobic digestion, and dewatering. The City is currently in the process of implementing improvements to their activated sludge system to achieve full nitrification and denitrification (to less than 10 mg/l nitrate plus nitrite). Figure 2 presents a schematic of the existing treatment plant processes.

Treated wastewater is conveyed to a system of wildlife ponds prior to final discharge to the Santa Clara River Estuary. Prior to entering the ponds, a portion of the treated wastewater is diverted as recycled water for landscape irrigation by several users. Additional discussion on the existing recycled water system and regulations is included in Sections 3.5 and 4.1, respectively.

2.3 Regulatory Setting

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

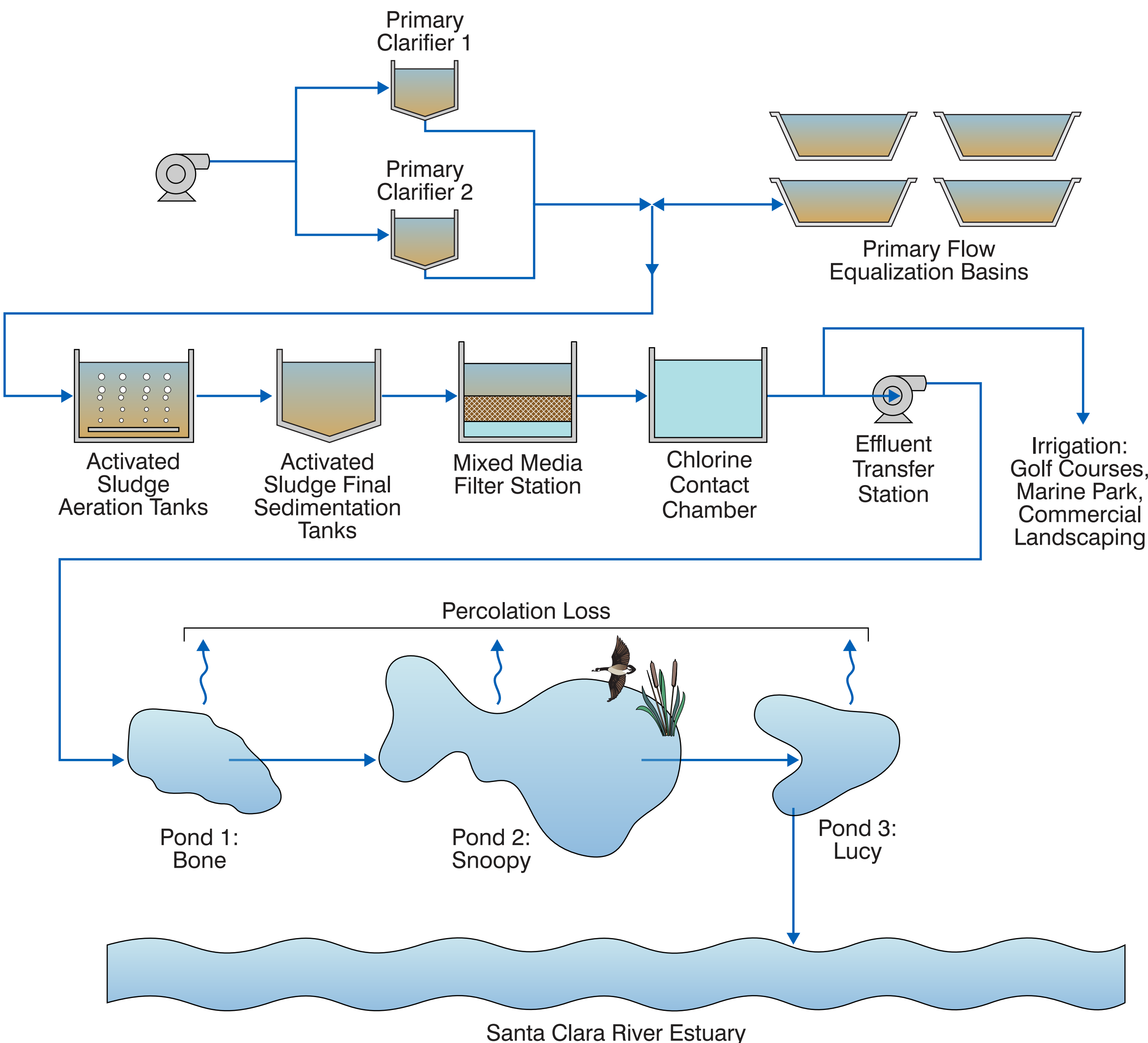

Figure 2
VWRF TREATMENT PROCESS SCHEMATIC
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the State's waters. The State Water Resources Control Board (SWRCB) and the nine Regional Water Quality Control Boards (RWQCBs) meet this requirement by establishing water quality criteria in regional Basin 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.

Detailed discussions of regulations pertaining to various types of recycled water use are included in Sections 4, 5 and 6.

2.4 Assumptions

As mentioned previously, a detailed analysis of existing and future water supplies/demands and wastewater flows was not conducted as part of this study. Several assumptions regarding the water and wastewater systems were made for the purpose of evaluating the recycled water market, developing preliminary alternatives, and developing planning level costs:

- The current VWRF influent annual average flow is approximately 9 mgd. A future annual average flow of 12 mgd was assumed based on a 25 percent increase from the existing flow. Sizing of the recycled water infrastructure and cost estimates were based on an annual average flow of 12 mgd.

- While the City's potable water sources and treatment facilities may experience some changes in the future, it is assumed that these changes will not significantly impact the overall VWRF influent salt and chloride concentrations.

2.5 Existing Recycled Water System

2.5.1 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 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.

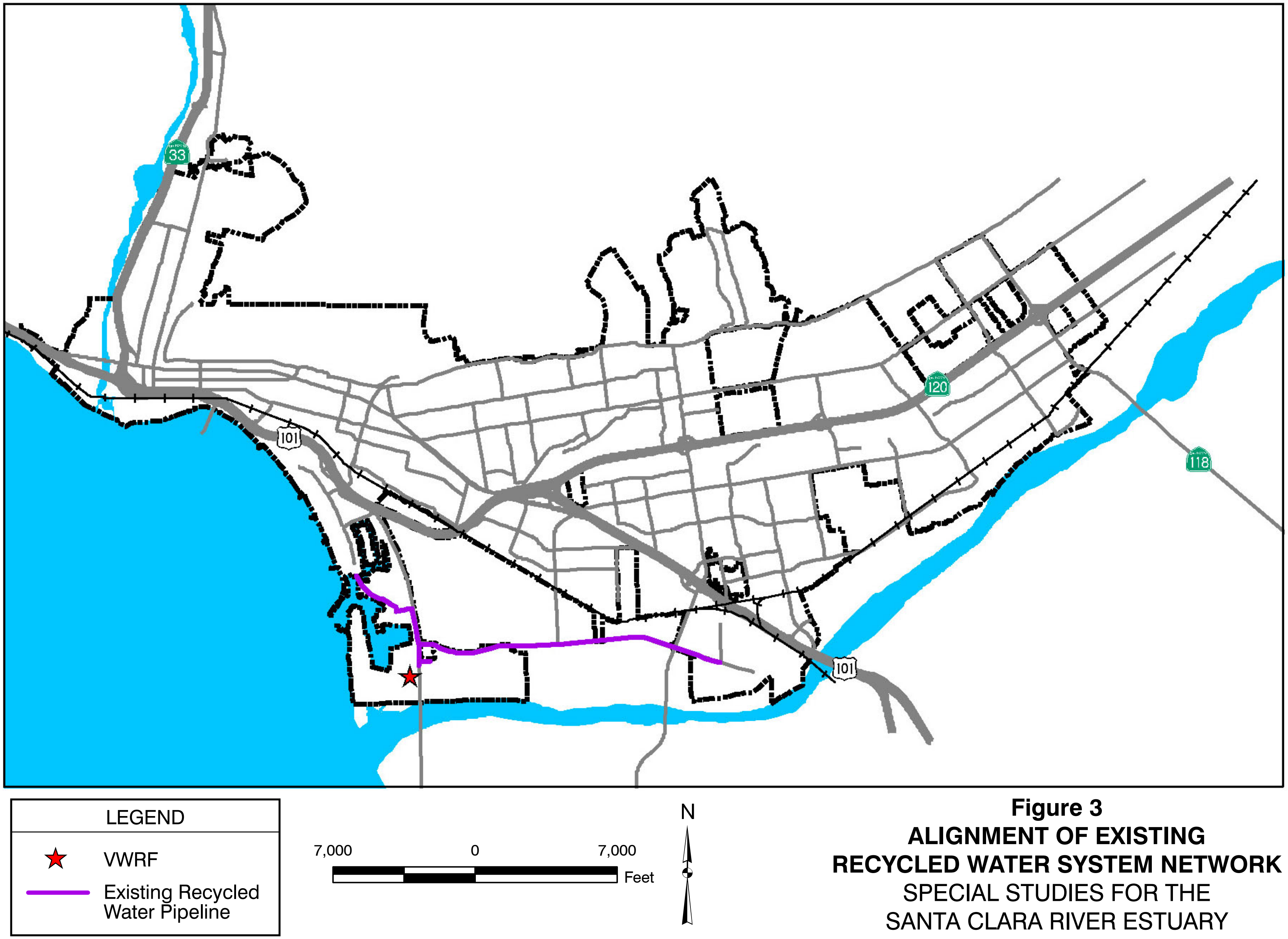

Figure 3
ALIGNMENT OF EXISTING RECYCLED WATER SYSTEM NETWORK
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2.5.2 Current Users and Demands

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

- Golf courses - Olivas Links Golf Course and Buenaventura Golf Course
- Parks - Marina Park
- Others - Landscape irrigation near Olivas Drive and in the Harbor area.

Figure 4 presents the total historical monthly average demands from 2006 through 2008. The recycled water demand varies seasonally with minimum demands in the winter and maximum demands in the summer. Monthly demands range from approximately 14 AF (0.2 mgd) to 93 AF (1 mgd), with an average demand of 49 AF (0.6 mgd).

The demands vary significantly across the recycled water customers. Figures 5 through 7 show the individual monthly demands for each user (note the differences in the y-axis scales in these figures). The two golf course customers, Olivas Links Golf Course and the Buenaventura Golf Course, account for between 78 percent and 91 percent of the total recycled water demand.

3.0 OVERVIEW OF RECYCLED WATER MARKET

The recycled water opportunities within a 5 mile radius from the VWRF were evaluated in this study. Using GIS layers including land use and planning designations, and City water billing records, an initial assessment of the different types of potential recycled water use was conducted. 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, this study focused on this opportunity because of these existing facilities, an existing source of diluent water, and potential available capacity.

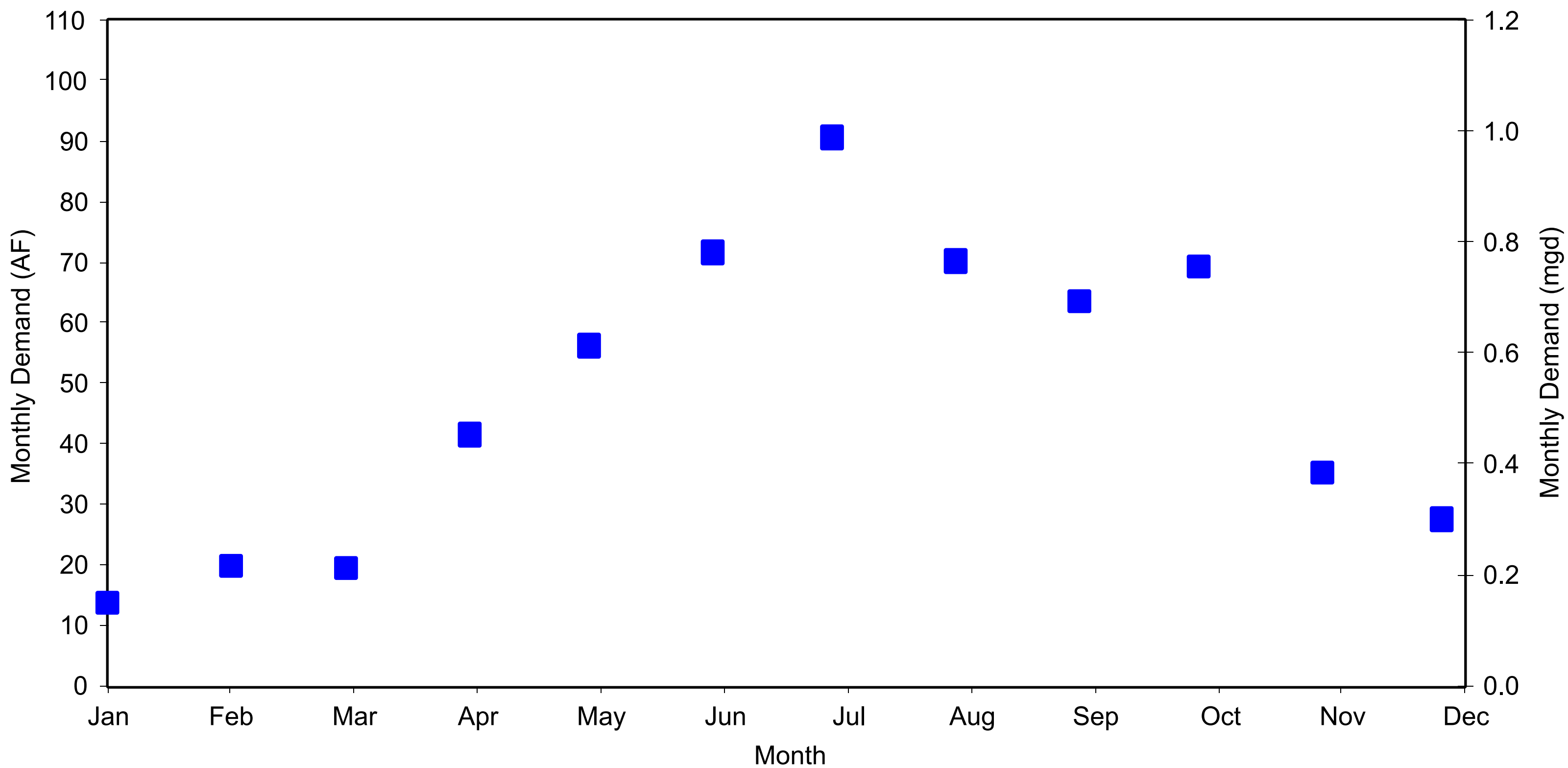

Figure 4
TOTAL MONTHLY AVERAGE RECYCLED WATER DEMANDS
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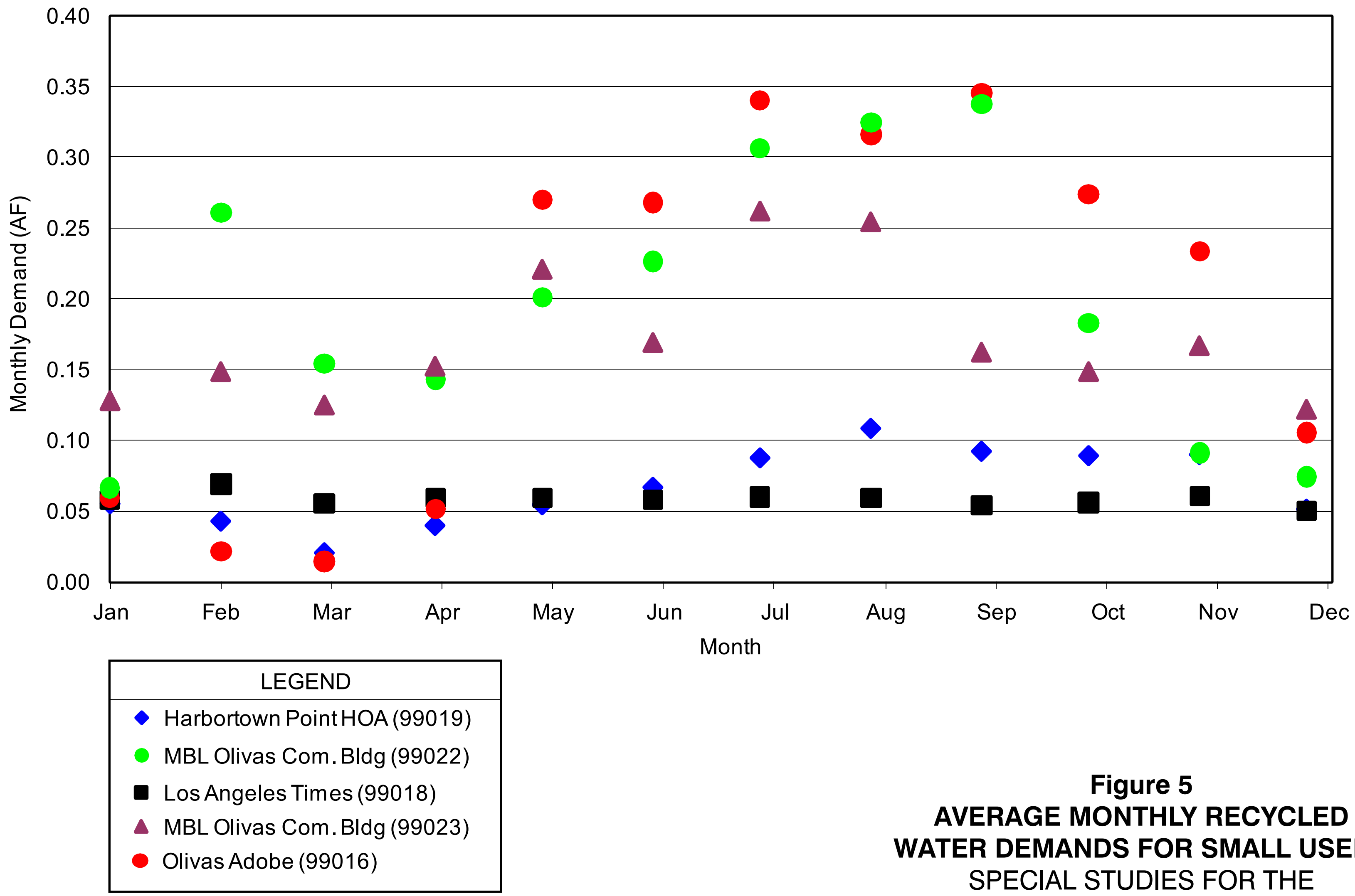

Figure 5
AVERAGE MONTHLY RECYCLED WATER DEMANDS FOR SMALL USERS
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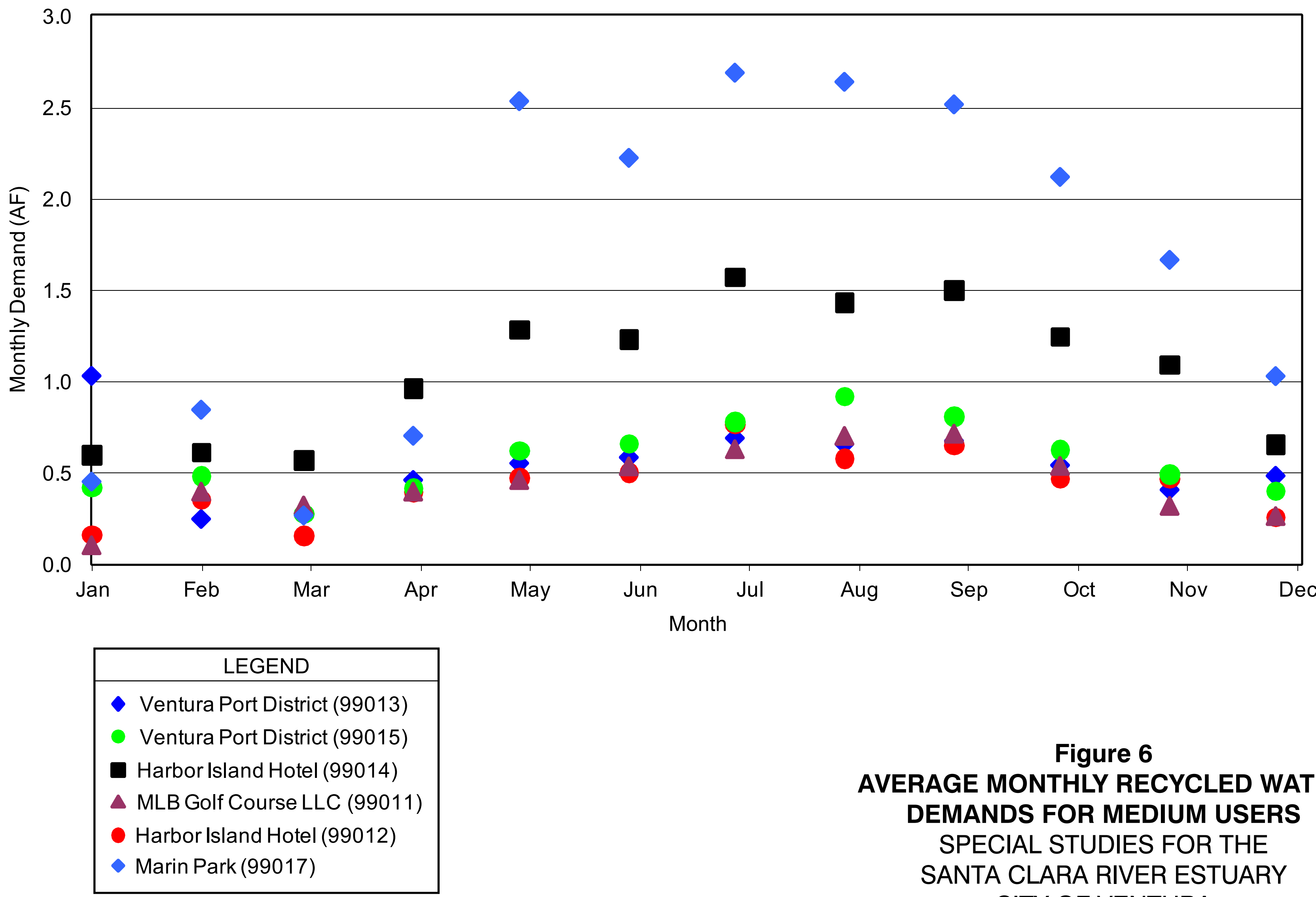

Figure 6
AVERAGE MONTHLY RECYCLED WATER DEMANDS FOR MEDIUM USERS
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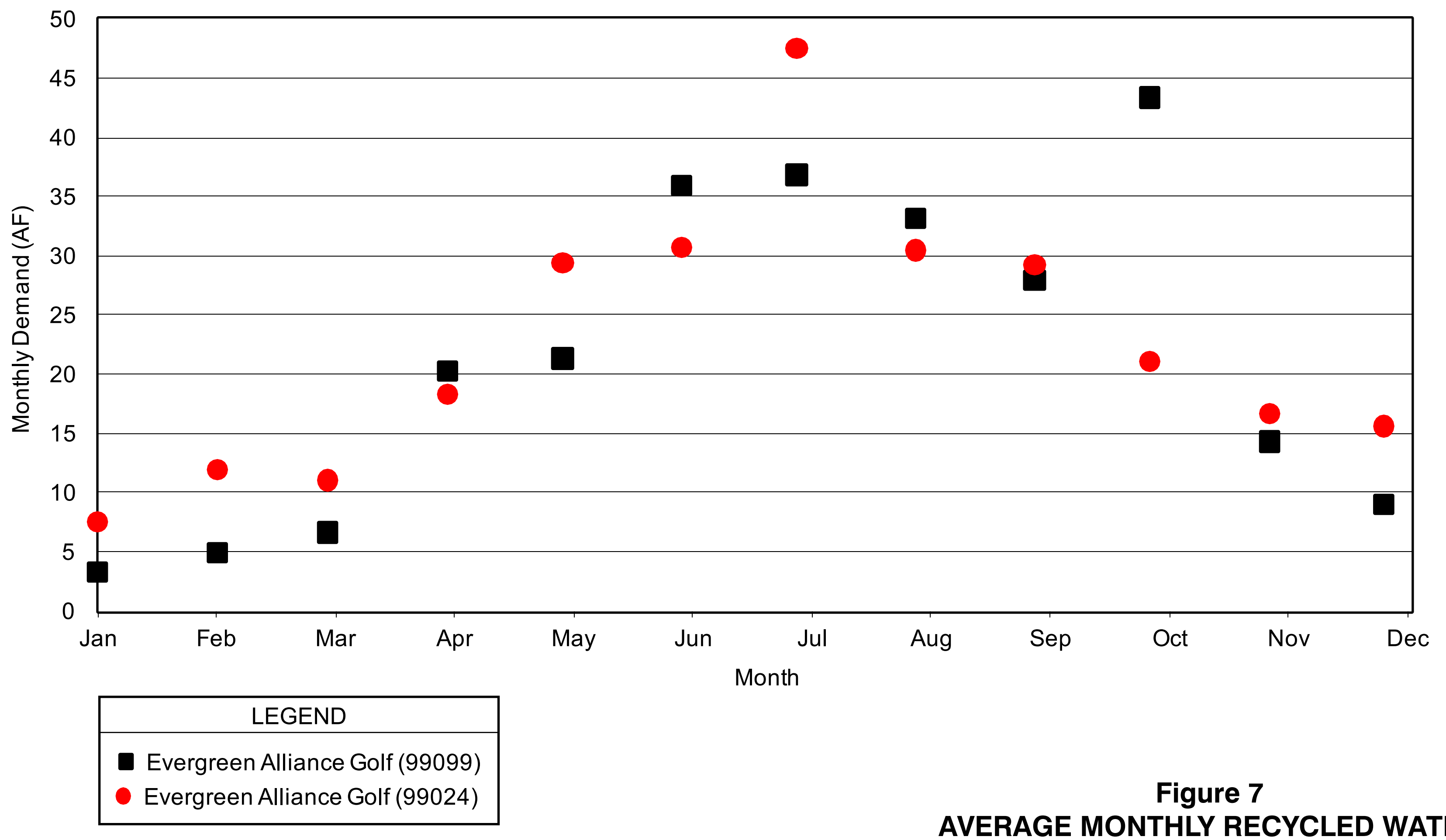

Figure 7
AVERAGE MONTHLY RECYCLED WATER DEMANDS FOR LARGE USERS
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Sections 5, 6 and 7 provide detailed discussions of the recycled water market opportunities associated with urban uses, agricultural uses and groundwater recharge, respectively. Each section includes an overview of existing and future regulations, water quality analysis specific to the use, improvements in water quality (if necessary), market identification and quantification, and preliminary alignment alternatives. Sections 8 and 9 include the planning level cost estimates, and an alternatives summary, respectively. All alternatives assume that recycled water will continue to be provided for existing recycled water customers.

4.0 RECYCLED WATER FOR URBAN IRRIGATION

This analysis focuses on evaluating the opportunities to use recycled water for general landscape irrigation within the study area.

4.1 Recycled Water Regulations

4.1.1 Existing Regulations

As mentioned previously, the SWRCB and the RWQCBs have regulatory authority along with the California Department of Public Health (CDPH) over projects using recycled water. The City of Ventura is in the jurisdiction of the Los Angeles Regional Water Quality Control Board (LARWQCB). The following sections summarize existing regulations that govern recycled water systems.

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 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.

Table 2 Approved Uses of Recycled Water
Recycled Water Market Study-Phase 1 Report
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.

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. After salt/nutrient management plans are developed, they will govern whether anti-degradation analyses are necessary for specific projects.

The RW Policy specifies that a Blue-Ribbon Advisory Panel be convened to guide future actions with respect to Compounds (or Contaminants) of Emerging Concern (CECs). If any regulations arise from new knowledge of risks associated CECs, then projects will be given compliance schedules.

4.1.2 Future Regulations

Future regulatory considerations for the use of recycled water consist of the anticipated updates to the 2010 California Plumbing Code, and also potential regulation of CECs.

California Plumbing Code

Updates to the California Plumbing Code include changes to sections pertaining to installing dual plumbing for recycled water and gray water. These changes pertain to Chapter 16 of Title 24, Part 5 of the California Code of Regulations, and if approved, will be adopted into the 2010 Plumbing Code that will go into effect in January 2011.

Contaminants of Emerging Concern

The term “contaminant of emerging concern” (CEC) is being used within the EPA Office of Water and includes chemicals and other substances that have no regulatory standard, have been recently “discovered” in natural streams, and potentially cause deleterious effects in aquatic life at environmentally relevant concentrations.

CECs include several types of chemicals:

- Persistent organic pollutants (POPs) such as polybrominated diphenyl ethers (PBDEs; used in flame retardants, furniture foam, plastics, etc.) and other organic contaminants.
- Pharmaceuticals and personal care products (PPCPs), including a wide suite of human prescribed drugs, over-the-counter medications, bactericides, sunscreens, and synthetic musks.
- Veterinary medicines such as antimicrobials, antibiotics, anti-fungals, growth promoters and hormones.
- Endocrine-disrupting chemicals (EDCs), including synthetic estrogens and androgens, naturally occurring estrogens, as well as many other compounds capable of modulating normal hormonal functions and steroidal synthesis in aquatic organisms;
- Nanomaterials such as carbon nanotubes or nano-scale particulate titanium dioxide.

Recently, some concerns have arisen regarding the use of recycled water containing CECs. No current regulations are in effect regarding many of these compounds in recycled water. However, the State Recycled Water Policy (Section 2.2.2) requires a Blue Ribbon Panel to advise regulators as to the best way to proceed with monitoring for CECs. It will be important to track research and regulations related to the use of recycled water, particularly as related to these concerns.

4.2 Attainment of Existing Recycled Water Regulations

VWRF produces disinfected tertiary recycled water. If regulatory limits are met, then VWRF recycled water is approved for unrestricted irrigation of golf courses, parks, playgrounds, school yards, and other landscaped areas with similar access (unrestricted reuse).

Use of recycled water at Marina Park (existing user) requires that the recycled water meets regulations for unrestricted reuse. VWRF has historically met these requirements but on occasion when high coliform counts were measured, recycled water delivery to Marina Park was temporarily suspended until coliform concentrations decreased to within regulatory limits.

In the past, effluent was withdrawn from the VWRF wildlife ponds and delivered to customers in a pressurized pipeline. As of January 2010, the withdrawal point for recycled water is upstream of the wildlife ponds. This modification will eliminate the contribution of coliform from the wildlife ponds to the recycled water flow. This modification is expected to significantly increase the reliability of the VWRF to deliver recycled water that meets the regulations for unrestricted reuse. Therefore, attainment of regulatory limits for unrestricted reuse is anticipated.

4.3 Water Quality Analysis for Urban Irrigation

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 3 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.

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:

Table 3 Comparison of VWRF Effluent with Irrigation Water Quality Criteria
Recycled Water Market Study-Phase 1 Report
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.

- 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.

4.4 Market Identification and Quantification

4.4.1 Market Identification

Potential users of recycled water for urban irrigation were identified in the study area using several different types of information, including:

- Information provided by the City on potential users and demands in the Recycled Water Focus Area.
- City records of the potable water users with separate irrigation accounts.
- GIS mapping of land use and planning designations.
- Caltrans water accounts.
- Water Master Plan.
- Comprehensive Annual Financial Report (CAFR).
- Pretreatment program.

The City previously identified the Recycled Water Focus area and potential users in this area. Information developed by the city on users and potential demands in the Recycled Water Focus Area was used. City records of potable water users with irrigation accounts were used to identify users that currently use potable water for the purpose of irrigation. The GIS mapping and planning designations were used to identify potential users in addition to those with potable water irrigation accounts. These additional users were identified through mapping analysis and included parks, schools, residential complexes, cemeteries, and others. The water master plan, the CAFR and information from the pretreatment program were all used to identify potential commercial and industrial uses for recycled water. Figure 8 shows the locations of the potential urban recycled water users identified in this study.

4.4.2 Market Quantification

Recycled water demands were estimated using several different methods depending on the source and type of information available. The following discussion includes a description of the approach and assumptions used to estimate the recycled water demands for urban irrigation.

Recycled Water Focus Area

It was assumed that all the potential users in the Recycled Water Focus Area could be converted to recycled water use. The estimated potential annual average demand from this area was 0.05 mgd.

Potable Water Irrigation Accounts

Approximately 450 irrigation accounts were identified in the study area. It was assumed that 100 percent of the potable water demands associated with these accounts could be converted to recycled water demands.

The irrigation account records from July 2008 through June 2009 were used to estimate the potential demand from these users. The billing records include the demands summarized every two months. To develop estimates of the monthly demands, it was assumed that half of the demand occurred in each month.

Mapping

There are hundreds of potable irrigation accounts in the study area. Additionally, there are many potable water users that use potable water for irrigation but do not have separate irrigation accounts with the City. Mapping analysis was conducted to identify and quantify the potential recycled water demands for users that currently do not have irrigation accounts. An additional 15 users were identified including schools, parks, churches, cemeteries, residential developments (Home Owners Associations), municipal properties, and commercial properties. The annual average and monthly demands for these users were based on the demands (per acre) of existing users for landscape irrigation. The total annual unit demand was assumed to be 2 AF/AC/year. GIS mapping was used to calculate parcel areas. These areas were then multiplied by the percentages in Table 4 to account for the fraction of the total parcel area that would provide an irrigation demand. The irrigation percentages were based on information in Metcalf and Eddy (2007).

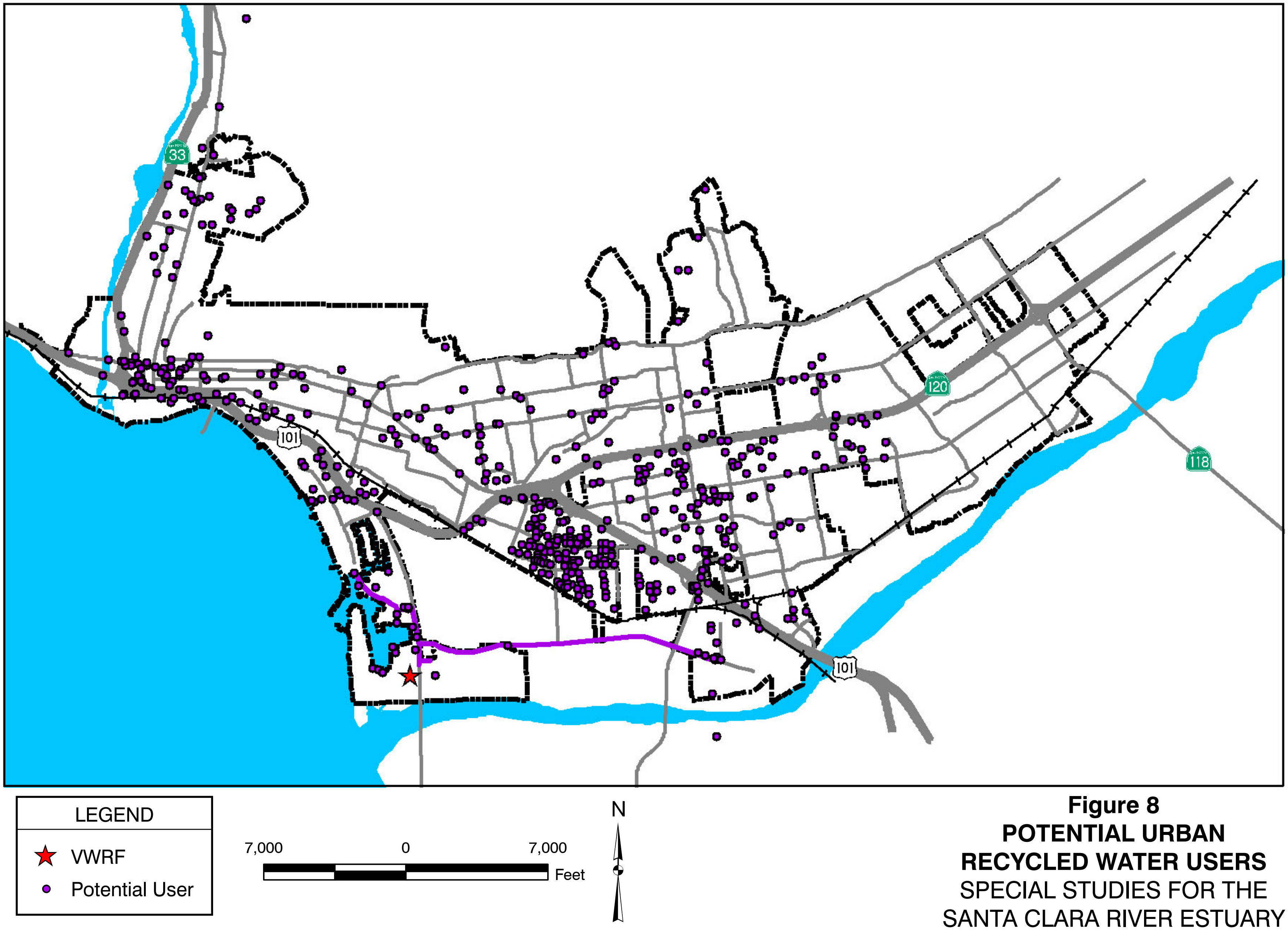

Figure 8
POTENTIAL URBAN RECYCLED WATER USERS
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Table 4	**Irrigation Area Percentages by Land Use Recycled Water Market Study-Phase 1 Report City of Ventura**
Land Use	**Irrigation Area Percentage**
Church	50%
School	50%
Municipal	20%
Park	95%
Cemeteries	95%
Commercial	20%
Residential Developments (Home Owners Associations)	20%

To develop monthly demands, the total annual demand was multiplied by the percentage of use expected during each month. These percentages were developed based on analysis of the monthly demands of existing recycled water users, with exception of the golf courses. Table 5 includes the monthly percentages used to disaggregate the total annual demand into monthly demands.

Table 5	**Monthly Demand Percentages Recycled Water Market Study-Phase 1 Report City of Ventura**
Month	**Monthly Demand Percentage**
January	6%
February	6%
March	4%
April	6%
May	10%
June	10%
July	12%
August	12%
September	12%
October	9%
November	8%
December	6%
Note: Monthly demand percentages based on the monthly demands data (2006 through 2008) for existing users with exception of the golf courses	

One additional user identified in this analysis was the River Ridge Golf Course, located on the south side of the Santa Clara River Estuary. The annual average and monthly demands for this user was based on the demands (per acre) of the two golf courses currently using recycled water. The total annual unit demand was assumed to be 2.7 AF/AC/year. It was assumed that 95 percent of the golf course area would be irrigated. Based on these assumptions the estimated annual average demand for the River Ridge Golf Course is approximately 1 mgd. It is possible that the City of Oxnard will provide recycled water to the River Ridge Golf Course, in which case recycled water from VWRF would not be provided to this user. For the purpose of this study, the potential demand from the River Ridge Golf course was included in the estimated total urban recycled water demand.

To develop monthly demands, the total annual demand was multiplied by the percentage of use expected during each month. These percentages were developed based on analysis of the monthly demands of the two golf courses that currently use recycled water. Table 6 includes the monthly percentages used to disaggregate the total annual demand into monthly demands.

Table 6 Monthly Demand Percentages for the River Ridge Golf Course
Recycled Water Market Study-Phase 1 Report
City of Ventura

Month	Monthly Demand Percentage
January	3%
February	4%
March	4%
April	7%
May	11%
June	11%
July	18%
August	11%
September	11%
October	8%
November	6%
December	6%

Note: Monthly demand percentages based on the monthly demands data (2006 through 2008) for the two golf courses that currently use recycled water

Caltrans Water Accounts

There were 28 Caltrans meters identified in the service area. The areas associated with these meters are currently irrigated with potable water. It was assumed that 100 percent of the potable demand associated with these meters could be converted to a recycled water demand.

To develop monthly demands, the total annual demand was multiplied by the percentage of use expected during each month. These percentages were developed based on analysis of the monthly demands of existing recycled water users, with exception of the golf courses.

Table 5 (above) includes the monthly percentages used to disaggregate the total annual demand into monthly demands.

Industrial Users

The Water Master Plan, the CAFR and information from the pretreatment program were all used to identify industrial users that could be potentially converted to recycled water. Several different types of users were identified, including food processing, electroplating/metal finishing, organic chemicals/plastics processing, electronic component manufacturing, and others.

There are two lemon processing facilities in the study area. While it is possible that recycled water could be used in this process there is no precedent for this type of use in California, most likely due to public perception issues. Therefore, the lemon processing facilities were not included in the urban demands.

The electroplating/metal finishing, organic chemicals/plastics processing, electronic component manufacturing facilities most likely require water with high quality to minimize interferences with process operations. Further investigation of the water quality criteria for individual facilities could be conducted to determine if conversion to recycled water is feasible. However, the total demand from the facilities in these categories is approximately 0.02 mgd. This is a small demand relative to the total urban demand in the study area.

Other industrial users include a car wash and municipal recycling facility. Further investigation into converting these facilities to recycled water use could be conducted. However, the combined demand for these facilities is approximately 0.01 mgd.

Other Users

McGrath State Beach is located south of the Santa Clara River Estuary, opposite the VWRF. Wastewater from McGrath State Beach is treated at VWRF. The recreational areas, including campgrounds, at McGrath State Beach are irrigated. However, there are potential public perception issues associated with using recycled water for irrigating campgrounds. Further coordination with McGrath State Beach staff would need to be conducted to determine the feasibility of using recycled water for onsite irrigation. Therefore, potential demands from McGrath State Beach were not included in the urban demands.

The total potential urban recycled water demand was calculated by summing the demands associated with the Recycled Water Focus Area, irrigation accounts, demands calculated based on the mapping analysis, and the demands associated with Caltrans meters. The total potential urban recycled water annual average demand was estimate at approximately

2.2 mgd. Monthly demands range from 1 mgd to 3.7 mgd. Figure 9 presents the estimated potential monthly urban recycled water demands for all users identified within the 5 mile radius.

4.5 Preliminary Alternatives

Preliminary alternatives for serving the potential urban recycled water users were developed. The VWRF is a centralized tertiary treatment facility that is currently producing recycled water for users in the area, and therefore a logical approach to expanding the recycled water system is to rely on the VWRF for supply of recycled water. An alternative approach is decentralized treatment, where relatively small treatment plants are constructed within a service area and recycled water from these facilities is provided to nearby users. In general, there are several factors/conditions within a service area that lend themselves to decentralized treatment including, relatively high demands from individual users, consistent demands from these users to minimize operational issues with seasonal demands, proximity of the high demand users to points in the collection system where flow is available, and systems where decentralized treatment has the potential to relieve collection system or treatment plant capacity problems. Preliminary analysis suggests that decentralized treatment would not be a cost effective approach for Ventura. However, detailed analysis of decentralized treatment is beyond the scope of this study and should therefore be more fully investigated as part of future work.

This analysis assumes that the source of recycled water is the VWRF. The alternatives consist of pipelines and pump stations required to deliver recycled water from the VWRF to potential urban recycled water users in the study area. Providing recycled water to the largest potential users in the study area was an important consideration in the development of the pipeline alignments.

The urban recycled water network includes several phases of expansion. The existing recycled water system has limited capacity for new users. However, it was assumed that the existing system had sufficient capacity to serve the users in the Recycled Water Focus Area and a limited number of Caltrans sites. This phase of expansion is referred to as the "Existing System Extension". Due to the capacity limitations of the existing recycled water system, all other phases of expansion require a new pipeline to be constructed along Olivas Park Drive.

The urban recycled water network phases of expansion include:

- Existing System Extension - The Existing System Extension is shown in Figure 10. The alignment shown in Figure 10 is consistent with plans to extend Olivas Park Drive further east and north towards Route 101. This extension would serve the users in the Recycled Water Focus Area and four Caltrans sites in the vicinity located along Route 101.

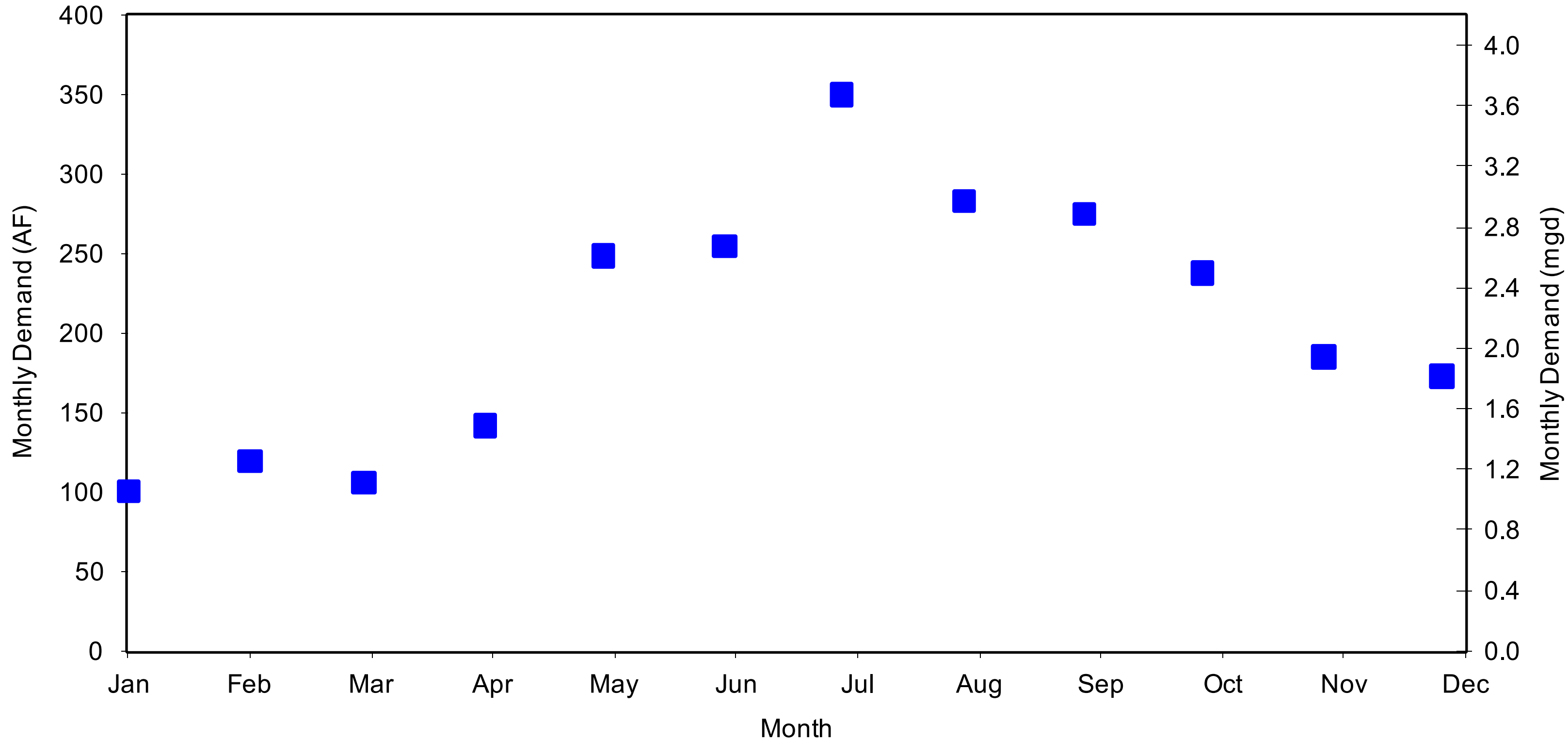

Figure 9
POTENTIAL MONTHLY URBAN IRRIGATION DEMANDS
SPECIAL STUDIES FOR THE SANTA CLARA RIVER ESTUARY
CITY OF VENTURA

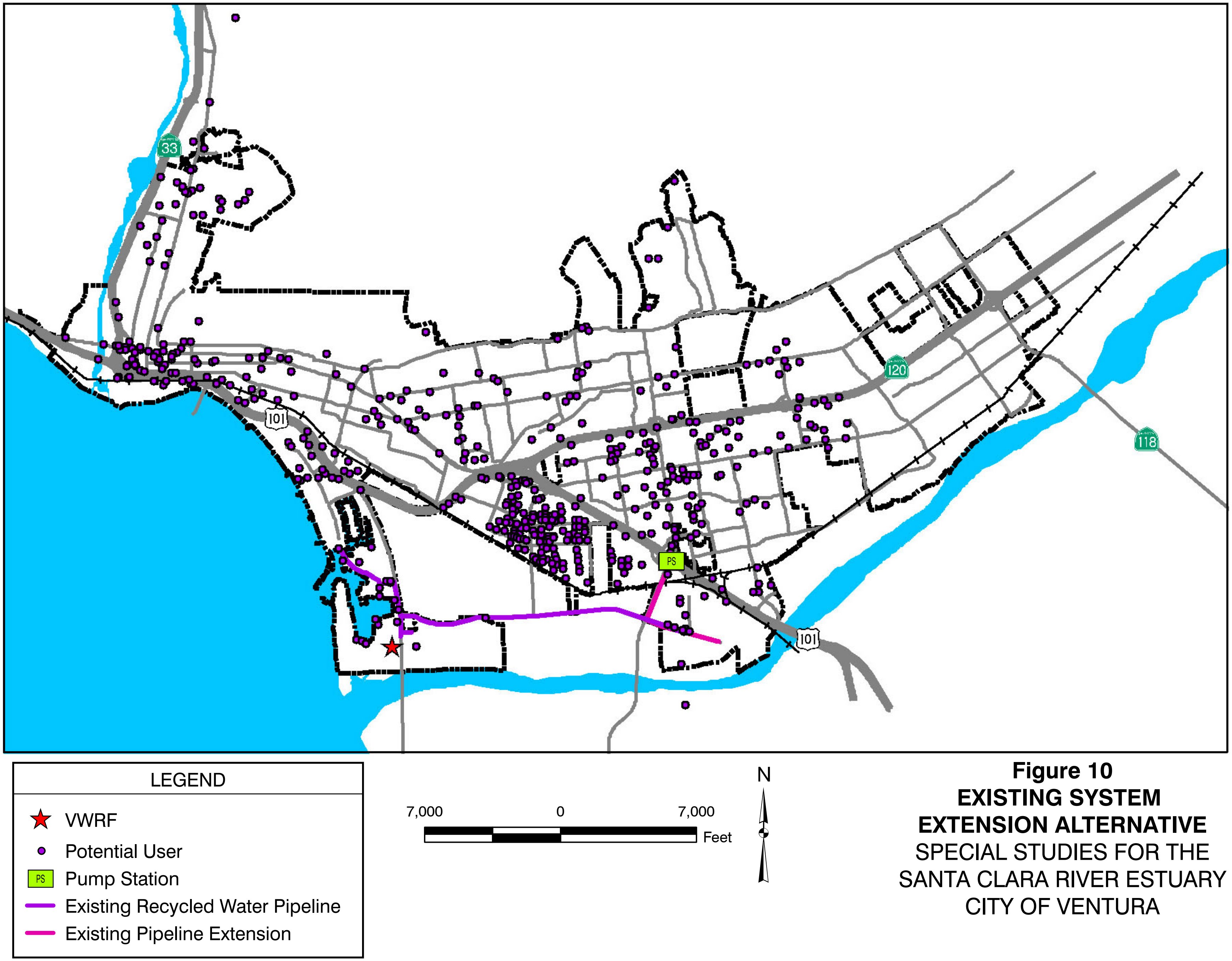

Figure 10
EXISTING SYSTEM EXTENSION ALTERNATIVE
SPECIAL STUDIES FOR THE SANTA CLARA RIVER ESTUARY
CITY OF VENTURA

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- Harbor Area and River Ridge Golf Course Expansion - Figure 11 shows the alignment of a new pipeline that would provide recycled water from the VWRF to users in the harbor located west of the treatment plant and to the River Ridge Golf Course located on the south side of the Santa Clara River Estuary.

- North Expansion - Figure 12 shows the North Expansion. The North Expansion would extend north off the new pipeline along Olivas Park Drive and would provide recycled water to areas both coastal and inland areas.

- East Expansion - Figure 12 shows the East Expansion. The East Expansion would extend east off the North Expansion to provide recycled water to potential users primarily east of Route 101.

- West Expansion - Figure 12 shows the West Expansion. The East Expansion would extend west off the North Expansion to provide recycled water to potential users primarily along the coast and north along Route 33.

The incremental and cumulative demands associated with each expansion phase are summarized in Table 7. These potential demands are in addition to the demands of the existing recycled water users.

Table 7 Incremental and Cumulative Urban Demands by Expansion Phase
Recycled Water Market Study-Phase 1 Report
City of Ventura

Expansion Phase	Incremental Annual Average Demand (mgd)	Cumulative Average Annual Demand (mgd)
Existing System Extension	0.1	0.1
Harbor Area and River Ridge Golf Course Expansion	0.9	1.0
North Expansion	0.5	1.5
East Expansion	0.4	1.9
West Expansion	0.3	2.2

The planning level cost estimates for the pipelines and pump stations associated with each level of expansion are discussed in Section 8.

5.0 RECYCLED WATER FOR AGRICULTURAL IRRIGATION

This analysis focuses on evaluating the opportunities to use recycled water for agricultural irrigation within the study area.

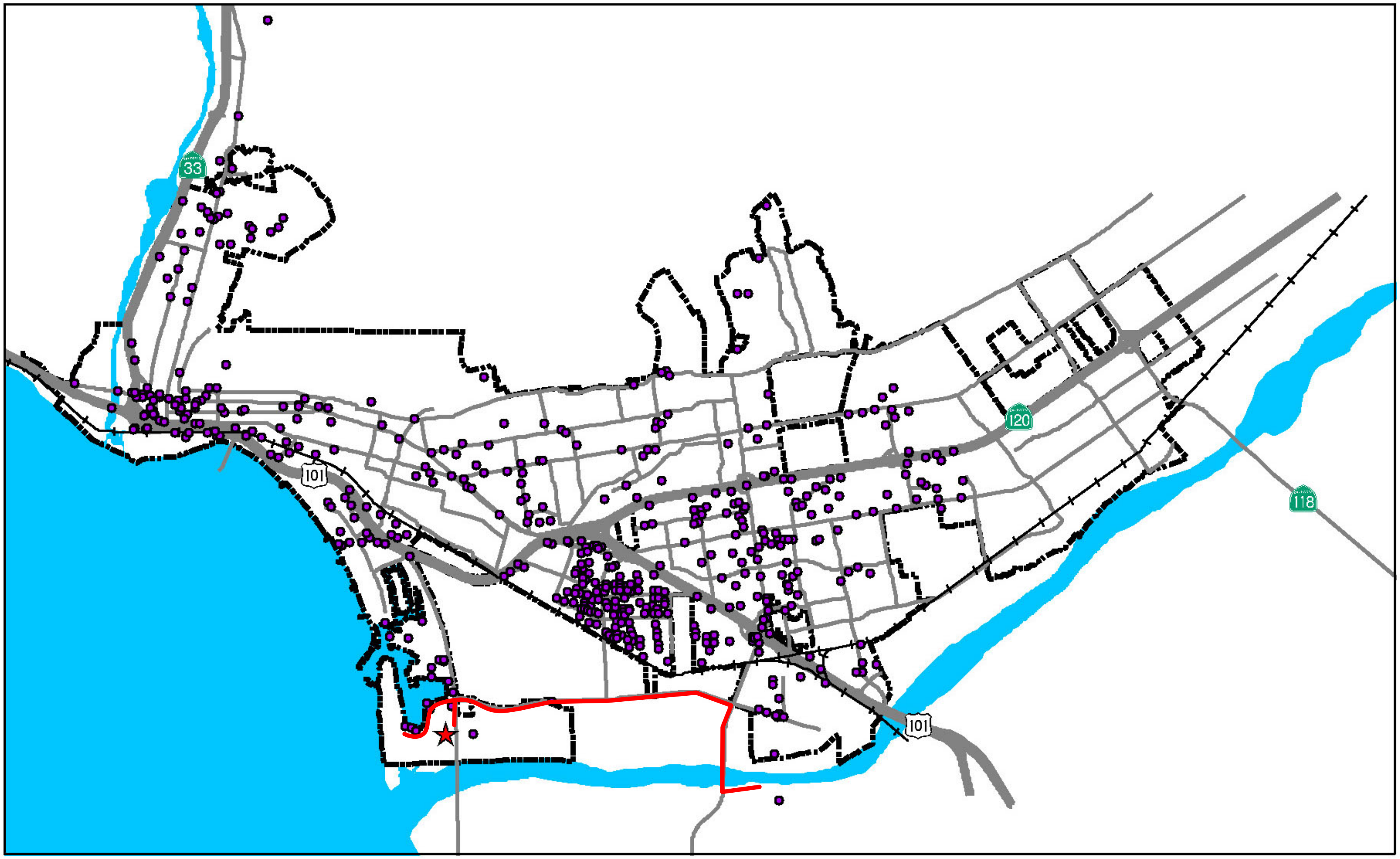

Figure 11
HARBOR AREA AND RIVER RIDGE
GOLF COURSE EXPANSION ALTERNATIVE
SPECIAL STUDIES FOR THE
SANTA CLARA RIVER ESTUARY
CITY OF VENTURA

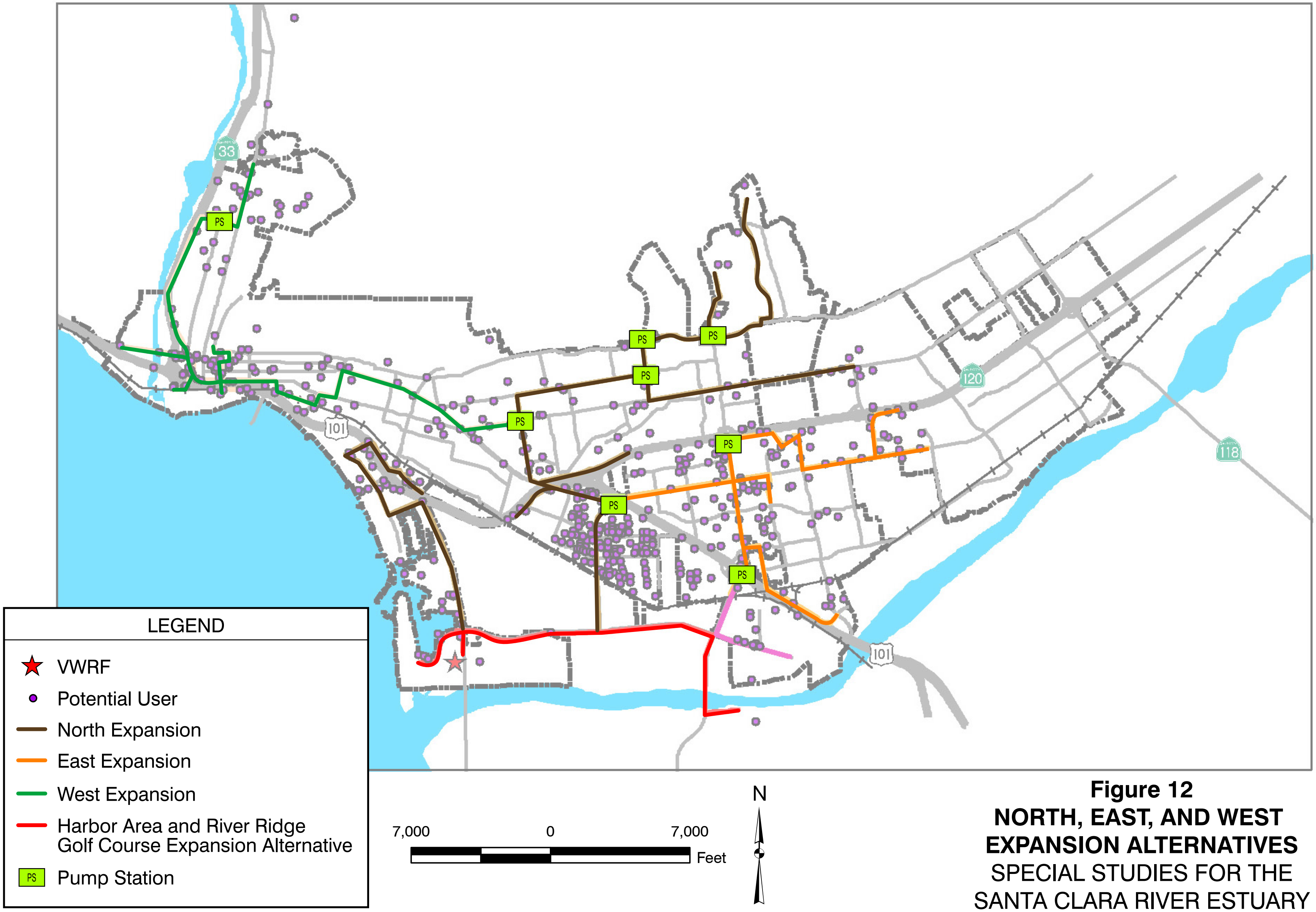

Figure 12
NORTH, EAST, AND WEST EXPANSION ALTERNATIVES
SPECIAL STUDIES FOR THE SANTA CLARA RIVER ESTUARY
CITY OF VENTURA

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5.1 Existing and Future Regulations

As discussed previously, the use of recycled is regulated under Title 22 of the California Code of Regulations. Irrigation of food crops is an approved use for disinfected tertiary recycled water. The ability of the VWRF (existing facilities) to produce recycled water that meets regulatory limits is discussed in Section 5.2. The regulations also specify a 50 foot separation between the irrigated area and potable groundwater wells. For the purpose of this study it was assumed that there were no potable wells within 50 feet of the agricultural parcels.

The discussion in section 6.3.2 includes evaluation of microfiltration (MF) reverse osmosis (RO) for removing TDS and chlorides in order to produce water that meets crop specific water quality guidelines. In addition to removing TDS and chloride, MF and RO are both effective at removing bacteria. Implementation of these processes at VWRF for treatment of some portion of the recycled water flow would contribute to the ability for VWRF to produce water that meets coliform limits for unrestricted reuse.

5.2 Water Quality Analysis for Agricultural Irrigation

Recycled water regulations are developed for the purpose of protecting public health. While a treatment plant can produce water that meets regulations for the irrigation of food crops, the quality of the recycled water may not be acceptable for irrigation of some crops. There are several constituents in recycled water that can adversely affect crop growth and irrigation practices/operations, including salinity, sodium, chloride and boron. Table 3 includes irrigation water quality criteria and a comparison with VWRF effluent. However, this information is generalized and crop specific criteria can be more stringent.

TDS is a measure of salinity and is comprised of inorganic salts and organic solutes. Chloride is an inorganic salt that contributes to TDS. The following discussion makes distinct reference to chlorides because many crops are sensitive to chlorides in particular, and therefore, the TDS and chloride concentrations are both relevant.

The predominant crops in the agricultural areas closest to the VWRF include row crops, strawberries, lemons and avocados. Among these crops, strawberries are the most sensitive to TDS and chloride. The literature includes a range of tolerance levels of specific crops for selected wastewater constituents. The variability in these numbers is due to several factors including:

- Challenges in quantifying the effects of constituents on crop yield.
- Site specific differences between research sites including climate.

- Differences in recycled water application practices (timing and irrigation method).
- Impacts of soil salinity on crop yield.

Table 8 presents constituent ranges for strawberries as well as the median VWRF effluent concentrations and a range of concentrations from groundwater wells located in the vicinity of the agricultural areas both north and south of the Estuary. Groundwater data is provided because growers in the region currently use primarily groundwater for irrigation. Table 9 presents constituent ranges for citrus/lemons and avocados as well as the same data in Table 8 for VWRF effluent and groundwater wells. The concentration limits for strawberries that are cited as "Personal communication with Ben Faber" were provided in the context of the upper limits at which a grower would not be expected to have any problems with irrigation operations/equipment or any reductions in yield of strawberries. These limits are 1000 mg/L TDS, 100 mg/L sodium, 100 mg/L chloride and 1 mg/L boron.

Comparison with VWRF effluent to the constituent limits for strawberries (most sensitive) suggests that the existing effluent quality would compromise or inhibit strawberry growth. The electrical conductance (surrogate for TDS), TDS, SAR, sodium and chloride concentrations of the effluent are well above recommended ranges. In particular, the 100 percent yield recommended concentration for chloride ranges from 100 to 120 mg/L while the median VWRF effluent concentration is 290 mg/L. It is noteworthy that groundwater TDS concentration exceeds the recommended TDS limit but that the groundwater chloride concentration is below the recommended chloride limit.

The water quality analysis for agricultural irrigation suggests that the TDS, SAR, sodium and chloride concentrations of the effluent would need to be reduced to provide acceptable water quality for agricultural irrigation in the region. If the City were to provide recycled water for agricultural irrigation then the approach would be to provide water that would be as good as or better than the groundwater that is currently being used, and would not lead to operational problems or compromise crop yields.

5.3 Water Quality Improvements

The water quality analysis for agricultural irrigation suggests that the TDS, SAR, sodium and chloride concentrations of the effluent would need to be reduced to provide acceptable water quality for agricultural irrigation in the region. Table 10 summarizes the existing VWRF effluent concentrations and the target water quality concentrations for agricultural irrigation.

Table 8 Constituent Ranges for Strawberries
Recycled Water Market Study-Phase 1 Report
City of Ventura

Parameter	Units	Strawberries (100% Yield)	Strawberries (50% Yield)	Strawberries (Yield not Quantified)	VWRF Effluent (Median Value)	Groundwater Wells (Range)[4]
Electrical Conductance	dS/m	<0.5[1] <1.2[2]	<1.1[1] <1.4[2]		2.2	
TDS	mg/L	<300[1] <1000[3]	<700[1]		1,489	1,130 - 2,010
SAR	-	< 5			9.4	
Sodium	mg/L	<100[3]		Range of tolerance 100 – 180 to avoid foliar injury from overhead irrigation	258	
Chloride (general)	mg/L	<100[3] <120[1]		Range of tolerance 175 - 180	290	53 - 106
Boron	mg/L	0.5 – 0.7 <0.5 <1[3]			0.7	
pH	-			6.8 – 7.2	7.3	
Nitrate-N	mg/L NO3-N			Values in water should be factored into fertilizer program	14.6 = 8.9 lbs. N per AF	0.1 - 12

Notes:
(1) Adapted from Thompson et al. (2006)
(2) Personal communication with Stuart Styles (California Polytechnic University)
(3) Personal communication with Ben Faber (University of California Davis, Extension)
(4) Adapted from Ventura County Watershed Protection District (2008)

Table 9 Constituent Ranges for Citrus and Avocados
Recycled Water Market Study-Phase 1 Report
City of Ventura

Parameter	Units	Citrus/Lemons (100% Yield)	Citrus/Lemons (50% Yield)	Citrus/Lemons (Yield not Quantified)	Avocados	VWRF Effluent (Median Value)	Groundwater Wells (Range)[c]
Electrical Conductance	dS/m	<0.7[(1)]	<2.4[(1)]	1500 - 1700[(4)]	1300 [(4)]	2,240	
TDS	mg/L	<400[(1)]	<1,500[(1)]			1,489	1,130 – 2,010
SAR	-			Levels higher than 5 may be acceptable if ECe >1500[(2)]	Levels higher than 5 may be acceptable if ECe >1500 [b]	9.4	
Sodium	mg/L					258	
Chloride (general)	mg/L			Range of tolerance 350 – 875[(5)]	Range of tolerances 180 – 290 [e]	290	53 - 106
Boron	mg/L			<0.75[(1)] 0.5 – 0.7[(6)]	0.5 – 0.7[(6)]	0.7	
pH	-					7.3	
Nitrate-N	mg/L NO3-N					14.6 = 8.9 lbs. N per AF	0.1 - 12

Notes:
(1) Adapted from Thompson et al. (2006)
(2) Adapted from Rhoades et al. 1992
(3) Adapted from Ventura County Watershed Protection District (2008)
(4) Adapted from Rhoades et al. 1992
(5) Adapted from California Fertilizer Association, 1985. Table B-23.
(6) Adapted from California Fertilizer Association, 1985. Table 2-2.

Table 10	Existing VWRF Effluent Concentrations Compared to Concentration Targets Recycled Water Market Study-Phase 1 Report City of Ventura	
Consistent	**Effluent Concentration (median) (mg/L)**	**Target Concentration (mg/L)**
TDS	1,498	1,000
Sodium	258	100
Chloride	290	100
Boron	0.7	1

5.3.1 Source Control

Source control measures can be used to control the contributions of various pollutant sources from the potable water supply through wastewater treatment. The focus of this analysis is TDS and chlorides, as these are the pollutants that most significantly impact the use of recycled water for agricultural irrigation.

The City's potable water sources include both surface water and groundwater sources of varying water quality. The potable water quality provided by these water sources varies by source and is summarized in Table 11. The data in Table 11 was used to calculate the flow weighted average TDS and chloride concentrations in the potable supply. In 2008, the flow weighted average TDS and chloride concentrations in the potable supply were approximately 906 mg/L and 46 mg/L, respectively. The average 2008 VWRF effluent TDS and chloride concentrations were 1,512 mg/L and 298 mg/L, respectively. The average TDS in the potable system is relatively high, and accounts for approximately 60 percent of the TDS in the VWRF effluent. The average chloride in the potable system is relatively low, and accounts for only 15 percent of the chloride in the VWRF effluent. The additions of TDS and chloride between the potable supply and the VWRF effluent were approximately 606 mg/L and 252 mg/L, respectively.

Table 11	Potable Source Water Quality Recycled Water Market Study-Phase 1 Report City of Ventura		
Source	**Usage (AF)**	**Average TDS (mg/L)**	**Average Chloride (mg/L)**
Ventura River	2,711	713	42
Groundwater Wells	9,983	1,296	65
Casitas Municipal Water District	5,659	310	14

Notes:
(1) 2008 Usage data provided by the City of Ventura
(2) Water Quality Confidence Report 2009

In addition to TDS in source waters, there are a number of sources of TDS associated with the treatment and use of water that contribute TDS concentrations in wastewater effluent, including:

- Human excretion.
- Gray water.
- Brines from household self regenerating water softeners (SRWS).
- Swimming pools.
- Industrial and commercial discharges.
- Chemicals used in water and wastewater treatment (Thompson et al., 2006).

The relative contributions of these sources is variable and site specific. For example, Thompson et al. (2006) reported that residential sources of TDS accounted for between 28 percent and 84 percent of the TDS gain at six wastewater treatment facilities.

The City is currently investigating improving the water quality in the potable water that originates from groundwater. It is not anticipated that there will be any significant near-term change in the potable water quality, but it is possible that the current investigation could lead to long-term improvements that would lead to lower TDS concentrations in the potable supply. Therefore, potential source control measures should focus on the contributions of TDS and chloride that result from the treatment and use of water (as listed previously). An investigation of the relative contributions of TDS and chlorides in the VWRF effluent should be conducted to form the basis for identifying and developing source control measures. This analysis would help to understand the potential reductions that could be achieved through source control measures relative to the target reductions in TDS and chloride for use of recycled water for agricultural irrigation.

With that said, one of the most promising source control approaches may be to eliminate the SRWS in the service area. Several utilities have had success in reducing TDS and chloride concentrations as a result of source control measures for SRWS. The TDS concentration from SRWS depends on the hardness of the source water, market penetration, regeneration control, efficiency, indoor water use and fraction of the water softened (Thompson et al. 2006). Thompson et al. (2006) reported results from several utilities and also conducted modeling analysis of the contributions of SRWS. Table 12 presents a summary of some of the analyses.

Until further analysis is completed on the potential long-term changes in source water quality, and the other contributions of TDS and chlorides in the VWRF effluent, it is not possible to accurately quantify the potential TDS and chloride reductions that could be achieved through source control. However, a significant reduction, in chlorides in particular

Table 12	Contributions of TDS and Chloride from SRWS Recycled Water Market Study-Phase 1 Report City of Ventura		
Location	**Market Penetration**	**TDS (mg/L)**	**Chloride (mg/L)**
Rancho Bernando	20%	108	-
Santa Clarita	6% to 15% Older Neighborhoods 51% to 61% Newer Neighborhoods	-	55
Los Angeles	3%	23	-
Model(1)	50%	300 (Low efficiency SRWS) 150 (High efficiency SRWS)	-

Notes:
(1) Model calculations assume a source water hardness of 250 mg/L (grains per gallon), effluent hardness of 35 mg/L (grains per gallon), 80% of interior water is softened, and interior water use is 90 gal/capita-day.
(2) Compiled from data presented in Thompson et al. (2006).

(approximately 190 mg/L), would need to be achieved to attain the target concentration of less than 100 mg/L. It is not likely that source control alone could result in achieving the required chloride reduction. Therefore, it is assumed that treatment to remove salts is required, but that the fraction of water requiring treatment could be reduced if source control measures are successfully implemented in the service area. The reduction in the amount of flow requiring salt removal would potentially lead to lower capital and operations and maintenance (O&M) treatment costs.

5.3.2 Treatment

TDS and chloride can be removed from wastewater using advanced wastewater treatment technologies. Wastewater processes capable of removing TDS, chlorides and other dissolved salts include reverse osmosis and electrodialysis.

RO is a membrane separation process where pressure is applied to the high salinity solution to overcome osmotic pressure and force water to diffuse in the opposite direction across the membrane. Diffusion of water through the membrane results in a relatively ion free effluent stream and a concentrated waste stream (brine), which requires further treatment, and disposal. Brine treatment and disposal alternatives include surface water, sewer, deep well injection, reuse (cooling water or land application), concentration, crystallization and land application, and evaporation ponds. In most wastewater applications, microfiltration (MF) precedes RO in order to provide a high quality feed water to the RO membranes.

Electrodialysis is also a membrane process, where ions migrate through ion-selective semi-permeable membranes under the influence of an electric charge. Electrodialysis units are configured with multiple membranes in a row, which alternately allow positively or negatively charged ions to flow through the membranes. This leads to formation of areas with high and low concentrations of salts. The high concentrated water is re-circulated until concentrations that enable precipitation are achieved. The precipitated salts require disposal. Typical pre-treatment processes for electrodialysis in addition to media filtration include chemical precipitation and activated carbon.

In wastewater treatment, RO has the significant advantage that in addition to removing ions (constituents contributing to salinity) other pollutants are removed. In contrast, electrodialysis only removes ions. In addition, there are multiple, large scale applications of RO in the wastewater treatment industry. For these reasons, RO was investigated as a treatment alternative for removing TDS and chlorides from the VWRF filtered effluent.

Typically MF/RO system are sized to meet specific water quality targets. In many cases, the final effluent is a blend of water that is treated through the MF/RO system and water that bypasses MF/RO treatment. The water quality target for the VWRF effluent is 1,000 mg/L TDS, 100 sodium, 100 mg/L chloride and 1 mg/L boron. The overall removal efficiencies of these constituents by MF/RO is estimated at 99 percent. The greatest percentage concentration reduction of 65 percent is required to reduce the effluent chloride concentration from 290 mg/L to 100 mg/L. Therefore, chloride is the limiting constituent for determining the amount of flow that requires MF/RO treatment. The analysis showed that approximately 70 percent of the flow would need to be treated by MF/RO to achieve the target chloride concentration of 100 mg/L. Table 13 is a summary of the calculation results, and Figure 13 shows a schematic of this treatment approach.

For agricultural irrigation, one disadvantage of RO is that the process also effectively removes nutrients. Depending on nutrient concentrations in the VWRF effluent and the percentage of flow that passes through the RO membrane, growers may need to add nutrients to meet needs for specific crops.

Table 13 Estimated Membrane Treatment Influent, Effluent and Resulting Blended Effluent Concentrations
Recycled Water Market Study-Phase 1 Report
City of Ventura

Source	MF/RO Influent	Approximate MF/RO Effluent	Approximate Blended Effluent
TDS (mg/L)	1498	15	500
Sodium (mg/L)	258	3	90
Chloride (mg/L)	290	3	100
Boron (mg/L)	0.7	0.01	0.2

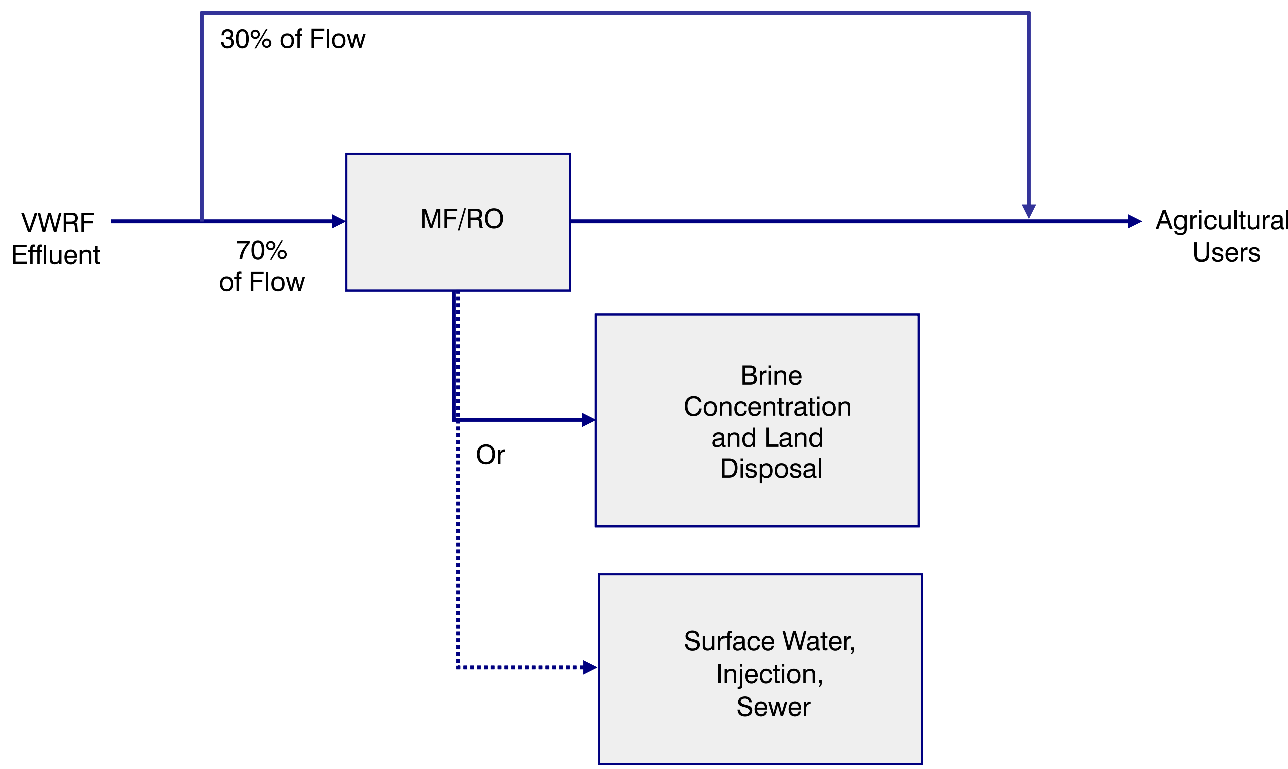

Figure 13
MF/RO TREATMENT PROCESS SCHEMATIC
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CITY OF VENTURA

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As discussed previously, there are several approaches for brine treatment and disposal. The complexity and costs of brine treatment alternatives are variable, and each approach is characterized by advantages and disadvantages. Further investigation of MF/RO treatment of the VWRF effluent for the purpose of using the water for agricultural irrigation will require thorough evaluation of brine treatment and disposal alternatives. There may be opportunities in the region for ocean disposal, deep well injection and/or other approaches. Brine treatment and disposal alternatives were not extensively examined as part of this study. However, for the purpose of calculating the total cost associated with providing recycled water for agricultural irrigation, brine treatment and disposal is assumed to include concentration followed by evaporation ponds. This is a conservative assumption as this approach is relatively expensive. Planning level cost estimates are presented in Section 8.

5.4 Market Identification and Quantification

5.4.1 Market Identification

Potential users of recycled water for agricultural irrigation were identified in the study area using GIS mapping of land use, planning designations and crop boundaries. The five mile radius study area extends both north and south of the estuary.

The metadata associated with the GIS boundary layer provided information on crop type within agricultural parcels. The predominant crops in the parcels closest to the VWRF include row crops, strawberries, lemons and avocados. It was assumed that if the VWRF could produce water quality with acceptable constituent concentrations (via a combination of source control and treatment), that all of the agricultural areas within the 5-mile radius could be converted from irrigation with groundwater to irrigation with recycled water.

The California Mushroom Farm is located along Olivas Park Drive. Most of the water demand from the California Mushroom Farm is used to prepare the substrate for mushroom cultivation. The use of VWRF recycled water for this purpose was investigated. Per discussion with David Beyer (Penn State University), there is little or no precedent for using recycled water to prepare mushroom substrate. Preliminary review of the VWRF water quality suggested the concentrations of TDS and heavy metals may be a concern. However, if MF/RO was implemented for the purpose of reducing TDS and chloride concentrations for irrigating other crops in the area then the water quality may be sufficient for preparing the mushroom substrate, as MF/RO will remove metals as well. Further investigation of the feasibility of using the MF/RO treated water for preparing mushroom substrate would need to be conducted. Therefore, the California Mushroom Farm annual average demand of 0.1 mgd was not included in the agricultural demands presented in the following section.

5.4.2 Market Quantification

GIS mapping was used to calculate the area of the identified agricultural parcels. Irrigation demands vary by crop, ranging from 2 to 4 AF/AC/year (Personal communication with Frank Brommenschenkel (Frank B and Associates), 2009). Crop specific demands were not used for this analysis. A slightly conservative value of 2.5 AF/AC/year was used for all identified agricultural parcels in the study area.

To develop monthly demands, the total annual demand was multiplied by the percentage of use expected during each month. These monthly use percentages were developed based on monthly groundwater usage by growers in the region. Table 14 includes the monthly percentages used to disaggregate the total annual demand into monthly demands.

Table 14 Monthly Demand Percentages for the Agricultural Irrigation
Recycled Water Market Study-Phase 1 Report
City of Ventura

Month	Monthly Demand Percentage
January	2%
February	2%
March	2%
April	6%
May	11%
June	13%
July	14%
August	14%
September	13%
October	12%
November	7%
December	5%

Note: Based on data provided by Frank Brommenschenkel (Frank B and Associates), 2009).

The total potential agricultural recycled water demand was calculated by summing the estimated demands for agricultural parcels located both north and south of the Estuary within the study area. The total potential agricultural recycled water annual average demand was estimated at approximately 14.1 mgd. Monthly demands range from 3.6 mgd to 23 mgd. Figure 14 presents the estimated potential monthly agricultural recycled water demands. Annual average demands from potential users north and south of the Estuary are 6.5 mgd and 7.6 mgd, respectively.

It is assumed that the available annual average recycled water supply is 11.4 mgd, calculated as 12 mgd less the 0.6 mgd annual average demand from existing customers. Therefore, the agricultural demand, estimated at 14.1 mgd, is greater than the supply.

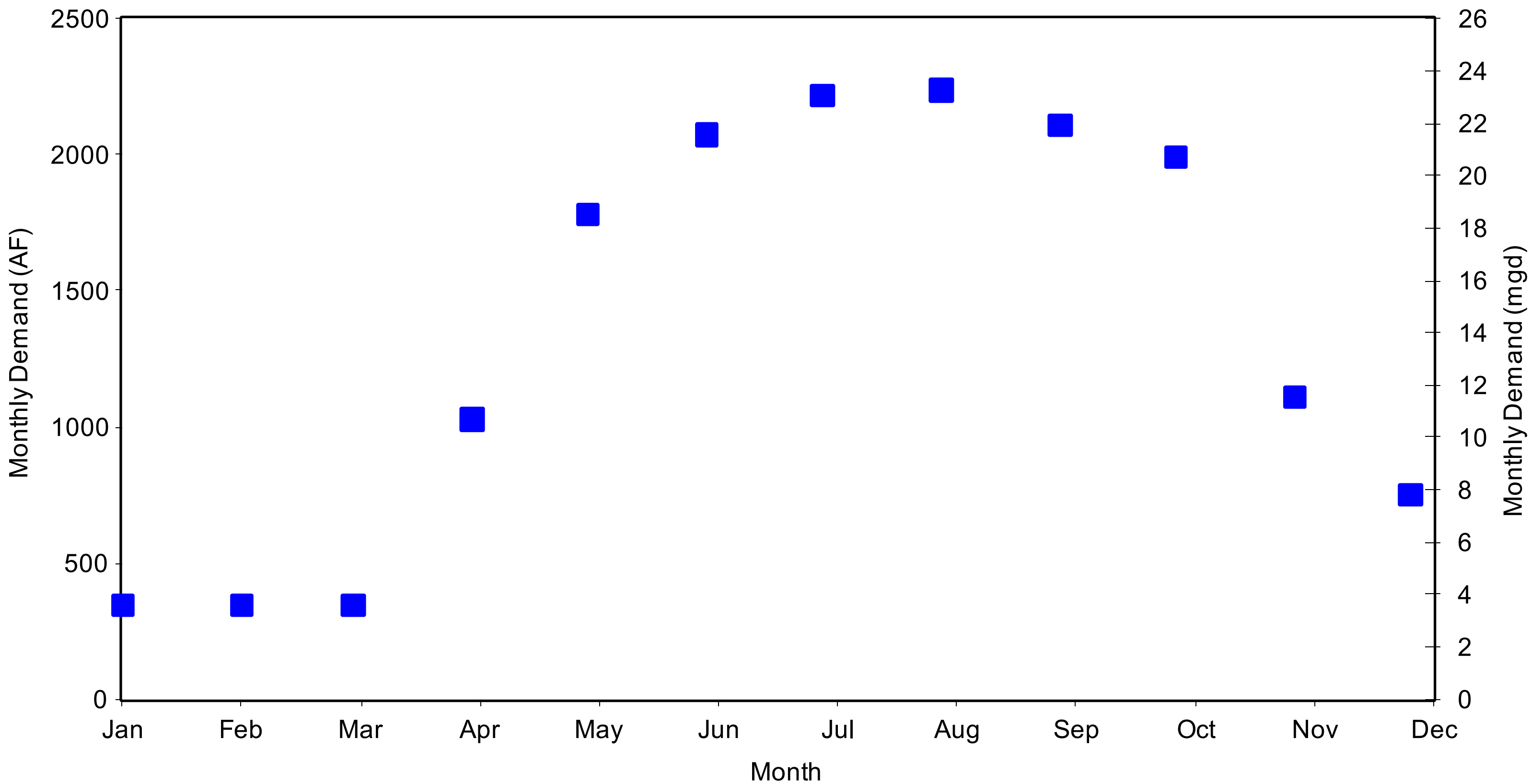

Figure 14
POTENTIAL MONTHLY AGRICULTURAL RECYCLED WATER DEMANDS (NORTH AND SOUTH OF THE ESTUARY)
SPECIAL STUDIES FOR THE SANTA CLARA RIVER ESTUARY
CITY OF VENTURA

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Storage is typically used to accommodate daily, monthly and hourly demand variations. The critical analysis is to determine if there is sufficient storage for the maximum daily demand, such that during the maximum month, these consecutive daily demands do not lead to depleting storage to a point where demands cannot be met.

The existing VWRF wildlife ponds, with a total pond volume of 34 million gallons (MG), are a potential storage location. However, as noted previously, the recycled water withdrawal location has been moved to upstream of the wildlife ponds per RWQCB requirements. It is possible that this would be a requirement in the future and therefore, offsite storage would need to be provided. For the purpose of this analysis, it is assumed that the City would be able to use the wildlife ponds for recycled water storage or that a similar volume of storage would be constructed at an offsite location. The costs in Section 8 do not include construction costs for offsite storage.

Analysis of flows and available storage was conducted to determine the greatest annual average irrigation demand that could be met with a reservoir storage volume of 34 MG. A peaking factor of 1.3 was used to convert the maximum month demand to a maximum day demand. A peaking factor of 3 was used to convert the maximum day demand to a peak hour demand by assuming that irrigation would occur over an 8 hour period. The estimated annual average and corresponding maximum month demands that could be accommodated with the available recycled water supply of 11.4 mgd and 34 MG of storage are 7.3 mgd and 11.8 mgd, respectively.

It is assumed that potential agricultural users north of the Estuary have a higher priority as they are located within the City. If the demands from users south of the estuary are removed then the annual average recycled water demands for the remaining potential users is 6.5 mgd. Monthly demands range from 1.6 mgd to 11 mgd. The average monthly demand from June through October is approximately 10 mgd. Figure 15 presents the estimated potential monthly agricultural recycled water demands excluding potential users south of the Estuary.

It is possible that in the future, the City may need to eliminate the discharge to the Estuary and, therefore, an additional 0.8 mgd annual average demand would need to be reused in addition to the north users. Agricultural irrigation provides sufficient demand to do this in the summer months. Several approaches could be used to attain an zero-discharge condition, including:

- Providing recycled water to some of the agricultural users south of the Estuary
- Providing recycled water to River Ridge Golf Course if the City of Oxnard was not going to provide recycled water to the course
- Providing water to the California Mushroom Farm provided that water quality criteria are met

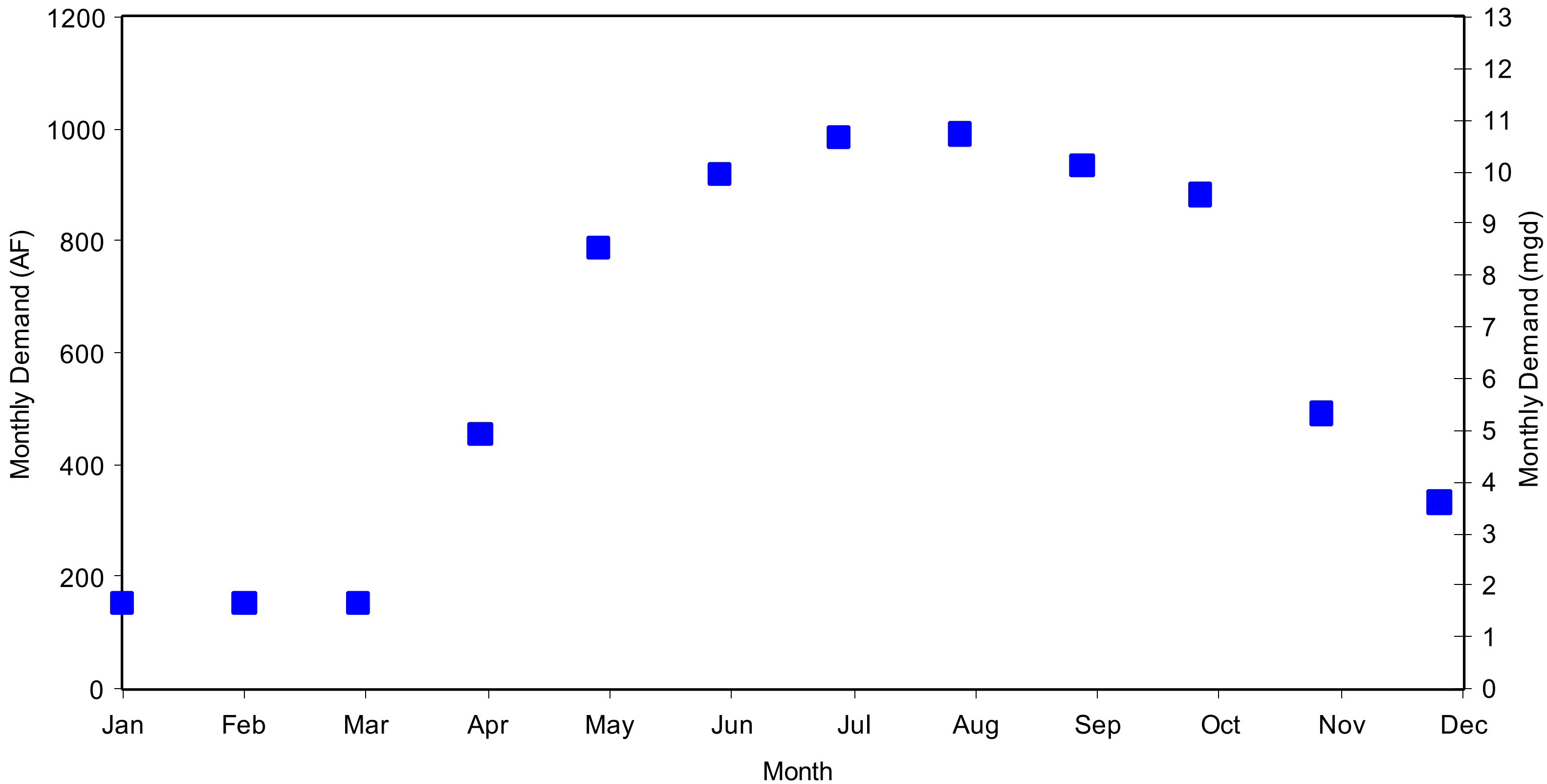

Figure 15
POTENTIAL MONTHLY AGRICULTURAL RECYCLED WATER DEMANDS (NORTH OF THE ESTUARY)
SPECIAL STUDIES FOR THE
SANTA CLARA RIVER ESTUARY
CITY OF VENTURA

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- Providing water to some of the identified urban users located near some of the agricultural users north of the Estuary

The preliminary pipeline alternatives and pipeline cost estimates assume that recycled water will be provided to users north of the Estuary. However, the treatment costs are based on a flow of 11.4 mgd (12 mgd future flow minus existing users) to accommodate the possibility of a zero-discharge condition.

5.5 Preliminary Alternatives

Preliminary alternatives for serving the potential agricultural recycled water users were developed. These alternatives consist of pipelines required to deliver recycled water from the VWRF to potential agricultural recycled water users on the north side of the Estuary. All pipelines are assumed to be new pipelines and not combined with any other recycled water use due to the difference in required treatment. In addition, these alternatives include conversion of a portion or all of the wildlife ponds (depends on demand) to recycled water storage and pump stations to deliver water to the potential agricultural recycled water users.

The agricultural recycled water network includes the following two phases of expansion.

- West of 101 Expansion - The West of 101 Expansion is shown in Figure 16. This expansion would consist of a new pipeline to serve potential agricultural recycled water users located primarily between the Estuary and Route 101.

- East of 101 Expansion - The East of 101 Expansion is shown in Figure 16. This expansion would extend the distribution system across Route 101 to serve potential agricultural recycled water users located primarily north of the Estuary and east of Route 101.

The incremental and cumulative demands associated with each expansion phase are summarized in Table 15. These potential demands are in addition to the demands of the existing recycled water users.

Table 15 Incremental and Cumulative Agricultural Demands by Expansion Phase
Recycled Water Market Study-Phase 1 Report
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Expansion Phase	Incremental Annual Average Demand (mgd)	Cumulative Average Annual Demand (mgd)
West of 101 Expansion	4.0	4.0
East of 101 Expansion	2.5	6.5

The planning level estimated costs for the pipelines and pump stations associated with each level of expansion are discussed in Section 8.

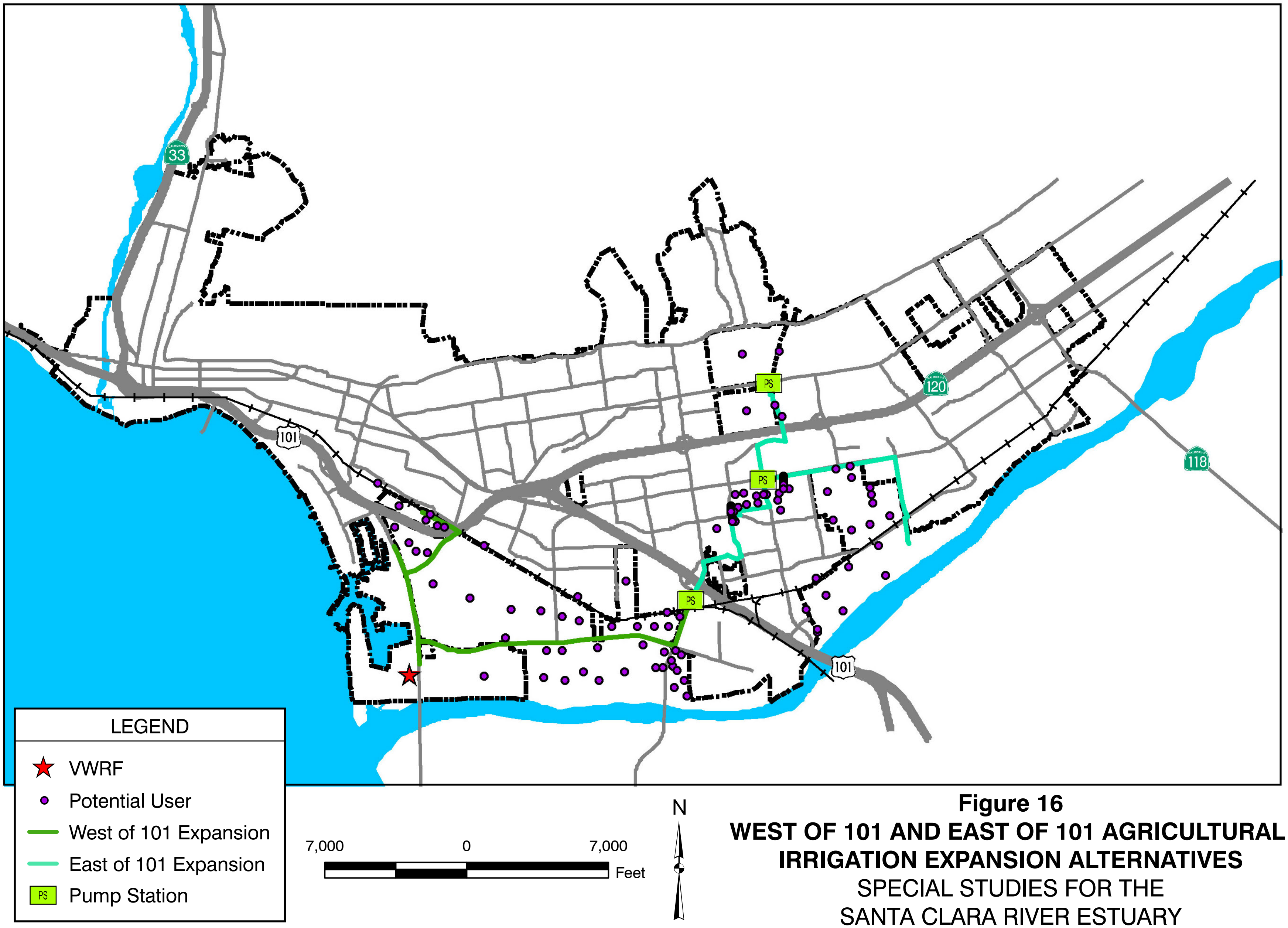

Figure 16
WEST OF 101 AND EAST OF 101 AGRICULTURAL IRRIGATION EXPANSION ALTERNATIVES
SPECIAL STUDIES FOR THE
SANTA CLARA RIVER ESTUARY
CITY OF VENTURA

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6.0 RECYCLED WATER FOR GROUNDWATER RECHARGE

This study focused on the potential for groundwater recharge at the 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, this study focused on this opportunity because there are existing facilities, a source of diluent water and available capacity.

There is precedent for using recycled water for groundwater recharge in California. In addition to investigating use of UWCD facilities, the City may explore other opportunities including developing other recharge sites within City limits.

6.1 Existing and Future Regulations

6.1.1 Existing Regulations

Groundwater recharge with recycled water is the practice of spreading or injecting recycled water into groundwater aquifers to augment groundwater supplies and to prevent salt water intrusion in coastal areas. This use of recycled water is referred to by CDPH as "Groundwater Recharge Reuse Project (GRRP)" or as "indirect potable reuse". Existing regulations and policies that pertain to groundwater recharge reuse include the Title 22 Draft Groundwater Recharge Reuse Regulations (August 2008), the Water Quality Control Plan Los Angeles Region (Basin Plans), and the Recycled Water State Policy. The following websites include additional information about these regulations and policies:

- Title 22 Draft Groundwater Recharge Reuse Regulations - http://www.cdph.ca.gov/healthinfo/environhealth/water/Pages/Waterrecycling.aspx
- Water Quality Control Plan Los Angeles Region (Basin Plans) http://www.swrcb.ca.gov/rwqcb4/water_issues/programs/basin_plan/
- Recycled Water State Policy http://www.swrcb.ca.gov/water_issues/programs/water_recycling_policy/

Title 22 Draft Groundwater Recharge Reuse Regulations

The latest CDPH draft recharge reuse regulations (August 2008) set treatment standards regarding pathogen microorganisms, nitrogen removal, total organic (TOC) carbon concentrations, and maximum contaminant limits (MCLs) for other organic and inorganic constituents. The draft regulations also outline monitoring and reporting requirements for demonstrating attainment of regulations. The following discussion briefly describes some of the key components of the draft regulations.

Engineering Report. Prior to recharge of recycled water, an engineering report must be submitted and a permit must be issued by the RWQCB. The engineering report shall include a comprehensive investigation and evaluation of the GRRP, impacts on the existing and potential uses of the impacted groundwater basin, and the proposed means for achieving compliance with Title 22 requirements.

Diluent Water and Recycled Water Contribution (RWC) Requirements. At a GRRP, the recharge water is defined as either recycled municipal wastewater or the combination of recycled municipal wastewater and diluent water. Examples of diluent water are: raw surface water, groundwater and stormwater. The regulations specify requirements for diluent water quality.

Recycled water contribution (RWC) is the quantity of recycled municipal wastewater applied at the GRRP, divided by the sum of the recycled municipal wastewater applied at the GRRP and diluent water. The RWC is calculated on a 60 month average.

Initial recycled water contribution (RWC) will be between 0.20 and 0.50, set at the discretion of the CDPH based on the engineering report and information from a public hearing. For surface applications of recycled water that is not treated by reverse osmosis and advanced oxidation the maximum initial RWC cannot exceed 0.20. The recycled water contribution may be increased thereafter in a phased manner over time with permission from the CDPH, and will entail progressively more stringent treatment, monitoring and reporting requirements.

Control of Pathogenic Microorganisms. The recycled water shall be disinfected, filtered tertiary treated. For surface spreading, the retention time underground shall be at least 6 months, and the extraction well shall be at least 500 feet away, horizontally. For direct injection, the retention time underground shall be at least 12 months, and the extraction well shall be at least 2000 feet away. The distances can be decreased if it can be demonstrated that the reduced distance meets the retention time requirements. The engineering report must include analysis to demonstrate that the minimum retention time will be achieved.

Control of Nitrogen Compounds. The concentration of nitrogen compounds is controlled by one of three methods. Each method includes a complicated set of scenarios where CDPH must be notified of exceedences. The three methods for nitrogen control are summarized below:

- Method 1 - Requires two samples per week of recharge water that is applied to the surface or injected into the subsurface. Samples may be collected before or after surface or subsurface application. If the total nitrogen (TN) concentration is greater than 5 mg/L for the average of 2 consecutive samples, remedial action (investigate, correct and notification) must be taken. If the 4-week average TN concentration of all samples is greater than 5 mg/L, then recharge will be suspended until TN is reduced to 5 mg/L or less for two consecutive samples.

- Method 2 - Requires samples of the groundwater that has been blended with the recharge water for analysis of dissolved oxygen concentrations, and samples of the recharge water for analysis of nitrate, nitrite, ammonia, organic nitrogen, DO, and BOD. Sample frequency is determined by CDPH. If the average of two consecutive samples exceeds 10 mg/L total nitrogen or a limit identified in the engineering report for another constituent, then remedial action (investigate, correct and notification) must be taken. Recharge will be suspended until an average of two consecutive samples meets the limit(s).

- Method 3 - This method may only be utilized by a GRRP that has been in operation for a minimum of twenty years. This method is not relevant to this study. Additional information can be found in the draft regulation.

Total Organic Carbon Requirements. Total organic carbon (TOC) has a limit established in the draft regulations. The methods for monitoring include:

- Monitoring in the filtered wastewater (unless subsequently treated with reverse osmosis) two 24-hour composite samples a week, taken at least three days apart.

- Monitoring the recycled municipal wastewater, at least one 24-hour composite sample each week prior to recharge.

- Monitoring surface application, at least one sample each week in a manner yielding TOC values representative of the recycled municipal wastewater TOC after infiltration and percolation, and not influenced by diluent water, native groundwater, or other sources of dilution.

The TOC limit in the filtered wastewater is 16 mg/L, based on two consecutive samples and the average of the last four results. For the recharge water, the limit (TOC_{max}) is based on a 20-week running average of all TOC results and the average of the last four results and calculated by dividing 0.5 mg/L by the RWC.

Monitoring and Control of Chemicals and Physical Characteristics. On a quarterly basis, the GRRP must also monitor the recycled water and downgradient monitoring wells specified by CDPH for priority toxic pollutants, chemicals with state notification levels that CDPH has specified, based on a review of the GRRP engineering report and the affected groundwater basin(s); and other chemicals that CDPH has specified, based on a review of the GRRP's engineering report, the affected groundwater basin(s).

On an annual basis, the GRRP shall monitor the recycled municipal wastewater for constituents indicating the presence of municipal wastewater, as specified by the CDPH, including pharmaceuticals, endocrine disrupting chemicals, personal care products, and other indicators of the presence of municipal wastewater.

Water Quality Control Plan Los Angeles Region (Basin Plan)

The SWRCB and RWQCBs govern the permitting of recycled water projects consistent with their role of protecting water quality and sustaining water supplies. Some groundwater basins in the State contain salts and nutrients that exceed or threaten to exceed water quality objectives established in the applicable Basin Plans. The SWRCB has determined that groundwater recharge projects using recycled water have the potential to lower water quality within a basin. Where applicable, RWQCBs shall establish requirements to prevent a water recharge reuse project from creating substantial adverse effect on the fate and transport of a contaminant plume or altering the geochemical equilibrium in the groundwater, thereby mobilizing geologic constituents such as arsenic, and violating water quality objectives. The SWRCB acknowledges that all groundwater recharge reuse projects must be reviewed and permitted on a project-specific basis.

The Basin Plan groundwater quality objectives vary by basin in the vicinity of UWCD. All or portions of eight groundwater basins lie within United Water Conservation District, including the Fillmore, Santa Paula, Oxnard Forebay, Oxnard Plain, Mound Basin, Pleasant Valley, Las Posas and the Piru groundwater basins. The groundwater objectives for these basins vary. Most of the groundwater objective concentrations for these basins fall within the range of values presented in Table 16.

Table 16 Approximate Range of Basin Plan Objectives
Recycled Water Market Study-Phase 1 Report
City of Ventura

Constituent	Basin Plan Objective (mg/L)
TDS	900 to 2,000
Sulfate	600 to 1,000
Chloride	100 to 200
Boron	1 to 2

Recycled Water State Policy

The Recycled Water 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.

After salt/nutrient management plans are developed, they will govern whether anti-degradation analyses are necessary for specific projects. While the plans are in the process of being drafted, antidegradation analyses will be required for recycling projects where the discharge will use more than 10 percent of the Basin's available assimilative capacity for one project, or 20 percent for multiple projects.

The Recycled Water Policy does not change or add significantly to the CDPH draft regulations for groundwater recharge.

6.1.2 Future Regulations

The Draft Groundwater Recharge Reuse Regulations (2008) have not been finalized and adopted as part of the Title 22 regulations. The process of finalizing and adopting these regulations is not anticipated in the near future. However, it will be important to track any changes in status or updates to the draft regulations.

The Recycled Water Policy specifies that a Blue-Ribbon Advisory Panel be convened to guide future actions with respect to Compounds of Emerging Concern (CECs). If any regulations arise from new knowledge of risks associated CECs, then projects will be given compliance schedules.

As discussed previously, there are some recent concerns regarding the use of recycled water containing CECs. No current regulations are in effect regarding many of these compounds in recycled water. However, monitoring of CECs (specific compounds not specified) is included in the Draft Groundwater Recharge Reuse Regulations. In addition, the State Recycled Water Policy (Section 2.2.2) requires a Blue Ribbon Panel to advise regulators as to the best way to proceed with monitoring for CECs. It will be important to track research and regulations related to the use of recycled water, particularly as related to these concerns.

6.2 Water Quality Analysis for Groundwater Recharge

Water quality analysis for groundwater recharge requires information on the quality of the recycled water and the diluent water. As noted previously, a preliminary investigation of the groundwater recharge reuse at UWCD was conducted as part of this study. UWCD currently diverts water from the Santa Clara River for groundwater recharge. Therefore, the most likely source of diluent water would be the Santa Clara River water.

The water quality of the Santa Clara River varies with season and hydrologic conditions. Table 17 summarizes several key constituent concentrations for the Santa Clara River and VWRF effluent. In general, constituent concentrations are lower in the river than in the recycled water.

The VWRF is currently undergoing a process upgrade from partial nitrification and denitrification to full nitrification and denitrification to meet a future permit limits of 10 mg/L nitrate plus nitrite. A concentration of 8 mg/L (nitrate plus nitrite) was the basis for the nutrient removal process design. The effluent has low organic nitrogen and ammonia concentrations. Therefore, in the future, it is reasonable to assume that the TN of the VWRF effluent will be approximately 10 mg/L.

Table 17	**Comparison of Santa Clara River and VWRF Effluent Water Quality Recycled Water Market Study-Phase 1 Report City of Ventura**						
		5th Percentile		**Median**		**95th Percentile**	
Constituent	**Units**	**SCR(1)**	**VWRF(2)**	**SCR(1)**	**VWRF(2)**	**SCR(1)**	**VWRF(2)**
Nitrate	mg/L as N	0.6	12.5	1.4	14.6	2.2	16.7
Total N	mg/L as N	1.2	14.4	2.6	17.6	6.1	19.1
TDS	mg/L	711	1,432	1,109	1,489	1,392	1,523
Chloride	mg/L	27	272	61	290	98	361

Notes:
(1) Data from 1997 thru 2009
(2) Data from 2006 thru 2008

As discussed in Section 6.1.1, there are several methods for demonstrating attainment of the nitrogen control requirements in the draft groundwater recharge reuse regulations. Data in Table 17, suggests that assuming a VWRF effluent TN concentration of 10 mg/L then mixing with the Santa Clara River water, at a 4:1 river to recycled water ratio, will yield a lower TN concentration as a result of dilution. Compliance with the RWC is on a 60 month running average basis; therefore the ratio can vary as long as the long-term 60 month average is met. In contrast, compliance with some of the nitrogen control requirements is based on the results of 2 samples per week. This small number of samples means that a single high concentration could significantly impact the average value and lead to an exceedence of the TN limit. Additional investigation of the regulatory feasibility (including which method should be adopted and associated regulatory risk) of potential future operational scenarios would need to be conducted.

Comparison of VWRF effluent quality and Basin Plan objectives suggests that there is some potential to violate these objectives. The median VWRF effluent and Santa Clara River sulfate and boron concentrations are below Basin Plan objectives, therefore, there is minimal risk of violating the objectives through a GRRP. The VWRF median effluent TDS and chloride concentrations are 1489 mg/L and 290 mg/L, respectively. The Santa Clara River median TDS and chloride concentrations are lower at 1109 mg/L and 61 mg/L, respectively. Santa Clara River water as a diluent would provide dilution of the VWRF effluent. A more detailed investigation is required to better understand the potential for recycled water recharge to lead to a violation of Basin Plan objectives. This evaluation would need to consider the recharge location, potential GRRP operating scenarios, and the impact of the recharge operations on underlying groundwater quality.

6.3 Water Quality Improvements

The need for improving VWRF recycled water quality for the purpose of groundwater recharge at UWCD's facilities was not investigated in detail in this study. It is possible that regulatory constraints will limit the use of VWRF recycled water for groundwater recharge unless additional treatment is implemented to remove TDS and chloride. The most common approach to TDS and chloride removal is through MF/RO.

There a numerous unknowns about the use of VWRF recycled water for groundwater recharge that impact the analysis of whether treatment is required and if so, how much of the flow would need treatment. Further investigation into operational alternatives, coordination with regulating agencies, and coordination with UWCD is necessary in order to assess the need for additional treatment. The preliminary groundwater recharge alternatives presented in this study do not include additional MF/RO treatment.

6.4 Market Identification and Quantification

This study focused on the potential for groundwater recharge at the UWCD facilities, where groundwater recharge via spreading ponds (i.e. percolation) is currently practiced. UWCD owns and operates facilities that are used to manage groundwater supplies and to provide water to municipalities and agricultural areas in Ventura County. UWCD diverts water from the Santa Clara River for the purpose of irrigation and groundwater recharge. UWCDs existing facilities include a diversion dam, control structures on the river, fish passage facilities, concrete and earth lined channels, and groundwater recharge ponds and pits, and pipelines. The capacity of the diversion system is approximately 213 mgd (330 cfs).

UCWDs existing recharge facilities include groundwater recharge ponds/spreading grounds, and a gravel pit that has been converted for the purpose of groundwater recharge, as follows:

- Saticoy Spreading Grounds - This recharge site consists of 140 acres of ponds located along highway 118 in Saticoy. Water diverted from the Santa Clara River is recharged in these ponds.
- Noble Pit - The Noble pit is part of the Saticoy recharge site. The Noble pit is a former gravel pit that has been used for groundwater recharge of Santa Clara River water.
- El Rio Spreading Grounds - This recharge site consists of 120 acres of ponds. Diverted Santa Clara River water passes though a moss screening facility at the Saticoy site and is then delivered to the spreading grounds at El Rio.

The volume of diverted Santa Clara River water that is recharged at these facilities varies on a monthly and annual basis, depending on several factors (hydrologic conditions, water demands, etc) and UWCDs priorities. Typically, during the summer months, UWCD's priority is to provide diverted waters to growers for the purpose of agricultural irrigation rather than to use the diverted water for groundwater recharge. Table 18 presents a summary of the amount of water diverted from the river and the amount of water used for recharge.

Quantifying the amount of recycled water that could be used by UWCD at their existing facilities would require a more detailed analysis of the UWCD diversion and recharge operations, Santa Clara River water quality, and recharge water quality. In addition, this analysis would need to examine the regulatory feasibility of potential alternatives for using recycled water from VWRF for recharge at UWCD facilities. This analysis is beyond the scope of this study.

However, preliminary analysis suggests that there could be some limitations for using recycled water for groundwater recharge at UWCD. Table 18 shows that during the peak summer months (June through August), UWCD's historical recharge of Santa Clara River water is minimal. Assuming that the initial RWC would be 0.20, then over a 60 month period the volumetric ratio of diluent water (diverted Santa Clara River Water available for recharge) to recycled water must be a minimum of 4:1. Assuming a recycled water flow of 11.4 mgd AAF (12 mgd AAF less 0.6 mgd AAF for existing recycled water users) and using monthly peaking factors developed from VWRF flow data from 2007, monthly flows were estimated. The maximum monthly flow was determined to be 12.6 mgd. Using the estimated monthly flows and the 1997 through 2008 monthly data for UCWD recharge, the 60 month running average RWCs were calculated. Using these assumptions, there are a few ways to meet the 0.20 RWC. One option is that recycled water is not used for recharge during the 4 to 5 month summer period. In this scenario, the average annual groundwater recharge demand would be between 7 and 8 mgd. Alternatively, it is possible that a lower recycled water flow could be used on a year round basis to comply with the 60-month running average RWC limit. As discussed, the water quality of the recharge water and underlying groundwater would need to be determined to assess the feasibility of meeting water quality limits in the draft regulations.

For the purpose of developing a pipeline alternative and cost estimates, it was assumed that the seasonal groundwater recharge approach would be adopted. Given that the existing recycled water demands in the winter months are low, the pipeline alternatives and cost estimates were based on a flow of 12.6 mgd to the recharge facilities.

6.5 Preliminary Alternatives

A preliminary alternative for delivering recycled water to UWCD was developed including the pipelines and pump station required to deliver water to the UWCD facilities. The pipeline alignment considered the alignment presented in Section 6.5 for the delivery of recycled water for agricultural reuse. There are seasonal limitations for agricultural irrigation with recycled water in the winter and groundwater recharge in the summer. Therefore, maximizing full year use of recycled water would require that both agricultural irrigation and groundwater recharge were implemented. Figure 17 presents the pipeline alignment to route recycled water to UWCDs existing groundwater recharge facilities.

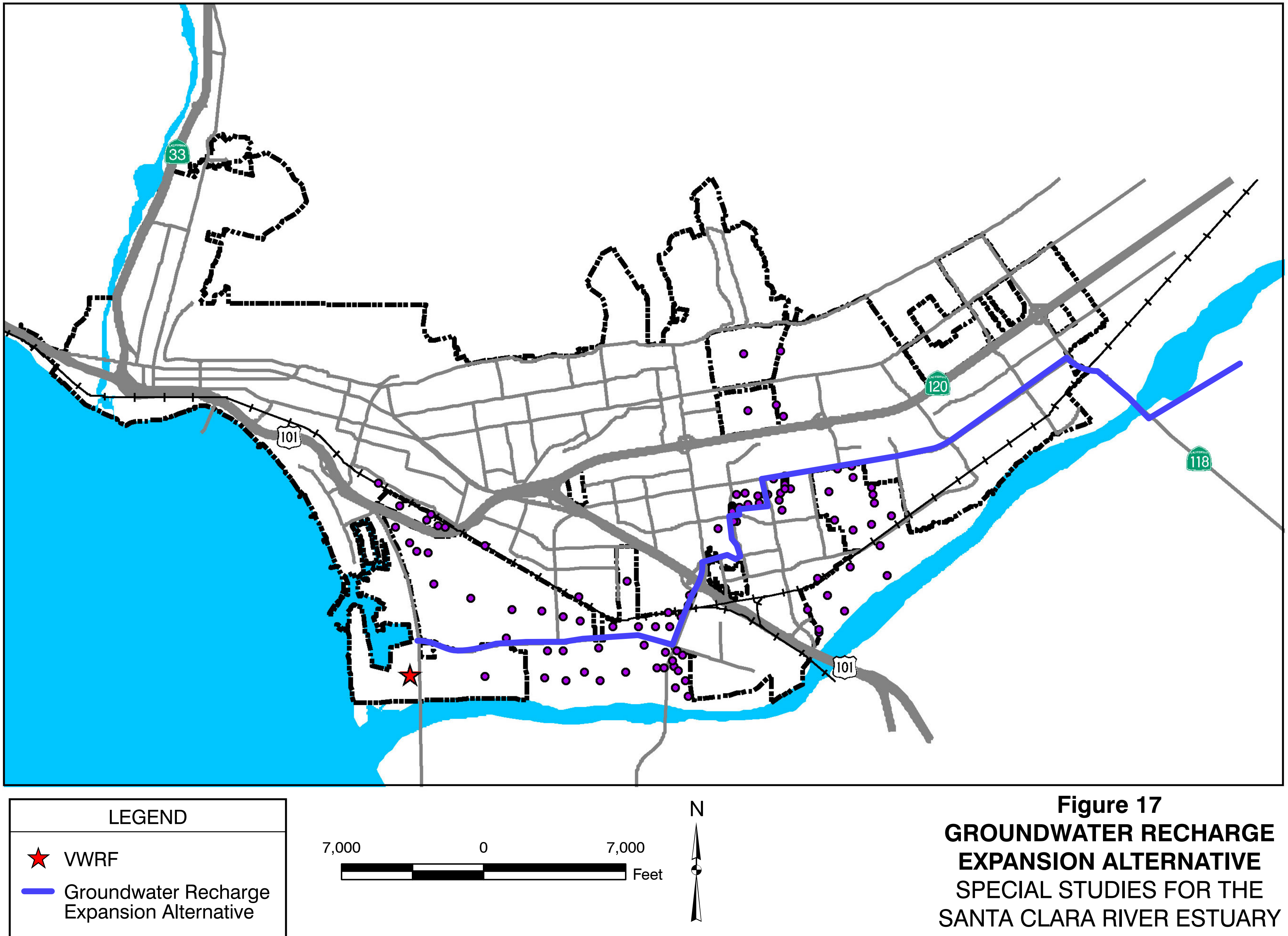

Figure 17
GROUNDWATER RECHARGE EXPANSION ALTERNATIVE
SPECIAL STUDIES FOR THE SANTA CLARA RIVER ESTUARY
CITY OF VENTURA

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Table 18	Summary of UWCD Diversion and Groundwater Recharge Flows Recycled Water Market Study-Phase 1 Report City of Ventura					
	Total Diversion (mgd)			**Groundwater Recharge (mgd)**		
Month	**5th Percentile**	**Median**	**95th Percentile**	**5th Percentile**	**Median**	**95th Percentile**
January	28	55	124	17	37	119
February	43	57	131	32	50	148
March	42	116	186	18	102	176
April	23	85	165	9	66	146
May	13	62	143	1	34	124
June	10	29	144	0	9	122
July	5	13	123	0	3	98
August	2	13	69	0	2	37
September	4	64	127	1	49	101
October	32	107	168	18	78	137
November	20	37	119	11	21	101
December	20	49	107	20	49	107

Note:
(1) Data from water years 1997 thru 2008

7.0 PLANNING LEVEL COST ESTIMATES

Planning level cost estimates were developed for each of the reuse types considered: urban irrigation, agricultural irrigation and groundwater recharge.

Planning level cost estimates are typically used for conceptual, comparative 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. Project costs, presented in this section are in January 2010 dollars and include construction costs, contingencies and a project cost factor for engineering, construction management, legal and administration.

Table 19 presents the planning level project cost estimates for urban irrigation. For the Existing System Extension, only costs for construction of the pipeline are included. All other expansion phases include pipelines and booster pump stations. In addition, these phases of expansion require a pump station at the treatment plant. It is assumed that a new pump station would be sized to accommodate all expansion phases (except as noted, the Extension of the Existing System). The cost for this pump station is shown as a separate line item in Table 19. The pipeline and pump station costs are based on the peak hour flow that corresponds to the demands associated with each expansion phase.

Table 19 Planning Level Project Cost Estimates for Urban Recycled Water Use
Recycled Water Market Study
City of Ventura

Expansion Phase	Cost (Millions of Dollars)
Existing System Extension	0.8
Harbor Area and River Ridge Golf Course Expansion	6
North Expansion	25
East Expansion	16
West Expansion	12
Treatment Plant Pump Station	2.5
Total	**62**

Table 20 presents the planning level project cost estimates for agricultural irrigation. The West of 101 Expansion and East of 101 Expansion phases include pipelines and booster pump stations. In addition, these phases of expansion require a pump station at the treatment plant. This pump station was sized to accommodate both expansion phases. The cost for this pump station is shown as a separate line item in Table 20. Treatment process costs are based on a flow of 11.4 mgd. The pipeline and pump station costs are based on the peak hour flow that corresponds to the demands associated with each expansion phase.

Table 20 Planning Level Project Cost Estimates for Agricultural Recycled Water Use
Recycled Water Market Study
City of Ventura

Expansion Phase	Cost (Millions of Dollars)
Treatment	
MF/RO	68
Brine Treatment	30
Treatment Total	**98**
Pipelines and Pump Stations	
West of 101 Expansion	21
East of 101 Expansion	23
Treatment Plant Pump Station	3
Total	**145**

Table 21 presents the planning level project cost estimates for groundwater recharge, and includes the costs for a pump station at the treatment plant and a pipeline to UWCD. These costs are based on an annual average flow of 12 mgd. These costs do not include any additional treatment that may be required, nor do they include costs for monitoring wells at the UWCD site.

Table 21 Planning Level Project Cost Estimates for Recycled Water Use for Groundwater Recharge
Recycled Water Market Study
City of Ventura

Expansion Phase	Cost (Millions of Dollars)
Pipeline	33
Treatment Plant Pump Station	2.8
Total [1]	**36**

Note:
(1) Does not include cost for potential additional treatment (MF, RO and brine disposal) which may be needed to remove TDS and chloride.

8.0 ALTERNATIVES SUMMARY

The recycled water market opportunities within a 5 mile radius from the VWRF were evaluated in this study. The three general types of recycled water uses include urban irrigation, agricultural irrigation and groundwater recharge.

The opportunities for each type of recycled water use range in potential demands, regulatory requirements and feasibility, treatment needs, and costs. The urban irrigation, agricultural irrigation and groundwater recharge opportunities are summarized in Table 22.

The Estuary Subwatershed Study will evaluate if the discharge is providing an enhancement to the Estuary. If the Estuary Subwatershed Study indicates that the discharge is not providing an enhancement then an alternative management scenario for the discharge will be developed. The Estuary Subwatershed Study will form the basis for determining how the discharge should be managed with respect to the volume and quality of discharge to the Estuary. Consequently, the outcome of the Subwatershed Study will strongly influence the development of management alternatives with respect to recycled water and wetlands treatment. The recycled water opportunities will be revisited to determine how recycled water fits into future management of the VWRF effluent. This evaluation will require that the recycled water opportunities are further developed. In general, the implementation of these alternatives ranges with urban irrigation as the most easily implemented, followed by agricultural irrigation and groundwater recharge. Implementation of agricultural irrigation is complicated by the need for additional treatment, the need for significant storage, and the need for the growers in the region to agree to use recycled water instead of existing supplies. Groundwater recharge is complicated by the need to develop an approach that will lead to regulatory attainment, the potential need for additional treatment, and the need for interagency agreements.

Table 22 Summary of Urban Irrigation, Agricultural Irrigation and Groundwater Recharge Opportunities in Study Area
Recycled Water Market 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 with greater demands in summer months (ranges from 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 with greater demands in summer months (ranges from 1.6 in winter to 11 in summer) • Requires additional treatment • Requires brine treatment and disposal • Requires conversion of wildlife ponds to recycled water storage reservoirs • Requires agreement by growers
Groundwater Recharge	7 Annual Ave 12.6 Max Month	36	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) • Regulatory feasibility uncertain • May require additional treatment (MF/RO and brine treatment • Requires agreement with UWCD • Requires long term monitoring effort

Future work associated with urban irrigation, agricultural irrigation and groundwater recharge includes:

- Urban Irrigation:
  - More detailed investigation of the potential for decentralized treatment to provide local sources of recycled water.
  - Coordination with the City of Oxnard on plans to provide recycled water to the River Ridge Golf Course.
- Agricultural Irrigation:
  - Further investigation into the feasibility of converting the wildlife ponds to recycled water storage.
  - Investigation into offsite storage options if the wildlife ponds cannot be used.
  - Public outreach and coordination with growers for acceptance of recycled water for irrigation and the expected water quality (resulting from partial treatment of the flow through MF/RO).
  - Further development of brine treatment alternatives.
- Groundwater Recharge:
  - Additional coordination with UWCD regarding use of recycled water for groundwater recharge at their facilities.
  - Coordination with the City of Oxnard on the possibility that they will provide recycled water to UWCD for groundwater recharge.
  - Further development of potential operational scenarios, assessment of the regulatory feasibility and assessment of level of treatment required to meet regulations (potential for MF/RO treatment versus existing tertiary).
  - Development of interagency agreements if groundwater recharge at UWCD is pursued.

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