

Kennedy/Jenks Consultants

707 Wilshire Boulevard, Suite 4700
Los Angeles, California 90017
213-624-6180
FAX: 213-624-9894

Feasibility Report for Development of Groundwater Resources in the Santa Monica and Hollywood Basins

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Table of Contents

<i>List of Tables</i>	v
<i>List of Figures</i>	vii
<i>List of Appendices</i>	viii
<i>List of Acronyms</i>	ix
<i>Executive Summary</i>	ES-I
 Section 1: Introduction	1-1
1.1 Introduction	1-1
1.2 Physiographic Setting of Study Area.....	1-1
1.3 Background	1-3
 Section 2: Hydrogeologic Characterization	2-1
2.1 Study Area	2-1
2.1.1 Setting, Drainage, and Climate	2-1
2.1.2 Regional Groundwater Basins	2-2
2.1.3 Regional Hydrogeology.....	2-2
2.1.4 Regional Groundwater	2-5
2.2 Hydrogeologic Data Compilation and Review	2-6
2.2.1 Previous Reports.....	2-6
2.2.2 Sources of Hydrogeologic Data	2-7
2.2.3 Definition of Safe Yield.....	2-7
2.3 Santa Monica Basin Assessment.....	2-9
2.3.1 Hydrogeology	2-9
2.3.2 Basin Description	2-10
2.3.3 Groundwater Conditions	2-11
2.3.3.1 Charnock	2-11
2.3.3.2 Coastal.....	2-14
2.3.3.3 Crestal	2-14
2.3.3.4 Arcadia.....	2-14
2.3.3.5 Olympic.....	2-15
2.3.4 Groundwater Production	2-15
2.3.4.1 History of Groundwater Production.....	2-15
2.3.4.2 Existing Wellfield Production	2-16
2.3.5 Previous Estimates of Safe Yield	2-17
2.4 Hollywood Basin Assessment	2-18
2.4.1 Hydrogeology	2-18
2.4.2 Basin Description	2-18
2.4.3 Groundwater Conditions	2-19
2.4.4 Groundwater Production	2-21
2.4.5 Previous Estimates of Safe Yield	2-22

Table of Contents (cont'd)

2.5	Potential Production Capacity	2-22
2.5.1	Assessment of Safe Yield	2-23
2.5.2	Assessment of Potential Issues	2-25
2.5.2.1	Seawater Intrusion	2-25
2.5.2.2	Well Interference	2-26
2.5.2.3	Overdraft	2-27
2.5.2.4	Land Subsidence	2-28
2.5.2.5	Water Quality	2-28
2.5.3	Potential Production Capacity	2-29
2.5.4	Potential Wellfield Location and Capacity	2-29
2.5.4.1	Santa Monica Basin	2-29
2.5.4.2	Hollywood Basin	2-29
2.5.4.3	Minimum Well Spacing	2-30
Section 3:	Groundwater Basin Governance and Management	3-1
3.1	Review of Local Basin Governance and Management	3-1
3.2	Opportunities for Cooperative Partnerships	3-3
3.2.1	City of Santa Monica	3-3
3.2.2	City of Beverly Hills	3-3
Section 4:	Description of Existing Wells and Infrastructure	4-1
4.1	Santa Monica Basin	4-1
4.1.1	Active City of Santa Monica Wells	4-1
4.1.2	City of Santa Monica Groundwater Treatment Facilities	4-1
4.1.3	Golden State Water Company Wells and Groundwater Treatment Facilities	4-3
4.2	Hollywood Basin	4-3
4.2.1	City of Beverly Hills Inactive Wells	4-4
4.2.2	Active City of Beverly Hills Wells	4-4
4.2.3	City of Beverly Hills Groundwater Treatment Facilities	4-5
Section 5:	Water Quality Characterization	5-1
5.1	Review of GeoTracker and Envirostore Databases	5-1
5.1.1	Santa Monica Basin	5-2
5.1.2	Hollywood Basin	5-2
5.2	Water Quality Characterization	5-7
5.2.1	Santa Monica Basin	5-8
5.2.1.1	Summary of Arcadia Subbasin Water Quality	5-8
5.2.1.2	Summary of Olympic Subbasin Water Quality	5-8
5.1.2.1	Summary of Charnock Subbasin Water Quality	5-12
5.1.2.2	Coastal and Crestal Subbasin Water Quality Assignments	5-15

Table of Contents (cont'd)

5.1.3	Hollywood Basin.....	5-17
5.1.3.1	Summary of Water Quality.....	5-17
5.1.3.2	Water Quality Assignments for Hollywood Basin	5-18
Section 6:	Treatment Scenarios.....	6-1
6.1	Iron and Manganese Treatment.....	6-5
6.1.1	General Process Description	6-5
6.1.2	Chemical Storage and Feed System	6-5
6.1.3	Greensand Filter Vessels.....	6-6
6.1.4	Backwash Storage and Recovery System.....	6-7
6.1.5	Option for Hexavalent Chrome Treatment	6-8
6.2	GAC Treatment for VOC, Odor & Color Removal	6-9
6.3	Total Dissolve Solids Reduction.....	6-10
6.3.1	Greensand Filter Break Tanks and RO Pumps.....	6-11
6.3.2	Antiscalant Feed System	6-11
6.3.3	Cartridge Filtration.....	6-12
6.3.4	Primary Treatment (Reverse Osmosis).....	6-12
6.3.5	RO Membrane Cleaning-In-Place System	6-13
6.4	Post Treatment.....	6-14
6.4.1	Chemical Addition	6-14
6.4.1.1	pH Stabilization with Sodium Hydroxide	6-14
6.4.1.2	Disinfection – Chloramination System	6-15
6.5	Clearwell	6-15
6.6	Product Water Pumping and Conveyance Piping	6-16
Section 7:	Alternatives	7-1
7.1	Hollywood Basin Pan Pacific Park	7-4
7.2	Santa Monica Basin/Crestal Subbasin	7-8
7.2.1	Cheviot Hills Park.....	7-9
7.2.2	Hillcrest Country Club	7-14
7.2.3	Northvale Road	7-18
7.2.4	Comparison of Crestal Subbasin Alternatives.....	7-20
7.3	Santa Monica Basin/Coastal Subbasin	7-20
7.3.1	Venice Reservoir Park	7-25
7.3.2	Penmar and Lake Street.....	7-29
7.3.3	Bluff Creek Drive.....	7-35
7.3.4	Comparison of Coastal Subbasin Alternatives.....	7-39
7.4	Comparison of All Alternatives Using Estimated Costs.....	7-39
Section 8:	Evaluation of Non-Economic Factors.....	8-1
8.1	Description of Non-Economic Factors.....	8-1
8.1.1	Water Quality Data Availability.....	8-1

Table of Contents (cont'd)

	8.1.2	Construction Impacts	8-1
	8.1.3	Tree Removal.....	8-2
	8.1.4	Access.....	8-2
	8.1.5	Security	8-2
	8.1.6	Aesthetics.....	8-2
	8.1.7	Community Impacts	8-3
	8.1.8	Environmental Impacts.....	8-3
8.2		Summary Analysis of Non-Economic Factors	8-3
	8.2.1	Pan Pacific Park	8-5
	8.2.2	Cheviot Hills Park.....	8-5
	8.2.3	Hillcrest Country Club	8-5
	8.2.4	Northvale Road	8-5
	8.2.5	Venice Reservoir.....	8-5
	8.2.6	Penmar and Lake Street.....	8-6
	8.2.7	Bluff Creek Drive.....	8-6
Section 9:		Results Screening and Ranking of Alternatives.....	9-1
	9.1	Rankings Based on Cost Estimates	9-1
	9.1.1	Lowest Cost Alternatives.....	9-1
	9.2	Non-Economic Screening.....	9-2
Section 10:		Conclusions and Recommendations.....	10-1
	10.1	Summary	10-1
	10.2	Conclusions.....	10-2
	10.3	Recommendation	10-3
Section 11:		References.....	11-1

Table of Contents (cont'd)

List of Tables

Table 2-1	Summary of Existing Well Characteristics by Subbasin
Table 2-2	Comparison of Groundwater Recharge Estimates
Table 3-1	Summary of Basin Governance Interviews
Table 4-1	City of Santa Monica Active Groundwater Wells
Table 4-2	Summary of City of Beverly Hills Wells Prior to 1976
Table 4-3	Summary of Active City of Beverly Hills Wells
Table 5-1	EnviroStor and GeoTracker Active Site Summary of the Santa Monica Basin
Table 5-2	EnviroStor and GeoTracker Active Site Summary for the Hollywood Basin
Table 5-3	Profile of Water Quality Analyses for City of Santa Monica Wells in the Arcadia Subbasin
Table 5-4	Water Quality Summary of Average Concentrations of Key COCs for Arcadia Subbasin
Table 5-5	Profile of Water Quality Analyses for City of Santa Monica Wells in the Olympic Subbasin
Table 5-6	Water Quality Summary of Average Concentrations of Key COCs for Olympic Subbasin
Table 5-7	Profile of Water Quality Analyses for City of Santa Monica Wells in Charnock Subbasin
Table 5-8	Water Quality Summary of Average Concentrations of Key COCs for Charnock Subbasin
Table 5-9	Profile of Water Quality Analyses for Golden State Water Company Charnock Wells
Table 5-10	Profile of Water Quality Analyses for City of Beverly Hills Wells
Table 5-11	Water Quality Summary of Average Concentrations of Key COCs for Hollywood Basin
Table 6-1	Iron and Manganese chemical Feed and Storage Requirements
Table 6-2	Design and Operating Criteria - Greensand Filters
Table 6-3	Design and Operating Criteria - Backwash Tank
Table 6-4	Design and Operating Criteria - GAC System
Table 6-5	Design and Operating Criteria - Greensand Filter Break Tanks and Transfer Pumps
Table 6-6	Design and Operating Criteria - Antiscalant Feed System
Table 6-7	Design Flow Rates - Reverse Osmosis System

Table of Contents (cont'd)

Table 6-8	Design and Operating Criteria - Reverse Osmosis System
Table 6-9	Design and Operating Criteria - Sodium Hydroxide Feed System
Table 6-10	Design and Operating Criteria - Chloramination System
Table 7-1	Summary of Alternatives
Table 7-2	Summary of Pan Pacific Park (Alternative 1) Capital Costs
Table 7-3	Summary of Pan Pacific Park (Alternative 1) O&M Costs
Table 7-4	Summary of Water Supply Costs for Pan Pacific Park (Alternative 1)
Table 7-5	Summary of Cheviot Hills Park (Alternative 2) Capital Costs
Table 7-6	Summary of Cheviot Hills Park (Alternative 2) O&M Costs
Table 7-7	Summary of Hillcrest Country Club (Alternative 3) Capital Costs
Table 7-8	Summary of Hillcrest Country Club (Alternative 3) O&M Costs
Table 7-9	Summary of Northvale Road (Alternative 4) Capital Costs
Table 7-10	Summary of Northvale Road (Alternative 4) O&M Costs
Table 7-11	Summary of Water Supply Costs for Crestal Subbasin Alternatives
Table 7-12	Summary of Venice Reservoir (Alternative 5) Capital Costs
Table 7-13	Summary of Venice Reservoir (Alternative 5) O&M Costs
Table 7-14	Summary of Penmar and Lake Street (Alternative 6) Capital Costs
Table 7-15	Summary of Penmar and Lake Street (Alternative 6) O&M Costs
Table 7-16	Summary of Bluff Creek Drive (Alternative 7) Capital Costs
Table 7-17	Summary of Bluff Creek Drive (Alternative 7) O&M Costs
Table 7-18	Summary of Water Supply Costs for Crestal Subbasin Alternatives
Table 7-19	Summary of Alternatives Ranked on Estimated Costs
Table 8-1	Non-Economic Ranking of Alternative

Table of Contents (cont'd)

List of Figures

- Figure 1-1 Study Area Location Map
- Figure 2-1 Key Geological Features within the Santa Monica and Hollywood Basins
- Figure 2-2 Stratigraphic Column for the Los Angeles Area
- Figure 2-3 Distribution of CDWR Well Logs
- Figure 2-4 Geologic Cross Section Across the Santa Monica Basin
- Figure 2-5 Representative Hydrographs from the Santa Monica Basin
- Figure 2-6 Representative Hydrographs from the Hollywood Basin
- Figure 4-1 Process Flow Schematic of Recently Constructed City of Santa Monica Charnock Treatment System (Shorney-Darby and others, 2011)
- Figure 4-2 Process Flow Schematic of Recently Upgraded City of Santa Monica Arcadia Water Treatment Plant (Shorney-Darby and others, 2011)
- Figure 6-1 Hollywood Basin Process Flow Diagram
- Figure 6-2 Santa Monica Crestal Subbasin Process Flow Diagram
- Figure 6-3 Santa Monica Coastal Subbasin Process Flow Diagram
- Figure 7-1 Water Treatment Plant Alternative Locations
- Figure 7-2 Hollywood Pan Pacific Park Alternative 1A Site Layout (10-Month)
- Figure 7-3 Hollywood Pan Pacific Park Alternative 1B Site Layout (6-Month)
- Figure 7-4 Crestal Subbasin Cheviot Hills Park Alternative 2A Site Layout (10-Month)
- Figure 7-5 Crestal Subbasin Cheviot Hills Park Alternative 2B Site Layout (6-Month)
- Figure 7-6 Crestal Subbasin Hillcrest Country Club Alternative 3A Site Layout (10-Month)
- Figure 7-7 Crestal Subbasin Hillcrest Country Club Alternative 3B Site Layout (6-Month)
- Figure 7-8 Crestal Subbasin Northvale Road Alternative 4A Site Layout (10-Month)
- Figure 7-9 Crestal Subbasin Northvale Road Alternative 4B Site Layout (6-Month)
- Figure 7-10 Coastal Subbasin Venice Reservoir Alternative 5A Site Layout (10-Month)
- Figure 7-11 Coastal Subbasin Venice Reservoir 5B Site Layout (6-Month)
- Figure 7-12 Coastal Subbasin Penmar and Lake Street Alternative 6A Site Layout (10/Mo)
- Figure 7-13 Coastal Subbasin Penmar and Lake Street 6B Site Layout (6-Month)
- Figure 7-14 Coastal Subbasin Bluff Creek Drive Alternative 7A Site Layout (10-Month)
- Figure 7-15 Coastal Subbasin Bluff Creek Drive 7B Site Layout (6-Month)

Table of Contents (cont'd)

List of Appendices

- A Summary of CDWR Well Log Information and Well Interference Calculations
- B Basin Governance Interview Minutes
- C Results of EnviroStor and GeoTracker Results
- D Water Quality Data
- E Cost Backup Data for Each Alternative

Table of Contents (cont'd)

List of Acronyms

AF/yr	acre-feet/year
BTEX	benzene, toluene, ethylbenzene, and xylenes
CaCO ₃	calcium carbonate
CIP	clean in place
CEQA	California Environmental Quality Act
COC	contaminant of concern
CDPH	California Department of Public Health
CDWR	California Department of Water Resources
CML&C	cement-mortar lined and coated steel pipe
DTSC	Department of Toxic Substance Control
EBCT	empty bed contact time
EDR	electrodialysis reversal
Fe	iron
fmsl	feet above mean sea level
GAC	granular activated carbon
gpm	gallons per minute
gpm/sf	gallons per minute per square foot
HCl	hydrochloric acid
LACDPW	Los Angeles County Department of Public Works
LADWP	Los Angeles Department of Water and Power

Table of Contents (cont'd)

MCL	maximum contaminant level
mgd	million gallons per day
mg/L	milligrams per liter
Mn	manganese
MTBE	methyl tertiary butyl ether
Na ₂ S ₂ O ₄	sodium hydrosulfite
NF	nanofiltration
NL	notification level
O&M	operation and maintenance
PCE	tetrachloroethylene
PHG	public health goal
PVC	polyvinyl chloride
RO	reverse osmosis
SCWC	Southern California Water Company
SLR	surface loading rate
SMCL	secondary maximum contaminant level
SVOC	semi-volatile organic compound
SWRCB	State Water Resources Control Board
TCE	trichloroethylene
TDS	total dissolved solids
TFC	thin film composite
µg/L	micrograms per liter
UWMP	Urban Water Management Plan

Table of Contents (cont'd)

VOC	volatile organic compound
WBMWD	West Basin Municipal Water District
WQM	CDPH Water Quality Monitoring database
WRCC	Western Regional Climate Center
WRD	Water Replenishment District of Southern California

Executive Summary

Introduction

Under Agreement 47818 with the Los Angeles Department of Water and Power (LADWP), Kennedy Jenks conducted Task Order No. 3 entitled, "*Strategic Planning Services Relating to Investigating the Feasibility of Developing the Santa Monica and Hollywood Basins as Sources of Groundwater Supply.*" The purpose of this study was to evaluate the feasibility of developing the Santa Monica and Hollywood groundwater basins as potable groundwater supply sources for the City of Los Angeles. LADWP conducted its own investigation of these groundwater basins in 1991 to assess potable groundwater development for the City of Los Angeles. This feasibility report represents the deliverable for Task Order No. 3, and it also serves to follow-up on the findings of LADWP's 1991 investigation.

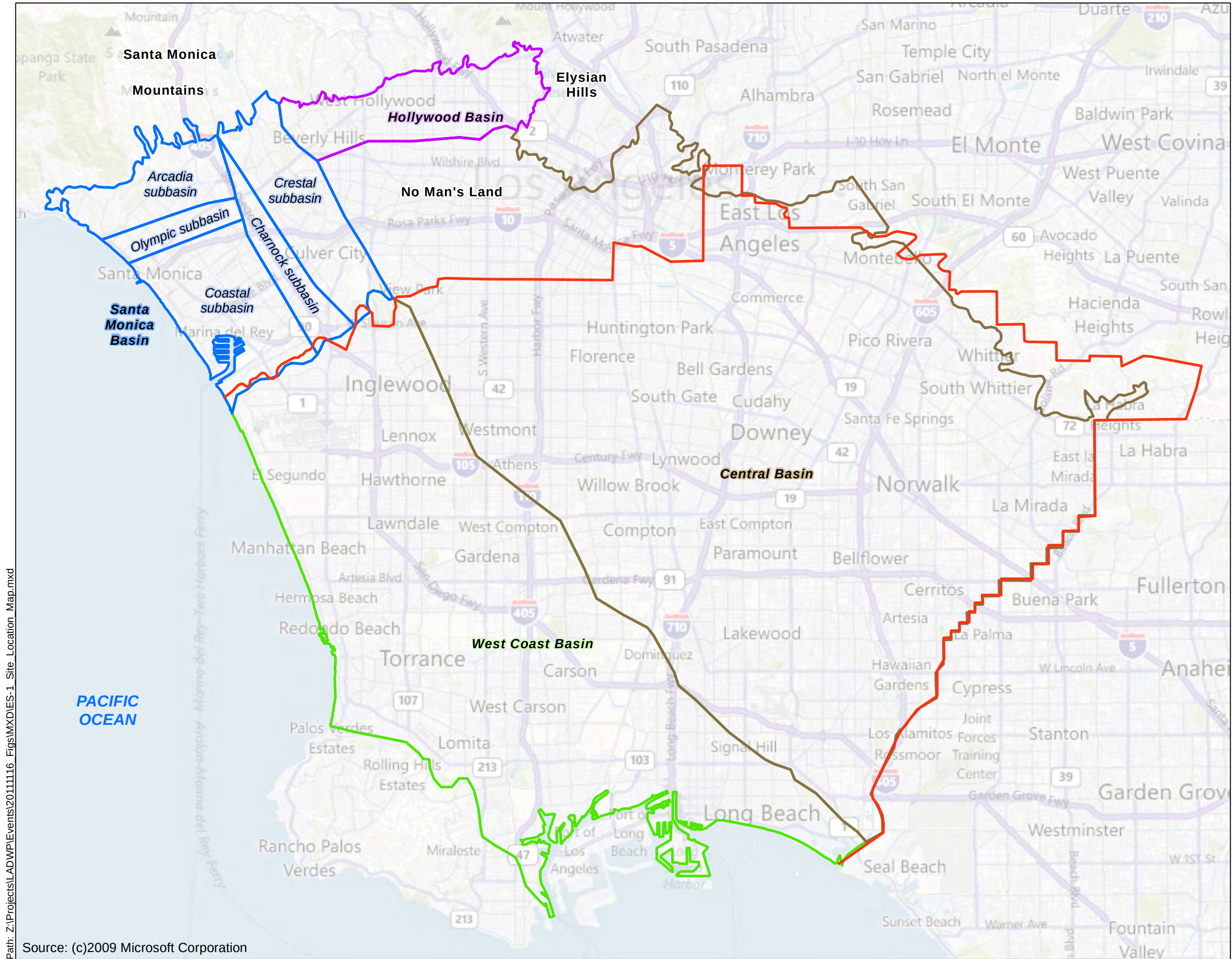
For each groundwater basin, the study included:

- Hydrogeologic characterization, including an estimation of groundwater quantity available and review of safe yield estimates;
- Evaluation of basin governance, including interviews with stakeholder agencies and quantification of groundwater production by other entities;
- Review of groundwater quality using available data from the California Department of Public Health public water supply database coupled with a review of the State Water Resources Control Board EnviroStor database and the California Department of Toxic Substance Control GeoTracker database;
- Review of existing facilities and groundwater production;
- Development of treatment scenarios needed to produce potable water; and
- Identification and development of production alternatives, including preliminary siting of wells, pipelines, and treatment facilities.

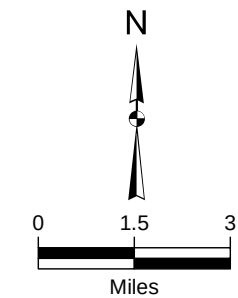
The study area consists of the Santa Monica and Hollywood Basins, both of which are located in the northwestern portion of the coastal plain of Los Angeles County (Figure ES-1). The Santa Monica Basin is further subdivided into five subbasins as shown on Figure ES-1.

Both the Santa Monica and Hollywood basins are unadjudicated groundwater basins, whereby any party owning property overlying the aquifers has a right to pump from the basin. The LADWP and the City of Los Angeles own property in these basins, and thereby have groundwater rights associated with property ownership.

Key findings and results of this feasibility study are presented herein.



- Legend**
- Water Replenishment District Boundary
 - Hollywood Basin
 - Santa Monica Basin
 - West Coast Basin
 - Central Basin



Kennedy/Jenks Consultants

Los Angeles Department of Water and Power
Los Angeles, CA
Task Order No. 3 (Agreement No. 47818)

Study Area Location Map

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Figure ES-1

Hydrogeologic Characterization

The hydrogeologic characterization included:

- Hydrogeological characterization of the Santa Monica and Hollywood Basins based on review of existing reports and data;
- Evaluation of the storage capacity, safe yield, and potential wellfield capacity of each basin and subbasin; and
- Discussion of the potential adverse conditions that may be encountered as a result of groundwater pumping such as seawater intrusion, well interference, overdraft, and land subsidence.

Previous safe yield estimates for the Santa Monica and Hollywood Basins range from 7,500 to 12,400 acre-feet/year (AF/yr) for the Santa Monica Basin and from 3,000 to 4,400 AF/yr for the Hollywood Basin. These estimates were based upon a water budget using a defined hydrology, water levels, or groundwater models, which in turn, required a number of assumptions to determine groundwater recharge, inflows, and outflows.

Kennedy/Jenks conducted a review and estimate of safe yield by focusing on the development of estimates for groundwater recharge. Using site-specific data, the estimated groundwater recharge was compared against that estimated by the U.S. Geological Survey's groundwater model for the area. Results indicate that groundwater recharge could be 8,400 AF/yr higher for the Santa Monica Basin and 2,340 AF/yr higher for the Hollywood Basin than that estimated by the U.S. Geological Survey study. This comparison suggests that the groundwater recharge estimates for the U.S. Geological Survey study may be overly conservative; however, these higher groundwater recharge rates do not necessarily translate to a proportional increase in the safe yield. Nevertheless, these estimates do indicate the potential for a higher safe yield for both the Santa Monica and Hollywood Basins.

The hydrogeologic characterization concluded that:

- The Arcadia, Olympic, and Charnock Subbasins in the Santa Monica Basin are fully utilized by City of Santa Monica's current and planned groundwater pumping operations. As a result, these subbasins are not considered to have any remaining potential capacity.
- The Coastal and Crestal Subbasins in the Santa Monica Basin and the western portion of the Hollywood Basin are considered to have potential capacity.

The safe yield for the Santa Monica Basin ranges from 7,500 to 12,400 AF/yr. For planning purposes, 2,000 AF/yr is considered as potentially available from either the Coastal or Crestal Subbasins.

The safe yield for the Hollywood Basin ranges from 3,000 to 4,400 AF/yr. The City of Beverly Hills produces about 800 to 1,400 AF/yr. Therefore, there is potential capacity of 1,600 to 3,600 AF/yr remaining in the Hollywood Basin.

Aquifer parameters (hydraulic conductivity, aquifer thickness, transmissivity, and storage coefficient) from the U.S. Geological Survey modeling study were used in conjunction with drawdown criterion to determine minimum well spacing for production alternatives. Well spacing considered potential issues such as sea water intrusion, well interference, overdraft, land subsidence, and water quality degradation. As a result of relatively shallow aquifer depths of approximately 300 to 500 ft, well capacities used for the development for alternatives ranged from 350 to 500 gpm.

Review of Basin Governance

Interviews were conducted with four agencies, including the City of Santa Monica, California Department of Water Resources who services as the Watermaster for the Central and West Coast Basins, the Water Replenishment District of Southern California, and the City of Beverly Hills. The purpose of the interviews was to evaluate basin governance, collect additional data, and meet with the relevant stakeholder agencies.

Summary of Existing Facilities

Santa Monica Basin

The City of Santa Monica is the only purveyor in the Santa Monica Basin actively producing groundwater. Groundwater wells are located in the following three subbasins: Charnock, Arcadia, and Olympic.

In the early 1960s the City of Santa Monica constructed the Arcadia Treatment Plant to treat groundwater from the Charnock Subbasin. Treatment consisted of ion exchange softening with seawater brine regeneration, a large reservoir, and a pump station, with brine disposal to a local storm drain that discharges this water to the ocean. Due to volatile organic compound (VOC), primarily trichloroethylene (TCE) contamination of the Charnock wells, a mechanical surface aeration system was installed in the reservoir in the early 1990's with granular activated carbon (GAC) off-gas control. An expansion of the ion exchange system was also completed as part of this project.

In 1996 methyl tertiary butyl ether (MTBE) contamination was discovered, and the City of Santa Monica Charnock wells were placed on inactive status. In January 2011, the City of Santa Monica placed a new treatment system on-line to treat three of the Charnock wells (13, 15, and 19) for MTBE. The Charnock treatment unit is designed to treat 5,400 gpm and is comprised of aeration, iron and manganese removal with greensand filtration, and adsorption with GAC to remove MTBE. Charnock groundwater is then pumped and conveyed to the Arcadia Treatment Plant via a transmission main that is approximately 3 miles in length. Groundwater from the Arcadia and Santa Monica wells is added to the headworks of the Arcadia Treatment Plant. The treatment system at this location is capable of treating 10 million gallons per day (mgd) and consists of chlorination, iron and manganese removal by greensand filtration, reverse osmosis (RO) treatment, decarbonation, chloramination, and final aeration using mechanical surface aerators with GAC off-gas control. Up to 1.5 million gallons of brine per day is generated by the RO facility that is discharged to the sewer, where it flows to the City of Los Angeles Hyperion Wastewater Treatment Plant.

Hollywood Basin

There is only one water purveyor, the City of Beverly Hills, with groundwater facilities in the Hollywood Basin.

The City of Beverly Hills owns and operates four active groundwater production wells in the Hollywood Basin. These wells have a combined capacity of 2,025 gpm and are treated by the City of Beverly Hills 2.7 mgd RO desalter that went on-line in April 2004. This plant is capable of being expanded to 5.4 mgd.

The desalter facilities include extraction wells, a collector pipeline, a treatment plant, and a brine line to deliver waste to the Hyperion Wastewater Treatment Plant. This facility is designed to produce about 2,600 AF/yr of treated water and discharge about 336 AF/yr to the brine line.

For the calendar years 2005 to 2009, groundwater production averaged 1,195 AF/yr with a range of 884 to 1,311 AF/yr. The low production amount of 884 AF/yr was associated with the RO plant being off-line for 3 months (City of Beverly Hills UWMP, 2010)

Water Quality Evaluation

The purpose of the water quality evaluation was to develop water quality profiles to determine potential treatment process requirements and treatment trains to produce potable water from the basins.

Initially, groundwater contamination, clean-up activities, and other readily available data on contamination in these basins was identified. Specifically, a review of the California Department of Toxic Substance Control's on-line Envirostor database and the Regional Water Quality Control Board's on-line Geotracker database was conducted. Next, water quality data from the California Department of Public Health (CDPH) water quality database was evaluated. These data were then used to develop water quality assignments for the potential production areas identified by the hydrogeologic characterization: Coastal Subbasin, Crestal Subbasins, and Hollywood Basin.

Water quality data was not directly available for the Coastal and Crestal Subbasins; therefore, an assignment of the water quality was required to develop the unit treatment process requirements, which included:

Coastal Subbasin

1. The baseline general minerals and total dissolved solids (TDS) are similar to the Charnock wells with an allowance for increased sodium chloride due to seawater intrusion. The assumed overall TDS is 1,800 mg/L, approximately a 50 percent increase of the blended raw Charnock groundwater from the City of Santa Monica wells.
2. There are no VOCs as contaminants of concern (COCs).
3. Iron and manganese are at concentrations that can be handled by pH control or anti-scalants.

Crestal Subbasin

1. The baseline general minerals and TDS are similar to the lower range for hardness and TDS of the Charnock wells. The assumed overall TDS was 900 mg/L, approximately 200 mg/L lower than the Charnock wells with high TDS.
2. There would be taste and odor compounds and perhaps some gasoline-related VOCs.
3. Iron and manganese would be at concentrations above the SMCL and would require removal.

The baseline water quality for new wells in the Hollywood Basin was based on the historical and current treatment provided by the City of Beverly Hills and includes the following COCs:

- TDS – between 527-561 mg/L (based on 3 active wells); maximum 829 mg/L (1 well)
- Iron – between non-detect (ND) to 0.5 mg/L
- Manganese – between ND and 0.3 mg/L
- Arsenic – between ND-2.8 µg/L (based on 3 active wells); maximum 19.4 µg/L (1 well)
- Color – between 10 – 30 units
- Odor - <5 to 40 units
- VOCs associated with gasoline - <10 µg/L

Treatment

Treatment trains were developed in order to bring water quality into compliance with CDPH water quality standards. Based on the existing water quality, the main three COCs that require treatment are as follows:

- Iron and Manganese - Santa Monica Crestal Subbasin and Hollywood Basin
- VOCs, Odor and Color - Santa Monica Crestal Subbasin and Hollywood Basin
- Total Dissolved Solids – Santa Monica Crestal Subbasin and Santa Monica Coastal Subbasin

The recommended treatment process trains are as follows:

- Hollywood Basin: Greensand – Granular Activated Carbon (GAC) – Chloramination
- Santa Monica Crestal Subbasin: Greensand – GAC – Reverse Osmosis (RO) - Chloramination
- Santa Monica Coastal Subbasin: RO – Chloramination

Alternatives

As a result of the hydrogeologic and water quality characterization along with the review of basin governance and existing groundwater pumping, target project sizes were established as 3,000 AF/yr for the Hollywood Basin and 2,000 AF/yr for the Crestal and Coastal Subbasins. However, constraints on well spacing and interference resulted in the 3,000 AF/yr target for the Hollywood Basin being reduced to 2,500 AF/yr for the 6-month pumping alternative. In addition, the Crestal and Coastal Subbasin alternatives should be considered as mutually exclusive, with the target for total production from the Santa Monica Basin limited to 2,000 AF/yr.

Seven (7) alternative sites were identified in the study area as shown on Figure ES-2 and summarized in Table ES-1. The summary table shows the basin/subbasin location, site name, operational scenario (6 or 10 months), alternative identification number (1 through 7), number of wells, and the amount of finished water in AF/yr.

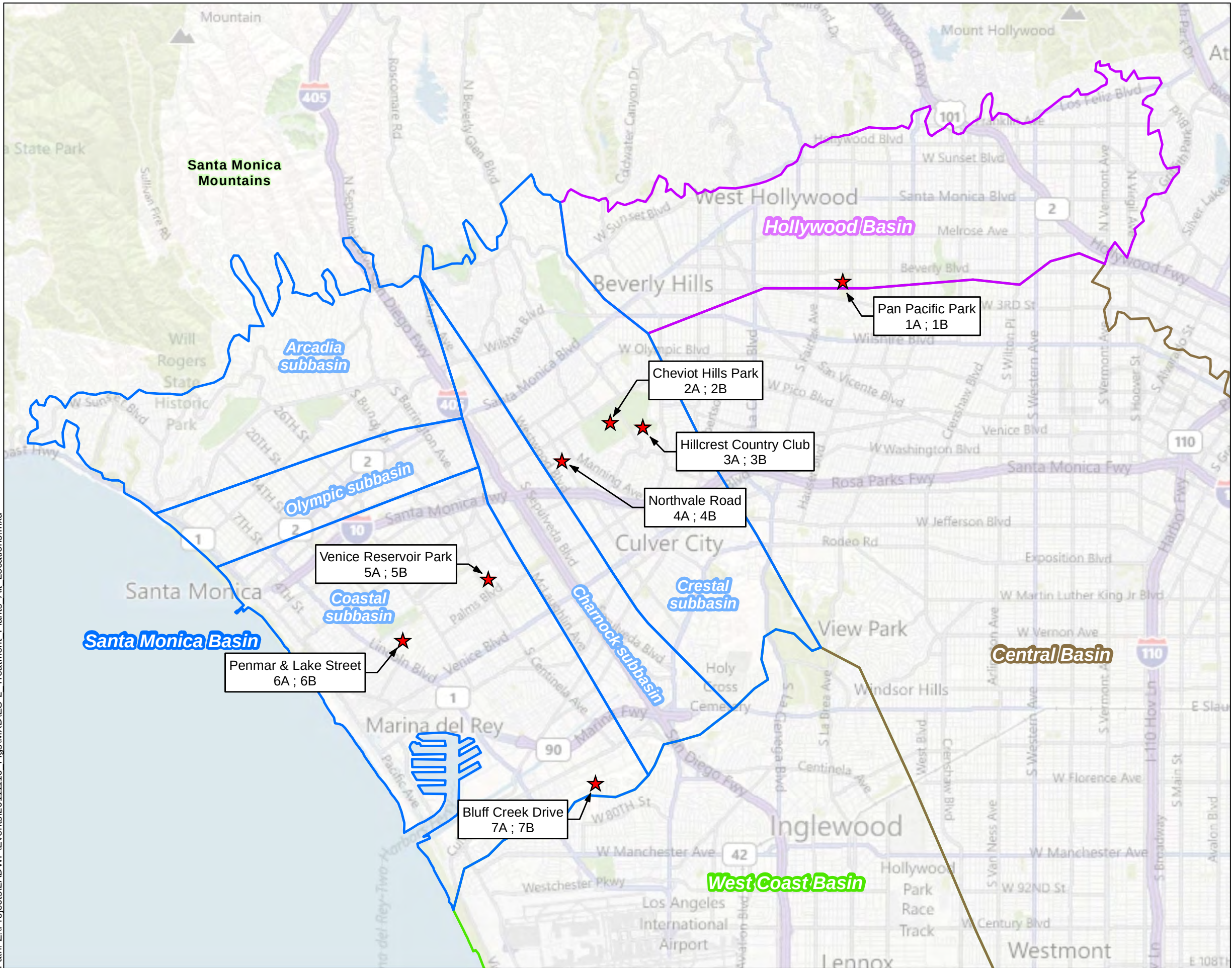
Each site has an "A" and a "B" option, whereby "A" denotes a 10-month operational scenario and "B" denotes a 6-month operational scenario. The purpose of a 10-month versus a 6-month operational scenario is to address the seasonality of demand and the added benefit of emergency supply. In effect, an annual water production for each well has been assumed such that groundwater production would be achieved in either 6 or 10 months.

Site identification was supplemented by a review of available open space. Specifically, vacant properties greater than or equal to 0.5 acres in size as well as appropriate multi-use properties (parks, golf courses, and other open space) that are of sufficient size for the construction of groundwater production wells and treatment facilities were considered. Furthermore, property owned by the City of Los Angeles was identified. For each site, the location, size, property features, slope, proximity to LADWP distribution pipelines, and proximity to available utilities (e.g., power, storm drain, and sewer) were evaluated.

Wells were spaced appropriately using hydrogeologic data so as to minimize well interference. Treatment scenarios were applied on a basin/subbasin-specific basis. A pipeline collection system was then sized and conceptually developed for each group of wells to feed a regional treatment facility. Finally, pump stations and pipeline facilities to deliver the treated groundwater to the nearest appropriate LADWP distribution pipeline were identified for each alternative.

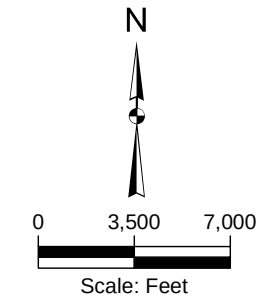
Estimates of probable cost for each alternative were developed. These include planning-level capital and operation & maintenance (O&M) costs for wells, treatment facilities, pump stations, ancillary features, as well as an estimate of pipeline requirements. These conceptual estimates were prepared to have level of accuracy of -30 percent to +50 percent.

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Legend

- ★ Proposed Treatment Plant Location
- Hollywood Basin
- Santa Monica Basin
- West Coast Basin
- Central Basin



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Los Angeles, CA
Task Order No. 3 (Agreement No. 47818)

Water Treatment Plant Alternative Locations

K/J 1179008*00
December 2011

Figure ES-2

Table ES-1: Summary of Alternatives

Basin/Subbasin	Site Name	10-Month Operation			6-Month Operation		
		Alternative No. ¹	No. of Wells	Finished Water (AF/yr)	Alternative No. ¹	No. of Wells	Finished Water (AF/yr)
Hollywood Basin	Pan Pacific Park	1A	6	3,000	1B	9	2,500
Santa Monica Basin/Crestal Subbasin	Cheviot Hills Park	2A	5	2,000	2B	8	2,000
	Hillcrest Country Club	3A	5	2,000	3B	8	2,000
	Northvale Road	4A	5	2,000	4B	8	2,000
Santa Monica Basin/Coastal Subbasin	Venice Reservoir Park	5A	4	2,000	5B	6	2,000
	Penmar & Lake Street	6A	5	2,000	6B	7	2,000
	Bluff Creek Drive	7A	5	2,000	7B	8	2,000

Notes:

1 - "A" denotes a 10-month operational scenario and "B" denotes a 6-month operational scenario.

Table ES-2 provides a comparison and ranking of all alternatives based on estimated probable costs. The alternatives are listed in order of increasing total cost per acre foot.

Table ES-2: Summary of Alternatives Ranked on Estimated Costs

Alternative No.	Basin/Site Name	Finished Water (AF/yr)	10 Month Operation		
			Capital	O&M	Total
1A	Hollywood – Pan Pacific	3,000	\$232/AF	\$201/AF	\$433/AF
5A	Coastal - Venice Reservoir	2,000	\$327/AF	\$562/AF	\$889/AF
6A	Coastal - Penmar & Lake St	2,000	\$404/AF	\$520/AF	\$924/AF
7A	Coastal - Bluff Creek Drive	2,000	\$410/AF	\$530/AF	\$940/AF
3A	Crestal - Hillcrest Country Club	2,000	\$488/AF	\$572/AF	\$1,060/AF
2A	Crestal - Cheviot Hills Park	2,000	\$483/AF	\$589/AF	\$1,072/AF
4A	Crestal - Northvale Road	2,000	\$472/AF	\$659/AF	\$1,131/AF
Alternative No.	Basin/Site Name	Finished Water (AF/yr)	6 Month Operation		
			Capital	O&M	Total
1B	Hollywood – Pan Pacific	2,500	\$370/AF	\$244/AF	\$614/AF
5B	Coastal - Venice Reservoir	2,000	\$443AF	\$572/AF	\$1,015AF
6B	Coastal - Penmar & Lake St	2,000	\$521/AF	\$530/AF	\$1,051/AF
7B	Coastal - Bluff Creek Drive	2,000	\$561/AF	\$536/AF	\$1,097/AF
3B	Crestal - Hillcrest Country Club	2,000	\$663/AF	\$613/AF	\$1,276/AF
2B	Crestal - Cheviot Hills Park	2,000	\$658AF	\$630/AF	\$1,288/AF
4B	Crestal - Northvale Road	2,000	\$643/AF	\$705/AF	\$1,348/AF

The capital costs of the 14 alternatives range from \$10.1 to \$15.0 million for the “A” scenarios operating over 10 months per year and \$13.6 to \$20.4 million for the “B” scenarios operating over 6 months per year. As alternatives 1A and 1B are comprised of larger capacity projects than the remaining alternatives, unit cost of production is used to compare the alternatives. On an amortized unit cost basis, the alternatives range from \$232/AF to \$488/AF for the 10-month scenarios and \$370/AF to \$663/AF for the 6-month scenarios.

The annual O&M costs range from \$604,000 to \$1,317,000 for the 10-month scenarios and \$611,000 to \$1,409,000 for the 6-month scenarios. Again, alternatives 1A and 1B produce a greater volume of product water, so unit cost of production is used to compare alternatives. These O&M costs equate to \$201/AF to \$659/AF for the 10-month scenarios and \$562/AF to \$705/AF for the 6-month scenarios.

On a total unit cost basis, the 14 alternatives range from \$433/AF to \$1,131/AF for the 10-month scenarios and \$614/AF to \$1,348 for the 6-month scenarios.

Non-Economic Factors

A non-economic evaluation was performed looking at numerous non-economic factors including: water quality availability (uncertainty), construction impacts, tree removal, access, security, aesthetics, community impacts, and environmental impacts. The ranking of these factors for each alternative resulted in one site, the Northvale Road site in the Santa Monica Basin, Crestal Subbasin (Alternatives 4A and 4B), as being sufficiently substantial as to place the project in question as to its viability as a public water supply project site. One of the concerns includes the potential for contamination in the surface and/or subsurface soils due to the previous use as a railroad transportation corridor.

Since Alternative 4A and 4B are the most expensive alternatives (on a unit cost basis) for the 10-month and 6-month operating scenarios, respectively, removing this site from further consideration has no impact on the recommended projects.

Summary

As a result of the study, it was determined that the development of a new potable water supply of up to 3,000 AF/yr from the Hollywood Basin and up to 2,000 AF/yr from the Santa Monica Basin (Crestal or Coastal subbasins) is viable and technically feasible. The political and legal merits, including the determination of water rights, for developing these supplies is outside the scope of this study.

The lowest cost project on a total unit cost basis of \$433/AF is Alternative 1A, the Hollywood Basin Pan Pacific Park site designed to produce 3,000 AF/yr over 10 months of operation using six wells and a Green Sand – GAC – Chloramination treatment process train. The second lowest cost project with a total unit cost of \$614/AF is Alternative 1B, the Hollywood Basin Pan Pacific Park site designed to produce 2,500 AF/yr over 6 months of operation using nine wells and a green sand – GAC – Chloramination treatment process train. However, these two projects are mutually exclusive and one project would need to be selected over the other. The non-economic analysis suggests that Alternative 1A would be less intrusive and disruptive than Alternative 1B, due to the construction of three fewer wells and associated collection pipelines within the existing park.

After the Pan Pacific Park Project in the Hollywood Basin, the next lowest cost project (on a unit cost basis) is Alternative 5A, the Santa Monica Basin, Coastal Subbasin, and Venice Reservoir Park Project at a total unit cost of \$889/AF. This project is designed to produce 2,000 AF/yr over 10 months of operation using four wells and a Green Sand – GAC- RO – Chloramination treatment process train. This project was ranked relatively high in the non-economic ranking with the greatest concern being aesthetics.

LADWP has expressed interest in potentially developing a potable groundwater supply in the No Man's Land area in the north end of the Central Basin (just south of the Hollywood Basin). LADWP suggested that property at its Western District Headquarters at 5898 West Venice Boulevard, Los Angeles, CA 90019, could serve as a demonstration project for a well or wells

and treatment using a package (potentially leased) treatment facility. Evaluation of this option is outside the scope of the current study.

Recommendation

Based on the findings of this study, Kennedy/Jenks recommends Alternative 1A and Alternative 5A for further study and potential implementation.

Alternative 1A involves the development of 3,000 AF/yr from the Hollywood Basin at the Pan Pacific Park site with 6 wells and a 10-month pumping operation using a Green Sand – GAC – Chloramination treatment process train. The production from this site would be pumped into LADWP's 579 Zone. The capital cost is estimated to be \$10.7 million. The total unit cost is estimated to be \$433/AF. This cost is approximately half of the current cost of purchasing treated imported water from MWD.

Alternative 5A involves the development of 2,000 AF/yr from the Santa Monica Basin at the LADWP-owned Venice Reservoir Park site with 4 wells and a 10-month pumping operation using Green Sand – GAC – RO- Chloramination treatment process train. The production from this site would be pumped into LADWP's 426 Zone. The capital cost is estimated to be \$10.1 million. The total unit cost is estimated to be \$889/AF. This cost is essentially equal to the current cost of purchasing treated imported water from MWD. However, MWD has stated their intention to increase its water rates approximately 7 to 8 percent per year over the next five years, which suggests a purchased water cost of roughly \$1,150/AF by 2017.

If a project is selected for implementation, additional study will be needed. One option is to construct a test well to allow site specific water quality sampling as well as confirmation of depth to bedrock and soil conditions. Furthermore, a CDPH-mandated drinking water source water assessment would be required to permit the source. This assessment would serve to further characterize potential contaminating activities for the selected alternative.

Section 1: Introduction

This section provides an introduction to the feasibility study, defines its purpose, describes the study area, and provides background information.

1.1 Introduction

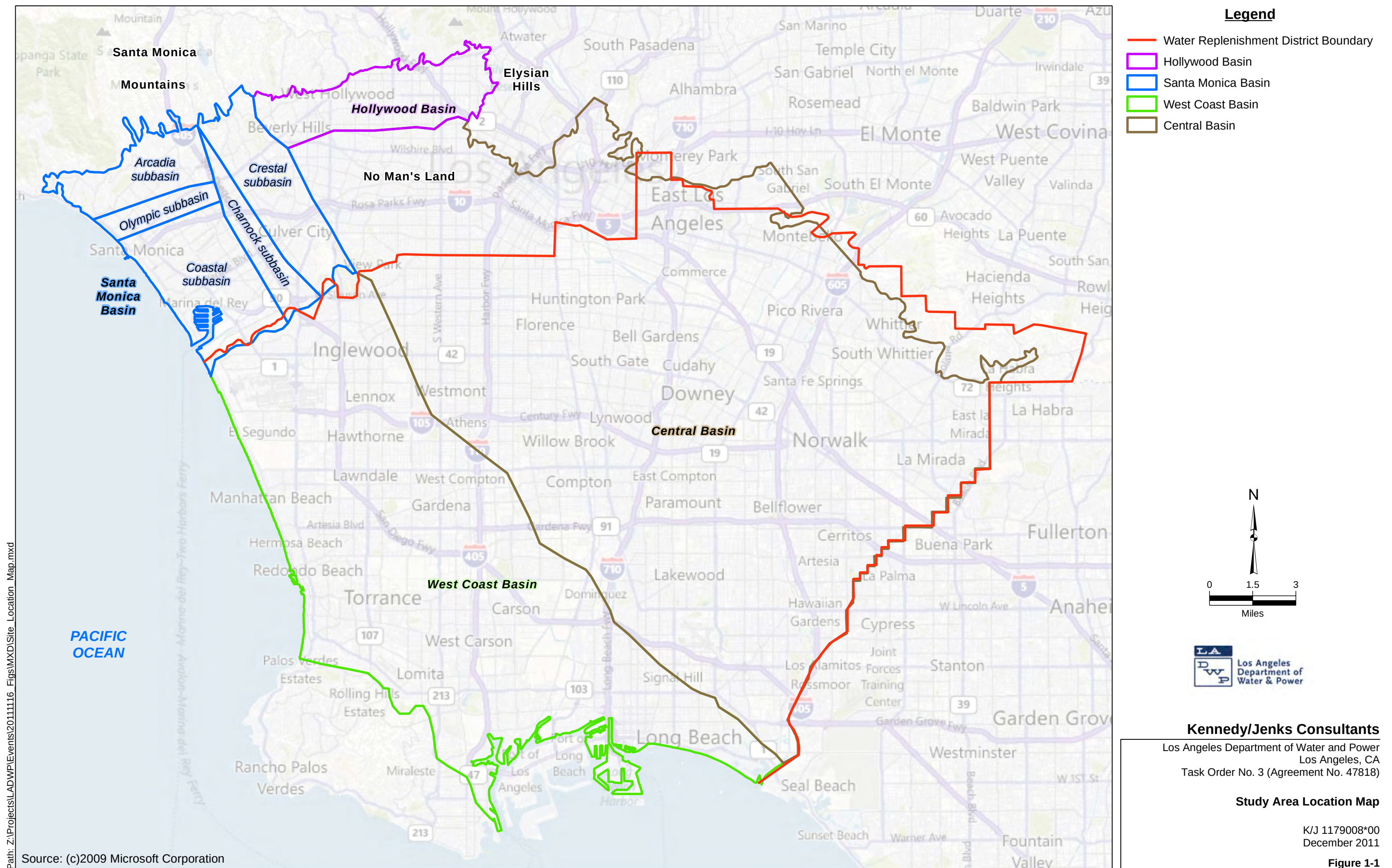
Under Agreement 47818 with the Los Angeles Department of Water and Power (LADWP), Kennedy Jenks conducted Task Order No. 3 entitled, *"Strategic Planning Services Relating to Investigating the Feasibility of Developing the Santa Monica and Hollywood Basins as Sources of Groundwater Supply."* The purpose of this study was to evaluate the feasibility of developing the Santa Monica and Hollywood groundwater basins as potable groundwater supply sources for the City of Los Angeles. LADWP conducted its own investigation of these groundwater basins in 1991 to assess potable groundwater development for the City of Los Angeles (LADWP, 1991). This feasibility report represents the deliverable for Task Order No. 3, and it also serves to follow-up on the findings of LADWP's 1991 investigation.

For each groundwater basin, the study included:

- Hydrogeologic characterization, including an estimation of groundwater quantity available and review of safe yield estimates;
- Evaluation of basin governance, including interviews with stakeholder agencies and quantification of groundwater production by other entities;
- Review of groundwater quality using available data from the California Department of Public Health (CDPH) public water supply database coupled with a review of the State Water Resources Control Board (SWRCB) EnviroStor database and the California Department of Toxic Substance Control (DTSC) GeoTracker database;
- Review of existing facilities and groundwater production in the study area;
- Development of treatment scenarios needed to produce potable water; and
- Identification and development of production alternatives, including preliminary siting of wells, pipelines, and treatment facilities.

1.2 Physiographic Setting of Study Area

The study area consists of the Santa Monica and Hollywood Basins, both of which are located in the northwestern portion of the coastal plain of Los Angeles County (Figure 1-1). This section provides a brief physiographic description of the study area, whereas Section 2 provides more detailed information on the study area physiography, climate, hydrogeology, groundwater basins, and structural geology (i.e., faults).



Several distinct groundwater basins comprise the Los Angeles Basin: Orange County Coastal Plain, Central, West Coast, Santa Monica, and Hollywood (CDWR, 2003). The Santa Monica and Hollywood Basins are within the service areas of the cities of Santa Monica, Los Angeles, and Beverly Hills.

Physiographically, the Santa Monica Basin is adjacent to the Santa Monica Mountains to the north, the Pacific Ocean to the west, the Hollywood Basin to the northeast, and the Central Basin to the southeast, and the West Coast Basin to the south. Overlying cities include the cities of Santa Monica, Culver City, and Beverly Hills as well as the communities of Pacific Palisades, Brentwood, Venice, Marina del Rey, West Los Angeles, Century City, and Mar Vista. Faults subdivide this basin into five subbasins:

- Charnock Subbasin;
- Coastal Subbasin;
- Crestal Subbasin;
- Arcadia Subbasin; and
- Olympic Subbasin.

The Hollywood Basin is immediately adjacent to the Santa Monica Mountains to the north, the Santa Monica Basin to the west, the Central Basin to the south, and the Elysian Hills to the east. Overlying cities include the cities of Beverly Hills, West Hollywood, and Los Angeles.

1.3 Background

Both the Santa Monica and Hollywood basins are unadjudicated groundwater basins, whereby any party owning property overlying the aquifers has a right to pump from the basin. The LADWP and the City of Los Angeles own property in these basins, and thereby have groundwater rights associated with property ownership. In 1991, LADWP completed an investigation on the development of these groundwater basins as water supply sources for the City of Los Angeles. The study included a review of existing data, hydrogeologic characterization of the groundwater basins, water quality analysis, review of current and future groundwater users, and identification of potential sites for a water supply project. A total of 19 potential sites were identified, with a total of six sites appearing to be the most feasible based on hydrogeology and water quality. Three sites were located in the Crestal Subbasin of the Santa Monica Basin, and three sites were located in the Hollywood Basin. For these six sites, LADWP identified the required facilities and operation & maintenance (O&M) needs. The analysis included a cost analysis for the water supply, and the study concluded that groundwater development in these basins is feasible for the City of Los Angeles.

Twenty years have passed since LADWP's 1991 feasibility study. As such, the purpose of this study is to not only build upon LADWP's previous work, but also to take a comprehensive look at new data and present-day conditions to evaluate the feasibility of groundwater development in the Santa Monica and Hollywood Basins.

Section 2: Hydrogeologic Characterization

The section provides an evaluation of the hydrogeological characterization of the Santa Monica and Hollywood Basins to evaluate the potential groundwater production capacities. This evaluation included the following:

- Hydrogeological characterization of the Santa Monica and Hollywood Basins based on review of existing reports and data;
- Evaluation of the storage capacity, safe yield, and potential wellfield capacity of each basin and subbasin; and
- Discussion of the potential adverse conditions that may be encountered as a result of groundwater pumping such as seawater intrusion, well interference, overdraft, and land subsidence.

2.1 Study Area

Provided herein is a brief overview of the regional setting of the study area that provides context for later more detailed discussion on the Santa Monica and Hollywood Basins.

2.1.1 Setting, Drainage, and Climate

The Santa Monica and Hollywood Basins are located in the northwestern portion of the coastal plain of Los Angeles County (Figure 1-1) and within the northwestern part of the Los Angeles Basin. The Los Angeles Basin is sub-divided into five distinct groundwater basins: Orange County Coastal Plain, Central, West Coast, Santa Monica, and Hollywood (CDWR, 2003) covering an area of approximately 860 square-miles in Los Angeles and Orange Counties, California (Figure 1-1).

General drainage patterns are from the Santa Monica Mountains on the north towards the Santa Monica and Hollywood Basins to the south. The Santa Monica Mountains are an east-west trending range that forms the northern boundary of the Santa Monica and Hollywood Basins. The rugged, deeply dissected mountains rise to 3,111 feet at Sandstone Peak (Parkinson and McCoy, 2006). Ballona Creek is the dominant hydrologic feature and drains surface waters west to the Pacific Ocean.

The climate is classified as Mediterranean, characterized by warm summers, cool winters, and markedly seasonal rainfall. Nearly all rain falls from late autumn to early spring; virtually no precipitation falls during the summer. The average rainfall in the Coastal Los Angeles Basin area ranges from about 12 inches in the lowlands to over 23 inches in the Santa Monica Mountains. Potential evapotranspiration in the coastal plain exceeds precipitation on an annual basis, and under natural conditions, the lower reaches of rivers that drain the basin are dry in the summer (CDWR, 2003).

2.1.2 Regional Groundwater Basins

The divisions of the regional groundwater basins are caused by geologic features such as non-water bearing bedrock, faults, and other features that impede the flow of groundwater such as folds and groundwater mounds. The understanding of the structural geology of the Los Angeles Basin is based on previous studies by Reichard and others (2003), Wright (1991), and Yerkes and others (1965).

The study area lies within the central and southwestern structural blocks of the Los Angeles Basin. The Central and Hollywood Basins are within the central block, and the West Coast and Santa Monica Basins are within the southwestern block. The Newport-Inglewood Uplift is a series of northwest-trending anticlinal folds and discontinuous faults that separates the central and southwestern blocks. The Newport-Inglewood Uplift extends from Beverly Hills southeast to Newport Beach in southern Orange County (Reichard and others, 2003; Wright, 1991). In the Santa Monica and Hollywood Basins, the associated uplifts along the Newport-Inglewood Uplift include the Beverly Hills and Baldwin Hills, and the primary fault is the Newport-Inglewood Fault (Figure 2-1). Wright (1991) includes Beverly Hills as part of the Santa Monica Fault system rather than the Newport-Inglewood Uplift.

2.1.3 Regional Hydrogeology

The geology in the Santa Monica and Hollywood Basins consists of unconsolidated and semi-consolidated fluvial and marine deposits (Reichard and others, 2003; CDWR, 1961, 2003; Yerkes and others, 1965; Poland and others, 1959). During the mid-Pliocene to Holocene to Mesozoic, encroachment of the sea and deposition of alluvium derived from erosion of the surrounding mountains filled the basins with heterogeneous deposits of clay, silt, sand, and gravel of various thicknesses (CDWR, 2003).

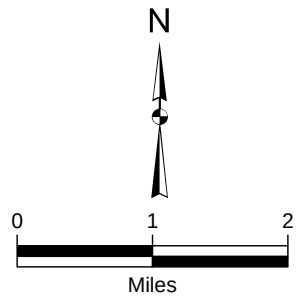
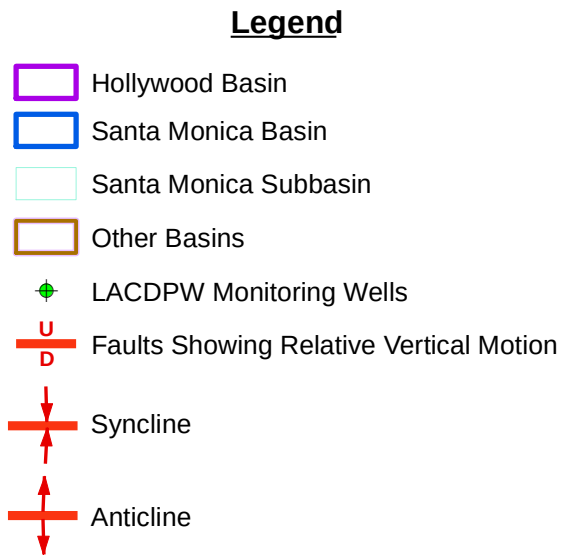
The main water-bearing formations occur in Holocene- and Pleistocene-age sediments. Figure 2-2 shows the correlation of the geologic formations and aquifer systems in the Los Angeles Basin (Reichard and others, 2003; CDWR, 1961, 2003; Yerkes and others, 1965; Poland and others, 1959).

The Recent aquifer system primarily includes the Ballona aquifer, whereby the primary feature of the Ballona aquifer is the "50-foot Gravel", so named for the depth below ground surface where the base of the unit is encountered. The Recent aquifer system also includes shallow, perched aquifers and the Bellflower confining layer or aquiclude (CDWR, 1961). The perched aquifers are relatively thin sand and gravel layers near the land surface. The Bellflower aquiclude includes all of the fine-grained sediments that extend from the ground surface or from the base of the perched aquifer, down to the underlying aquifer.

The Lakewood Formation includes all late-Pleistocene-age stream and flood plain type deposits excluding those corresponding to Older Dune Sands. The maximum thickness of the Lakewood Formation is on the order of 340 feet. The aquifers in the Lakewood Formation include the Exposition, Artesia, Gardena, and Gage. However, these aquifers are not well developed in the Santa Monica and Hollywood Basins, where they provide only minor water supply potential. In the study area, the aquifers of the Lakewood Formation are often referred to as the shallow aquifer rather than their regional names since they are not as important for water supply in this area.



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**Key Geologic Features within the
Santa Monica and Hollywood Basins**

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December 2011

Figure 2-1

AGE	FORMATION	AQUIFER	AQUIFER SYSTEM	
HOLOCENE	ACTIVE SAND DUNE	SEMIPERCHED	RECENT AQUIFER SYSTEM	UPPER AQUIFER SYSTEMS
UPPER PLEISTOCENE	OLDER SAND DUNE	GASPUR BALLONA	LAKEWOOD AQUIFER SYSTEM	
	<i>LAKEWOOD FORMATION</i> (California Dept. of Water Resources, 1961) <i>(UNNAMED UPPER PLEISTOCENE</i> Poland and others 1966, 1968)	EXPOSITION ARTESIA GARDENA GAGE (200-FOOT SAND)		
LOWER PLEISTOCENE	<i>SAN PEDRO FORMATION</i>	HOLLYDALE	UPPER SAN PEDRO AQUIFER SYSTEM	
		JEFFERSON		
		LYNWOOD (400-FOOT GRAVEL)		
		SILVERADO	LOWER SAN PEDRO AQUIFER SYSTEM	
		SUNNYSIDE LOWER SAN PEDRO		
UPPER PLIOCENE	<i>PICO FORMATION, UPPER DIVISION</i>			PICO UNIT

Source: USGS Water Resource Investigation Report 03-4065
(Reichard and others, 2003)

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Stratigraphic Column for the Los Angeles Area

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December 2011

Figure 2-2

The most important water-bearing formation in the study area is the San Pedro Formation, a lower-Pleistocene deposit with significant sand and gravel layers (Poland and others, 1959). The San Pedro Formation includes all strata of early-Pleistocene age and ranges in thickness from about 400 feet to 1,350 feet. The formation underlies almost the entire coastal plain, and contains most of the important aquifers used for production in the study area. Only those members of the formation capable of storing or transmitting groundwater in suitable quantities have been formally named. These aquifers include the Jefferson, Lynwood, Silverado, and Sunnyside aquifers. In the Santa Monica and Hollywood Basins, the Silverado aquifer is considered to be the primary aquifer. The other aquifers may be present, but typically all of the San Pedro Formation aquifers are referred to as the Silverado in the study area.

Underlying these primary aquifer systems is the Pico Formation. The Pico Formation consists of up to 5,800 feet of semi-consolidated marine sediments that do not contain potable water due to high salinity (Poland and others, 1959). The Pico Formation represents the base of the groundwater basin in the Santa Monica and Hollywood Basins.

2.1.4 Regional Groundwater

In general, groundwater in the study area occurs in the following conditions:

- A body of shallow, unconfined, semi-perched water;
- The principal fresh water body; and
- Brackish and saline water underlying the principal fresh water body.

This study is concerned with the principal fresh water body.

Groundwater recharge in the Santa Monica and Hollywood Basins is mainly from percolation of precipitation and surface runoff onto the coastal plain deposits from the Santa Monica Mountains. Groundwater movement is generally towards the south away from the Santa Monica Mountains. Historically, groundwater recharge was also derived from seepage from the numerous small stream beds and major streams crossing the area and by direct percolation of precipitation and other applied water; however, this recharge mechanism has been restricted due to urbanization.

Along the coastal areas near the City of Santa Monica, groundwater movement is primarily westward with discharge into Santa Monica Bay. The Newport-Inglewood Uplift limits groundwater flow from the Santa Monica Basin to either the Hollywood or the Central Basin. Groundwater flow from the Hollywood Basin into the Central Basin is restricted by the La Brea High. The La Brea High is an anticline where most of the San Pedro Formation was eroded prior to deposition of the Lakewood Formation (CDWR, 1961).

For the Santa Monica and Hollywood Basins, safe yields have not been formally established but estimates have been provided in previous technical reports. The Santa Monica and Hollywood Basins are not adjudicated or identified as basins in overdraft based on the California Department of Water Resources (CDWR) official bulletins (CDWR, 2003). However, the California Water Plan Update does state that groundwater overdraft is a challenge for the South Coast Hydrologic Region. This designation primarily relates to the Central and West Coast

Basins that are adjudicated. An assessment of the safe yield for the Santa Monica and Hollywood Basins is provided later in Section 2.2.3.

2.2 Hydrogeologic Data Compilation and Review

For this feasibility study, available reports and data were compiled for review to summarize existing hydrogeology and the conceptual understanding of the Santa Monica and Hollywood Basins. This section provides a brief summary of the key reports and data used for this feasibility study.

2.2.1 Previous Reports

Reports on the geology and groundwater conditions in the Santa Monica and Hollywood Basins were compiled and reviewed. Some of the key references include reports from the U. S. Geological Survey, CDWR, the Charnock Superfund Site, as well as groundwater reports for the City of Santa Monica and Beverly Hills. References are cited in the report and listed in the references section. Key reports on the hydrogeology of the Santa Monica and Hollywood Basins include:

- The recent U.S. Geological Survey (Reichard and others, 2003) "*Geohydrology, Geochemistry, and Groundwater Simulation – Optimization of the Central and West Coast Basins, Los Angeles County, California*" provides a regional overview of the hydrogeology of the Los Angeles Basin, and includes a groundwater model study used for quantifying groundwater flow between groundwater basins.
- A series of reports were generated as part of the environmental investigation and remediation of the Charnock MTBE Project under the oversight of the California Regional Water Quality Control Board, Los Angeles Region, and the US Environmental Protection Agency Region IX. These reports were prepared by various consultants including Geomatrix (1997, 1999), Environ (2000, 2001), and GeoTrans (2005) to evaluate the geology, groundwater flow, groundwater modeling, and future groundwater pumping potential in the Charnock Subbasin and portions of the adjoining subbasins.
- Updated Urban Water Management Plans (UWMP) by the Cities of Santa Monica and Beverly Hills (Santa Monica, 2011; Beverly Hills, 2011) provides recent updates of the water supply, groundwater pumping operations, and upcoming plans for groundwater production by the two largest groundwater producers in the study area.
- A Water Supply Assessment performed for the City of Santa Monica (PBS&J, 2010) provided a summary of local history, operations, and a revised safe yield for the Santa Monica Basin.
- The CDWR Bulletin 118 provides a basic overview of the Santa Monica and Hollywood Basins (CDWR, 2003).
- Development of the Santa Monica and Hollywood Groundwater Basins as a Water Supply Source for the City of Los Angeles, report prepared by LADWP Aqueduct Division – Hydrology Section, April 1991.

2.2.2 Sources of Hydrogeologic Data

The first water wells were drilled in the mid-1800s, and by the early 1900s there were more than 4,000 wells in the Los Angeles area (Reichard and others, 2003). For this study, well logs in the Santa Monica and Hollywood Basins were requested from CDWR for wells equal to or greater than 200 feet in total depth. Well logs for a large number of shallow wells are available through CDWR; however, the deeper wells were considered most relevant to this feasibility study.

A summary of the data compiled from the 314 well logs received from CDWR is presented in Appendix A. Figure 2-3 is a map showing the distribution of wells that were plotted using township, range, and section information provided on the logs. The highest density of wells is located in the western portion of the Hollywood Basin and the central portion of the Santa Monica Basin. Other parts of the study area have few or no well logs available. Data analysis using well log information was conducted to assess the Santa Monica and Hollywood Basins.

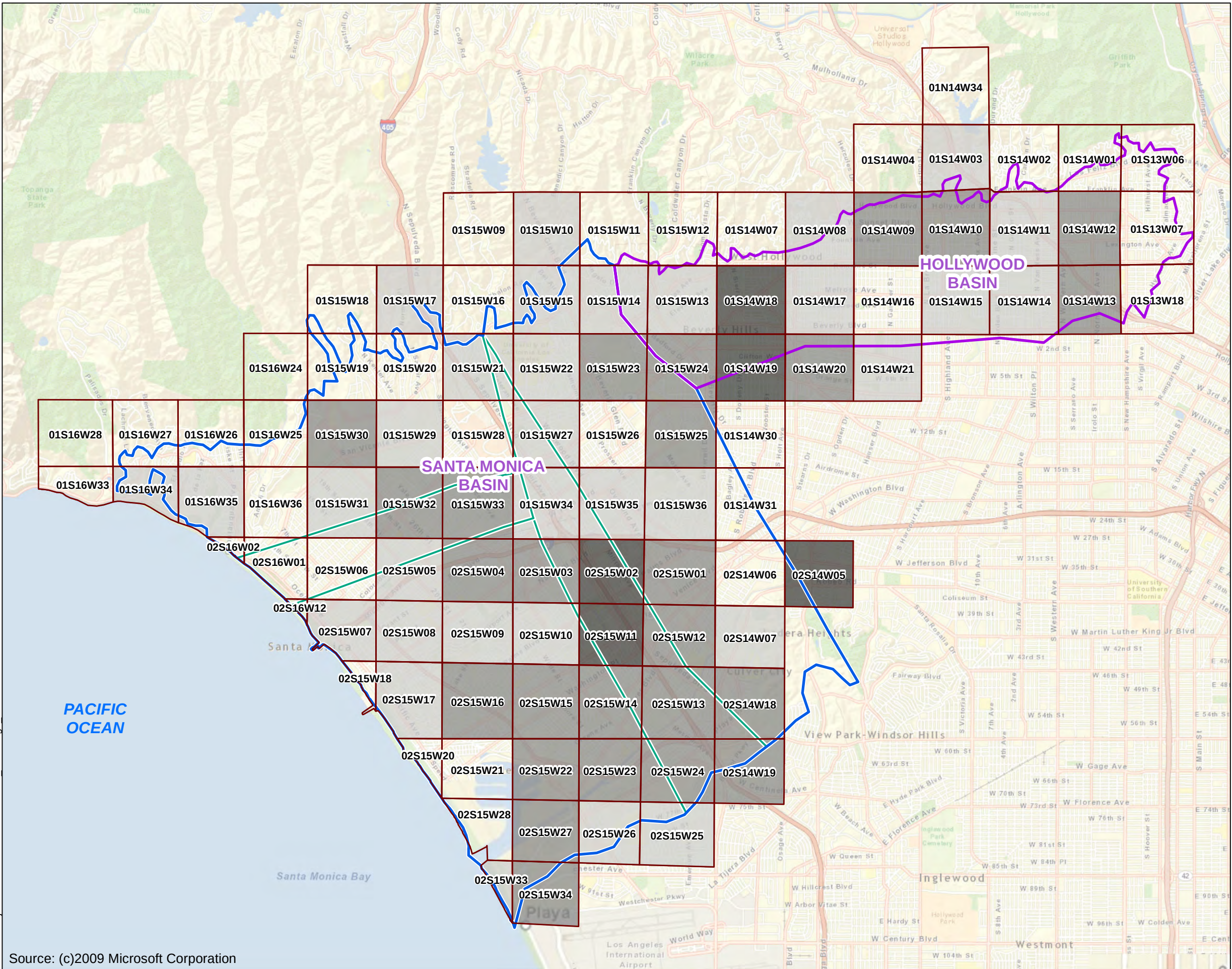
Groundwater elevation data was collected from the Los Angeles County Department of Public Works web site (LACDPW, 2011) for routinely measured monitoring wells in the Santa Monica and Hollywood Basins. The locations of the wells are shown on Figure 2-1. Representative hydrographs are discussed in following sections regarding the assessment of the Santa Monica and Hollywood Basins.

Rainfall data was compiled for precipitation stations with a long record for different areas in the study area. The rainfall data was utilized to assess the water balance used for the safe yield estimates. Data was downloaded from the Western Regional Climate Center (WRCC, 2011) at the Desert Research Institute Website for the following stations:

- Topanga Ranger Station – records from 1949 to 2011 for station representative of the Santa Monica Mountains;
- North Hollywood – records from 1936 to 2011 for station representative of the Hollywood Basin;
- UCLA – records from 1933 to 2011 for station representative of the northern Santa Monica Basin ;
- Culver City – records from 1935 to 2011 for station representative of the southern Santa Monica Basin; and
- Santa Monica Pier – records from 1936 to 2011 for station representative of the coastal Santa Monica Basin.

2.2.3 Definition of Safe Yield

Safe yield is a concept that is applied to groundwater basins as a mechanism to define the natural limit of groundwater pumping. The definition of “safe yield” is the annual amount of groundwater that can be taken from an aquifer over a period of years without depleting it beyond its ability to be replenished naturally (Todd, 1980). For example, overpumping of a basin may lead to perennial declines in groundwater levels that over time may result in widespread loss of well production.



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Distribution of CDWR Well Logs

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December 2011

Figure 2-3

Safe yield is typically determined based upon a water budget using a defined hydrology, water levels, or groundwater models. Other terms that are loosely correlative with “safe yield” include “perennial yield” or “sustainable yield”. In cases where groundwater pumping has been adjudicated in a court decision, the term “safe yield” is commonly applied to define the legal rights to extract groundwater in a basin.

The determination of safe yield may also include quantitative measures to evaluate when adverse conditions occur. Adverse conditions include such things as permanently lowered groundwater levels, subsidence, or degradation of water quality in the aquifer. Water quality degradation is particularly important in basins where seawater intrusion is a factor.

2.3 Santa Monica Basin Assessment

The assessment of the Santa Monica Basin provides a regional understanding of groundwater based on a review of existing hydrogeological data and reports. The following discussion is a summary of this review based on key reports that primarily include CDWR (1961, 2003), Reichard and others (2003), Santa Monica (2011), LACDPW (2011), MWD (2007), PBS&J (2010), Environ (2000, 2001), GeoTrans (2005), Geomatrix (1997, 1999) and Kennedy/Jenks (1992).

2.3.1 Hydrogeology

The primary water-producing units include the relatively coarse-grained sediments of the Recent alluvium, Lakewood Formation, and San Pedro Formation.

The recent alluvium reaches a maximum thickness of approximately 90 feet and includes the clays of the Bellflower aquiclude and the underlying Ballona aquifer, which is also referred to as the “50-Foot Gravel.” The “50-Foot Gravel” was formed by an ancient stream channel that cut through older sediments, depositing gravels resulting in the present Ballona Gap structure. These gravels are dominant at a depth of approximately 50 feet. The “50-Foot Gravel” is generally separated from the underlying San Pedro Formation by the confining layer; however, in some areas, particularly in the Marina del Rey area, the two formations may be hydrologically continuous (Poland and others, 1959). This relationship becomes important when evaluating the potential for seawater intrusion.

The Lakewood Formation appears to be present only in the northern half of the Santa Monica Basin. Some of the wells in the Arcadia Subbasin are interpreted to be screened across both the Lakewood and San Pedro Formations.

The most important water-bearing units are the sands and gravels within the San Pedro Formation (Poland and others, 1959). The Silverado aquifer of the San Pedro Formation has the greatest lateral extent and saturated thickness, and is considered as the primary source of groundwater. The San Pedro Formation averages about 200 feet in thickness in the Santa Monica Basin. The estimated transmissivity of the San Pedro aquifer ranges from 50,000 to 150,000 gallons per day per foot (gpd/ft) within the study area (CDWR, 1961). Specific yields of the sediments range up to 26 percent (CDWR, 1961). Beneath the Silverado aquifer are relatively low-permeability sediments of the lower San Pedro and upper Pico formations.

2.3.2 Basin Description

The Santa Monica Basin underlies the northwestern part of the Los Angeles Basin. It is bounded by the Santa Monica Mountains on the north and by the Ballona escarpment on the south. The basin extends from the Pacific Ocean on the west to the Newport-Inglewood Fault on the east (CDWR, 2003). The Newport-Inglewood Fault is part of the Newport-Inglewood Uplift, a northwest-trending zone that includes from Beverly Hills and Baldwin Hills, characterized by right-lateral strike slip which forms a significant regional barrier to groundwater flow (Reichard and others, 2003; Hill, 1971).

The Santa Monica Basin is divided into five subbasins by a series of faults that cut through the Basin (Figure 2-1), including:

- Charnock Subbasin;
- Coastal Sub basin;
- Crestal Subbasin;
- Arcadia Subbasin; and
- Olympic Subbasin.

The major faults that divide the Santa Monica Basin into its constituent subbasins include the Charnock Fault, the Overland Avenue Fault, the Potrero Canyon Fault, and the Santa Monica Fault. The Charnock and Overland Avenue Faults, which run southeast-to-northwest, are believed to offset the San Pedro Formation but not the overlying Holocene sediments. These faults are interpreted as having several tens of feet of vertical displacement. The Potrero Canyon and the Santa Monica Faults (Brown and Caldwell, 1986) run roughly east-west through the Basin. These two faults are interpreted to offset both the San Pedro Formation and Holocene sediments. The effect of these faults on groundwater movement is discussed in the following section.

An evaluation of key groundwater characteristics for the different subbasins was made based on the CDWR well logs obtained for this study. A summary of these characteristics by subbasin is provided in Table 2-1.

Table 2-1: Summary of Existing Well Characteristics by Subbasin

Subbasin	Approximate Depth of Wells (feet)	Production Rates (gpm)
Charnock	500 - 800	800 - 1,200
Coastal	200 - 500	200 - 600
Crestal	200 - 500	100 - 500
Arcadia	200 - 400	300 - 400
Olympic	300 - 500	300 - 600

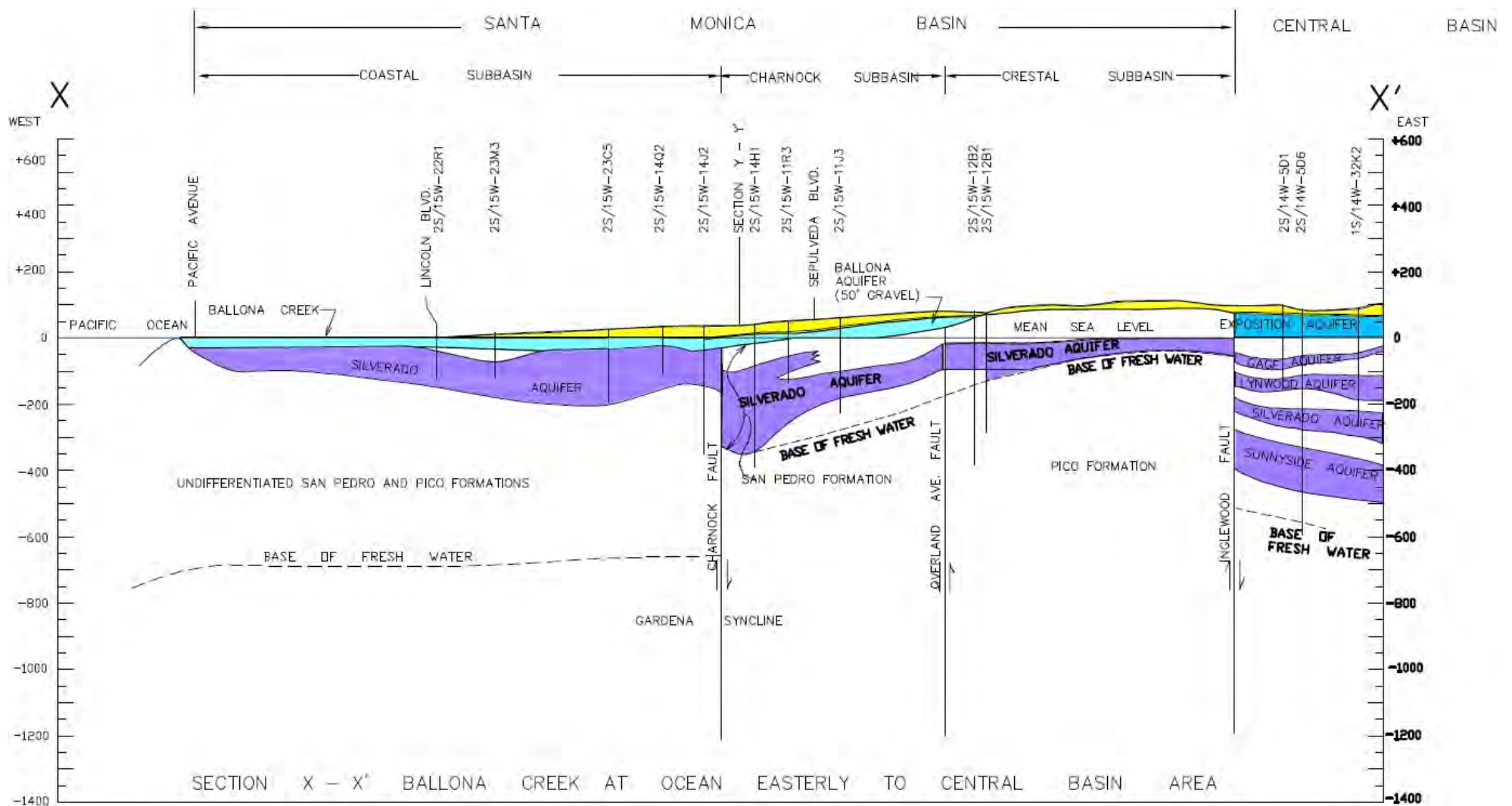
2.3.3 Groundwater Conditions

The subbasins have different groundwater characteristics due to the complex geology. This section provides a summary of the groundwater conditions in each of the five subbasins.

2.3.3.1 Charnock

Figure 2-4 shows a cross section developed by Geomatrix (1997, 1999) and Environ (2000, 2001) through the Coastal, Charnock, and Crestal Subbasins. The Charnock Subbasin is separated from the Coastal Subbasin by the Charnock Fault and from the Crestal Subbasin by the Overland Avenue Fault. The relative movement on both of these faults is downward towards the Charnock Subbasin. Therefore, the aquifers in the Charnock Subbasin occur at a lower elevation and have significantly thicker aquifers than those in either of the adjoining subbasins. This is the primary reason why the Charnock Subbasin has the most productive groundwater wells in the Santa Monica Basin.

Well 1290P provides a representative hydrograph to show the groundwater history of the Charnock Subbasin (Figure 2-5). Prior to 1980, groundwater elevations were between 30 to 40 feet below sea level. Between 1980 and 1995, groundwater levels rose but were still below sea level. In 1996, groundwater production stopped, and groundwater levels rose to about 10 feet above mean sea level (fmsl) in Well 1290P. Because of its historically low groundwater levels, groundwater flow has been directed towards the Charnock Subbasin from adjoining areas. The fault boundaries for the Charnock Subbasin behave as a hydrologic barrier to groundwater flow through the San Pedro Formation but do not affect the overlying younger sediments. Therefore, the Charnock Subbasin receives groundwater inflow across the faults through these younger sediments. This is likely a significant source of recharge for the Charnock Subbasin.



Source: Figure 2-3a, Task 10.1.2, Numerical Groundwater Flow Model Report (Environ, 2001)

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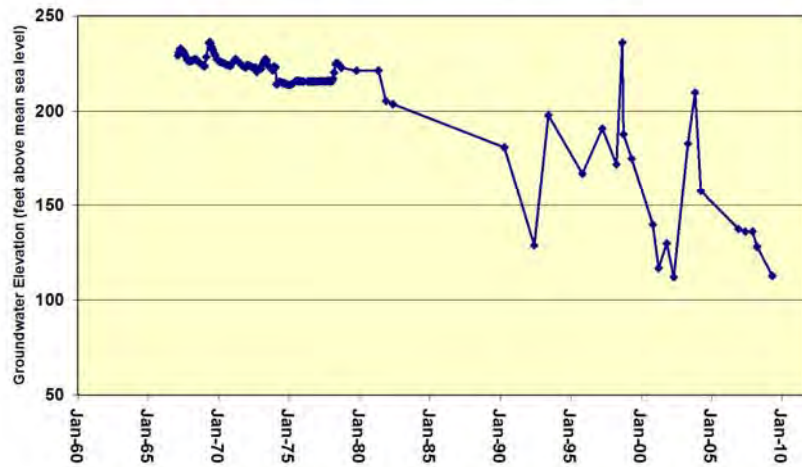
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Geologic Cross Section Across the Santa Monica Basin

K/J 1179008*00
December 2011

Figure 2-4

Well 2505 - Arcadia Subbasin
Groundwater Elevation Change over Time



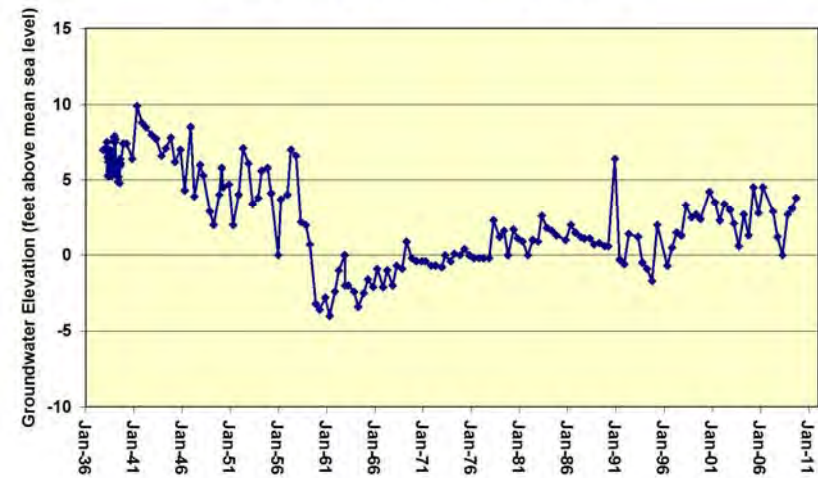
Well 1290P - Charnock Subbasin
Groundwater Elevation Change over Time



Well 2546L - Olympic Subbasin
Groundwater Elevation Change over Time



Well 1281C - Coastal Subbasin
Groundwater Elevation Change over Time



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Representative Hydrographs from the Santa Monica Basin

K/J 1179008*00
December 2011

Figure 2-5

2.3.3.2 Coastal

The Coastal Subbasin is located south of the Santa Monica Fault, which forms the boundary with the Olympic Subbasin, and it is located west of the Charnock Fault, which forms the boundary with the Charnock Subbasin. Well 1281C provides a representative hydrograph to show the groundwater history of the Coastal Subbasin (Figure 2-5). Measurements for Well 1281C go back to 1968 and show that groundwater elevations were about 5 to 10 feet above sea level. As pumping increased, groundwater elevations declined to below sea level in the 1950s and 1960s. This decline results in areas of the Coastal Subbasin experiencing elevated salinity due to seawater intrusion. The path for seawater intrusion was primarily through the 50-foot Gravel and down to the San Pedro Formation where these two units were in hydraulic connection in the southern portion of the subbasin. As groundwater pumping has declined, groundwater levels have risen to above sea level. Groundwater data indicate that the groundwater gradient is currently directed towards Santa Monica Bay so that groundwater is discharging to the ocean. Therefore, the seawater-freshwater interface is considered to be stable or migrating seaward as a result of the increasing groundwater levels in the subbasin.

2.3.3.3 Crestal

No groundwater monitoring wells were available through LACDPW (2011) for the Crestal Subbasin; therefore, the discussion of the Crestal Subbasin is conceptual. Groundwater recharge occurs mainly by percolation of precipitation and surface runoff from the Santa Monica Mountains. Groundwater flow is considered to be primarily southerly and eventually discharging towards the east into the Charnock Subbasin or to the east into the Central and Hollywood Basins. The Crestal Subbasin is bounded by the Overland Avenue Fault to the west and the Newport-Inglewood Fault to the east. The southern boundary is the Baldwin Hills, which are a part of the Newport-Inglewood Uplift and composed of older, less permeable sediments. The relative vertical movement on both of these faults is upwards towards the Crestal Subbasin, so the aquifers in the Crestal Subbasin are high relative to the adjoining areas. A review of CDWR well logs did show that some irrigation wells in the Crestal Subbasin were able to sustain flow rates of 200 to 500 gpm, and the wells were completed to depths of up to 600 feet below ground surface. This suggests that groundwater conditions in the Crestal Subbasin may have some potential for future development.

2.3.3.4 Arcadia

The Arcadia Subbasin is bordered by the Santa Monica Mountains to the north and the Potrero Canyon Fault, which forms the boundary with the Olympic Subbasin. Because of this location, the Arcadia Subbasin receives significant groundwater recharge from infiltration of runoff from the Santa Monica Mountains. This recharge is reflected in that the groundwater levels in the Arcadia Subbasin are the highest in the Santa Monica Basin. The Well 2505 hydrograph shows that historic groundwater levels were greater than 200 fmsl in the 1960s and 1970s (Figure 2-5). Well 2505 show declines of about 100 feet in groundwater elevations from 1980 to 2010. This is likely the result of increased groundwater pumping in the subbasin. Since groundwater levels are highest in the Arcadia Subbasin, groundwater is interpreted as flowing away primarily towards Santa Monica Bay. Groundwater flow from the Arcadia Subbasin into the Charnock and Olympic Subbasins is considered as an important component of groundwater recharge into these subbasins.

2.3.3.5 Olympic

The Olympic Subbasin lies between the Potrero Canyon and Santa Monica Faults. The relative movement on these faults is downwards to the south. Therefore, the aquifers in the Arcadia Subbasin are higher than those in the Olympic Subbasin. The result of this relationship is that groundwater levels in the Olympic Subbasin are significantly lower than those in the Arcadia Subbasin. This is observed when comparing the hydrographs for Well 2546L in the Olympic Subbasin with Well 2505 in the Arcadia Subbasin. The hydrograph for Well 2546L (Figure 2-5) has a relatively short history; however, in the 1980s and 1990s groundwater levels in Well 2546L were below sea level for parts of the time. Since 1996, groundwater levels have increased to about 40 fmsl. The hydrograph for W2546L suggests more hydraulic communication with the Charnock Subbasin implying the potential for significant interaction between the Olympic and Charnock Subbasins.

2.3.4 Groundwater Production

The Santa Monica Basin has served as a groundwater resource since the late 1800s. The Santa Monica Basin is not adjudicated or identified as a basin in overdraft based on CDWR departmental bulletins (CDWR, 2004). The California Water Plan Update, however, does state that groundwater overdraft is a challenge for the South Coast Hydrologic Region, which includes the Santa Monica Basin.

2.3.4.1 History of Groundwater Production

The first water wells were drilled in the late 1800s and early 1900s (Reichard and others, 2003). In these early years, water was produced by individual domestic, industrial, and irrigation wells rather than from municipal systems.

The City of Santa Monica has extracted groundwater from the Santa Monica Basin since 1924, and groundwater extractions increased steadily to 6,969 acre-feet (AF) in 1940. In 1941, the City of Santa Monica began receiving imported water deliveries from the Metropolitan Water District (MWD). During the 1940's, groundwater use was discontinued. In 1954, the City of Santa Monica began to utilize groundwater again. Currently, the City of Santa Monica operates three groundwater wellfields within the following subbasins:

- The Santa Monica Wellfield, located in the Olympic Subbasin;
- The Charnock Wellfield located in the Charnock Subbasin; and
- The Arcadia Wellfield located in the Arcadia Subbasin.

Starting in 1990, the City of Santa Monica undertook measures to reduce the amount of imported water purchased from MWD. From 1990 to 1995, the percentage of total water supply from groundwater increased from 31 to 70 percent. In 1996, the City of Santa Monica produced 10,030 acre-feet per year (AF/yr) of groundwater.

In 1995, MTBE was first detected in the groundwater from the Charnock Subbasin. In 1996, due to MTBE contamination, the City of Santa Monica ceased groundwater production from both the Arcadia and Charnock Wellfields. In 2009, the City of Santa Monica produced 2,062 AF/yr from the Arcadia and Santa Monica Wellfields. The Charnock Wellfield began operations

in 2011 after being shut down from 1996 to 2010 due to MTBE contamination. During this time, the City of Santa Monica increased its reliance on imported water.

The City of Santa Monica intends to obtain 100 percent, approximately 12,400 AF/yr, from local groundwater sources by 2020 in order to reduce reliance on imported water sources. To achieve this, the City of Santa Monica intends to maximize their groundwater production capacity in order to achieve a production rate of 12,400 AF/yr.

The Golden State Water Company, formerly the Southern California Water Company (SCWC), serves the Culver City area. In 1949, the SCWC utilized 8,970 AF of groundwater from the Charnock Subbasin, of which 5,566 AF was produced by SCWC wells and an additional 3,404 AF was produced from City of Santa Monica wells leased to SCWC. When Culver City annexed to MWD in 1958, SCWC utilized increased quantities of imported water purchased from the West Basin Municipal Water District (WBMWD). From 1958 to 1986, extractions from the Charnock Subbasin were reduced to less than 1,000 AF/yr. After 1986, only minor amounts of groundwater were produced. In 2002, the California Public Utilities Commission approved the transfer of limited water rights held by the SCWC (now Golden State Water Company) within the Charnock Subbasin to the City of Santa Monica.

Much of the Santa Monica Basin area is served by either the City of Santa Monica, LADWP, or WBMWD. LADWP water supplies are provided primarily from imported MWD water as well as water from the Eastern Sierra Nevada, and do not include the use of local groundwater. Purveyors who receive imported replenishment supplies from MWD, via the WBMWD, do make use of groundwater supplies from the Central and West Coast Basins to the south the Santa Monica Basin. The Golden State Water Company does maintain some minor groundwater production capacity in the Charnock Subbasin.

It is unclear whether the Veterans Administration area east of Santa Monica is on imported water or a local groundwater well. Private wells for irrigation and industrial uses are known to exist in the Santa Monica Basin, but there are no available records on their current usage.

2.3.4.2 Existing Wellfield Production

The Arcadia Wellfield has two active (Acadia #4 and Acadia #5) groundwater wells. These wells have a combined rated capacity of 250 gpm, but the pumps cannot be run simultaneously due to their close proximity to each other. In 2008, the Arcadia wells produced approximately 381 AF, and in 2009, production was approximately 366 AF (Santa Monica, 2011; PBS&J, 2010).

The Santa Monica Wellfield has three active groundwater wells (Santa Monica #1, Santa Monica #3, and Santa Monica #4). Santa Monica #1, counted as part of the Santa Monica Wellfield, is actually located two miles west of the Arcadia Wellfield and draws from the Arcadia Subbasin. The Santa Monica wells, including Santa Monica #1, have a combined rated capacity of 2,800 gpm, with a current operating capacity of 1,860 gpm. In 2008, the Santa Monica Wellfield produced approximately 1,997 AF, and most recently in 2009 produced approximately 2,064 AF (Santa Monica, 2011; PBS&J, 2010).

The Charnock Wellfield has five groundwater wells (Charnock #13, Charnock #15, Charnock #16, Charnock #18, and Charnock #19) that have a combined capacity of 9,000 gpm; however,

this production rate is not considered to be sustainable, as it exceeds the perennial safe yield from the Charnock Subbasin, estimated to be 8,200 AF/yr or 5,500 gpm (Santa Monica, 2011; PBS&J, 2010). At the end of 2010, construction of a new water treatment facility for the Charnock Wellfield was completed, and the new facility has a maximum capacity of 7,000 gpm, which, if running continually could produce up to 11,290 AF/yr (PBS&J, 2010).

The City of Santa Monica production wells are considered to be screened in the Silverado Aquifer within the San Pedro Formation. However, Santa Monica #1 and Arcadia #4 appear to also be screened across both the Lakewood Formation and San Pedro Formation (Brown and Caldwell, 1986).

In addition to the municipal well system, the City of Santa Monica operates two saltwater wells, SW-1 and SW-2, located near the shoreline. These wells are used to provide brine to replenish softening resins used at the Arcadia Water Treatment Plant.

2.3.5 Previous Estimates of Safe Yield

For the Santa Monica Basin, safe yields have not been formally established, but estimates have been provided in previous technical reports. A summary of safe yield estimates from previous technical reports is summarized as follows:

- The Santa Monica Basin Groundwater Management Plan (Kennedy/Jenks, 1992) estimated a safe yield for the Coastal, Arcadia, and Olympic Subbasins of at least 4,225 AF/yr and up to a maximum of 10,455 AF/yr. This does not include the Crestal Subbasin.
- A Water Supply Assessment (PBS&J, 2010) used a safe yield of 12,400 AF/yr based on 8,200 AF/yr from the Charnock Subbasin and 4,200 AF/yr from the Arcadia and Olympic Subbasins. These safe yield numbers are used in the 2010 UWMP (Santa Monica, 2011). The City of Santa Monica is undertaking preparation of an updated Groundwater Management Plan to determine the safe yield from the Santa Monica Basin, which is expected to be completed in 2012.
- Based upon a groundwater modeling study of the Coastal Plain of Los Angeles Groundwater Basin performed by the U.S. Geological Survey, the estimated safe yield using estimated inflows and outflows between 1971 and 2000 was about 7,500 AF/yr (Reichard and others, 2003).
- A groundwater modeling study of the Charnock Subbasin related to the MTBE remediation activities estimated a safe yield for just the Charnock Subbasin ranging from 8,200 to 9,020 AF/yr based on maintaining groundwater levels at or above historical low levels for periods of 7.5 to 16 years (Komex, 2001; Environ, 2001; GeoTrans, 2005).
- CDWR Bulletin 118 (CDWR, 2003) does not include as estimate of safe yield for the Santa Monica Basin. Total groundwater storage in the Santa Monica Basin has been estimated to be approximately 1.1 million AF (CDWR, 2003, 1961). Current storage space is unknown.

Estimates of safe yield in the Santa Monica Basin have focused on the Charnock Subbasin by itself because of the history of groundwater production and the recent environmental remediation project for MTBE. Estimates for the Coastal, Arcadia, and Olympic Subbasins have treated them as a single unit. The Crestal Subbasin typically has been poorly characterized and has not been included in these estimates except for the U.S. Geological Survey report (Reichard and others, 2003), which was a regional study.

2.4 Hollywood Basin Assessment

The assessment of the Hollywood Basin provides a regional understanding of groundwater based on a review of existing hydrogeological data and reports. The ensuing discussion is a summary of this review based on key reports that primarily include Beverly Hills (2011), CDWR (1961, 2003), LACDPW (2011), MWD (2007), JMM (1985), and Reichard and others (2003).

2.4.1 Hydrogeology

The geologic sequence in the Hollywood Basin includes the Lakewood and San Pedro Formation that comprise the primary water-producing units.

The shallower aquifer is interpreted as the Gage aquifer of the Lakewood Formation, which ranges in thickness from five to 35 feet and covers about half of the basin (CDWR, 1961). Shallow perched to semi-perched groundwater occurs in the alluvium causing shallow groundwater conditions over large areas of the western portion of the Hollywood Basin. Limited groundwater is produced from this zone, but it is still an important component of basin management as water from this zone can percolate into the underlying aquifers (CDWR, 2003; MWD, 2007; JMM, 1985).

The main production aquifers are in the San Pedro Formation. The regional aquifer is generally interpreted as the Silverado Aquifer; however, the layers may correlate to the Jefferson, Lynwood, and Sunnyside aquifers as well. The San Pedro Formation is only found in the westernmost portion of the basin in the Beverly Hills area (CDWR, 2003; MWD, 2007; JMM, 1985). The thickness of the primary aquifer units (sand and gravel layers) is typically in the range of 60 to 175 feet.

In the eastern Hollywood Basin, the San Pedro Formation is either poorly developed or missing, which leads to low producing wells in the eastern half of the Basin. In general, aquifers in the Hollywood Basin are neither highly transmissive, nor do they yield significant groundwater except in the western portion where the basin is deeper (JMM, 1985).

2.4.2 Basin Description

The Hollywood Basin is bounded on the north by Santa Monica Mountains and the Hollywood fault, on the east by the Elysian Hills, on the west by the Newport-Inglewood uplift, and on the south by the La Brea High. The La Brea High is formed by an anticline that brings impermeable rocks close to the surface and where most of the San Pedro Formation was eroded prior to deposition of the Lakewood Formation (CDWR, 1961).

Along the base of the Santa Monica Mountains, the sedimentary layers are folded downward into a geologic structure parallel to the Santa Monica Mountain front, known as the Hollywood

Syncline. The Hollywood syncline is the primary geologic feature that forms the Hollywood Basin. The depth of the Hollywood Basin is as much as 660 feet (CDWR, 1961).

The character of the Hollywood Basin varies due to the geologic complexity. An evaluation of key groundwater characteristics was made based on the CDWR well logs obtained for this study. A summary of these characteristics include:

- Wells in the northwest quarter of the Hollywood Basin near Beverly Hills are the most productive. The wells are typically 600 to 800 feet deep with production rates of about 700 to 1,200 gpm.
- Wells in the southwest quarter of the Hollywood Basin south of Beverly Hills are less productive because of the La Brea High; however, the aquifers are relatively well developed in the western half of the Hollywood Basin. The wells are typically 200 to 300 feet deep with production rates of about 200 to 400 gpm.
- Wells in the eastern half of the Hollywood Basin in the Hollywood area are less productive because the aquifers are poorly developed or absent. Wells are typically 200 to 400 feet deep with production rates of less than 100 gpm.
- The logs for wells in the eastern half of the Hollywood Basin, especially in the southeastern portion of the basin, indicate the presence of oil sands. Several of the well logs from this area are oil wells rather than water wells. Few water wells are present, likely due to poor water quality. The La Brea Tar Pits, located south of the Hollywood Basin, are where these oil sands occur near the surface.

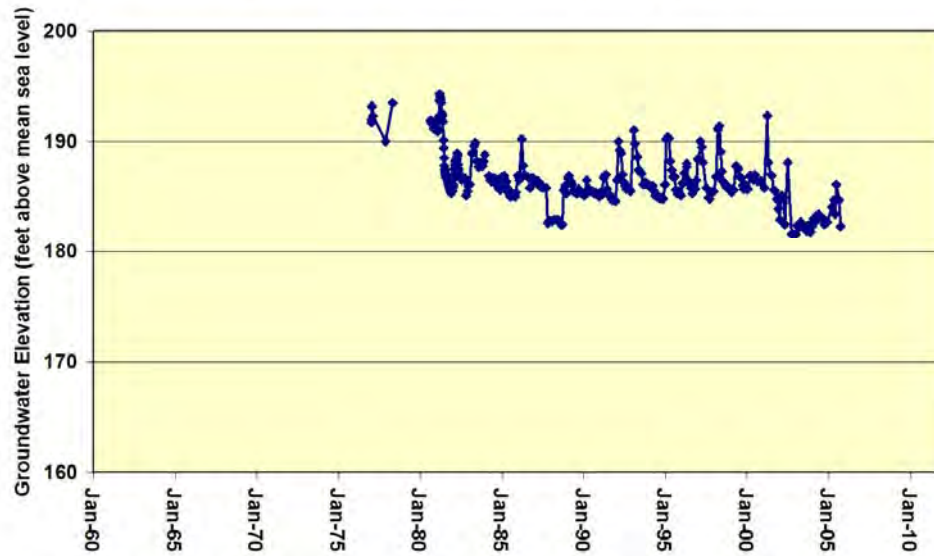
2.4.3 Groundwater Conditions

Groundwater flow in the Hollywood Basin is generally from the Santa Monica Mountains (in the north) south towards the Central Basin. The Hollywood Fault forms a restrictive subsurface boundary along the northern part of the Hollywood Basin by placing the alluvial materials against basement rocks of the Santa Monica Mountains.

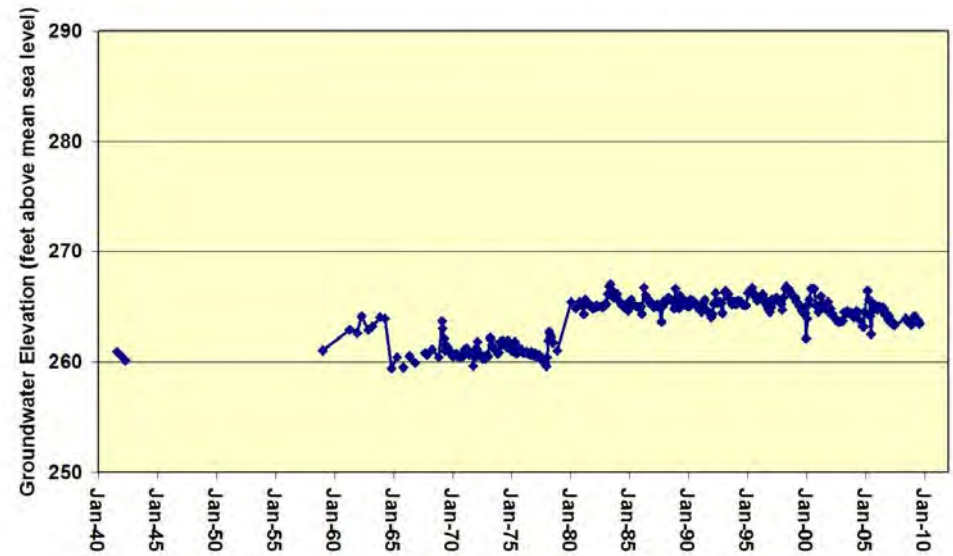
The Hollywood syncline is the geologic feature where the sedimentary layers are folded downward. This axis of the syncline plunges westward. Thicker, more transmissive aquifer deposits are found in the western half of the Hollywood Basin that helps direct subsurface flow westward. The La Brea High is formed by an anticline where most of the San Pedro Formation was eroded prior to deposition of the Lakewood Formation. Groundwater flow is restricted because of the lack of the San Pedro Formation aquifers across the La Brea High. Groundwater moves around the structure at the western end where the San Pedro Formation remains (CDWR, 1961). The U.S. Geological Survey (Reichard and others, 2003) has estimated groundwater outflows of about 5,900 AF/yr towards the Central Basin.

Groundwater levels in the Beverly Hills area are reported to be generally at or above mean sea level. A pumping depression from increased future groundwater pumping in the Hollywood Subbasin could cause groundwater from the Central Basin to flow around the southern end of the La Brea High. Since the aquifers underlying the Beverly Hills are not located near the ocean, seawater intrusion does not pose a risk for the Hollywood Basin. Due to the Newport-Inglewood uplift, inflows from the Santa Monica Basin are also restricted.

Well 2642E - Hollywood Basin
Groundwater Elevation Change over Time



Well 2671A - Hollywood Basin
Groundwater Elevation Change over Time



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**Representative Hydrographs from the
Hollywood Basin**

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December 2011

Figure 2-6

Hydrographs from the LACDPW (2011) are from the central and eastern areas and are presumed to represent shallow groundwater conditions. Groundwater elevations for the Wells 2642E and 2671A (Figure 2-6) are about 185 and 265 fmsl, respectively. These wells vary within a narrow range of less than 10 feet over the over 40 years of data records. This is more indicative of shallow aquifer conditions.

2.4.4 Groundwater Production

The Hollywood Basin has served as a groundwater resource since the late 1800s. In these early years, water was produced by individual domestic, industrial, and irrigation wells rather than from municipal systems.

The City of Beverly Hills is the primary municipal water purveyor to use groundwater from the Hollywood Basin. Similar to the Santa Monica Basin, much of the Hollywood Basin area outside of Beverly Hills is served by the LADWP. LADWP water supplies are provided primarily from imported water and do not include any groundwater from the Hollywood Basin. Private wells for irrigation and industrial uses are known to exist in the Hollywood Basin, but there are no available records on their current usage.

The City of Beverly Hills has a long history of using groundwater. In 1906, the Beverly Hills Utilities Corporation was formed to provide water utility services. In 1923, the City of Beverly Hills acquired the Beverly Hills Utilities Corporation. In 1928, the City of Beverly Hills purchased the Sherman Water Company, which served the West Hollywood area with groundwater extracted from the Hollywood Basin and the La Brea Subarea of the Central Basin. Beverly Hills started receiving water from MWD in the early 1940s.

Historically, the City of Beverly Hills extracted an average of 3,015 AF/yr from the Hollywood Basin from 13 wells that operated during the period 1950 to 1975. Production data show that the City of Beverly Hills extracted about 4,460 AF/yr of groundwater from 16 water wells that operated in the La Brea Subarea of the Central Basin at various times during the period between 1950 and 1974.

In 1976, Beverly Hills decided to discontinue producing water from both the Hollywood Basin and the La Brea Subarea in favor of purchasing all of their water supply from MWD. However, Beverly Hills retained its "rights" to extract groundwater from the Hollywood Basin for future use by submitting annual statements to the California State Water Resources Control Board.

In 1996, Beverly Hills began evaluating groundwater as a viable partial alternative to their total reliance on imported supplies. Three new groundwater production wells were added for a total of four production wells (Wells Nos. 2, 4, 5, and 6). Beverly Hills currently obtains its groundwater supply only from the Hollywood Basin. In 2009, Beverly Hills pumped 1,311 AF of groundwater representing approximately 10 percent of the City's average annual consumption. The average groundwater pumping from 2005 through 2009 was about 1,200 AF/yr.

The UWMP (Beverly Hills, 2011) projects groundwater production conservatively at 800 AF/yr, the low end of the previous 6 years. In the future, Beverly Hills expects to increase groundwater production in order to further reduce their dependency on imported water. Beverly Hills is looking into additional groundwater production from shallow groundwater wells in its Robertson

Yard facility in West Hollywood and from wells in the La Brea Subarea of the Central Basin where Beverly Hills has historic groundwater rights.

2.4.5 Previous Estimates of Safe Yield

A safe yield for the Hollywood Basins has not been formally established, but estimates have been provided through previous technical reports. A summary of safe yield estimates for the Hollywood Basin from previous technical reports includes:

- In a Water Management Plan for the City of Beverly Hills, JMM (1985) noted that an earlier report prepared by Bookman-Edmonston determined that long-term safe yield of the Hollywood Basin is about 3,000 AF/yr.
- In the same report, JMM (1985) noted that estimated long-term safe yield for the La Brea subarea of the Central Basin was also determined by Bookman-Edmonston to be about 3,000 AF/yr.
- CDWR Bulletin 118 (CDWR, 2003) noted that the Hollywood Basin was operated by the City of Beverly Hills using an operating maximum safe yield of 4,400 AF/yr based on the CDWR (1962) report. The total storage in the basin is estimated to be approximately 200,000 AF. Unused storage space has not been estimated.
- The U.S. Geological Survey (Reichard and others, 2003) estimated that the groundwater outflow from the Hollywood Basin into the Central Basin is approximately 5,900 AF/yr (based upon a groundwater model using an historical 1971 to 2000 base period). However, no safe yield estimate was provided.

The La Brea Subarea is that portion of the Central Basin south of the Hollywood Basin but north of the current adjudication line that defines the northern limit of the Central Basin. Therefore, the La Brea subarea is not within the adjudicated areas of the Central Basin. This area is referred to as "No Man's Land."

Based on the historical extraction of groundwater, the City of Beverly Hills considers that it possesses appropriative rights in local groundwater that could serve as the basis for a prescriptive right if its pumping activities were contested. The water rights in the Hollywood Basin have never been adjudicated; therefore, the water rights held by the City are considered to be imperfect rights since they have not been subject to court action. The Hollywood Basin is unadjudicated and is presently managed by Beverly Hills through municipal ordinances. These municipal ordinances regulate the production of groundwater, prohibit waste, protect water quality, and require dewatering activities to mitigate adverse impacts on the Hollywood Basin.

2.5 Potential Production Capacity

Based on the hydrogeological characterization, a assessment of the potential production capacity of the Santa Monica and Hollywood Basins was developed. An evaluation of the safe yield, potential adverse conditions, and groundwater production capacities is presented in this section.

2.5.1 Assessment of Safe Yield

This section discusses the assessment and estimate of safe yield. Previous safe yield estimates for the Santa Monica and Hollywood Basins are based upon a water budget using a defined hydrology, water levels, or groundwater models. These calculations required a number of assumptions to determine groundwater recharge, inflows, and outflows. In addition, assumptions on what constitutes an adverse condition, which is part of the safe yield definition, are also variable. Recognizing the uncertainties associated with these types of calculations, the safe yield estimates for the Santa Monica Basin range from 7,500 to 12,400 AF/yr, and for the Hollywood Basin they range from 3,000 to 4,400 AF/yr.

Although no "formal" safe yield determination has been made for the Santa Monica Basin, the U.S. Geological Survey groundwater modeling study (Reichard and others, 2003) estimates that the average safe yield is about 7,500 AF/yr. This estimate is based on adding together the average annual pumping used in the model simulation of 6,760 AF/yr and the average annual increase in groundwater storage of 780 AF/yr. Using the groundwater model has the advantage of providing a more robust method for estimating groundwater inflows and outflows from the adjoining basins through the groundwater model. However, the model uses 1 square-mile grid cells, which are too coarse to resolve the complex geology of the Santa Monica and Hollywood Basins.

In order to evaluate the safe yield, Kennedy/Jenks focused on the development of estimates for groundwater recharge. For comparative purposes, it is noted that the U.S. Geological Survey study (Reichard and others, 2003) based groundwater recharge estimates on the assumption that there was 1.5 inches per year of uniform surficial recharge (i.e., pipe leakage, precipitation, and irrigation return flows). Kennedy/Jenks estimated groundwater recharge components separately as follows:

- Pipe leakage is the amount of water that leaks from water and sewer pipes that percolates to groundwater. The following data were used to estimate pipe leakage.
 - Used an estimate of 5 percent of the total water demand for the study area. This is a conservative estimate of recharge from pipe leakage. Studies of pipe leakage range from 5 to 30 percent (Lerner, 1986; Leauber, 1997; HydroFocus, 2007; CDWR, 2011).
 - Total water demand was not available that conformed with the groundwater basin. The total water demand was approximated by proportionalizing the total demand for Santa Monica and Beverly Hills over the total area of their respective groundwater basins. Using this approach, the total demand was estimated at 78,000 AF/yr for the Santa Monica Basin and 25,000 AF/yr for Hollywood Basin.
- Recharge from direct rainfall precipitation is the amount of precipitation that falls in the basin that percolates through the soil to groundwater. The following data were used to estimate recharge from direct precipitation.
 - Average annual rainfall data was obtained for local stations. These include UCLA, North Hollywood, Santa Monica Pier, and Culver City. Average annual rainfall ranged from 17 inches at UCLA to 12 inches at Santa Monica Pier.

- Groundwater recharge is estimated at 5 percent of the total rainfall.
- The total area of the groundwater basins was calculated using GIS, whereby the Santa Monica Basin is 31,730 acres and the Hollywood Basin is 10,070 acres.
- Irrigation return flow is the volume of water applied as irrigation that infiltrates below the root zone and percolates to groundwater. The following data were used to estimate recharge from irrigation return flow.
 - Irrigation return flow was estimated only for the large parks and golf courses in the study area. The total area of these areas were identified using aerial photographs and the areas calculated using GIS. These areas were estimated at 1,790 acres for the Santa Monica Basin and 208 acres for the Hollywood Basin.
 - The volume of irrigation water applied was assumed to match the annual average evapotranspiration for the study area of 50 inches per year (Snyder and others, 1992).
 - Groundwater recharge was estimated at 33 percent of the estimated applied irrigation. The percentage is considered as typical for turf areas (Allen and other, 1998).

Mountain front recharge is recharge to the groundwater system as a result of runoff from the Santa Monica Mountains. Classically, this recharge occurs from infiltration from tributary streams and ungauged runoff from small watersheds between tributary streams. The mountain front recharge estimate by the U.S. Geological Survey is based on a regional statistical assessment of rainfall that mixes coastal and inland mountain ranges. Using this approach, the U.S. Geological Survey uses an average annual rainfall to derive mountain front recharge of 19.3 inches per year for the Santa Monica Basin and 17.4 inches per year for the Hollywood Basin. The Topanga Ranger Station rainfall gauge is located in the mountains above Santa Monica, and its long-term annual average rainfall is 23.65 inches per year.

For this study's estimate, the average rainfall at Topanga Ranger Station was used. The area watershed of the watershed draining into the Santa Monica Basin is about 20,000 acres and 9,300 acres into the Hollywood Basin. These areas were based on a GIS analysis of the U.S. Geological Survey topographic maps of the Santa Monica Mountains. A runoff coefficient of 35 percent was used, which is similar to what was used by the U.S. Geological Survey study (Reichard and others, 2003). Multiplying the rainfall, watershed area, and runoff coefficient produced the estimated mountain front recharge shown in Table 2-2.

Table 2-2 provides a comparison of the groundwater recharge estimates by the U.S. Geological Survey study (Reichard and others, 2003) against Kennedy/Jenks estimates based on the approach outlined above. Using site-specific data, the estimated groundwater recharge was 8,400 AF/yr higher for the Santa Monica Basin and 2,340 AF/yr higher for the Hollywood Basin than that which was estimated by the U.S. Geological Survey study. These calculations suggest that the groundwater recharge estimates for the U.S. Geological Survey study may be overly conservative.

These higher groundwater recharge rates do not necessarily translate to a proportional increase in the safe yield. However, these rates do indicate the potential for a higher safe yield for both the Santa Monica and Hollywood Basins.

Table 2-2: Comparison of Groundwater Recharge Estimates

	Surficial Recharge Components			Recharge Subtotals		Total Recharge (acre-feet)
	Pipe Leakage (acre-feet)	Direct Rainfall (acre-feet)	Irrigation Return Flow (acre-feet)	Surficial Recharge Subtotal (acre-feet)	Mountain Front Recharge (acre-feet)	
Santa Monica Basin						
USGS Model Water Balance (2003)	-	-	-	4,560	8,540	13,100
Feasibility Study Estimate	3,911	1,755	2,463	8,129	13,435	21,564
Hollywood Basin						
USGS Model Water Balance (2003)	-	-	-	1,600	4,300	5,900
Feasibility Study Estimate	1,241	629	286	2,156	6,265	8,241

2.5.2 Assessment of Potential Issues

The evaluation of a prospective wellfield includes an assessment of potential adverse conditions or impacts that could result from operating a new wellfield. Adverse conditions include such things as permanently lowered groundwater levels, subsidence, or degradation of water quality in the aquifer. This section provides a qualitative discussion of these potential impacts.

2.5.2.1 Seawater Intrusion

Seawater intrusion is the movement of saline water from the ocean or bay into freshwater aquifers. Seawater intrusion occurs in virtually all coastal aquifers as long as the aquifer is hydraulically connected with saline water. Seawater is denser than freshwater, so the two waters do not readily mix. Typically, a wedge-shaped freshwater-seawater interface forms with the denser seawater at the base. Based on this difference in densities, the Ghyben-Herzberg principle states that, "for every foot of fresh water in an unconfined aquifer above sea level, there will be 38 feet of fresh water in the aquifer below sea level at equilibrium" (Freeze and Cherry, 1979).

When freshwater levels drop due to groundwater pumping, the saltwater-freshwater interface can migrate inland, and over time it may eventually reach coastal wells. If the groundwater levels rise again, the saltwater-freshwater interface will migrate back seaward. Movement of the saltwater-freshwater interface is a slow process. Seawater intrusion may not manifest in a production well for a number of years, and only when the conditions leading to seawater intrusion are continuously sustained for an extended period of time depending on aquifer conditions.

If screened over only a portion of the aquifer, the reduced pressure around the screen leads to upward movement of groundwater below the well. If a saltwater-freshwater interface exists below the well, the upward movement of groundwater deflects this interface upward, a process called “upconing.”

Historically, seawater intrusion affected the southern parts of the Coastal and Charnock Subbasins during the peak years of groundwater pumping in the area. Chloride levels reached over 500 mg/l near the coast and exceeded 100 mg/l in the Charnock Subbasin. This historic occurrence of seawater intrusion demonstrates that seawater intrusion is an issue that will require attention for future groundwater pumping in the Coastal Subbasin.

Currently, the groundwater gradient in the Coastal Subbasin is towards Santa Monica Bay; therefore, the freshwater-seawater interface is considered to be stable or migrating seaward as a result of the increasing groundwater levels in the subbasin. Future pumping could reverse the hydraulic gradient allowing for the potential for seawater intrusion into the Coastal Subbasin. For the feasibility study, the preliminary criteria for siting a wellfield in the Coastal Subbasin are to locate the wellfield more than one mile from the coast and to reduce the criteria for total wellfield drawdown.

The primary path for seawater intrusion is through the 50-foot Gravel that is open to the ocean along the coast and down to the San Pedro Formation where these two units are in hydraulic connection in the Marina del Rey and Ballona Creek areas in the southern portion of the Coastal Subbasin. When groundwater pumping in the San Pedro Formation causes groundwater levels to decline sufficiently, the freshwater-seawater interface can move inland. The fault boundaries for the Charnock Subbasin do not affect the overlying younger sediments. Therefore, the Charnock Subbasin receives groundwater inflow from the Coastal Subbasin, and could potentially be susceptible to future seawater intrusion.

To monitor for seawater intrusion, a network of monitoring wells is typically installed to monitor groundwater levels and water quality at different depth intervals between the wellfield and the coast. Monitoring different depth ranges is necessary because, since seawater intrusion occurs as a wedge, the presence of vertical variations in water quality is important. Also, aquifer heterogeneity may cause seawater intrusion to find preferential pathways through the aquifer that a single well screen might miss.

Seawater intrusion can be controlled hydrologically using artificial means through injection of freshwater into the aquifer landward of the intrusion wedge and seaward of production wells. The injected freshwater can be locally-sourced groundwater, imported surface water, or reclaimed wastewater. The goal of this method is to build up a mound of freshwater with sufficient head to prevent seawater from intruding into the base of the aquifer. These seawater barriers are being used to control seawater intrusion in the West Coast Basin to the south of Santa Monica.

2.5.2.2 Well Interference

Pumping of groundwater wells has the potential to interfere with existing groundwater production wells. Groundwater pumping lowers the groundwater levels near the well forming a cone of depression. If two cones of depression overlap, then the interference reduces the water available to each well. When multiple wells are competing for the water of the same area, this

can result in excessive drawdown that, if severe, may reduce the long-term sustainable pumping rate for the entire wellfield. The well spacing for a wellfield needs to be evaluated to minimize these compounding drawdown impacts.

For planning of the proposed wellfields, the drawdown from pumping can be estimated using standard aquifer analysis methods. For this, the drawdown from pumping for each well in a wellfield is calculated independently. The drawdown at a well is the summation of the drawdown resulting from pumping each well in the wellfield. Calculating this flow can be estimated using the Theis equation for non-steady radial flow into a well (Kruseman and de Ridder, 1990; Freeze and Cherry, 1979; Lohman, 1972). For this application, it is considered appropriate to use the confined solution of the Theis equation (Lohman, 1972). The Theis equation is as follows:

$$Q = \frac{4 * \pi * \Delta h * T}{W(u)}$$

where Q is the discharge rate from the shallow aquifer zone into the well, T is the aquifer transmissivity of the shallow aquifer zone, Δh is the relative difference in groundwater levels between the well and the shallow aquifer zone, and $W(u)$ is the well function.

The well function $W(u)$ represents an integral that cannot be solved directly, but its value is given by the infinite series using the following equation (Lohman, 1972; Kruseman and de Ridder, 1990):

$$W(u) = -0.577216 - \ln(u) + u - \frac{u^2}{2 * 2!} + \frac{u^3}{3 * 3!} - \frac{u^4}{4 * 4!} + \frac{u^5}{5 * 5!} - \dots$$

The variable u in the equation above is defined by the following equation (Lohman, 1972, Kruseman and de Ridder, 1990):

$$u = \frac{r^2 * S}{4 * T * t}$$

Where r is the distance to an observation well, S is the storage coefficient, T is transmissivity and t is time.

2.5.2.3 Overdraft

A basin is in overdraft if the amount of water pumped from the basin exceeds the safe yield of the basin over a period of time. Pumping in individual years may vary above or below the long-term yield of the basin during drought or wet years, or as dictated by basin management strategies and does not necessarily mean that a basin is in overdraft. This would result in long-term declines in groundwater levels that would eventually lead to diminished yields and reduced flow rates at wells.

The safe yield for the Santa Monica and Hollywood Basins has not been established formally, so there is uncertainty as to how much water is available. This study's assessment of the safe

yield demonstrates that there is uncertainty in determining these values without long-term monitoring results to support them.

In many southern California groundwater basins, groundwater recharge projects are being implemented that use imported water, stormwater, and/or recycled water to recharge the groundwater basin and underlying aquifers to help mitigate overdraft. An example project is the large Los Angeles County Department of Public Works groundwater recharge facilities in the Montebello Forebay area of the Los Angeles Basin.

2.5.2.4 Land Subsidence

Pumping of groundwater wells has the potential to induce land subsidence. If this subsidence is severe, it can cause structural impacts to foundations and other structures. Induced land subsidence is caused by the lowering of groundwater levels causing compaction of the aquifer materials to a degree that the ground surface changes elevation. As water is withdrawn and groundwater levels decline, the effective pressure in the drained sediments is increased. Compressible layers then compact under the over-pressure burden that is no longer compensated by hydrostatic pressure. The resulting land subsidence, includes both a component of elastic (recoverable) and inelastic (unrecoverable) subsidence, and is most pronounced in poorly compacted sediments.

Subsidence examples include the peat deposits in the Sacramento-San Joaquin Delta, lake deposits such as the Corcoran Clay in the San Joaquin Valley, or Bay Muds such as in San Jose. South of Santa Monica, there is evidence for subsidence near Redondo Beach of about 2 millimeters per year that is attributed to oil and gas extraction (Hodgkinson and others, 1996).

A review of the well logs for wells completed in the Santa Monica and Hollywood Basins does not show evidence of a significant compressible layer. Groundwater levels have also experienced significant drawdown in the past prior to the importation of water into the area. Inelastic subsidence, which is of most concern, by nature can only occur once; therefore, any potential subsidence would have already occurred. Land subsidence in the study area does not appear to be a significant concern; however, a site-specific investigation of the local geologic conditions with test borings would be necessary for confirmation.

2.5.2.5 Water Quality

Groundwater pumping changes the natural direction and amount of groundwater flow within the area of influence. Changes in groundwater levels can saturate and reactivate plumes trapped in the unsaturated zone, or changes in pumping can alter groundwater gradients causing plumes to migrate towards the production wells.

There are known contaminants present in the groundwater that are derived from both natural and anthropogenic sources. These are discussed in more detail in Section 4. The development of a Drinking Water Source Assessment and Protection Report will require identification of potential sources of contamination within the capture or source area of the production wells (CDPH, 1999).

2.5.3 Potential Production Capacity

Based on the evaluation of the safe yield, hydrogeological characterization, potential adverse conditions, the following recommendations for potential wellfield locations, capacities and conditions are presented.

2.5.4 Potential Wellfield Location and Capacity

Based on the analysis of the safe yield, hydrogeologic characterization, as well as current and planned groundwater pumping operations by other agencies, the following conclusions can be drawn:

- The Arcadia, Olympic, and Charnock Subbasins in the Santa Monica Basin are considered to be fully utilized by City of Santa Monica current and planned groundwater pumping operations. As a result, these subbasins are not considered to have any remaining potential capacity.
- The Coastal and Crestal Subbasins in the Santa Monica Basin and the Hollywood Basin are considered as having remaining potential capacity.

2.5.4.1 Santa Monica Basin

Coastal Subbasin. The Coastal Subbasin does not currently have municipal pumping wells located here but has in the past. However, the potential for seawater intrusion exists. To adjust for these factors, the wellfield would need to be based on a lower available drawdown in order to minimize potential seawater intrusion. It is recommended that the wells be located 1 mile or more from the coastline to further minimize potential seawater intrusion. A limited number of well logs were available from the CDWR for the Coastal Subbasin, and these show a range in pumping rates from 200 to 600 gpm. The higher pumping rates are in the northeastern portion of the subbasin and the lower rates were along the coast. More wells are likely present in this area, but the logs were not available from CDWR.

Crestal Subbasin. There are a few wells in the Crestal Subbasin that are mostly irrigation wells for the country clubs and golf courses. Well capacities are variable, but in the central part of the Crestal Subbasin, there are a few wells with pumping rates of 300 to 500 gpm. The lowest pumping rates are in the north closer to the mountains. There may be some potential for development in the Crestal Subbasin.

To summarize, the safe yield for the Santa Monica Basin ranges from 7,500 to 12,400 AF/yr. However, estimates for groundwater recharge indicate that more recharge may be available that could affect the determination of safe yield. For planning purposes associated with this feasibility study, 2,000 AF/yr is considered as potentially available from either the Coastal or Crestal Subbasins.

2.5.4.2 Hollywood Basin

The Hollywood Basin is quite variable with the highest capacity wells located near Beverly Hills while the eastern part of the basin has low capacity wells. Based on a review of available well logs from the CDWR, the area east of La Brea Avenue is considered as not being able to support groundwater production at the needed scale. Therefore, potential wellfields for the Hollywood Basin should only be considered for the area west of La Brea Avenue. The City of

Beverly Hills wells are located in the western part of the Basin. Therefore, the southwestern part of the Hollywood Basin is considered to have potential. The safe yield for the basin ranges from 3,000 to 4,400 AF/yr. The City of Beverly Hills produces about 800 to 1,400 AF/yr. Therefore, there is potential capacity of 1,600 to 3,600 AF/yr remaining in the Hollywood Basin.

2.5.4.3 Minimum Well Spacing

A key factor necessary in designing a prospective wellfield is to develop an estimate of minimum well spacings to minimize mutual well interference from the wells in the wellfield. The well spacings were calculated solving the Theis equation for drawdown. These calculations are for minimum well spacings to minimize well interference assuming that the wells are located equally spaced along a single line. Well spacing greater than the minimum well spacing would significantly decrease the well interference effects.

The calculations are based on a scenario where the wellfield operates for 6-months and 10-months out of the year using aquifer parameters from the regional U.S. Geological Survey model (Reichard and others, 2003) of the area. Actual conditions will be more variable, but the U.S. Geological Survey report is considered as providing a reasonable and consistent source of information in the area. Aquifer parameters based on the U.S. Geological Survey modeling report (Reichard, 2003) include:

- For the Coastal Subbasin, the parameters used
 - Hydraulic Conductivity = 25 feet per day
 - Average aquifer thickness = 250 feet
 - Calculated transmissivity = 6,250 feet² per day or 46,750 gpd/ft²
 - Storage coefficient = 0.0005
- For the Crestal Subbasin, the parameters used:
 - Hydraulic Conductivity = 15 feet per day
 - Average aquifer thickness = 300 feet
 - Calculated transmissivity = 4,500 feet² per day or 33,660 gpd/ft²
 - Storage coefficient = 0.0003
- For the southwestern portion of the Hollywood Basin, the parameters used:
 - Hydraulic Conductivity =s 20 feet per day
 - Average aquifer thickness = 225 feet
 - Calculated transmissivity = 4,500 feet² per day or 33,660 gpd/ft²
 - Storage coefficient = 0.00075

CDWR (1961) presents the transmissivity of individual aquifers typically as ranging from less than 10,000 gpd/ft to over 50,000 gpd/ft. The combined transmissivity of the aquifers representing what may be encountered in a well screened across several aquifers is on the order of 100,000 to 200,000 gpd/ft. The U.S. Geological Survey aquifer parameters are lower because they represent bulk characteristics that represent both the aquifer materials and the intervening finer-grained deposits. Therefore, these estimates are reasonable and conservative for this area.

For the Coastal Subbasin, the drawdown criterion used was 50 ft to minimize potential seawater intrusion. Wells were considered to be located 1 mile or greater from the coastline to further minimize potential seawater intrusion. Based on the initial analysis, the minimum well spacings are:

- Coastal – 5 wells @ 400 gpm for 10 months for 2,000 AF/yr – recommended minimum well spacing is 250 ft and
- Coastal – 8 wells @ 400 gpm for 6 months for 2,000 AF/yr – recommended minimum well spacing is 600 ft.

For the Crestal Subbasin, the drawdown criterion was 100 ft. This provides about 70% of the operational drawdown for good well performance, and is a conservative estimate for long-term production. The Crestal Subbasin has a lower hydraulic conductivity based on the U.S. Geological Survey study. Therefore, the well spacing increases from the 6-month to 10-month scenarios. Based on the initial analysis, the minimum well spacings are:

- Crestal – 5 wells @ 400 gpm for 10 months for 2,000 AF/yr – recommended minimum well spacing is 200 ft and
- Crestal – 8 wells @ 400 gpm for 6 months for 2,000 AF/yr – recommended minimum well spacing is 750 ft.

Well spacing calculations for the Hollywood Basin are only for the area west of Le Brea Avenue. The Hollywood Basin assumes that area south and east of Beverly Hills where there are still reasonable aquifer materials but the aquifer is thinner over the La Brea High. Because of the thinner aquifer in this area, the total capacity decreases for the 9-well, 6-month scenario. Based on the initial analysis, the minimum well spacings are:

- Hollywood – 6 wells @ 400 gpm for 10 months for 3,000 AF/yr – recommended minimum well spacing is 250 ft and
- Hollywood – 9 wells @ 350 gpm for 6 months for 2,500 AF/yr – recommended minimum well spacing is 700 ft.

These calculations are presented as the guidelines used by this feasibility study for evaluating potential wellfields. For the proposed wellfield alternatives presented in Section 7, the estimated drawdowns based on the well layouts were recalculated using the same well interference calculations based on the measured distances between the proposed well. The supporting calculations are presented in Appendix A.

Section 3: Groundwater Basin Governance and Management

Groundwater basin governance and management for the Santa Monica and Hollywood Basins was reviewed alongside applicable groundwater basin governance and management for the adjacent West Coast and Central Basins. This review included conducting interviews with key agencies and review of supporting documents.

3.1 Review of Local Basin Governance and Management

Interviews were conducted with four agencies as summarized in Table 3-1. Each meeting was attended by representatives from both Kennedy/Jenks and LADWP. A standardized set of interview questions was developed for use during agency interviews. Key findings from the interviews have been incorporated into this feasibility report, and a complete set of meeting minutes is included in Appendix B.

Table 3-1: Summary of Basin Governance Interviews

Agency	Date of Interview	Representatives in Attendance
City of Santa Monica	October 12, 2011	Gilbert Borboa - City of Santa Monica Myriam Cardenas - City of Santa Monica Richard Slade - Richard Slade & Associates
California Department of Water Resources (Watermaster for Central and West Coast Basins)	October 13, 2011	Mark Stuart - CDWR Tim Ross - CDWR
Water Replenishment District	October 13, 2011	Everett Ferguson - WRD Ted Johnson - WRD
City of Beverly Hills	November 9, 2011	Chris Theisen - Beverly Hills Daniel Cartagena - Beverly Hills David Gustauson - Beverly Hills Kevin Watson - Beverly Hills Richard Slate - Richard Slade & Associates Scott Slater - Brownstein Hyatt Farber Schrek, LLP

Both the Santa Monica and Hollywood basins are unadjudicated groundwater basins whereby any party owning property overlying the aquifers has a right to pump from the basin. The City of Santa Monica is the only municipality pumping from the Santa Monica Basin. In the Hollywood Basin, the City of Beverly Hills is the only municipality pumping groundwater. The City of Beverly Hills consistently files statements with the SWRCB for prescriptive rights through non-tributary water use. These filings represent a claim; however, the City of Beverly Hills does not have court-decided rights to this groundwater (LADWP, 1991). In addition, both basins have golf courses that utilize local on-site wells for irrigation. A more detailed description of current activities and existing facilities for both the City of Santa Monica and the City of Beverly Hills is described in Section 4.

As previously described, the West Coast and Central Basins are located to the south of the Santa Monica and Hollywood Basins, respectively. CDWR serves as Watermaster for both

basins. The main purpose of the Watermaster Program is to ensure that water is allocated according to established water rights as determined by court adjudications or agreements by an unbiased, qualified person, thereby reducing water rights court litigation, civil lawsuits, and law enforcement workload. Watermaster service is administered by the CDWR in accordance with Part 4, Division 2 of the California Water Code (<http://www.water.ca.gov/watermaster/>, accessed November 2011).

In 1955, the court approved an Interim Agreement drafted by the water users in the West Coast Basin and appointed the CDWR as Watermaster to administer it. In 1961, the court rescinded the Interim Agreement and signed the West Coast Basin Judgment, retaining the CDWR as Watermaster. The judgment has been amended four times since then. The final judgment in the Central Basin case was signed in 1965 and became effective a year later. CDWR was appointed Watermaster for this basin also. The judgment has been amended twice.

Every groundwater pumper reports its extractions each month to the Watermaster, who computes the amount pumped thus far in the current fiscal year and the amount that can legally be pumped during the remainder of the fiscal year. An updated copy of its account is provided to each pumper every month. At the end of the year, the Watermaster prepares an annual report for the court and for each party to the judgment.

The judgments provide for establishment of an exchange pool in each basin to make additional water rights available to parties without a supplemental supply. To use the pool, each pumper, at the beginning of the year, estimates its demand and supply for the year. Those pumpers whose total supply is less than their estimated demand are able to obtain, through the exchange pool, water rights from pumpers that have foreseen a surplus. Both judgments also contain provisions for transfer of water rights ("adjudicated rights" in the West Coast Basin and "allowed pumping allocations" in the Central Basin) by lease or sale. Records of these transactions are maintained by the Watermaster (<http://www.water.ca.gov/watermaster/>, accessed November 2011).

The role of the Water Replenishment District (WRD) is to manage groundwater for 4 million people in southern Los Angeles County within the Central and West Coast Basins. WRD is the official groundwater level monitoring entity for the basins, which includes a 420-square mile service area using about 250,000 AF/yr of groundwater from both basins. Specifically, WRD is responsible for groundwater monitoring, safe drinking water programs, combating seawater intrusion, and groundwater replenishment operations throughout Southern Los Angeles County (<http://www.wrd.org/>, accessed November 2011).

WRD's interest in the Santa Monica and Hollywood Basins is two-fold. First, from a scientific perspective, WRD has worked alongside the U.S. Geological Survey to develop the previously-described numerical groundwater model for the Central and West Coast Basins. Data from both the Santa Monica and Hollywood basins is limited; therefore, WRD is interested in any new data to improve the function and accuracy of the U.S. Geological Survey groundwater model. Second, from a water supply and replenishment perspective, the U.S. Geological Survey model estimates that 5,900 AF/yr of groundwater flows from the Hollywood Basin into the Central Basin. Therefore, future groundwater development in these basins could influence outflow to the adjoining basins managed by WRD.

Both WRD and CDWR acknowledged the existence of the area termed "No Man's Land," located immediately south of the Hollywood Basin and approximately north of Martin Luther King Blvd. This area is located in the CDWR-defined boundary of the Central Basin, but it is outside of WRD's jurisdiction. In effect, it is an unadjudicated area located within the Central Basin.

LADWP has expressed interest in potentially developing a potable groundwater supply in the No Man's Land area in the north end of the Central Basin (just south of the Hollywood Basin). LADWP suggested that property at its Western District Headquarters at 5898 West Venice Boulevard, Los Angeles, CA 90019, could serve as a demonstration project for a well or wells and treatment using a package (potentially leased) treatment facility. This option is presented in Section 10 and the Executive Summary for further consideration.

3.2 Opportunities for Cooperative Partnerships

During the basin governance interviews with the City of Santa Monica and the City of Beverly Hills, opportunities for cooperative partnerships with LADWP were discussed. These discussions and opportunities are captured in this section.

3.2.1 City of Santa Monica

The City of Santa Monica expressed its goal to become water independent by 2020. Currently, the City obtains about 28% of its supply from MWD with a strategy to close this gap by increasing local groundwater supply coupled with water conservation. Demand is about 13,000 F. Existing capacity is about 9,500 AF/yr. The supply gap between capacity and demand is estimated to be about 3,500 AF/yr. In reality, this gap cannot be filled by groundwater alone, and the City of Santa Monica plans to be more aggressive with demand management and conservation. They have retained Richard Slade & Associates to further characterize the hydrogeology of the basin and identify potential additional groundwater supply for the City of Santa Monica.

A variety of strategic/partnership ideas were discussed in concept with the City of Santa Monica to determine their level of interest. For example, the idea of LADWP funding a treatment plant for its use in 3 dry years (3 years out of 10 years) and Santa Monica's use for normal and wet years (7 years out of 10 years) was discussed. The City of Santa Monica is open to working collaboratively and developing a cooperative, regional approach for basin management. They are also open to strategic discussions on other groundwater development scenarios. It was noted that funding sources and grants look favorably on "joint" projects.

3.2.2 City of Beverly Hills

The City of Beverly Hills is interested in a cooperative agreement with LADWP relative to groundwater development, treatment, and groundwater basin management. The City of Beverly Hills has continued to file on its water rights since it originally stopped pumping back in 1975, and the City believes that they have exclusive water rights to the Hollywood Basin and the north end of the Central Basin (No Man's Land), and not just the land underlying the City of Beverly Hills boundary. However, the interests of the City of Beverly Hills and LADWP are potentially complementary, and the City of Beverly Hills is open to a cooperative partnership.

The City of Beverly Hills believes that the safe yield for the Hollywood Basin ranges from 2,800 to 3,300 AF/yr. At present, the City of Beverly Hills is producing approximately 1,100 acre-

feet/yr of groundwater; only about 10 to 15 percent of the City's water demand. This amount is much lower than they originally expected, and they would like to produce and treat more. However, the City of Beverly Hills is limited by the capacity of its four wells, of which they only operate three at one time due to well interference. During project concept development in the late 1990's, the City of Beverly Hills had expected that the RO plant would treat 3,000 AF/yr. The plant has a minimum capacity of 750 gpm, and it currently operates at about 850 gpm (inflow to the RO) with about 25% bypass.

Since the City of Beverley Hills' RO treatment plant could treat twice the current flow in its present configuration and was designed with space for expansion, the City of Beverley Hills staff suggested that LADWP could potentially fund new wells that would be treated by the existing RO plant with interties back to LADWP's transmission system, including potentially deliveries into the 68-inch LADWP feeder that runs right past the plant site. The City of Beverly Hills stated that they have a number of potential well sites that they consider as good sites for future wells.

Section 4: Description of Existing Wells and Infrastructure

This section describes the groundwater wells and treatment systems in place and used by the cities of Santa Monica and Beverly Hills.

4.1 Santa Monica Basin

There are two water utilities that have facilities within the Santa Monica Basin and include the City of Santa Monica and Golden State Water Company.

4.1.1 Active City of Santa Monica Wells

Of the five subbasins within the Santa Monica Groundwater Basin, the City of Santa Monica has wells in three: Charnock, Arcadia, and Olympic. Table 4-1 summarizes the well names, the sub-basin, and design capacity of these wells.

Table 4-1: City of Santa Monica Active Groundwater Wells

Well Name	Subbasin	Capacity (gpm)
Charnock 13	Charnock	1,800
Charnock 15		1,800
Charnock 16		1,800
Charnock 18		1,800
Charnock 19		1,800
Arcadia 4	Arcadia	250
Arcadia 5		250
Santa Monica 1	Olympic	900
Santa Monica 3		1,000
Santa Monica 4		900
Total Capacity		12,300

4.1.2 City of Santa Monica Groundwater Treatment Facilities

In the early 1960s the City of Santa Monica constructed the Arcadia Treatment Plant to treat groundwater from the Charnock Subbasin. The treatment plant is located approximately 3 miles from the Charnock wells. Treatment consisted of ion exchange softening with seawater brine regeneration, a large reservoir, and a pump station, with brine disposal to a local storm drain that discharges this water to the ocean. Due to volatile organic compound (VOC), primarily trichloroethylene (TCE) contamination of the Charnock wells, a mechanical surface aeration system was installed in the reservoir in the early 1990's with granular activated carbon (GAC) off-gas control. An expansion of the ion exchange system was also completed as part of this project.

In 1996 methyl tertiary butyl ether (MTBE) contamination was discovered, and the City of Santa Monica Charnock wells were placed on inactive status. In January 2011, the City of Santa Monica placed a treatment system on-line to treat three of the Charnock wells (13, 15, and 19) for MTBE. The Charnock treatment unit (See Figure 4-1) is designed to treat 5,400 gpm and is comprised of aeration, iron and manganese removal with greensand filtration, and adsorption

with GAC to remove MTBE. As noted in the figure, Charnock Wells 16 and 18 are blended into the filtered water tank without treatment.

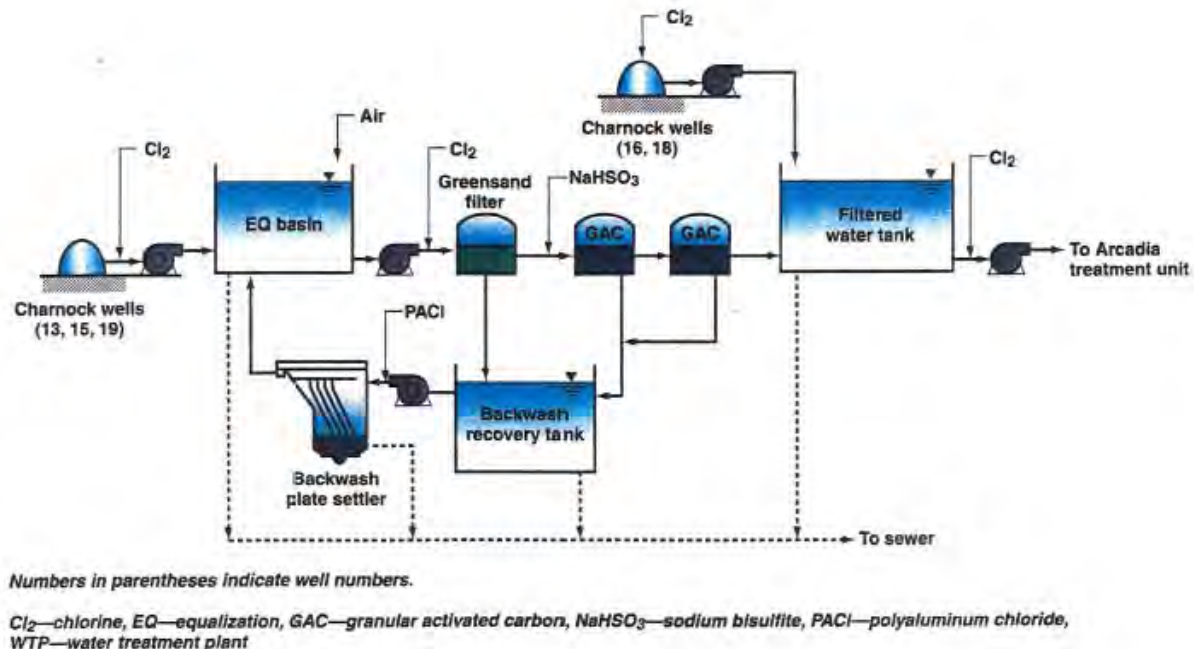


Figure 4-1: Process Flow Schematic of Recently Constructed City of Santa Monica Charnock Treatment System (Shorney-Darby and others, 2011)

Charnock groundwater is then pumped and conveyed to the Arcadia Treatment Plant via a transmission main that is approximately 3 miles in length. Groundwater from the Arcadia and Santa Monica wells is added to the headworks of the Arcadia Treatment Plant. The ion exchange softening treatment was removed to provide more usable space for the new treatment train. The treatment system (See Figure 4-2) at this location is capable of treating 10 million gallons per day (mgd) and consists of chlorination, iron and manganese removal by greensand filtration, reverse osmosis (RO) treatment, decarbonation, chloramination, and final aeration using mechanical surface aerators with GAC off-gas control. Up to 1.5 million gallons of brine per day is generated by the RO facility that is discharged to the sewer, where it flows to the City of Los Angeles Hyperion Wastewater Treatment Plant.

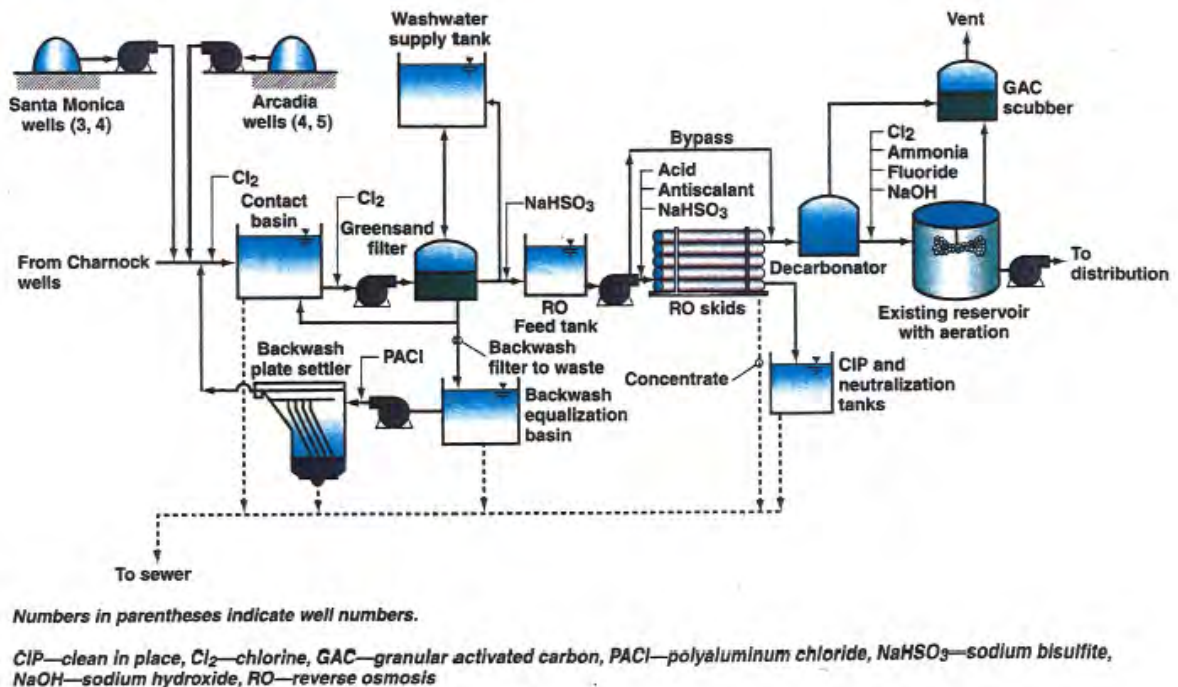


Figure 4-2: Process Flow Schematic of Recently Upgraded City of Santa Monica Arcadia Water Treatment Plant (Shorney-Darby and others, 2011)

4.1.3 Golden State Water Company Wells and Groundwater Treatment Facilities

Historically, the Golden State Water Company operated two Charnock wells (Charnock Well 9 and Charnock Well 10). When operating, both wells pumped to an iron and manganese filtration removal plant. The treated water was then transported to their Culver City water system that is about 0.5 miles away. In 1996, with the discovery of MTBE impacting the City of Santa Monica Charnock wells, these two wells were also taken off-line. There was concern that these two wells could also draw the MTBE plume toward the City of Santa Monica and Golden State Water Company Charnock Wellfield even though Golden State's wells never tested positive for MTBE.

Since this period, the Golden State Water Company has stopped pumping these wells. Currently, these wells have an inactive status in California Department of Public Health (CDPH) Water Quality Monitoring database (WQM).

4.2 Hollywood Basin

There is only one water purveyor, the City of Beverly Hills, with groundwater facilities in the Hollywood Basin. Historically, the City of Beverly Hills extracted groundwater from both the Hollywood Basin (10 wells) and Central Basin (11 wells). This water was treated at the La Cienega Water Treatment Plant that was constructed in the 1920's and provided aeration to

remove hydrogen sulfide (Los Angeles Times, November 16, 1986 (<http://www.flickr.com/photos/vokoban/sets/72157623067744749/>) and softening water treatment. Water quality problems and costs associated with rebuilding the treatment facilities caused by sulfide corrosion and the 1972 Sylmar earthquake (<http://www.landscapeonline.com/research/article/769>) caused the City of Beverly Hills to abandon its use of groundwater resources in 1976 (JMM, 1985).

4.2.1 City of Beverly Hills Inactive Wells

Table 4-2 summarizes the 10 wells that were in the Hollywood Basin, the city location, and whether the well was in the CDPH WQM. Although five of these wells were in the WQM, there was no historical water quality data for any of these 10 wells.

Table 4-2: Summary of City of Beverly Hills Wells Prior to 1976

Identification Number	Well Name	City Location	Referenced in CDPH WQM? (Yes/No)
1	Franklin	Beverly Hills	No
2	West Knoll	West Hollywood	Yes
3	Sherman 06A	West Hollywood	Yes
4	Sherman 05B	West Hollywood	Yes
5	Melrose L	West Hollywood	No
6	Melrose M	West Hollywood	Yes
7	Melrose A	West Hollywood	Yes
8	Foothill No. 3	Beverly Hills	No
9	Foothill No. 4	Beverly Hills	No
10	Tatum	Beverly Hills	No

4.2.2 Active City of Beverly Hills Wells

The City of Beverly Hills has four active groundwater wells (Table 4-3), three in the Beverly Gardens Park, where the park is approximately 160 feet wide by one mile long that borders Santa Monica Blvd from Camden to Wilshire Blvd, and one in the Burton Way median. Groundwater is conveyed to the treatment plant through a transmission main owned and maintained by the City of Beverly Hills.

Table 4-3: Summary of Active City of Beverly Hills Wells

Well Name	Capacity (gpm)
Well 2	400
Well 4	250
Well 5	550
Well 6	350
Total Capacity	1,550

4.2.3 City of Beverly Hills Groundwater Treatment Facilities

As previously described, the City of Beverly Hills owns and operates four active groundwater production wells in the Hollywood Basin. These wells have a combined capacity of approximately 1,550 gpm and are treated by the City of Beverly Hills 2.7 mgd RO desalter that went on-line in April 2004. This plant is capable of being expanded to 5.4 mgd (City of Beverly Hills General Plan Update Technical Background Report, 2005).

The desalter facilities include extraction wells (See Table 4-3), a collector pipeline, a treatment plant, and a brine line to deliver waste to the Hyperion Wastewater Treatment Plant. This facility is designed to produce about 2,600 AF/yr of treated water and discharge about 336 AF/yr to the brine line.

For the calendar years 2005 to 2009, groundwater production averaged 1,195 AF/yr with a range of 884 to 1,311 AF/yr. The low production amount of 884 AF/yr was associated with the RO plant being off-line for 3 months (City of Beverly Hills UWMP, 2010)

Section 5: Water Quality Characterization

The purpose of the water quality evaluation was to develop water quality profiles for both new wells that LADWP may construct and existing abandoned wells that LADWP may participate in rehabilitating in the Santa Monica and Hollywood Basins. These profiles allowed for a determination of the potential treatment process requirements and treatment trains required to produce potable water from the basins.

Initially, groundwater contamination, clean-up activities, and other readily available data on contamination in these basins was identified. Specifically, a review of the California Department of Toxic Substance Control's (DTSC) on-line Envirostore database and the Regional Water Quality Control Board's (RWQCB) on-line Geotracker database was conducted.

Next, the historical (prior to 2011) water quality for operating production wells (present and past) with available data in the CDPH WQM compliance database was used to characterize the raw water quality. The City of Beverly Hills provided water quality data for their four production wells sampled in 2011. The focus of this water quality review was to determine whether there are contaminants of concern (COCs) that exceed or are about to exceed CDPH regulatory limits for potable water. The CDPH regulatory limits include Maximum Contaminant Levels (MCLs), Secondary MCLs (SMCLs), notification levels (NL), and public health goals (PHGs). In addition, the raw water characterization was also examined to determine whether there are water quality issues that could affect the potential treatment process such as scaling, fouling, or competing with the COC being removed.

5.1 Review of GeoTracker and Envirostore Databases

A review of the California Department of Toxic Substance Control (DTSC) on-line EnviroStor database and the California Regional Water Quality Control Board (RWQCB) on-line GeoTracker database was conducted between September 1, 2011 - September 15, 2011.

- GeoTracker is the RWQCB data management system for managing sites that impact groundwater, and in particular those that require groundwater cleanup. In addition, permitted facilities are tracked.
- EnviroStor is the DTSC data management system that provides access to information on hazardous waste permitted and corrective action facilities, as well as existing site cleanup information.

The purpose of this review was to identify any hazardous waste federal, state, or voluntary cleanup sites potentially affecting groundwater within the Santa Monica and/or Hollywood Groundwater Basins. Specifically, the databases were searched by postal zip code, and further refined to review only active sites. In addition, a thorough internet search was conducted to identify other federally- or state-administered cleanup sites possibly not listed in the EnviroStor and GeoTracker data management systems.

Detailed results from the EnviroStor and GeoTracker database searches by groundwater basin are summarized in Appendix C. Each basin has three tables:

- EnviroStor Table;
- GeoTracker Table; and
- Leaking Underground Storage Tank (LUST) Table.

5.1.1 Santa Monica Basin

The EnviroStor database search yielded 12 active sites, and the GeoTracker database search identified 15 active cleanup sites potentially affecting the groundwater within the Santa Monica Basin. Table 5-1 contains a listing of the identified sites, showing the potential contaminants of concern. The Santa Monica Basin is largely an urbanized area. As such, numerous LUST sites were identified. The GeoTracker database lists 157 active LUST sites (not shown on Table 5-1). A detailed inventory of all active and historic sites within the Santa Monica Basin is contained in Appendix C.

The broader internet search did not identify any additional active EPA administered Superfund or other sites within the Santa Monica Basin. In addition, no potentially affective local or regional contaminant plumes located outside of the Santa Monica Basin were identified.

Based on the review of readily available information, the types of sites that impact groundwater include LUSTs associated with former gas stations or alternate uses, dry cleaners, and heavy manufacturing. MTBE and TCE contamination has been a primary concern in the Charnock Subbasin. In the Olympic Subbasin, there is PCE and TCE contamination. Responsible parties potentially include Gillette and Proctor & Gamble. There was a PaperMate ball point pen manufacturing facility in the area. In addition, Boeing had a manufacturing facility in the late 1940s - 1960s that contributed to contamination. The City of Santa Monica indicated that 1,4 Dioxane is also present as a co-contaminant. The potential for perchlorate contamination was noted for the Gillette site in the Santa Monica Basin.

5.1.2 Hollywood Basin

The EnviroStor database search yielded 6 active sites, and the GeoTracker database search identified 12 sites potentially affecting the groundwater within the Hollywood Basin. Table 5-2 contains a listing of the identified sites, showing the potential contaminants of concern. Similar to the Santa Monica Basin and other urban areas, a large number of LUST sites were identified in the Hollywood Basin. A detailed inventory of all active and historic sites as well as the 98 active LUST sites within the Hollywood Basin are contained in Appendix C.

The broader internet search did not identify any additional active EPA administered Superfund or other sites within the Hollywood Basin. In addition, no potentially affective local or regional contaminant plumes located outside of the Hollywood Basin were identified.

In the Hollywood Basin, there is isolated TCE and PCE contamination (. Perchlorate has not been detected in the Hollywood Basin. There is potential for hexavalent chromium contamination to the north of Pan Pacific Park. Two sites (Laser Pacific Media Company and Veiling Plating) to the north cite hexavalent chromium as a contaminant; however, the detailed extent of contamination is not known. Given the direction of groundwater flow in this area, it is a reasonable assumption that this contamination could migrate southward to the Pan Pacific Park area.

Table 5-1: EnviroStor and GeoTracker Active Site Summary of the Santa Monica Basin

Project Name	Address	City	Zip Code	Past Uses	Potential Contaminants
EnviroStor					
Cornell-Dubilier Electronics	4144 Glencoe Ave.	Marina Del Rey	90292	Manufacturing - Electronic	Halogenated Organic Compounds; Halogenated Solvents; Oxygenated Solvents; Unspec. Solvent Mixtures; Benzene; PCB's; PCE; TCE; Acetone; Chloroform; 1,2 Dichlorobenzene; 1,4 Dichloro-2-butane; 1,1 Dichloroethylene; 1,2 Dichloroethylene; Ethylbenzene; 1,1,1,2 Tetrachloroethane; Toluene; 1,2,4 Trichlorobenzene; 1,1,2 Trichloroethane; 1,2,3 Trichloropropane; Xylenes
Charles Caine Company, Inc.	8325 Hindry Ave.	Los Angeles	90045	Paint Manufacturing	Halogenated Solvents; Hydrocarbon Solvents; Liquids w/ pH <=2; Other organic solids; Oxygenated Solvents; Unspec. Aqueous Soln.; Unspec. Solvent Mixtures; Other Organic Solid Waste; PCB's; PCE; TCE
Former Apex Metal Polishing	5977 W. Washington Blvd.	Culver City	90232	Metal Finishing	PCE; TCE; 1,1 Dichloroethane; 1,1 Dichloroethylene (Cis & Trans); 1,2 Dichloroethylene (Trans),
Central Region Elementary School #22 (Playa Vista)	13150 West Bluff Creek Drive	Los Angeles	90094	LDF, Oil Field, Unknown	Benzene; Methane; TPH-diesel, gas, motor oil; TCE; Vinyl Chloride; 1,2 Dichloroethylene (Cis & Trans); Hydrogen sulfide
Willows II Community School	8490 Warner Drive	Culver City	90232	Manufacturing	PCE; TPH - diesel, gas, motor oil; TCE; Vinyl Chloride; 1,2 Dichloroethylene (Cis & Trans)
Modern Plating Company	5400 104th Street	Los Angeles	90045	Metal Plating - Chrome	PCE; TCE
Beverly Hills - Lots 12 & 13	9315 Civic Center Drive	Beverly Hills	90210	Railroad Right of Way	None Specified
Marina One-Hour Cleaners	4019 Lincoln Boulevard	Marina Del Rey	90292	Dry Cleaning, Retail - Service Station	PCE; Acetone; Ethylbenzene; Toluene; Xylenes
Former Sears Auto Center #6081	402 Colorado Avenue	Santa Monica	90401	Vehicle Maintenance	Benzene; TPH - diesel, gas
Proposed Herb Alpert Educational Village	3131 Olympic Boulevard	Santa Monica	90404	Educational Services	Arsenic; Total Chromium; Lead; Antimony; Barium; Copper
Barry Ave Plating Company	2210 Barry Ave	Los Angeles	90064	Agricultural - Row Crops, Metal Finishing, Metal Plating - Chrome & Other	Arsenic; Total Chromium; Lead; PCE; TCE; Chromium III; Chromium VI
Extra Space	1707 Cloverfield Blvd.	Santa Monica	90404	Aerospace Manufacturing/Maintenance, Fuel - Vehicle Storage/ Refueling, Hazardous Waste Storage - Tanks/Containers	Total Chromium; Lead; PCE; TPH-diesel, gas, motor oil; TCE; Vinyl Chloride; n-butylbenzene; Sec-butylbenzene; Tert-butylbenzene; Carbon tetrachloride; Chloroform; 1,1 Dichloroethane; 1,2 Dichloroethane; Ethylbenzene; Toluene; 1,1,2 Trichloroethane; Trichlorofluoromethane; Xylenes
GeoTracker					
Boeing Co.	3000 Ocean Park Blvd.	Santa Monica	90405	Aerospace Manufacturing	Trichloroethylene (TCE)
Verizon Santa Monica Plant Yard	2902 Exposition Blvd.	Santa Monica	90404		Benzene, Other Chlorinated Hydrocarbons, Tetrachloroethylene (PCE), Trichloroethylene (TCE), Vinyl chloride, Gasoline

Project Name	Address	City	Zip Code	Past Uses	Potential Contaminants
Beverly Crest Cleaners	10301 Santa Monica Blvd.	Los Angeles	90025	Dry Cleaner	Other Chlorinated Hydrocarbons, Tetrachloroethylene (PCE), Trichloroethylene (TCE)
Gillette Co.	1681 26th Street	Santa Monica	90404		Other Chlorinated Hydrocarbons, Other Solvent or Non-Petroleum Hydrocarbon, Tetrachloroethylene (PCE), Trichloroethylene (TCE), Perchlorate
O'Neil Data System	12655 Beatrice Street	Los Angeles	90066		Other Chlorinated Hydrocarbons, Tetrachloroethylene (PCE), Trichloroethylene (TCE)
Pacifica Equities, LLC	1639 11th Street	Santa Monica	90404		Diesel, Trichloroethylene (TCE)
Watch Holdings, LLC/Raytheon Company	11200 Hindry Ave.	Los Angeles	90045	Aerospace Manufacturing	Other Solvent or Non-Petroleum Hydrocarbon, Tetrachloroethylene (PCE), Trichloroethylene (TCE)
Paulee Auto Body Shop	1135 La Cienega Blvd.	Los Angeles	90035	Vehicle Maintenance	Tetrachloroethylene (PCE)
11105 La Cienega Properties	11105 S. La Cienega Blvd.	Los Angeles	90045		Tetrachloroethylene (PCE), Trichloroethylene (TCE)
Davis Fluorescents	8536 Venice Blvd.	Los Angeles	90034		Tetrachloroethylene (PCE), Volatile Organic Compounds (VOC)
Richard K. Squire Trust	11100 Hindry Ave.	Los Angeles	90045		Tetrachloroethylene (PCE), Trichloroethylene (TCE)
Brothers Paint Store	8550 Venice Blvd.	Los Angeles	90034	Paint Manufacturing	Volatile Organic Compounds (VOC)
Surfside Cleaners	17340 W. Sunset Blvd.	Pacific Palisades	90272	Dry Cleaner	Tetrachloroethylene (PCE)
Former Cleaning Baron	510 Washington Blvd.	Marina del Rey	90292	Dry Cleaner	Tetrachloroethylene (PCE), Trichloroethylene (TCE)
Former Chevron Chemical Facility	3344 Medford	City Terrace	90292		Acetone, Benzene, Other Chlorinated Hydrocarbons, Toluene, Trichloroethylene (TCE), Vinyl chloride, Xylene, Gasoline

Table 5-2: EnviroStor and GeoTracker Active Site Summary for the Hollywood Basin

Project/Business Name	Address	City	Zip Code	Past Uses	Potential Contaminants
EnviroStor					
Southern Pacific - Taylor Yard	2800 Kerr Street	Los Angeles	90039	Railroad Maintenance Shop	Alkaline Soln. w/o Metals; Unspecified Acid; Unspecified Solvent
				Fuel- Vehicle Storage/Refueling, Fuel Terminals, Paint Manufacturing, School - Middle, Transportation - Warehousing, Degreasing Facility, Engine Testing/Repair, Equipment/Instrument Repair, Fuel Hydrant Pumping Stations, Machine Shop, Oil Field, Vehicle Maintenance	
Central Region Elementary School #20 Site 11	Council Street/Juanita Ave & Madison Ave/Eastern Portion of Virgil MS and 108 South Bimini Place	Los Angeles	90004		Benzene; Lead; Methane; PCE; TPH - diesel, gas, jet fuel, motor oil; TCA; TCE; Vinyl Chloride; Hydrogen Sulfide
La Brea Motors	339 South La Brea Avenue	Los Angeles	90036	Vehicle Maintenance	PCE; TCE
				Underground Storage Tanks, Vehicle Maintenance	
Beverly Hills Lincoln Mercury	8955 West Olympic Boulevard	Beverly Hills	90211		PCB's; TPH-diesel; TPH-gas; TPH-motor oil
Beverly Hills - Lots 12 & 13	9315 Civic Center Drive	Beverly Hills	90210	Railroad Right of Way	Arsenic
				Fuel - Vehicle Storage/Refueling, Fuel Hydrant Pumping Stations, Office Building, Vehicle Maintenance, Waste - Industrial Treatment Facility	
Pueblo Nuevo Charter Academy	3501-3515 West Temple Street and 325 North Hoover Street	Los Angeles	90004		Arsenic; Lead
GeoTracker					
Lido Cleaners	1901-1907 N. Wilcox Ave.	Los Angeles	90068	Dry Cleaner	Other Chlorinated Hydrocarbons, Tetrachloroethylene (PCE)
					Benzene, Other Chlorinated Hydrocarbons, Tetrachloroethylene (PCE), Trichloroethylene (TCE), Vinyl chloride, Gasoline
Mole Richardson Company	937 N. Sycamore Ave.	Hollywood	90038		Other Chlorinated Hydrocarbons, Tetrachloroethylene (PCE), Trichloroethylene (TCE)
				Dry Cleaner	
Hollyway Cleaners	1157 Echo Park Ave.	Los Angeles	90026		
				Metal Plating	Arsenic, Chromium, Mercury (elemental), Nickel, Other Metal
Excello Plating Co., Inc.	4057 Goodwin Ave.	Los Angeles	90039		
Mole Richardson Company	951 Sycamore Ave. N.	Hollywood	90038		Tetrachloroethylene (PCE)

Project/Business Name	Address	City	Zip Code	Past Uses	Potential Contaminants
Four Seasons Dry Cleaners & Laundry	8032 Santa Monica Blvd.	West Hollywood	90046	Dry Cleaner	Tetrachloroethylene (PCE)
Fountain-Vine Plaza	1253 N. Vine Street	Hollywood	90038		Tetrachloroethylene (PCE), Trichloroethylene (TCE), Gasoline
Wardrobe Cleaners	8389 W. 3rd Street	Los Angeles	90048	Dry Cleaner	Tetrachloroethylene (PCE), Trichloroethylene (TCE)
Laser - Pacific Media Company	823-835 Seward St. N.	Los Angeles	90038		Benzene, Tetrachloroethylene (PCE), Toluene, Trichloroethylene (TCE), Xylene, Cyanide, Nitrate, Arsenic, Chromium, Diesel
Paragon Cleaners	1310 Vine Street	Hollywood	90028	Dry Cleaner	Tetrachloroethylene (PCE)
Beverly Laurel Center	8023 Beverly Blvd.	Los Angeles	90048		Benzene, Tetrachloroethylene (PCE), Toluene, Trichloroethylene (TCE), Fuel Oxygenates, Gasoline
BRE 5220 Wilshire	5220 Wilshire Blvd.	Los Angeles	90036		Tetrachloroethylene (PCE), Heating Oil / Fuel Oil, Methane

Note - LUST sites are included in Appendix C.

5.2 Water Quality Characterization

The focus of this section is on the potable production wells within the Santa Monica and Hollywood Basins. There have been three water agencies with potable production wells in the two groundwater basins, whereby the City of Santa Monica and Golden State Water Company have production wells in the Santa Monica Basin and the City of Beverly Hills has production wells in the Hollywood Basin.

As part of this study, summary tables were generated for each subbasin in the Santa Monica Basin as well as for the Hollywood Basin. Accordingly, the first summary table provides a profile of the available water quality data and a framework to identify COCs. The purpose of the profile is to present the time frame and frequency of the results so that the water quality summaries can be placed in context in terms of robustness of the raw water characterization. The profile of the available water quality consists of the following:

- Well name and CDPH well identification number;
- CDPH Status;
- Water Quality Period – year(s) for the water quality results;
- Typical number of samples in WQM for the broader Title 22 categories of parameters;
- Number of samples for selected parameters within these categories; and
- Identification of whether there is or not a water quality concern in the “Comment” column.

This summary table also includes summary descriptive statistics such as number of samples, averages, maxima, and minima for the applicable wells are presented in Appendix C for each of the parameters where there was data in WQM. Also in these tables are the regulatory limits such as the MCL, SMCL, NL, and PHG where appropriate. The parameters are grouped into either Title 22 categories such as general physical or logical analytical categories such as heavy metals, radiological, volatile organic chemicals, and semi-volatile organic chemicals.

The second summary table summarizes the key COCs that may need to be removed to provide a suitable potable water. In part, these particular COCs were based on staff experience with water treatment, historical activities, and current treatment processes being implemented by municipalities utilizing these groundwater supplies. This summary table is color coded in the following manner:

- Primary MCL = rose and rose colored average values are over the MCL;
- Secondary MCL = orange and orange colored average values are over the SMCL;
- Notification Level = purple and purple colored average values are over the NL;

- No color = grey colored average values are over the “acceptance level”; there is currently no regulatory limits, so a consumer acceptance level for customers who live in Southern California is used;
- Green = average value is below the limit; and
- Blue = Not analyzed.

5.2.1 Santa Monica Basin

Of the five subbasins within the Santa Monica Basin, there is water quality data in the CDPH WQM only for water production wells in the Arcadia, Olympic, and Charnock Subbasins. This implies that there have not been any potable water production wells for a public water system as defined by CDPH in the Coastal and Crestal Subbasins.

5.2.1.1 Summary of Arcadia Subbasin Water Quality

Table 5-3 provides a profile of the available water quality data and a broad perspective to identify COCs for the Arcadia Subbasin. Table 5-4 summarizes the key COCs in the Arcadia Subbasin that may to be removed to provide a suitable potable water. In part, the COCs were selected from Project staff's experience and knowledge of water treatment as well as historical and current treatment provided by the City of Santa Monica.

Since no wells for this feasibility study are planned for this subbasin, no further analysis was performed.

5.2.1.2 Summary of Olympic Subbasin Water Quality

Table 5-5 provides a profile of the available water quality data and a broad perspective to identify COCs for the Olympic Subbasin. Table 5-6 summarizes the key COCs in the Olympic Subbasin that may to be removed to provide a suitable potable water.

Table 5-3: Profile of Water Quality Analyses for City of Santa Monica Wells in the Arcadia Subbasin

Element	Arcadia Well No 03	Arcadia Well No 04	Arcadia Well No 05	Comment
CDPH Well ID Number	1910146-002	1910146-003	1910146-001	
CDPH Status	Destroyed	Active	Active	
Water Quality Period	2006	'85-'10	'90-'10	
Water Quality Parameter	Typical No. of Samples in WQM			
General Physical	0	4-7	3-7	
TDS	0	5	6	
General Minerals	0	6	7	
Chloride	0	6	7	High TDS and hardness Nitrate < 50 % of MCL No perchlorate
Sulfate	0	6	7	
Perchlorate	0	5	5	
Heavy Metals	0	6	6	No MCL issues
Arsenic	0	6	7	No hits
Iron	0	11	24	Occasional Fe and routine Mn > MCL in one well
Manganese	0	16	88	
Radiological	1	4-10	2-19	
VOCs	0	23	19	
TCE	0	69	140	No hits
PCE	0	69	140	Not hits
MTBE	0	32	104	Some hits but < MCL
1,4 Dioxane	0	1	1	No data
BTEX	0	34-37	84	
BTEX Hits	0	1	0	One BTEX detection
SVOCs	0	3	1-6	No SVOC hits

Table 5-4: Water Quality Summary of Average Concentrations of Key COCs for Arcadia Subbasin

Parameter (limit)	Statistic (Units)	Well Name	
		Arcadia Well 04	Arcadia Well 05
TDS (500 mg/L)	Avg (mg/L)	751	735
	Min (mg/L)	680	664
	Max (mg/L)	820	777
Hardness (200 mg/L)	Avg (mg/L)	478	465
Color (15 units)	Avg (Units)	<5	<5
Odor (3 Units)	Avg (Units)	1.9	2.1
Chloride (250 mg/L)	Avg (mg/L)	106.2	98.8
Nitrate (45 mg/L)	Avg (mg/L)	24.8	11.5
Iron (0.3 mg/L)	Avg (mg/L)	0.147	0.221
	Min (mg/L)	ND	ND
	Max (mg/L)	0.39	0.86
Manganese (0.05 mg/L)	Avg (mg/L)	0.016	0.057
	Min (mg/L)	ND	0.008
	Max (mg/L)	0.098	0.12
Arsenic (10 µg/L)	Avg (µg/L)	ND	ND
Chromium VI (0.02 µg/L)	Avg (µg/L)	0.9	0.2
Perchlorate (6 µg/L)	Avg (µg/L)	ND	NA
Trichloroethylene [TCE] (5 µg/L)	Avg (µg/L)	<0.5	ND
Tetrachloroethylene [PCE] (5 µg/L)	Avg (µg/L)	ND	ND
MTBE (13 µg/L)	Avg (µg/L)	<3	3.7
MTBE (5 µg/L)	Avg (µg/L)	<3	3.7
1,4 Dioxane (1 µg/L)	Avg (µg/L)	NA	NA

ND = Zero in WQM NA = Not Analyzed

Table 5-5: Profile of Water Quality Analyses for City of Santa Monica Wells in the Olympic Subbasin

Element	Well Identification					Comment
	Santa Monica Well No 01	Santa Monica Well No 02	Santa Monica Well No 03	Santa Monica Well No 04	Santa Monica Well No 07	
CDPH Status	Active	Destroyed	Active	Active	Inactive	
Testing Period	'85-'10	'85-'87	'90-'10	'85-'10	'89-'97	
Water Quality Parameter	Typical No. of Samples in WQM					
General Physical	8	0	8	8	4	
TDS	7	0	8	8	4	
General Minerals	8	0	8	8	4	High TDS and Hardness Nitrate < 50 % MCL
Chloride	8	0	8	8	4	
Sulfate	8	0	8	8	4	
Perchlorate	9	0	8		0	No perchlorate
Heavy Metals	8	0	8	8	4	
Arsenic	8	0	8	8	4	< MCL in all wells
Iron	7	0	8	8	4	< MCL in all active wells
Manganese	7	0	8	8	4	
Radiological	2-30	5	1-19	1-23	0-9	
VOCs	27	5	20	22	9	None except as noted below
TCE	254	5	195	147	12	Three wells > MCL
PCE	254	5	195	147	9	Two wells > MCL
MTBE	165	0	144	105	2	None detected
1,4 Dioxane	1	0	0	10	0	Two wells have high levels
BTEX	152	2	122-126	81-84	9	No BTEX hits
BTEX Hits	0	0	0	0	0	
SVOCs	1-6	1	1-5	1-14	1-5	No SVOC hits

Table 5-6: Water Quality Summary of Average Concentrations of Key COCs for Olympic Subbasin

Parameter (limit)	Statistic (Units)	Well Name			
		Santa Monica Well No 01	Santa Monica Well No 03	Santa Monica Well No 04	Santa Monica Well No 07
TDS (500 mg/L)	Avg (mg/L)	854	883	955	706
	Min (mg/L)	800	806	1041	502
	Max (mg/L)	889	850	1068	850
Hardness (200 mg/L)	Avg (mg/L)	544	602	639	424
Color (15 units)	Avg (Units)	2.3	2.6	2.6	<5
Odor (3 Units)	Avg (Units)	1.6	1.4	1.8	2.3
Chloride (250 mg/L)	Avg (mg/L)	94.2	81.9	95.6	108
Nitrate (45 mg/L)	Avg (mg/L)	20.3	28.9	28.8	12
Iron (0.3 mg/L)	Avg (mg/L)	0.003	0.021	0.045	0.350
	Min (mg/L)	ND	ND	ND	0.085
	Max (mg/L)	0.010	0.110	0.168	0.75
Manganese (0.05 mg/L)	Avg (mg/L)	0.005	0.003	0.018	0.033
	Min (mg/L)	ND	ND	0.0034	0.014
	Max (mg/L)	0.0115	0.007	0.0349	0.063
Arsenic (10 µg/L)	Avg (µg/L)	0.4	0.4	0.6	ND
Chromium VI (0.02 µg/L)	Avg (µg/L)	1.0	2.2	1.5	NA
Perchlorate (6 µg/L)	Avg (µg/L)	0.2	0.3	0.2	NA
Trichloroethylene [TCE] (5 µg/L)	Avg (µg/L)	0.047	27.0	57.3	88
Tetrachloroethylene [PCE] (5 µg/L)	Avg (µg/L)	0.037	8.4	7.9	ND
MTBE (13 µg/L)	Avg (µg/L)	0.1	0.1	0.1	ND
MTBE (5 µg/L)	Avg (µg/L)	0.1	0.1	0.1	ND
1,4 Dioxane (1 µg/L)	Avg (µg/L)	ND	13.2	20.7	NA

ND = Zero in WQM

NA = Not Analyzed

5.2.1.3 Summary of Charnock Subbasin Water Quality

This section discusses Charnock Subbasin water quality, and the discussion is further subdivided by water purveyor (City of Santa Monica and Golden State Water Company).

5.2.1.3.1 City of Santa Monica

Table 5-7 provides a profile of the available water quality data and a broad perspective to identify COCs. Table 5-8 summarizes the key COCs in the Charnock Subbasin that may to be removed to provide a suitable potable water. In part, the COCs were selected from knowledge of Project staff's knowledge and experience with water treatment as well as historical and current treatment provided by the City of Santa Monica.

5.2.1.3.2 Golden State Water Company

Table 5-9 provides a profile of the available water quality data and a broad perspective to identify COCs for the Charnock Subbasin. Table 5-8 summarizes the key COCs in the Charnock Subbasin that may to be removed to provide a suitable potable water.

Table 5-7: Profile of Water Quality Analyses for City of Santa Monica Wells in Charnock Subbasin

Element	Well Identification							Comment
	Charnock Well No 12	Charnock Well No 13	Charnock Well No 14	Charnock Well No 15	Charnock Well No 16	Charnock Well No 18	Charnock Well No 19	
CDPH Well ID Number	1910146-004	1910146-005	1910146-006	1910146-007	1910146-008	1910146-010	1910146-011	
CDPH Status	Destroyed	Active	Destroyed	Active	Active	Active	Active	
Testing Period	'85-'88	'85-'96	1985	'87-'96	'85-'96	'85-'96	'92-'96	
Water Quality Parameter	Typical No. of Samples in WQM							
General Physical	1-2	4-5	0	3-4	3-4	3-4	2	
TDS	1	4	0	3	3	3	2	TDS>SMCL of 500 mg/L
General Minerals	1	4	0	3	3	3	2	High hardness and TDS, installed RO in 2010, no perchlorate, <50% MCL for nitrate
Chloride	1	4	0	3	3	3	2	
Sulfate	1	4	0	3	3	3	2	
Perchlorate	0	0	0	0	0	0	0	
Heavy Metals	1	2-4	0	2-3	2-4	2-4	2	Heavy metals < MCL
Arsenic	1	3	0	3	3	3	2	
Iron	1	4	0	3	3	3	2	Fe & Mn treatment installed in 2010
Manganese	1	4	0	3	3	3	2	
Radiological	2	2-13	0	1-18	5-14	2-11	1-9	
VOCs	5	7-59	0	10-66	9-66	11-69	6-27	Except as noted below no VOCs
TCE	12	59	0	66	66	69	27	> MCL in some wells
PCE	5	57	0	62	62	68	25	No PCE hits
MTBE	0	11	0	9	5	12	7	>MCL & SMCL in some wells
1,4 Dioxane	0	0	0	0	0	0	0	No Dioxane
BTEX	1	9	0	11	10-12	12-14	7-8	No BTEX hits
BTEX Hits	1	0	0	0	0	0	0	
SVOCs	1	1-7	1	1-7	1-6	1-6	1-7	No SVOC hits

Table 5-8: Water Quality Summary of Average Concentrations of Key COCs for Charnock Subbasin

Parameter (limit)	Statistic (Units)	City of Santa Monica						Golden State	
		Charnock Well 12	Charnock Well 13	Charnock Well 15	Charnock Well 16	Charnock Well 18	Charnock Well 19	Charnock Well 09	Charnock Well 10
TDS (500 mg/L)	Avg (mg/L)	710	861	1166	660	748	1116	904	1100
	Min (mg/L)	710	787	1096	655	710	1110	729	1005
	Max (mg/L)	710	922	1251	670	778	1121	1119	1156
Hardness (200 mg/L)	Avg (mg/L)	453	537	697	409	484	584	509	763
Color (15 units)	Avg (Units)	<3	4.1	5.75	4	7	11	26.6	35.4
Odor (3 Units)	Avg (Units)	3.0	3.0	3.00	3	3	7.5	2.2	1.3
Chloride (250 mg/L)	Avg (mg/L)	109	160	218	83	69	168	120	179
Nitrate (45 mg/L)	Avg (mg/L)	14.5	5.3	0.83	7.4	0.3	2.7	1.2	0.7
Iron (0.3 mg/L)	Avg (mg/L)	0.27	0.3	1.25	0.290	0.886	0.508	1.52	0.99
	Min (mg/L)	0.27	0.017	0.496	0.226	0.758	0.216	0.06	0.05
	Max (mg/L)	0.27	0.563	2.243	0.34	0.980	0.800	7.47	1.29
Manganese (0.05 mg/L)	Avg (mg/L)	<0.027	0.1	0.08	0.052	0.056	0.072	0.081	0.058
	Min (mg/L)	<0.027	0.0048	0.056	0.032	0.047	0.060	0.030	0.015
	Max (mg/L)	<0.027	0.173	0.095	0.067	0.063	0.084	0.256	0.071
Arsenic (10 µg/L)	Avg (µg/L)	<1	ND	ND	ND	ND	ND	3.1	<2
Chromium VI (0.02 µg/L)	Avg (µg/L)	NA	NA	NA	NA	NA	NA	NA	NA
Perchlorate (6 µg/L)	Avg (µg/L)	NA	NA	NA	NA	NA	NA	NA	NA
Trichloroethylene [TCE] (5 µg/L)	Avg (µg/L)	5.1	2.0	2.26	8.1	1.2	6.5	ND	ND
Tetrachloroethylene [PCE] (5 µg/L)	Avg (µg/L)	<0.5	<0.5	ND	ND	ND	ND	ND	ND
MTBE (13 µg/L)	Avg (µg/L)	NA	185.2	14.01	0.6	12.6	301.7	ND	ND
MTBE (5 µg/L)	Avg (µg/L)	NA	185.2	14.01	0.6	12.6	301.7	ND	ND
1,4 Dioxane (1 µg/L)	Avg (µg/L)	NA	NA	NA	NA	NA	NA	NA	NA

ND = Zero in WQM

NA = Not Analyzed

Table 5-9: Profile of Water Quality Analyses for Golden State Water Company Charnock Wells

Element	Well Identification			Comment
	Charnock Well No 06	Charnock Well No 09	Charnock Well No 10	
CDPH Well ID Number	1910030-001	1910030-003	1910030-010	
CDPH Status	Destroyed	Inactive	Inactive	
Testing Period	1992	1987-2001	1995-2001	
Water Quality Parameters	Typical No. of Samples in WQM			
General Physical	0	8	2-4	
TDS	0	6	3	
General Minerals	0	6	2	High TDS, hardness, nitrate < 50% of MCL, no perchlorate hits
Chloride	0	6	2	
Sulfate	0	6	2	
Perchlorate	0	0	0	
Heavy Metals	0	6	2	All heavy metals < MCL
Arsenic	0	6	2	
Iron	0	14	21	GSWC had Fe & Mn treatment
Manganese	0	15	21	
Radiological	0	0-8	0-5	
VOCs	1	7	5	Well No 6 had hits of 1,2 Dichloroethylene (1.2 µg/L) and TCE (4.2 µg/L), no evidence of MTBE or BTEX
TCE	1	7	5	
PCE	1	7	5	
MTBE	0	3	12	
1,4 Dioxane	0	0	0	
BTEX	0	7	5	
BTEX Hits	0	0	0	
SVOCs	No Data	1-6	1-5	No SVOC hits

5.2.1.4 Coastal and Crestal Subbasin Water Quality Assignments

Water quality data was not available for the Coastal and Crestal Subbasins; therefore, an assignment of the water quality was required to develop the unit treatment process requirements.

5.2.1.4.1 Coastal Subbasin

As indicated previously, there are no potable production wells within this subbasin. As a result, a water quality assignment was developed. This assignment was based on the following assumptions.

1. The Coastal Subbasin receives a major portion of its groundwater recharge from the Charnock Subbasin.
2. The Charnock Subbasin production wells were characterized until 1996 after which both the City of Santa Monica and Golden State Water Company Charnock wells were placed on inactive status due to MTBE contamination.

3. The Charnock Subbasin has recently been returned to service providing the City of Santa Monica almost 70 percent of its water supply.
4. Although the Charnock wellfield has been idle for about 14 years and presently has relatively high static groundwater levels, it was assumed that the water quality looking forward 10 to 15 years would be similar to the historic water quality.

Based on the above, the water quality assignment for the Coastal Subbasin is:

1. The baseline general minerals and TDS are similar to the Charnock wells with an allowance for increased sodium chloride due to seawater intrusion. The assumed overall TDS is 1,800 mg/L, approximately a 50 percent increase of the blended raw Charnock groundwater from the City of Santa Monica wells.
2. There are no VOCs as COCs.
3. Iron and manganese are at concentrations that can be handled by pH control or anti-scalants.

5.2.1.4.2 Crestal Subbasin

As indicated previously, there are no potable production wells within this subbasin. As a result, a water quality assignment was developed. The assignment was based on the following assumptions.

1. The Crestal Subbasin receives a major portion of its groundwater recharge from the Charnock Subbasin and the surrounding more easterly Santa Monica Mountains.
2. The Charnock production wells were characterized up until 1996 after which both the City of Santa Monica and Golden State Water Company Charnock wells were placed on inactive status due to MTBE contamination.
3. The Charnock production wells have recently been returned to service providing the City of Santa Monica almost 70 percent of its water supply.
4. Even though the wellfield has been idle for about 14 years and has relatively high static groundwater levels, it has been assumed that the current water quality will be similar to the historic water quality looking forward, 10 to 15 years.
5. The Charnock groundwater has elevated average iron and manganese levels, in some cases as high as 5 times the SMCL.
6. The Hollywood Basin receives the majority of its recharge from the more easterly Santa Monica Mountains than the Crestal Subbasin. The Hollywood Basin has a lower TDS and hardness than the Charnock Subbasin.
7. The Hollywood Basin has iron and manganese in some of the City of Beverly Hills production wells that are above their respective SMCLs, although not as high as the Charnock Subbasin groundwater.

Based on the above, the water quality assignment for the Crestal Subbasin is:

1. The baseline general minerals and TDS are similar to the lower hardness and TDS of the Charnock wells. The assumed overall TDS was 900 mg/L, approximately 200 mg/L lower than Charnock wells with high TDS.
2. There would be taste and odor compounds and perhaps some gasoline-related VOCs.
3. Iron and manganese would be at concentrations above the SMCL and would require removal.

5.2.2 Hollywood Basin

The City of Beverly Hills is the only purveyor with drinking water wells in this groundwater basin. Prior to 1976, the City of Beverly Hills operated 10 water production wells within this groundwater basin. In 1976, the City of Beverly Hills discontinued use of their groundwater wells and only provided their customers with surface water supplied by MWD. As a result, there is no water quality in the CDPH WQM database for these wells.

In 1985, the City of Beverly Hills retained JMM Consulting Engineers (JMM) to perform a groundwater feasibility study. Two locations were selected and four pilot wells were installed and tested for water quality. These data were reviewed and are in Appendix D.

In 2004, the City of Beverly Hills installed four new water production wells that are treated by an RO desalter. There are water quality data in the WQM database for the new four wells, but since Title 22 only requires compliance monitoring every 3 years for a groundwater well, there is a limited historical water quality record for these wells. It should be noted that the B site for the 1985 JMM report is in the same vicinity of the three new wells located in the Beverly Gardens Park. The water quality record for these three wells may be defined as commencing in 1985 with a gap to 2004. This assumes that the well perforations are similar between the Site B pilot wells and the three Beverly Garden Park wells.

Appendix D contains the summary descriptive statistics (number of samples, average, median, minimum, and maximum) for the water quality parameters that have been tested for each well within the Hollywood Basin.

Based on the results of the EnviroStor and GeoTracker database searches, there appears to be a potential for Chromium 6 contamination to the north of Pan Pacific Park. Two sites (Laser Pacific Media Company and Veiling Plating) cite chromium as a contaminant; however, the detailed extent of contamination is not known. Given the direction of groundwater flow in this area, it is a reasonable assumption that this contamination could migrate southward to the Pan Pacific Park area.

5.2.2.1 Summary of Water Quality

Table 5-10 provides a profile of the available water quality data and a broad perspective to identify COCs for the Hollywood basin. Since the 1985 JMM report included the Site B wells that were in close proximity to the wells located within the Beverly Gardens Park, the 1985 JMM well data from both pilot sites are also included in this table.

The Appendix D tables indicate that no nitrate VOCs were detected. In part the COCs were selected from historical or current treatment provided by the City of Beverly Hills, which currently includes RO Treatment; therefore, COCs that impact this process were included in Table 5-11.

5.2.2.2 Water Quality Assignments for Hollywood Basin

The baseline water quality for new wells developed by LADWP in the Hollywood Basin is summarized in Table 5-11 and Appendix D. Based on the historical and current treatment provided by the City of Beverly Hills the COC are as follows:

- TDS – between 525-825 mg/L
- Iron – between ND to 0.5 mg/L
- Manganese – between ND and 0.3 mg/L
- Arsenic – between ND and 20 µg/L
- Color – between 10 – 30 units
- Odor - <5 to 40 units
- VOCs associated with gasoline - <10 µg/L

Table 5-10: Profile of Water Quality Analyses for City of Beverly Hills Wells

Element	Well Identification						Comments
	No. 2	No. 4	No. 5	No. 6	Site B 4 Wells	Site A 4 Wells	
CDPH Well ID Number	1910156-012	1910156-013	1910156-014	1910156-015	NA	NA	
CDPH Status	Active	Active	Active	Active	NA	NA	
Water Quality Period	'02 to '11	'02 to '11	'02 to '11	'02 to '11	1985	1985	
Water Quality Parameter	Typical Number of Samples in WQM						
General Physical	4	4	4	4	4	4	High musty odors for JMM wells Historically had sulfides
TDS	78	85	85	82	4	4	Elevated TDS so currently has RO
General Minerals	4	4	4	4	4	4	Nitrate levels < 50 % of MCL
Chloride	78	85	85	82	4	4	One well had chloride > SMCL
Sulfate	78	85	85	82	4	4	
Perchlorate	6		6	6	NS	NS	No hits for perchlorate
Heavy Metals	4	4	4	4	4	4	All metals except Arsenic < MCL
Arsenic	27	27	26	28	4	4	Well No. 4 arsenic > MCL
Iron	4	4	4	4	4	4	Potential iron > MCL
Manganese	78	85	85	84	4	4	Potential manganese > MCL
Radiological	4	4	5	4	4	4	
VOCs	14	14	14	14	4	4	
TCE	14		14	15	4	4	
PCE	14		14	15	4	4	
MTBE	13		14	14	NS	NS	No VOCs hits except BTEX
1,4 Dioxane	3		2	2	NS	NS	
BTEX	14	15	14	15	4	4	
BTEX Hits	0	5	3	0	1	1	Occasional BTEX hits
SVOCs	3	2	2	3	4	4	No SVOC hits

Table 5-11: Water Quality Summary of Average Concentrations of Key COCs for Hollywood Basin

Parameter (limit)	Statistic (Units)	City of Beverly Hills Well Name				JMM 1985	
		Well 02	Well 04	Well 05	Well 06	B-1, B-2, B-3, B-4	A-1, A-2, A-3, A-4
TDS (500 mg/L)	Avg (mg/L)	829	561	550	527	568	654
Hardness (200 mg/L)	Avg (mg/L)	199	245	288	219	283	233
Color (15 units)	Avg (Units)	7.5	10.0	25.0	12.0	9.5	8.75
Odor (3 Units)	Avg (Units)	0.3	3.7	0.5	0.5	35	26
	Min (mg/L)	ND	0.5	0.5	0.5	17	8
	Max (mg/L)	0.5	10	0.5	0.5	67	40
Chloride (250 mg/L)	Avg (mg/L)	251	86	41	57	103	183
Iron (0.3 mg/L)	Avg (mg/L)	ND	ND	0.034	0.48	0.92	1.0625
	Min (mg/L)	ND	ND	ND	ND	0.2	0.69
	Max (mg/L)	0.025	ND	0.10	0.81	2.4	1.5
Manganese (0.05 mg/L)	Avg (mg/L)	0.001	0.049	0.036	0.12	0.31	0.273
	Min (mg/L)	ND	ND	0.020	ND	0.05	0.056
	Max (mg/L)	0.03	0.144	0.097	0.265	0.85	0.670
Arsenic (10 µg/L)	Avg (µg/L)	ND	19.4	1.7	2.8	<1	<10
Detection of BTEX		No	Yes	No	No	Yes	Yes

Section 6: Treatment Scenarios

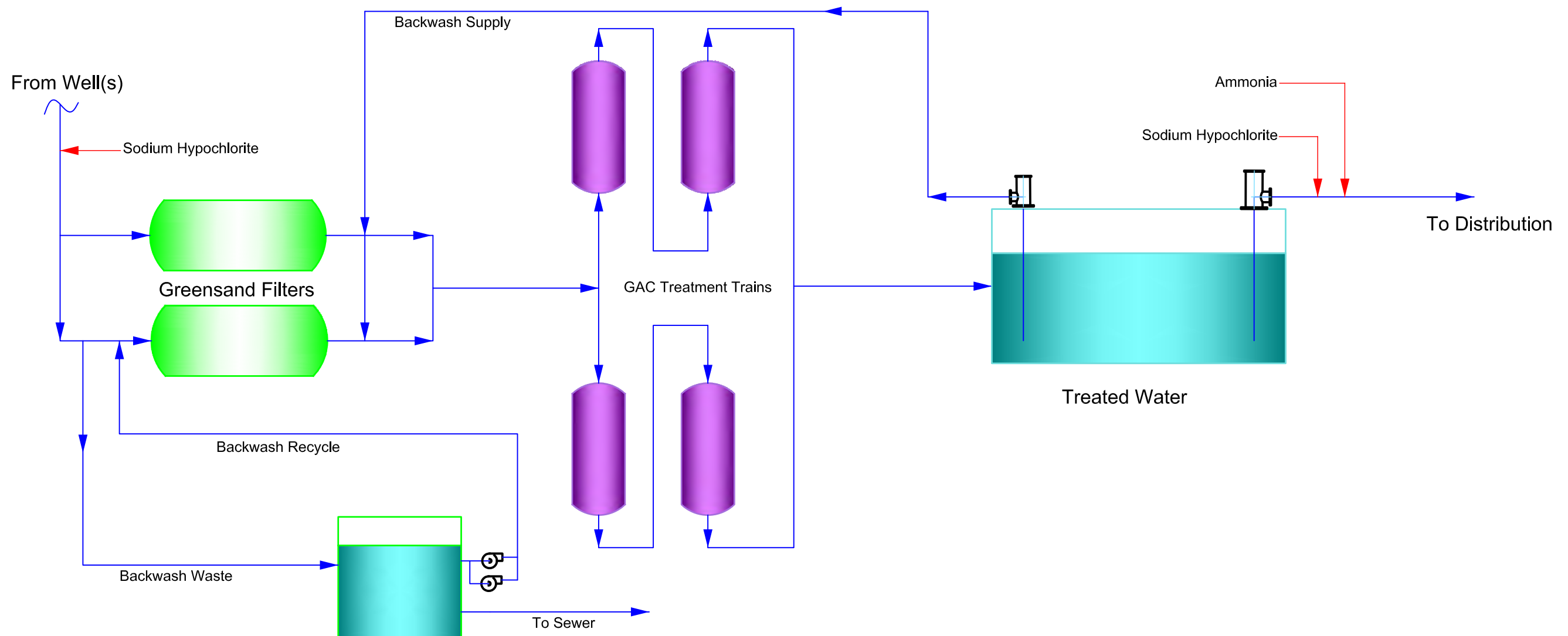
Treatment trains were developed in order to bring water quality into compliance with CDPH water quality standards. Based on the existing water quality, the main three COCs that require treatment are as follows:

- Iron and Manganese - Santa Monica Crestal and Hollywood;
- VOCs, Odor and Color - Santa Monica Crestal and Hollywood; and
- Total Dissolved Solids (TDS) – Santa Monica Crestal and Santa Monica Coastal.

The treatment trains recommended at this feasibility level are based on assumed water quality developed from historical water quality data in different parts of each basin. When a specific location has been selected for production wells that will require treatment, one or more monitoring wells should be constructed to identify any additional COC's that may emerge in that area. The recommended treatment process trains for each basin are illustrated on Figures 6-1 through 6-3 as follows:

- Hollywood Basin: Greensand – Granular Activated Carbon (GAC) – Chloramination;
- Santa Monica Crestal Subbasin: Greensand – GAC – Reverse Osmosis (RO) – Chloramination; and
- Santa Monica Coastal Subbasin: RO – Chloramination.

Each of these treatment technologies is discussed herein.



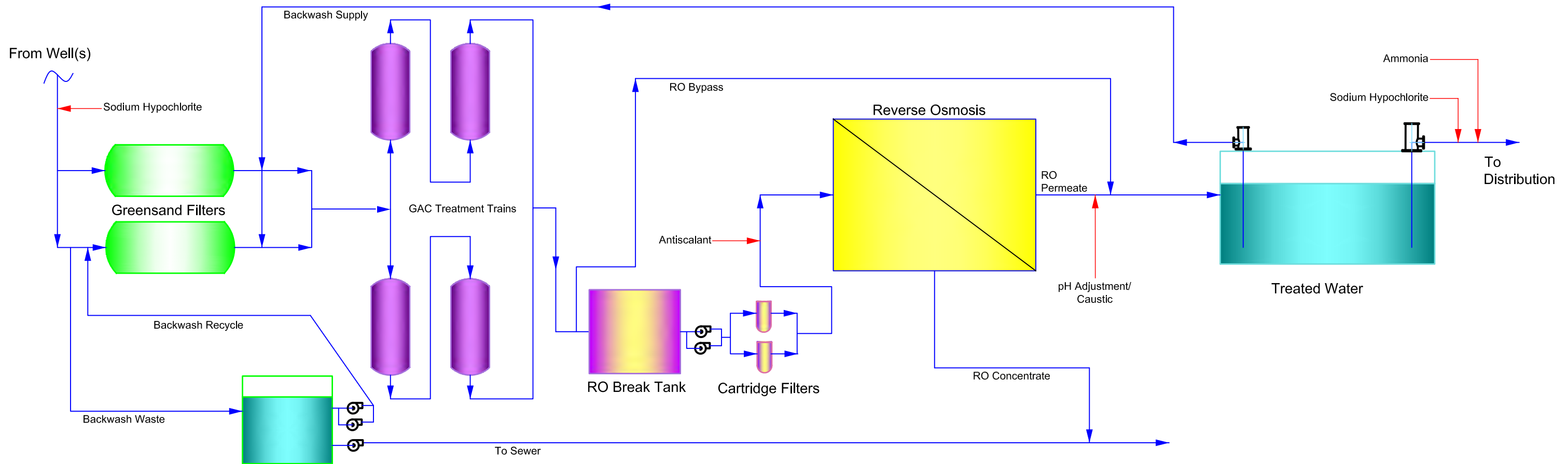
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Los Angeles, CA
Task Order No. 3 (Agreement No. 47818)

Hollywood Basin Process Flow Diagram

K/J 1179008*00
December 2011

Figure 6-1



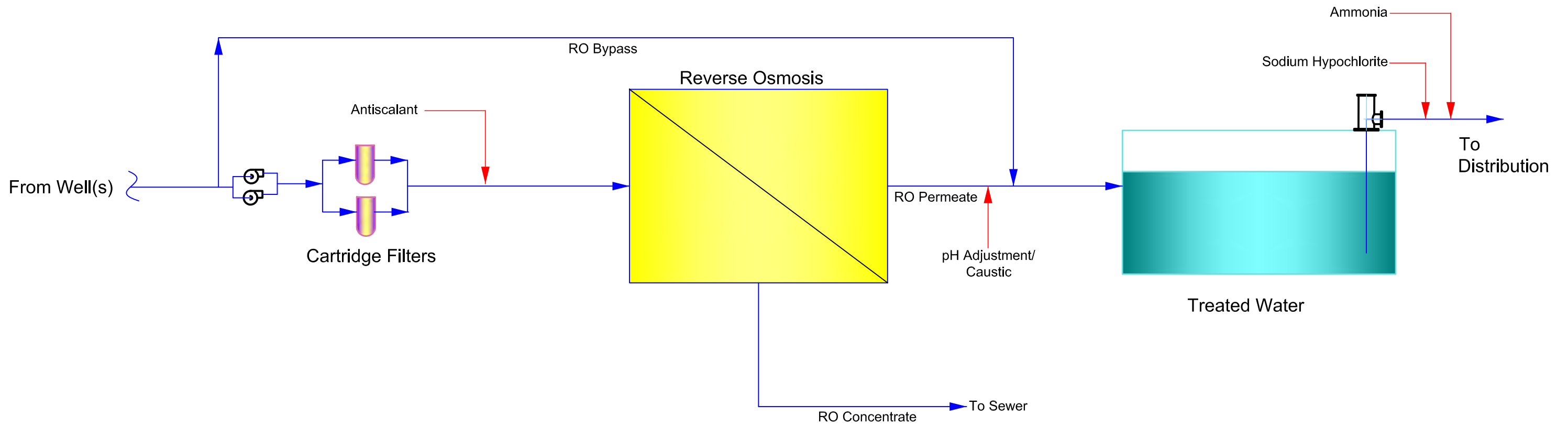
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**Santa Monica Crestal Subbasin
Process Flow Diagram**

K/J 1179008*00
December 2011

Figure 6-2



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**Santa Monica Coastal Subbasin
Process Flow Diagram**

K/J 1179008*00
December 2011

Figure 6-3

6.1 Iron and Manganese Treatment

Common processes for addressing iron and manganese issues are oxygen quenching, oxidation/filtration, and adsorption/catalytic oxidation. Based on cost and maintenance requirements for these technologies adsorption/catalytic oxidation was selected. In this process, an oxidant is added to the filter influent. The filter media has catalytic properties that accelerate the oxidation of manganese. In operation, the iron is oxidized in the process influent, precipitated, and captured in the media through filtration. The manganese is adsorbed onto the media surfaces, where it is catalytically oxidized. Both the oxidant doses and oxidant contact times are typically lower than for direct oxidation/filtration processes.

The media types typically used in an adsorption/catalytic oxidation processes include manganese dioxide coated silica sand, greensand, or pyrolusite, as well as several proprietary media. The media are housed in pressure vessels and are operated much like conventional media pressure filtration systems. Each of these media is very similar in treatment performance and process requirements but do exhibit unique treatment kinetics, resulting in differences such as loading rates and backwash requirements. Of the three non-proprietary media, pyrolusite-based systems are generally anticipated to have the highest capital cost. Both the manganese coated silica sand and greensand systems are anticipated to have lower costs in the same size range. However, silica sand systems have a separate coating period requirement. Therefore, a greensand media was assumed for this report, as it is cost competitive with the silica sand media but does not have the additional coating period requirement.

6.1.1 General Process Description

The greensand treatment process for iron and manganese treatment includes the following steps:

1. Oxidation. Sodium hypochlorite would be dosed into the influent pipeline via metering pumps.
2. Treatment through adsorption/catalytic oxidation and filtration. The process water would pass through pressure filter vessels to remove the iron and manganese. Total dynamic head (TDH) to move the water through the system would be supplied by the well pumps. Vessels would be configured for duty operation; no standby vessels are included in this configuration.
3. Periodic Backwash Cycles. The waste backwash water would be piped to an above ground tank, where the water would be allowed to settle. Roughly half of this backwash water would then be decanted and recycled through the filters. The remaining water containing the iron and manganese precipitates would be discharged into a waste tank which would then either gravity drain or be pumped to the nearby sanitary sewer. It is assumed that roughly 50 percent of the backwash water would be sent to waste. The percentage of backwash waste could be reduced through pilot studies and operational optimization.

6.1.2 Chemical Storage and Feed System

The recommended oxidant is chlorine (sodium hypochlorite) due to its low cost, availability onsite, and strong oxidant capacity. The use of chlorine would require a continuous chlorine

residual analyzer. Chemical dose rates have been recommended to oxidize all of the soluble iron and manganese present in the groundwater based on average concentrations. These dosing rates would be confirmed through pilot testing or during start-up and initial operational experience. Table 6-1 presents the assumed chemical feed equipment requirements.

Table 6-1: Iron and Manganese chemical Feed and Storage Requirements

Description	Oxidant
Metering Pumps	2 (1 duty, 1 standby)
Chemical	Sodium Hypochlorite
Concentration	12.5%
Estimated Dosage	0.6 mg/l
Pump Type	Peristaltic
Storage Type	Double wall polyethylene
Days of Storage	30

6.1.3 Greensand Filter Vessels

The vessel configuration and preliminary design criteria presented in this section are based on existing system designs for treatment of groundwater with water quality characteristics similar to those assumed for the source water in this report. Differences in these parameters from the configuration and treatment criteria of proprietary or vendor specific systems would need to be evaluated once the source water iron and manganese water quality, and subsequent treatment requirements, are verified. The filter vessels assumed for this project are two cell, welded steel horizontal pressure filters. Table 6-2 presents the design criteria used for sizing the iron and manganese treatment system assuming greensand media for both a 10-month and 6-month per year operation.

Table 6-2: Design and Operating Criteria - Greensand Filters

Design Criteria	Hollywood		Santa Monica Crestal	
	10 months	6 months	10 months	6 months
Media Type	Anthracite and Greensand			
Media Depth	12 inches Anthracite over 24 inches Greensand			
Loading Rate (gpm/sf)	5.7	7.9	4.4	7.2
Diameter (ft)	10			
Sideshell Length (ft)	25			
No. Vessels Required	2			
Flow per vessel (gpm)	1,140	1,575	875	1,440

Each filter vessel would require an electrically actuated control valve and flow meter to evenly distribute flow between duty vessels. Flow and backwash to filter cell would also include electrically actuated valves. All filter vessels would be configured for duty mode during operation; no standby vessels are included as part of the operating strategy for this process.

Surface Loading Rates (SLR) for greensand filter systems can vary significantly and can range from 3 gpm/sf to 12 gpm/sf. Data from existing systems currently in operation in California use a typical loading rate of 7.5 gpm/sf for similar applications. Therefore it was assumed that under the maximum flows seen during the 6 month operating scenario two filters would operate in the 7.2-7.9 gpm/sf range. Under the 10 month condition, the filters would operate at lower surface loading rates (4.4 – 5.7 gpm/sf).

It is highly recommended the loading rate for a greensand filter system be confirmed through field pilot testing during the project design phase.

6.1.4 Backwash Storage and Recovery System

The specific backwash requirements (duration, rate, and frequency) would depend on the final selection of the media and findings from any pilot testing that is conducted. The backwash rate is dictated by bed expansion; typically 40 percent is desired in iron and manganese systems. Backwashing would require one filter vessel to be off line at a time. When in backwash mode, one of the two filter cells within the vessel would be isolated and backwashed using water supplied from the product water tank. The vessel would then backwash the second filter cell to complete the backwash cycle. The filter would also have a filter-to-waste feature following the backwash. At the completion of the full backwash cycle, the filter vessel would be placed back into service. Backwash would be initiated automatically either on time, on differential pressure (typically 10 psi), or under a manual operator-initiated mode. Normal backwash operation would be automatic based on time. Table 6-3 provides a summary of the backwash design and operating criteria.

Table 6-3: Design and Operating Criteria - Backwash Tank

Design Criteria	Value
Backwash Rate	15 gpm/sf
Backwash Duration	15 minutes
Backwash Volume per Vessel	45,000 gallons
Surface Wash Rate	2.5 gpm/sf
Surface Wash Duration	2 minutes
Surface Wash Volume per Vessel	1,000 gallons
Filter to Waste Rate	(Varies based on SLR)
Filter to Waste Duration	5 minutes
Filter to Waste Volume per Vessel	4,375 – 7,875 gallons
Total Backwash Cycle Volume Per Vessel	50,375 – 53,875 gallons
Backwash Frequency	36 hours
Total Backwash Cycles Per Week	9.4
Backwash Decant Tank Size	60,000 gallons
Number of Backwash Decant Tanks	1

Each filter vessel is anticipated to be backwashed 4.7 times per week which would yield 9.4 backwashes per week, or one backwash cycle approximately every 18 hours. Backwash would include a surface wash at a reduced backwash rate followed by a ramped up full backwash flow. Cells would be run in a filter to waste mode following the full backwash flow step. The filter to waste flow would go to the backwash tank.

Spent backwash water would be discharged to a welded steel backwash decant tank sized to capture one full backwash cycle. Backwash reclamation includes a settling period followed by decanting of the settled water using a floating intake. The backwash tank would include an overflow to sewer. The tanks would include a solids removal system to collect and discharge settled solids to the sanitary sewer.

The recovered water would be pumped to the head of the iron and manganese process at a rate not to exceed 10 percent of the wellfield production. It is anticipated that approximately 50 percent of the backwash flow would be recycled through the treatment system. The residual iron and manganese precipitate waste stream (estimated at 50 percent of the backwash flow) would be pumped and discharged to the sanitary sewer. As mentioned above, pilot studies and/or operational optimization should allow a higher ratio of recycling and a reduction in waste flow to the sewer.

The backwash recovery pump station would be equipped with two pumps, one duty and one standby. Each pump would be equipped with a variable frequency drive (VFD) and flow paced to match 10 percent of the total production flow rate.

6.1.5 Option for Hexavalent Chrome Treatment

Potentially, for the Pan Pacific Park site in the Hollywood Basin there may be local hexavalent chrome contamination in the shallow aquifer. It is assumed that the wells would have a cement seal meeting the CDPH requirements that should reduce the potential for hexavalent chrome contamination of the raw well water. However, it is possible that hexavalent chrome removal may be required. The City of Glendale is piloting removal technologies for hexavalent chrome. Two technologies are currently being piloted at the City of Glendale (Blute, 2011). One process is a single-pass ion exchange. The other is hexavalent chrome reduction with ferrous ion, co-precipitation of trivalent chrome with oxidized (oxidizer addition) excess ferric iron, aeration, and pressure filtration.

If hexavalent chrome becomes an issue at the Pan Pacific Park site (see Section 7), the pressure filtration option would be recommended as the major components of this treatment train are already included (oxidizer addition and pressure filtration) in the capital and O&M costs for this site. Some additional chemical feed equipment (ferrous iron), tankage and air compressor (30 minute aeration process) would be added to an iron and manganese treatment system. The hexavalent chrome pilot effluent results are reported to be <1 µg/L. The capital cost for these additions would add roughly 2 percent to the current capital cost estimate for this site. There would be a slightly higher backwash volume due to shorter filter run times since there would be a higher total iron load to the filters. It is assumed that the backwash water could be discharged to the sanitary sewer. There would be a small increase in the O&M costs which are well within the accuracy of the current O&M cost estimate for these added components at this site.

6.2 GAC Treatment for VOC, Odor & Color Removal

The selected treatment technology for odor and color, VOCs (such as TCE), and other trace organics is Granulated Activated Carbon (GAC). The GAC is packed in pressure vessels (contactors) and adsorbs the organics. The GAC would also take up any remaining chlorine residual from the iron and manganese treatment that could damage the downstream Reverse Osmosis membranes that are proposed for total dissolved solids reduction for the Crestal Subbasin.

GAC contactors can be arranged in a number of different configurations, with the flow passing through the contactors either in parallel or series. Operating GAC contactors in series is roughly equivalent to combining the depth of the individual beds. Two other important design parameters for design of the GAC system are surface loading rate (SLR) and empty bed contact time (EBCT).

SLR is calculated as the volumetric flow rate divided by the cross sectional area of the filter and is expressed as gallons per minute per square foot (gpm/sf). For this application the SLR should be kept below 11 gpm/sf.

EBCT is calculated as the volume of the empty bed (occupied by the GAC) divided by the volumetric flow rate of the water through the bed. The recommended EBCT varies depending on the targeted contaminant. For odor and color the minimum recommended EBCT is 10 minutes.

The design criteria assumed for each treatment train is provided in Table 6-4 below.

Table 6-4: Design and Operating Criteria - GAC System

Parameter	Hollywood 10 months	Hollywood 6 months	Crestal 10 months	Crestal 6 months
Influent Flow	2,280	3,150	1,750	2,880
Vessels per Train (run in series)	2	2	2	2
No. of Trains	2	3	2	3
Total No. of Vessels	4	6	4	6
Vessel Diameter (ft)	12	12	12	12
Vessel Height (ft)	5	5	5	5
Piping Connection Diameter (in)	8	8	8	8
Carbon Fill/Discharge Diameter (in)	4	4	4	4
Media Type	Washed Bituminous base GAC			
Media/Vessel (lbs)	20,000	20,000	20,000	20,000
Total Media (lbs)	80,000	120,000	80,000	120,000
Density of GAC (lbs/cf)	27	27	27	27
SLR (gpm/sf)	10.1	9.3	7.7	8.5
EBCT (minutes)	10	11	13	12

Each treatment train would consist of two contactors connected in series. The first contactor would act as the treatment vessel with the second acting as the polishing vessel. Each treatment train would be connected in parallel and controlled so that equal flow would be directed to each treatment train.

The media would need to be backwashed after initial fill. Water for this operation could be taken from the finished water tank. Waste from this operation could be routed temporarily to the greensand filter backwash tank as long as a backwash is not in progress. This water could then be settled and sent to the sanitary sewer.

Since the GAC would be operated for 10- and 6-month periods, it is recommended that the filters be drained at the end of an operational period and the media emptied and disposed of to prevent the tank from going septic during the down months. Because the GAC media would be replaced annually, it is assumed that no periodic backwashing would be required of the GAC units while in operation.

6.3 Total Dissolve Solids Reduction

The selected treatment technology for TDS reduction is Reverse Osmosis (RO). In principle, RO generates desalted water when a significant portion of the water component of pressurized feed passes through a semi-permeable membrane, while the dissolved minerals in the pressurized feed water are restricted by the membrane and becomes the “concentrate”. The concentrate is the waste stream of this process which requires disposal. The water which passes through the membrane, or permeate, is very low in TDS and is the product water. Standard RO elements used for large scale commercial applications consist of thin film composite (TFC) membranes constructed in a spiral wound configuration. Elements are commercially available with industry standard dimensions of 8-inches in diameter by 40-inches in length. Pressure vessels for these elements generally house between 5 and 7 elements in series, with multiple vessels operating in parallel to achieve the permeate production capacity required.

RO offers the highest rejection of TDS (i.e., highest fraction of TDS remains in the concentrate) when compared to Nanofiltration (NF) and Electrodialysis Reversal (EDR) technologies. RO elements in this size are commonly used in a number of industries and have an established track record of operation. Capital costs for 8-inch diameter RO and NF systems are generally lower than equivalent EDR systems.

The RO system has the following elements:

- Break Tank and transfer pumps to equalize any flow variances from up-stream treatment trains (only relevant to Santa Monica, Crestal Subbasin);
- Antiscalant Feed System;
- Cartridge Filters;
- RO System;
- RO Membrane Clean-in-Place (CIP) system; and

- RO Post Treatment System.

6.3.1 Greensand Filter Break Tanks and RO Pumps

The greensand filter break tank would serve as a buffer to allow filter vessels to undergo a backwash cycle without interrupting process flow to the RO system. The RO pumps would convey the process water from the break tank through the cartridge filters and RO skid. Table 6-5 presents the design and operating criteria for the greensand filter break tanks.

Table 6-5: Design and Operating Criteria - Greensand Filter Break Tanks and Transfer Pumps

Parameter	Unit	Initial
Number of Tanks	number	1
Operational Capacity (each)	gal	69,000
RO Pumps		
Duty	number	1
Standby	number	1
Flow Rate (each)	gpm	1,800 – 3,000

The break tank would be a buried concrete tank and is sized to allow the RO system to operate without interruption to process flow through one complete greensand filter backwash cycle.

6.3.2 Antiscalant Feed System

Antiscalant chemicals are frequently used in RO systems to suppress the precipitation of inorganics in the concentrate. As a result, the allowable recovery of the RO system is increased, thereby increasing the quantity of permeate that can be extracted from each unit volume of feed water treated by the RO system.

The antiscalant feed system would consist of a solution tank, two metering pumps, and instrumentation and controls, all housed within a secondary containment area. The antiscalant would be injected into the RO feed water as a neat solution (not diluted) upstream of the cartridge filters. An in-line static mixer would be used to uniformly disperse the antiscalant solution into the RO feed water. Table 6-6 presents the design and operating criteria for the antiscalant feed system.

Table 6-6: Design and Operating Criteria - Antiscalant Feed System

Parameter	Unit	Initial
Dosage (Min/Avg/Max)	mg/l	2 / 3 / 4
Use (Min/Avg/Max)	ppd	75 / 113 / 150
Metering Pumps (Duty/Standby)	number	1/1
Chemical Conc. @ 100% Solution	lb/gal	10
Storage Tank	number	1
Supply at Max	days	30

6.3.3 Cartridge Filtration

Cartridge filtration would protect the RO membranes from damage from any potential particles that could get past the greensand filters. The cartridge filter housings would be arranged in parallel to allow duty and standby service during normal operation.

Horizontal cartridge filter housings would be specified to reduce maintenance requirements on the operational staff. Vertical housing could be used; however, the orientation of the housing with respect to the elements requires access platforms for maintenance.

Either two or three cartridge filter units (1 duty, 1 standby or 2 duty, 1 standby) would be provided upstream of the RO system to remove particulates and suspended solids from the source water. Each cartridge filter would consist of a filter housing containing filter elements with a nominal filtration rating of 5 microns, complete with a sample valve, and inlet and outlet isolation valves.

6.3.4 Primary Treatment (Reverse Osmosis)

This section presents the projected RO system performance, anticipated equipment components, and membrane cleaning requirements. Based on the assumed flow and treatment goals, a packaged RO skid system can be used. The packaged RO System includes booster pumps to boost the influent to the required treatment pressure.

A treatment goal of 400 mg/l TDS (80% of the long term SMCL) was assumed. In order to reach this treatment goal flow rates were assumed as identified in Table 6-7. Additional criteria for the RO system are presented in Table 6-8.

The RO system would utilize two RO skids in parallel to achieve the permeate water capacity under the 10 month operational scenario. Under the 6 month operating scenario a third skid in parallel would be required. Under both scenarios the permeate flow would be blended with the by-pass flow (greensand filter effluent for Crestal and raw water by-pass for Coastal at the finished water tank to meet the design product water quality. The RO concentrate would be routed to a new sewer connection. Depending on local requirements an equalization tank may be required to hold the concentrate which would then be pumped to the sewer during off-peak hours. The following would be monitored for each RO skid:

- Flow rates would be continuously monitored on the feed, permeate, and concentrate lines for each skid. The flow signals would be used to modulate the control valves on each stream to maintain the target permeate production rate and target recovery for each skid.
- Pressures would be monitored at the RO feed, the permeate, and the concentrate. If the differential pressure between the feed and concentrate increases by 15 percent or greater than the original startup value, the RO membrane elements in the vessels would need to be taken offline for cleaning.
- In-line conductivity probes would be installed on permeate lines to provide continuous monitoring of conductivity. Operator-defined high conductivity set points would trigger local and remote alarms to alert treatment plant staff of these conditions.

Table 6-7: Design Flow Rates - Reverse Osmosis System

	Santa Monica Crestal		Santa Monica Coastal	
	10 months	6 months	10 months	6 months
RO Feed (gpm)	1,120	1,860	1,530	2,550
RO Bypass (gpm)	630	1,040	270	450
RO Permeate (gpm)	900	1,490	1,220	2,040
RO Concentrate (gpm)	220	370	310	510

Table 6-8: Design and Operating Criteria - Reverse Osmosis System

Parameter	Crestal 10 months	Crestal 6 months	Coastal 10 months	Crestal 6 months
RO Process Trains	2	3	2	3
Design Recovery (%)	80	80	80	80
RO Membrane Array	1 Stage	1 Stage	1 Stage	1 Stage
RO Membrane Material	TFC	TFC	TFC	TFC
RO Membrane Element				
Diameter (inches)	8	8	8	8
Elements per Pressure Vessel	6	6	6	6
Vessels per Train	126	126	126	126
Total Elements	252	378	252	378

6.3.5 RO Membrane Cleaning-In-Place System

Scale and foulants tend to gradually accumulate on the membrane surfaces over time, even when reasonable pretreatment measures are taken. To remove them, the membranes are periodically cleaned using a cleaning-in-place (CIP) process. In a well-designed system, CIP events are generally required at intervals of 3 to 6 months.

Cleaning is typically performed under the following conditions:

- When the normalized permeate flow drops by ≥ 10 percent
- When the normalized salt leakage in the permeate increases by ≥ 5 percent
- When the normalized differential pressure (feed pressure minus concentrate pressure) increases by ≥ 15 percent from the reference condition established during the first 48 hours of operation of new membranes.

The RO membrane would require cleaning by a caustic CIP solution should organic fouling occur. The CIP cleaning solution would be 0.1 percent sodium hydroxide (NaOH), by weight, at a pH of 12 and 30°C (maximum). The CIP solution may be used to remove organic fouling, biofilms, silica, and inorganic colloids (silt).

The RO membranes would require cleaning by acid CIP solution should inorganic scaling occur. The acid cleaning solution would be of 0.2 percent hydrochloric acid (HCl), by weight. The HCl solution may be used to remove inorganic calcium carbonate (CaCO₃) scale. An acid cleaning

solution of sodium hydrosulfite ($\text{Na}_2\text{S}_2\text{O}_4$), 1.0 percent by weight, or phosphoric acid (H_3PO_4), 0.5 percent by weight, may be used to remove metal oxides such as iron. These may also be used as alternative CIP solutions to remove inorganic CaCO_3 scale.

The RO membrane CIP system would consist of one solution tank, two pumps, a cartridge filter and instrumentation and controls. These components can be provided as a skid system or provided separately. The CIP waste would need to be contained in a separate waste tank and be neutralized prior to discharge to the sanitary sewer.

6.4 Post Treatment

Following the RO process, the permeate must undergo a series of post treatment steps prior to being introduced into the domestic water distribution system. These steps include:

- Chemical Addition. This includes the use of sodium hydroxide (caustic soda) for pH stabilization of the permeate and chloramination for disinfection.
- Blending with greensand filter effluent or raw water (depending on site) to meet the water quality goal. The blended, or product water, is then ready for potable water use.
- Pumping of the product water to the domestic water distribution system.

Each of these post treatment steps is described below.

6.4.1 Chemical Addition

This section discussed chemical addition, including pH stabilization with sodium hydroxide and disinfection with a chloramination system.

6.4.1.1 pH Stabilization with Sodium Hydroxide

Permeate is a highly aggressive water that can present corrosion issues if it is directly introduced into the domestic water distribution system without prior stabilization. The recommended means to provide stabilization is through both blending to add hardness and alkalinity and the addition of sodium hydroxide. Sodium hydroxide is a chemical commonly used to increase the permeate pH that addresses the internal distribution system corrosion issue.

Table 6-9 presents the design and operating criteria for the sodium hydroxide feed system proposed for the RO system.

Table 6-9: Design and Operating Criteria - Sodium Hydroxide Feed System

Parameter	Unit	Value
Dosage (Min/Avg/Max)	mg/l	10 / 15 / 20
Chemical Solution Strength	----	25%
Chemical Solution Density	lb/gal	12.76
Storage Tank	number	1
Supply at Max	days	30

Sodium hydroxide would be fed to the permeate prior to blending and disinfection. The feed system would consist of skid-mounted system with a single storage tank, two metering pumps, and associated instrumentation and controls would be arranged in a duty/standby configuration.

6.4.1.2 Disinfection – Chloramination System

Chloramination would be provided prior to pumping the water to the transmission or distribution main. The chloramination system would consist of two chemical feed systems: one to inject sodium hypochlorite followed by a second to inject ammonia (ammonium hydroxide). The design and operating criteria for each feed system is presented in Table 6-10.

Table 6-10: Design and Operating Criteria - Chloramination System

System Capacity				
Parameter	Unit	Value	Average	Min/Max
Aqueous Ammonia Feed System (Post-Treatment for Disinfection Residual)				
Dosage (as NH 4OH)	mg/l		0.5	0.2 to 0.6
Metering Pumps (Duty/Standby)	number	1/1		
Density @ 19% NH 4OH	lb/gal	7.67		
Storage Tank	number	1		
Supply	days	30		
Sodium Hypochlorite Feed System (Post-Treatment for Disinfection Residual)				
Dosage (as NaClO)	mg/l		2.5	1.0 to 4.0
Metering Pumps (Duty/Standby)	number	1/1		
Density @ 12.5% NaClO	lb/gal	9.27		
Storage Tank	number	1		
Supply	days	30		

Each chemical feed system would consist of skid-mounted system with a solution tank, two metering pumps, and associated instrumentation and controls. Two motor-driven metering pumps would be included on the skid for each feed system. Each pair would be arranged in a duty/standby configuration.

6.5 Clearwell

The clearwell serves several system purposes:

- It provides a buffer between the treatment system and the domestic distribution water system. In the event of a distribution water system problem, the clearwell would allow the treatment system to ramp down to reduced operation or shutdown without risk of pressure shocking the treatment units.
- It provides supply source water to backwash the greensand filters.
- It provides blending time to ensure a consistent water quality is delivered to the domestic water system.

The clearwell tank would be a buried concrete tank sized to provide a minimum 30 minutes of storage at maximum flow. The buried tank would act as a dual wet well. One end of the sump would house vertical turbine pumps which supply backwash water to the greensand filters (except for Santa Monica Coastal where no greensand filters are required). The other end of the tank would act as a wet well for the finished water pumps which would pump to the distribution system. The treated water pump discharge piping would run along the top of the buried tank to provide above ground injection and monitoring for sodium hypochlorite and ammonia.

6.6 Product Water Pumping and Conveyance Piping

Treated water pumps would be installed on top of the clearwell. The size and number of these pumps is dependent on the site specific conditions, including conveyance to the appropriate LADWP pressure zone: 205, 426, 579, and 865 across the various alternatives. In order to meet variations in well production and treated water production using fixed-speed pumps, the pump capacity has been sized for 110 percent of the design flow. The design and operating criteria for these pumps are presented for each of the alternatives in the following section (Section 7).

Section 7: Alternatives

As a result of the hydrogeologic and water quality characterization along with the review of basin governance and existing groundwater pumping, target project sizes were established as 3,000 AF/yr for the Hollywood Basin and 2,000 AF/yr for the Crestal and Coastal Subbasins. However, constraints on well spacing and interference resulted in the 3,000 AF/yr target for the Hollywood Basin being reduced to 2,500 AF/yr for the 6-month pumping alternative. In addition, the Crestal and Coastal Subbasin alternatives should be considered as mutually exclusive, with the target for total production from the Santa Monica Basin limited to 2,000 AF/yr.

Seven (7) alternative sites were identified in the study area as shown on Figure 7-1 and summarized in Table 7-1. The summary table shows the basin/subbasin location, site name, operational scenario (6 or 10 months), alternative identification number (1 through 7), number of wells, and the amount of finished water in AF/yr.

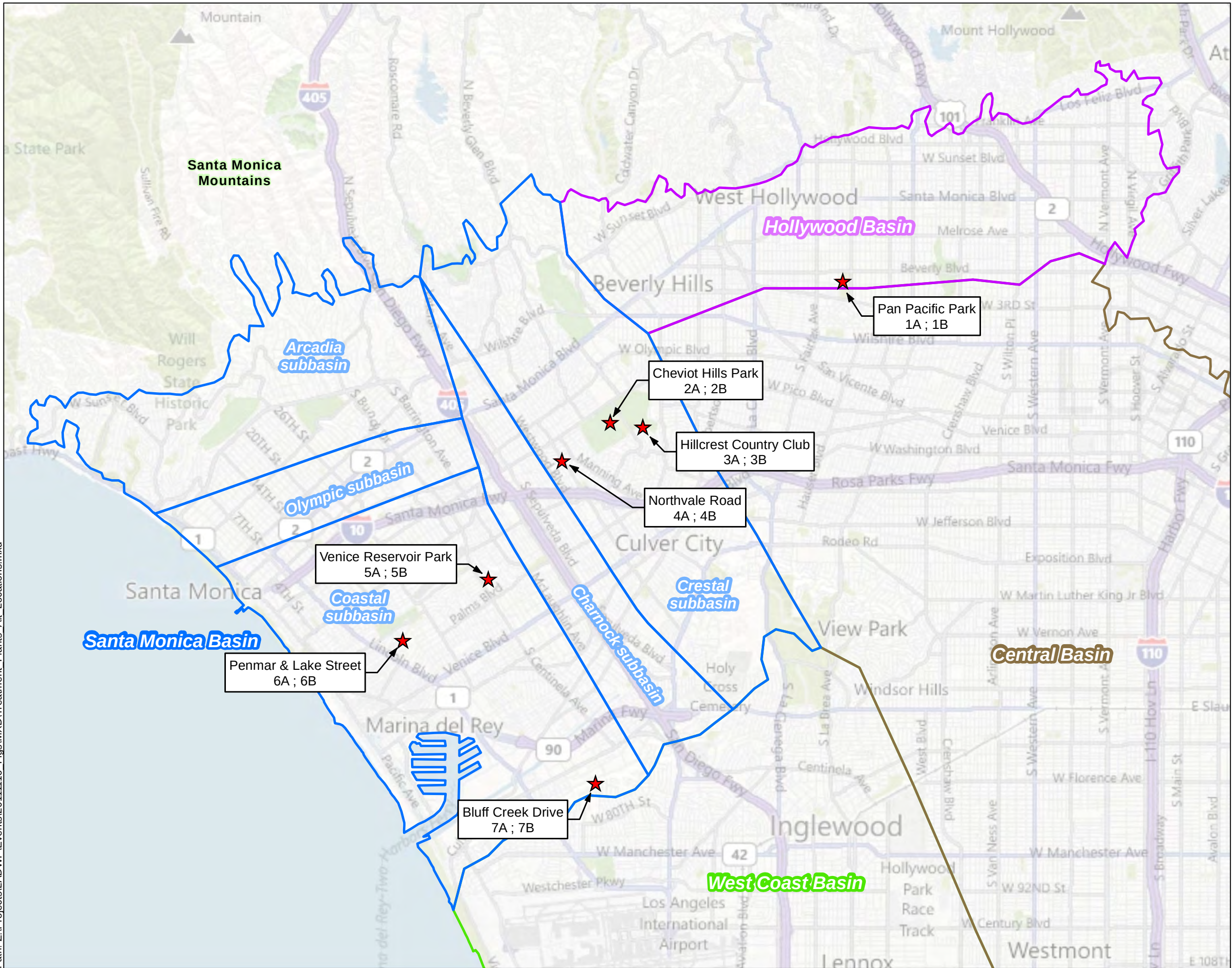
Each site has an "A" and a "B" option, whereby "A" denotes a 10-month operational scenario and "B" denotes a 6-month operational scenario. The purpose of a 10-month versus a 6-month operational scenario is to address the seasonality of demand and the added benefit of emergency supply. In effect, an annual water production for each well has been assumed such that groundwater production would be achieved in either 6 or 10 months.

Site selection was supplemented by a review of available open space. Specifically, vacant properties greater than or equal to 0.5 acres in size as well as appropriate multi-use properties (parks, golf courses, and other open space) that are of sufficient size for the construction of groundwater production wells and treatment facilities were considered. Furthermore, property owned by the City of Los Angeles was identified. For each site, the location, size, property features, slope, proximity to LADWP distribution pipelines, and proximity to available utilities (e.g., power, storm drain, and sewer) were evaluated.

Wells were spaced appropriately using hydrogeologic data so as to minimize well interference. Treatment scenarios previously described were applied on a basin/subbasin-specific basis. A pipeline collection system was then sized and conceptually developed for each group of wells to feed a regional treatment facility. Finally, pump stations and pipeline facilities to deliver the treated groundwater to the nearest appropriate LADWP distribution pipeline were identified for each alternative.

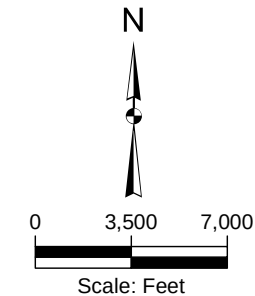
Estimates of probable cost for each alternative were developed. These include planning-level capital and operation & maintenance (O&M) costs for wells, treatment facilities, pump stations, ancillary features, as well as an estimate of pipeline requirements. These conceptual estimates were prepared to have level of accuracy of -30 percent to +50 percent. Specifically, the following costs were developed for each alternative:

- Capital Cost. Capital costs generally include capital costs for new wells, pipelines, site improvements, the treatment facility, pump stations, contingency, engineering & administration fees, sewer connection, and property acquisition. Assumptions associated with property acquisition costs are listed below



Legend

- ★ Proposed Treatment Plant Location
- Hollywood Basin
- Santa Monica Basin
- West Coast Basin
- Central Basin



Kennedy/Jenks Consultants

Los Angeles Department of Water and Power
Los Angeles, CA
Task Order No. 3 (Agreement No. 47818)

Water Treatment Plant Alternative Locations

K/J 1179008*00
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Figure 7-1

Table 7-1: Summary of Alternatives

Basin/Subbasin	Site Name	10-Month Operation			6-Month Operation		
		Alternative No. ¹	No. of Wells	Finished Water (AF/yr)	Alternative No. ¹	No. of Wells	Finished Water (AF/yr)
Hollywood Basin	Pan Pacific Park	1A	6	3,000	1B	9	2,500
Santa Monica Basin/Crestal Subbasin	Cheviot Hills Park	2A	5	2,000	2B	8	2,000
	Hillcrest Country Club	3A	5	2,000	3B	8	2,000
	Northvale Road	4A	5	2,000	4B	8	2,000
	Venice Reservoir Park	5A	4	2,000	5B	6	2,000
Santa Monica Basin/Coastal Subbasin	Penmar & Lake Street	6A	5	2,000	6B	7	2,000
	Bluff Creek Drive	7A	5	2,000	7B	8	2,000

Notes:

1 - "A" denotes a 10-month operational scenario and "B" denotes a 6-month operational scenario.

- Treatment Plant Site - purchase site at \$20/square foot, whereby estimates range from:
 - o \$550,000 (0.63 acres) to \$1,040,000 (1.13 acres)
 - o Alternative 6 assumes purchasing a full 1.75 acre lot at \$1.5 million
- Well Sites - purchase 50 x 50 foot areas at \$20/square foot, whereby estimates range from:
 - o \$200,000 (4 wells) up to \$450,000 (9 wells)
- Pipeline Easements - \$5/square foot, whereby estimates range from:
 - o \$70,000 to \$550,000
- Operation & Maintenance Costs. O&M costs generally include the cost of well, process, chemical and distribution pumping, treatment chemicals replenishment, treatment facility media replacement, equipment maintenance and replacement, operator labor, and sewer disposal fees. Assumptions include:
 - The well pumps, treatment plant facilities, and distribution pumps would operate continuously, 24 hours per day 7 days per week, during the operation period.

- The distribution pumps were sized for anticipated treatment plant outflow plus 10 percent to account for fluctuations in well field capacity due to changing groundwater levels. For energy costs to operate the distribution pumps, it was assumed that the distribution pumps would be in a 1 + 1 (1 duty, 1 standby) configuration, except as noted below. The pump operation would be staggered to give each pump a rest period. Due to their location in the LADWP pressure zones, the distribution pumps for Alternatives 1 and 4 would need to lift the treated water a significant amount to tie-in to the existing LADWP facilities. As a result, these pumps would have high head requirements and would be configured with 2 + 1 pumps to limit the pump size to 350 hp.
- Greensand and anthracite would be changed out every 10 years
- RO membranes would be changed out every 4 years for the 10-month scenarios and every 6 years for the 6-month scenarios.
- GAC would be replaced annually
- Equipment maintenance and replacement costs would be 0.5 percent of total capital cost including the 20% contingency
- Minimum chemical storage volumes would be sized for replenishment every 30 days
- Operator Labor would be 60 percent of full-time employee wage for 10 or 6 months. Full-time employee wage is assumed to be \$100,000 per year.
- Unit Cost for the Water Supply. The unit cost for each alternative's water supply provided is presented in dollars per acre-foot of water and accounts for both capital costs and annual O&M costs. Capital costs have been amortized over a 30-year period at 5% interest.

Provided herein is a detailed description of each alternative including a presentation of estimated probable costs.

7.1 Hollywood Basin Pan Pacific Park

The Hollywood Basin Pan Pacific Park site is located primarily in the Hollywood Basin, with the upper two-thirds of the site located in the Hollywood Basin and the lower one-third located in "No Man's Land" (see Figure 7-1) just south and outside of the Hollywood Basin boundary. The park is a multi-use park operated by the City of Los Angeles Department of Recreation and Parks. Park features include an auditorium, barbeque pits, a baseball diamond, basketball courts, children's play area, gym, picnic tables, and restrooms. The park is bounded by Beverly Boulevard to the north; West 3rd Street to the south; Gardner Street to the east; and The Grove Drive to the west. Even though the site is owned by the City of Los Angeles Department of Recreation and Parks, it is anticipated that LADWP would need to perform property acquisition at market value.

The wells were located using a minimum spacing of 450 feet to reduce pumping interference and excessive drawdown. The specific placement of each well within the park was selected to reduce impact to the park features and to allow ease of access for construction and maintenance. The well collection pipelines were also aligned to minimize impact to the park features by keeping to the park perimeter or to existing access roads within the park interior. The pipelines were laid out to reduce the length required while considering park facilities and capital cost. The treatment facility has been sited at the south end of the park in what appears to be a low use area with accessibility from West 3rd Street or South Gardner Street. The treatment plant consists of pressure filters for iron and manganese removal, GAC vessels, and a 2,600 square-foot chemical building. The treatment train for this alternative is shown in Figure 6-1. Ancillary facility features include a clearwell tank, pump station, and off-site pipelines. Additional elements of this alternative include site improvements, a sewer connection, and property acquisition. LADWP has an existing 57-inch diameter pipeline aligned along the north side of West 3rd Street which serves the 579 pressure zone. Distribution pumps located on top of the clearwell would lift treated water from the clearwell to the 579 pressure zone. A cement-mortar lined and coated steel pipeline (CML&C) would be used to convey treated water from the treatment plant to LADWP's existing distribution pipeline.

Alternative 1A: 10-Month Operational Scenario. The layout for the 10-month operational scenario is shown on Figure 7-2. This alternative (1A) consists of 6 wells at 380 gpm connected by 6 - 12-inch PVC piping. Water would be collected and sent to a centralized on-site treatment plant. Specifically, the treatment plant would be equipped with four GAC vessels, and the amount of finished water would be 3,000 AF/yr. This amount assumes a 1.5% loss and requires 2,280 gpm inflow (2,246 gpm outflow). Three 200 HP distribution pumps in a 2 + 1 spare configuration would discharge to a 12-inch CML&C pipeline conveys treated water from the treatment plant to LADWP's existing 57-inch diameter pipeline in West 3rd Street.

Alternative 1B: 6-Month Operational Scenario. The layout for the 6-month operational scenario is shown on Figure 7-3. This alternative (1B) consists of 9 wells at 360 gpm connected by 6 – 16-inch PVC piping. Water would be collected and sent to a centralized on-site treatment plant. Specifically, the treatment plant would be equipped with six GAC vessels, and the amount of finished water would be 2,500 AF/yr. This amount assumes a 1.5% loss and requires 3,150 gpm inflow (3,103 gpm outflow). Three 250 HP distribution pumps in a 2 + 1 spare configuration would discharge to a 16-inch CML&C pipeline conveys treated water from the treatment plant to LADWP's existing 57-inch diameter pipeline in West 3rd Street.

Capital costs are summarized in Table 7-2, and supporting documentation is provided in Appendix E. The 10-month scenario has an estimated capital cost of \$10.7 million, whereas the 6-month scenario has an estimated capital cost of \$14.2 million. Amortized over 30 years at 5% interest, the capital costs for the water supply associated with the 10-month and 6-month scenarios are \$232/AF and \$370/AF, respectively.

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- Legend**
- Proposed Well Location
 - LADWP Pipeline $\geq 12"$

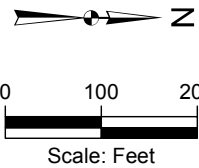


Image Source: (c)2009 Microsoft Corporation

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**Hollywood Pan Pacific Park
Alternative 1A Site Layout (10-Month)**

K/J 1179008*00
December 2011

Figure 7-2

Path: Z:\Projects\LADWP\Events\20111102_Sites\MXD\Fig7-3.mxd



Legend

- ◆ Proposed Well Location
- LADWP Pipeline ≥ 12"

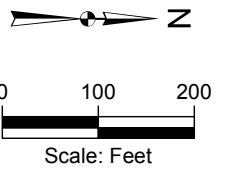


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Task Order No. 3 (Agreement No. 47818)

Hollywood Pan Pacific Park Alternative 1B Site Layout (6-Month)

K/J 1179008*00
December 2011

Figure 7-3

Table 7-2: Summary of Pan Pacific Park (Alternative 1) Capital Costs

Description	1A- 10 month 3,000 AF/YR	1B – 6 month 2,500 AF/YR
Wells (6 at 380 gpm)/(9 at 360 gpm)	\$2,907,000	\$4,360,000
Off-Site Pipelines	\$283,000	\$356,000
Site Improvements	\$175,000	\$175,000
Pressure Filters (Fe & Mn Removal)	\$949,000	\$1,213,000
GAC (4 vessels)/(6 vessels)	\$1,175,000	\$1,691,000
Chemical Building (2,600 sq ft)	\$823,000	\$823,000
Clearwell & Pump Station	<u>\$382,000</u>	<u>\$403,000</u>
Subtotal	\$6,694,000	\$9,021,000
Contingency (20%)	\$1,339,000	\$1,804,000
Engineering & Administration (20%)	\$1,339,000	\$1,804,000
Sewer Connection Fee	\$140,000	\$200,000
Property Acquisition	<u>\$1,200,000</u>	<u>\$1,400,000</u>
Total	\$10,710,000	\$14,230,000
Unit Cost	\$232/AF	\$370/AF

O&M costs are summarized in Table 7-3, and supporting documentation is provided in Appendix E. The 10-month scenario has an estimated annual O&M cost of \$604,000 or \$201/AF, whereas the 6-month scenario has an estimated annual O&M cost of \$611,000 or \$244/AF.

Costs for the water supply associated with this alternative are summarized in Table 7-4. Total costs for the 10-month scenario are \$433/AF, and costs for the 6-month scenario are \$614/AF.

7.2 Santa Monica Basin/Crestal Subbasin

Three alternative sites were identified in the Santa Monica Basin/Crestal Subbasin:

- Cheviot Hills Park
- Hillcrest Country Club
- Northvale Road

These alternatives are discussed herein.

Table 7-3: Summary of Pan Pacific Park (Alternative 1) O&M Costs

Description	1A – 10 month 3,000 AF	1B – 6 month 2,500 AF
Well Pumps	\$75,000	\$74,000
Treatment Chemicals	\$63,000	\$52,000
Pressure Filter Media Replacement (every 10 years)	\$4,000	\$4,000
GAC Media Replacement (Change-out: once/year)	\$144,000	\$216,000
Process Pumping (Chemical, Backwash)	\$2,000	\$1,000
Distribution Pumping	\$215,000	\$178,000
Maintenance (0.5% of capital/year)	\$27,000	\$30,000
Operator Labor (\$100,000/FTE)	\$25,000	\$15,000
Sewer Disposal Fee	<u>\$49,000</u>	<u>\$41,000</u>
Total	\$604,000	\$611,000
Unit Cost	\$201/AF	\$244/AF

Table 7-4: Summary of Water Supply Costs for Pan Pacific Park (Alternative 1)

Alternative No.	Site Name	Finished Water (AF/yr)	10-Month Operation		
			Capital	O&M	Total
1A	Pan Pacific Park	3,000	\$232/AF	\$201/AF	\$433/AF
Alternative No.	Site Name	Finished Water (AF/yr)	6-Month Operation		
			Capital	O&M	Total
1B	Pan Pacific Park	2,500	\$370/AF	\$244/AF	\$614/AF

7.2.1 Cheviot Hills Park

The Cheviot Hills Park site is located within a portion of both Cheviot Hills Park and Rancho Park Golf Course in the northern section of the Crestal Subbasin (see Figure 7-1). Both facilities are operated by the City of Los Angeles Department of Recreation and Parks. The park itself is a multi-use park, and facilities include an auditorium, barbeque pits, a baseball diamond, basketball courts, children's play area, community room, indoor gym, picnic tables, volleyball courts, and restrooms. Rancho Park Golf Course is an 18-hole, par 71 championship course.

The site is bounded by Motor Avenue to the north/northwest, with the rest of the site falling within the park and golf course area. Even though the site is owned by the City of Los Angeles

Department of Recreation and Parks, it is anticipated that LADWP would need to perform property acquisition at market value.

The wells were located using a minimum spacing of 500 feet to reduce pumping interference and excessive drawdown. The specific placement of each well within the park and golf course was selected to reduce impact to the park and golf course features and to allow ease of access for construction and maintenance with five of the wells located outside of active park use areas. The well collection pipelines were also aligned to minimize impact to the park and golf course features by keeping to the park perimeter and outside of the greens and fairways within the park and golf course interiors. The pipelines were laid out to reduce the length required while considering park/golf course facilities and capital cost. The treatment facility has been sited at the south/southwest portion of the site perimeter immediately south of the golf course parking lot and north of a golf fairway in what appears to be a low use area with accessibility from the golf course drive approach. The treatment plant site is partially secluded on three sides by mature trees. Treatment would consist of pressure filters for iron and manganese removal, GAC vessels, an RO system, and a 2,600 square-foot chemical building. The treatment train for this alternative is shown in Figure 6-2. Ancillary facility features include a clearwell tank, pump station, and off-site pipelines. Additional elements of this alternative include site improvements, a sewer connection, and property acquisition. LADWP has an existing 30-inch pipeline on West Pico Boulevard which serves the 426 pressure zone. Distribution pumps located on top of the clearwell would lift treated water to the 426 pressure zone. A CML&C pipeline would be used to convey treated water from the treatment plant to LADWP's existing distribution pipeline via Motor Avenue.

Alternative 2A: 10-Month Operational Scenario. The layout for the 10-month operational scenario is shown on Figure 7-4. This alternative (2A) consists of 5 wells at 350 gpm connected by 6 - 12-inch PVC piping. Water would be collected and sent to a centralized on-site treatment plant. Specifically, the treatment plant would be equipped with four GAC vessels and a 1.3 mgd RO system. The amount of finished water would be 2,000 AF/yr. This amount assumes a 14.3% loss and requires 1,738 gpm inflow (1,489 gpm outflow). Two 125 HP distribution pumps in a 1 + 1 spare configuration would discharge to a 12-inch CML&C pipeline to convey treated water from the treatment plant to LADWP's existing 30-inch diameter pipeline in West Pico Boulevard via Motor Avenue.

Alternative 2B: 6-Month Operational Scenario. The layout for the 6-month operational scenario is shown on Figure 7-5. This alternative (2B) consists of 8 wells at 360 gpm connected by 6 - 12-inch PVC piping. Water would be collected and sent to a centralized on-site treatment plant. Specifically, the treatment plant would be equipped with six GAC vessels and a 2.1 mgd RO system. The amount of finished water would be 2,000 AF/yr. This amount assumes a 14.3% loss and requires 2,901 gpm inflow (2,486 gpm outflow). Two 200 HP distribution pumps in a 1 + 1 spare configuration would discharge to a 16-inch CML&C pipeline conveys treated water from the treatment plant to LADWP's existing 30-inch diameter pipeline in West Pico Boulevard via Motor Avenue.

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Legend

- Proposed Well Location
- LADWP Pipeline ≥ 12 "

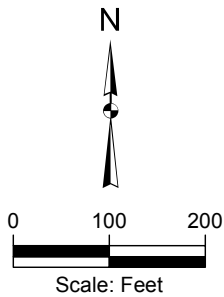


Image Source: (c)2009 Microsoft Corporation

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Crestal Subbasin Cheviot Hills Park Alternative 2A Site Layout (10-Month)

K/J 1179008*00
December 2011

Figure 7-4

Path: Z:\Projects\LADWP\Events\20111102_Sites\MXD\Fig7-5.mxd



Legend

- Proposed Well Location
- LADWP Pipeline $\geq 12"$

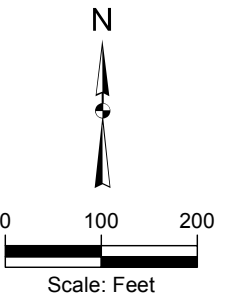


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Los Angeles, CA
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Crestal Subbasin Cheviot Hills Park Alternative 2B Site Layout (6-Month)

K/J 1179008*00
December 2011

Figure 7-5

Capital costs are summarized in Table 7-5, and supporting documentation is provided in Appendix E. The 10-month scenario has an estimated capital cost of \$14.8 million, whereas the 6-month scenario has an estimated capital cost of \$20.2 million. Amortized over 30 years at 5% interest, the capital costs for the water supply associated with the 10-month and 6-month scenarios are \$483/AF and \$658/AF, respectively.

Table 7-5: Summary of Cheviot Hills Park (Alternative 2) Capital Costs

Description	2A – 10 month 2,000 AF/YR	2B – 6 month 2,000 AF/YR
Wells (5 at 350 gpm)/(8 at 360 gpm)	\$2,604,000	\$4,166,000
Off-Site Pipelines	\$451,000	\$723,000
Site Improvements	\$232,000	\$232,000
Pressure Filters (Fe & Mn Removal)	\$949,000	\$1,213,000
GAC (4 vessels)/(6 vessels)	\$1,175,000	\$1,691,000
RO System (1.3 mgd)/(2.1 mgd)	\$2,190,000	\$2,624,000
Chemical Building (2,600 sq ft)	\$823,000	\$823,000
Clearwell & Pump Station	<u>\$289,000</u>	<u>\$317,000</u>
Subtotal	\$8,713,000	\$11,789,000
Contingency (20%)	\$1,743,000	\$2,358,000
Engineering & Admin (20%)	\$1,743,000	\$2,358,000
Sewer Connection	\$1,040,000	\$1,740,000
Property Acquisition	<u>\$1,600,000</u>	<u>\$2,000,000</u>
Total	\$14,840,000	\$20,240,000
Unit Cost	\$483/AF	\$658/AF

O&M costs are summarized in Table 7-6, and supporting documentation is provided in Appendix E. The 10-month scenario has an estimated annual O&M cost of \$1.18 million or \$589/AF, whereas the 6-month scenario has an estimated annual O&M cost of \$1.26 million or \$630/AF.

Costs for the water supply associated with this alternative are compared against other alternatives in the Crestal Subbasin in Section 7.2.4. Total costs for the 10-month scenario are \$1,072/AF, and costs for the 6-month scenario are \$1,288/AF.

Table 7-6: Summary of Cheviot Hills Park (Alternative 2) O&M Costs

Description	2A – 10 month 2,000 AF	2B – 6 month 2,000 AF
Well Pumps	\$133,000	\$144,000
Treatment Chemicals	\$254,000	\$252,000
Pressure Filter Media Replacement (every 10 years)	\$4,000	\$4,000
GAC Media Replacement (Change-out: once/year)	\$144,000	\$216,000
RO Membrane Replacement	\$19,000	\$28,000
Process Pumping	\$94,000	\$94,000
Distribution Pumping	\$71,000	\$70,000
Maintenance (0.5% of capital/year)	\$53,000	\$71,000
Operator Labor (\$100,000/FTE)	\$50,000	\$30,000
Sewer Disposal Fee	<u>\$355,000</u>	<u>\$351,000</u>
Total	\$1,177,000	\$1,260,000
Unit Cost	\$589/AF	\$630/AF

7.2.2 Hillcrest Country Club

The Hillcrest Country Club site is located within and around the southeasterly portion of the Hillcrest Country Club (see Figure 7-1). Hillcrest Country Club is a private club that offers an 18-hole par 72 golf course. The facility was constructed in the late 1920's and includes an on-site well and several miles of pipeline to irrigate the course (http://www.hillcrestcountryclub.com/golf_history.asp, November 22, 2011).

From west to east, the site is bounded by Motor Place to the far west; Monte Mar Drive/Monte Mar Terrace along the South; and Beverly Drive to the East. It is assumed that LADWP would need to perform property acquisition at market value for this site.

The wells were located using a minimum spacing of 500 feet to reduce pumping interference and excessive drawdown. The specific placement of each well within the golf course was selected to reduce impact to the golf course features and to allow ease of access for construction and maintenance. Wells were also placed along the right of way for the drainage channel located to the east of the golf course and on the northwest corner of a school playing field located south of Beverlywood Street. The well collection pipelines were also aligned to minimize impact to the golf course features by keeping outside of the greens and fairways or to existing golf cart paths within the golf course interior. The pipelines were laid out to reduce the length required while considering golf course facilities and capital cost. The treatment facility has been sited within the central portion of the site perimeter north of Monte Mar Drive/Monte Mar Terrace at a triangular-shaped location that appears to be used for cultivation of greens for the golf course. The treatment plant site is in a secluded area of the golf course. Treatment would consist of pressure filters for Iron and manganese removal, GAC vessels, an RO system,

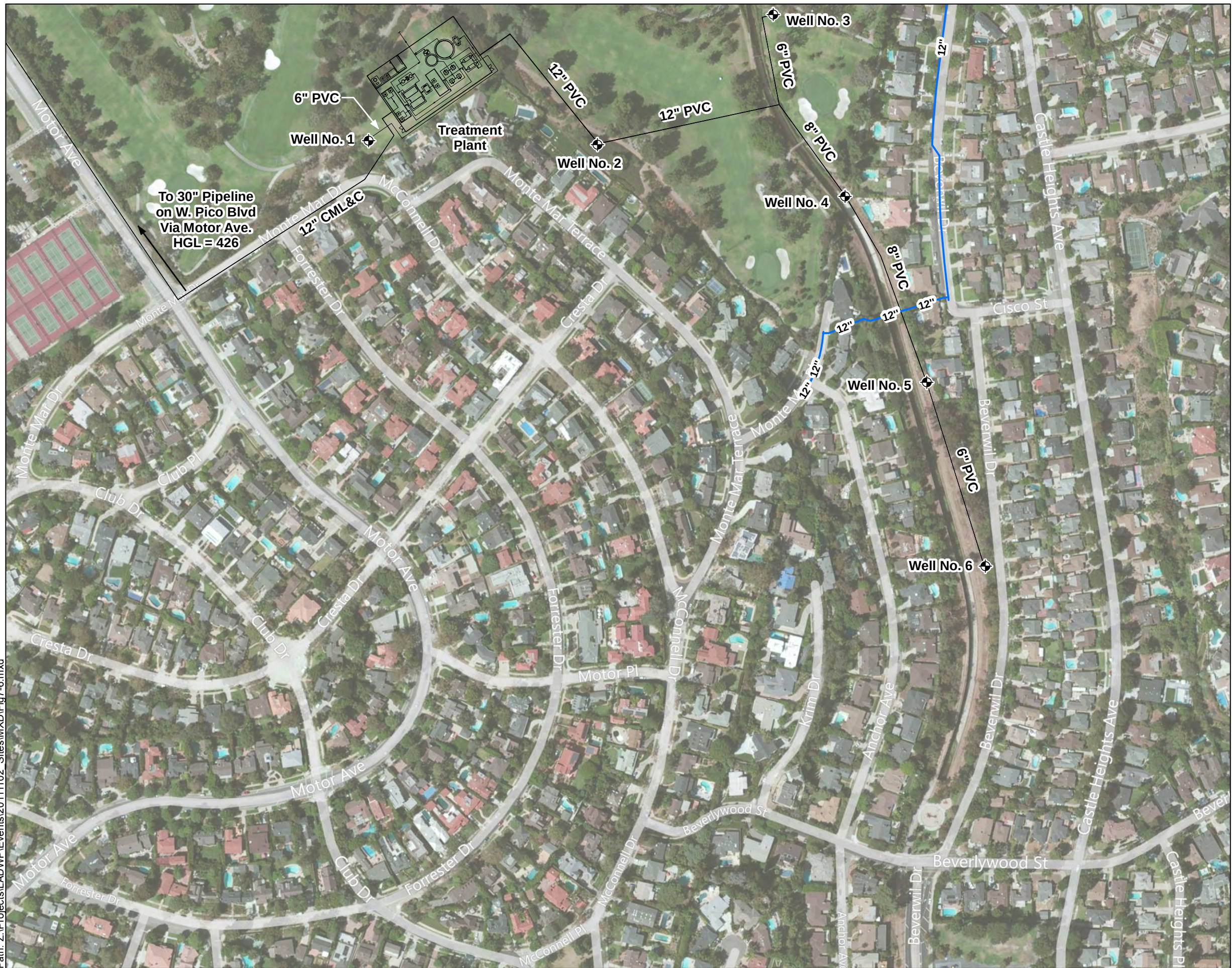
and a 2,600 square-foot chemical building. The treatment train for this alternative is shown in Figure 6-2. Ancillary facility features include a clearwell tank, pump station, and off-site pipelines. Additional elements of this alternative include site improvements, a sewer connection, and property acquisition. LADWP has an existing 30-inch diameter pipeline on West Pico Boulevard which serves the 426 pressure zone. Distribution pumps located on top of the clearwell would lift treated water to the 426 pressure zone. A CML&C pipeline would be used to convey treated water from the treatment plant to LADWP's existing distribution pipeline via Motor Avenue.

Alternative 3A: 10-Month Operational Scenario. The layout for the 10-month operational scenario is shown on Figure 7-6. This alternative (3A) consists of 5 wells at 350 gpm connected by 6-12-inch PVC piping. Water would be collected and sent to a centralized on-site treatment plant. Specifically, the treatment plant would be equipped with four GAC vessels and a 1.3 mgd RO system. The amount of finished water would be 2,000 AF/yr. This amount assumes a 14.3% loss and requires 1,738 gpm inflow (1,489 gpm outflow). Two 125 HP distribution pumps in a 1 + 1 spare configuration would discharge to a 12-inch CML&C pipeline conveys treated water from the treatment plant to LADWP's existing 30-inch diameter pipeline in West Pico Boulevard via Motor Avenue.

Alternative 3B: 6-Month Operational Scenario. The layout for the 6-month operational scenario is shown on Figure 7-7. This alternative (3B) consists of 8 wells at 360 gpm connected by 6-12-inch PVC piping. Water would be collected and sent to a centralized on-site treatment plant. Specifically, the treatment plant would be equipped with six GAC vessels and a 2.1 mgd RO system. The amount of finished water would be 2,000 AF/yr. This amount assumes a 14.3% loss and requires 2,901 gpm inflow (2,486 gpm outflow). Two 200 HP distribution pumps in a 1 + 1 spare configuration would discharge to a 16-inch CML&C pipeline conveys treated water from the treatment plant to LADWP's existing 30-inch diameter pipeline in West Pico Boulevard via Motor Avenue.

Capital costs are summarized in Table 7-7, and supporting documentation is provided in Appendix E. The 10-month scenario has an estimated capital cost of \$15.0 million, whereas the 6-month scenario has an estimated capital cost of \$20.4 million. Amortized over 30 years at 5% interest, the capital costs for the water supply associated with the 10-month and 6-month scenarios are \$488/AF and \$663/AF, respectively.

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Legend

- Proposed Well Location
- LADWP Pipeline $\geq 12"$

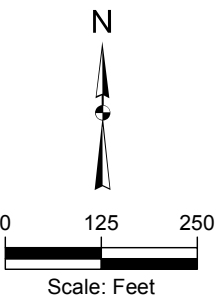


Image Source: (c)2009 Microsoft Corporation

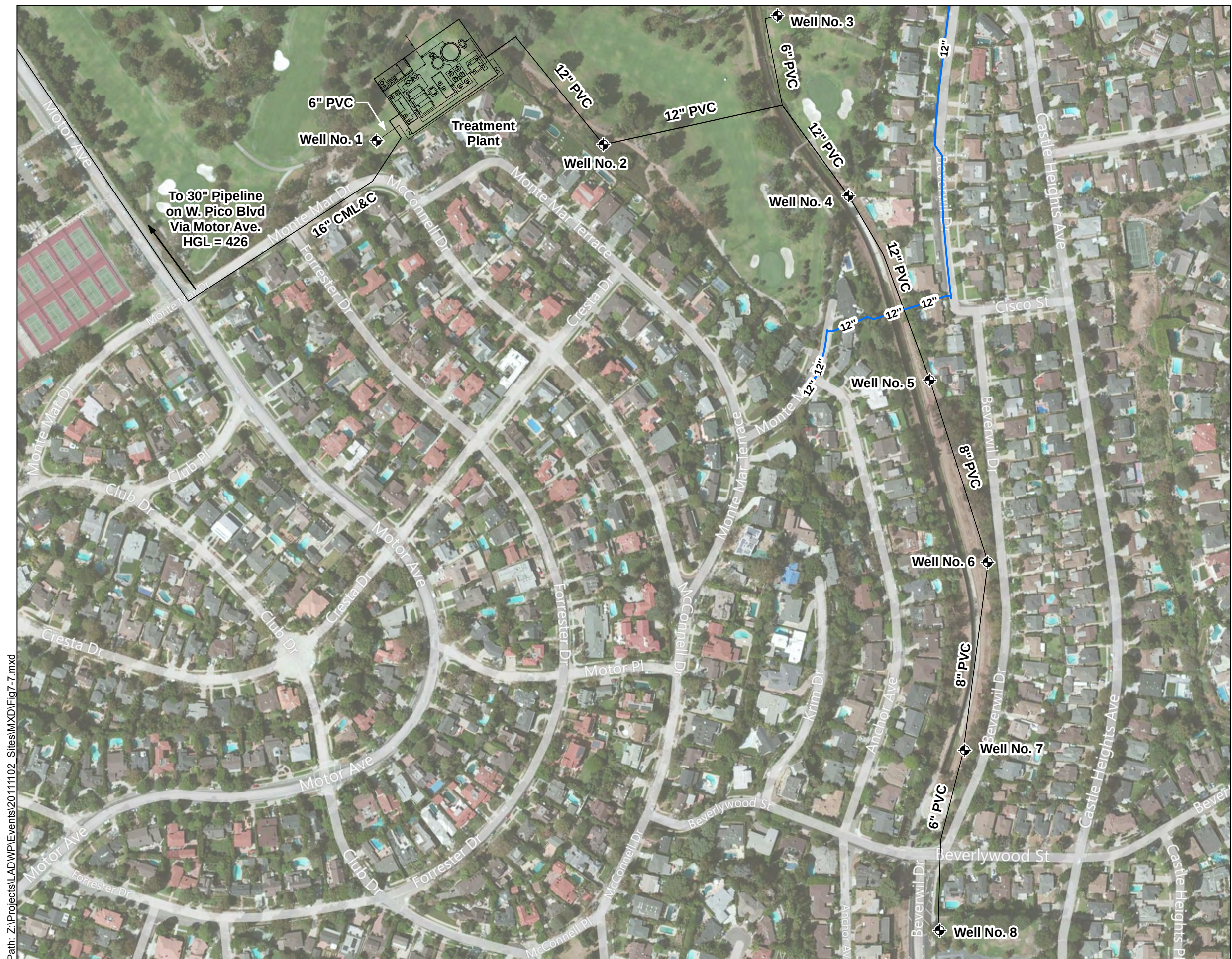
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Crestal Subbasin Hillcrest Country Club Alternative 3A Site Layout (10-Month)

K/J 1179008*00
December 2011

Figure 7-6



Legend

-  Proposed Well Location
 LADWP Pipeline $\geq 12"$

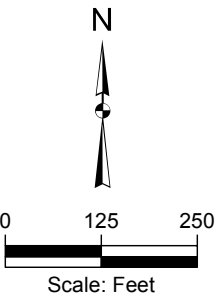


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Crestal Subbasin Hillcrest Country Club Alternative 3B Site Layout (6-Month)

K/J 1179008*00
December 2011

Figure 7-7

Table 7-7: Summary of Hillcrest Country Club (Alternative 3) Capital Costs

Description	3A – 10 month 2,000 AF/YR	3B – 6 month 2,000 AF/YR
Wells (5 at 350 gpm)/(8 at 360 gpm)	\$2,604,000	\$4,166,000
Off-Site Pipelines	\$649,000	\$967,000
Site Improvements	\$237,000	\$237,000
Pressure Filters (Fe & Mn Removal)	\$949,000	\$1,213,000
GAC (4 vessels)/(6 vessels)	\$1,167,000	\$1,691,000
RO System (1.3 mgd)/(2.1 mgd)	\$2,190,000	\$2,624,000
Chemical Building (2,600 sq ft)	\$823,000	\$823,000
Clearwell & Pump Station	<u>\$289,000</u>	<u>\$317,000</u>
Subtotal	\$8,908,000	\$12,038,000
Contingency (20%)	\$1,782,000	\$2,408,000
Engineering & Admin (20%)	\$1,782,000	\$2,408,000
Sewer Connection	\$1,040,000	\$1,740,000
Property Acquisition	<u>\$1,500,000</u>	<u>\$1,800,000</u>
Total	\$15,010,000	\$20,390,000
Unit Cost	\$488/AF	\$663/AF

O&M costs are summarized in Table 7-8, and supporting documentation is provided in Appendix E. The 10-month scenario has an estimated annual O&M cost of \$1.14 million or \$572/AF, whereas the 6-month scenario has an estimated annual O&M cost of \$1.23 million or \$613/AF.

Costs for the water supply associated with this alternative are compared against other alternatives in the Crestal Subbasin in Section 7.2.4. Total costs for the 10-month scenario are \$1,060/AF, and costs for the 6-month scenario are \$1,276/AF.

7.2.3 Northvale Road

The Northvale Road site is located along the alignment of Northvale Road between Dunleer Drive to the south east and Overland Avenue to the west, with some additional wells and the treatment plant sited to the west of Overland Avenue, north of Richland Avenue, and south of Ashby Avenue (see Figure 7-1). The site is entirely on an old abandoned railroad right of way with the exception of a well collection pipeline crossing a public street. It is assumed that LADWP would need to perform property acquisition at market value for this site.

Table 7-8: Summary of Hillcrest Country Club (Alternative 3) O&M Costs

Description	3A – 10 month 2,000 AF	3B – 6 month 2,000 AF
Well Pumps	\$104,000	\$115,000
Treatment Chemicals	\$254,000	\$252,000
Pressure Filter Media Replacement (every 10 years)	\$4,000	\$4,000
GAC Media Replacement (Change-out: once/year)	\$144,000	\$216,000
RO Membrane Replacement	\$19,000	\$28,000
Process Pumping	\$94,000	\$94,000
Distribution Pumping	\$66,000	\$64,000
Maintenance (0.5% of capital/year)	\$54,000	\$71,000
Operator Labor (\$100,000/FTE)	\$50,000	\$30,000
Sewer Disposal Fee	<u>\$355,000</u>	<u>\$351,000</u>
Total	\$1,144,000	\$1,225,000
Unit Cost	\$572/AF	\$613/AF

The wells were located using a minimum spacing of 500 feet to reduce pumping interference and excessive drawdown. The specific placement of each well within the site was selected to reduce impact to the adjacent residences and to allow ease of access for construction and maintenance. The well collection pipelines were also aligned to minimize impact to the adjacent residences by keeping to the center of the site. The pipelines were laid out to reduce the length required while considering adjacent residences and capital cost. The treatment facility has been sited south of Ashby Avenue and North of Richland Avenue, immediately west of Selby Avenue. Treatment would consist of pressure filters for Iron and manganese removal, GAC vessels, an RO system, and a 2,600 square-foot chemical building. The treatment train for this alternative is shown in Figure 6-2. Ancillary facility features include a clearwell tank, pump station, and off-site pipelines. Additional elements of this alternative include site improvements, a sewer connection, and property acquisition. LADWP has an existing 36-inch pipeline along Overland Avenue that trends northeast onto Putney Road. The 36-inch diameter pipeline serves the 865 pressure zone. Distribution pumps located on top of the clearwell tank would lift treated water from the clearwell to the 865 pressure zone. A CML&C pipeline would be used to convey treated water from the treatment plant to LADWP's existing distribution pipeline.

Alternative 4A: 10-Month Operational Scenario. The layout for the 10-month operational scenario is shown on Figure 7-8. This alternative (4A) consists of 5 wells at 350 gpm connected by 6 - 12-inch PVC piping. Water would be collected and sent to a centralized on-site treatment plant. Specifically, the treatment plant would be equipped with four GAC vessels and a 1.3 mgd RO system. The amount of finished water would be 2,000 AF/yr. This amount assumes a 14.3% loss and requires 1,748 gpm inflow (1,489 gpm outflow). Three 200 HP distribution pumps in a 2 + 1 spare configuration would discharge to a 12-inch CML&C pipeline conveys

treated water from the treatment plant to LADWP's existing 36-inch diameter pipeline in Putney Road.

Alternative 4B: 6-Month Operational Scenario. The layout for the 6-month operational scenario is shown on Figure 7-9. This alternative (4B) consists of 8 wells at 360 gpm connected by 6 - 12-inch PVC piping. Water would be collected and sent to a centralized on-site treatment plant. Specifically, the treatment plant would be equipped with six GAC vessels and a 2.1 mgd RO system. The amount of finished water would be 2,000 AF/yr. This amount assumes a 14.3% loss and requires 2,901 gpm inflow (2,486 gpm outflow). Three 350 HP distribution pumps in a 2 + 1 spare configuration would discharge to a 16-inch CML&C pipeline conveys treated water from the treatment plant to LADWP's existing 36-inch diameter pipeline in Putney Road.

Capital costs are summarized in Table 7-9, and supporting documentation is provided in Appendix E. The 10-month scenario has an estimated capital cost of \$14.5 million, whereas the 6-month scenario has an estimated capital cost of \$19.8 million. Amortized over 30 years at 5% interest, the capital costs for the water supply associated with the 10-month and 6-month scenarios are \$472/AF and \$643/AF, respectively.

O&M costs are summarized in Table 7-10, and supporting documentation is provided in Appendix E. The 10-month scenario has an estimated annual O&M cost of \$1.32 million or \$659/AF, whereas the 6-month scenario has an estimated annual O&M cost of \$1.41 million or \$705/AF.

Costs for the water supply associated with this alternative are compared against other alternatives in the Crestal Subbasin in Section 7.2.4. Total costs for the 10-month scenario are \$1,131/AF, and costs for the 6-month scenario are \$1,348/AF.

7.2.4 Comparison of Crestal Subbasin Alternatives

A comparison of total unit costs for the Crestal Subbasin alternatives are shown below in Table 7-11.

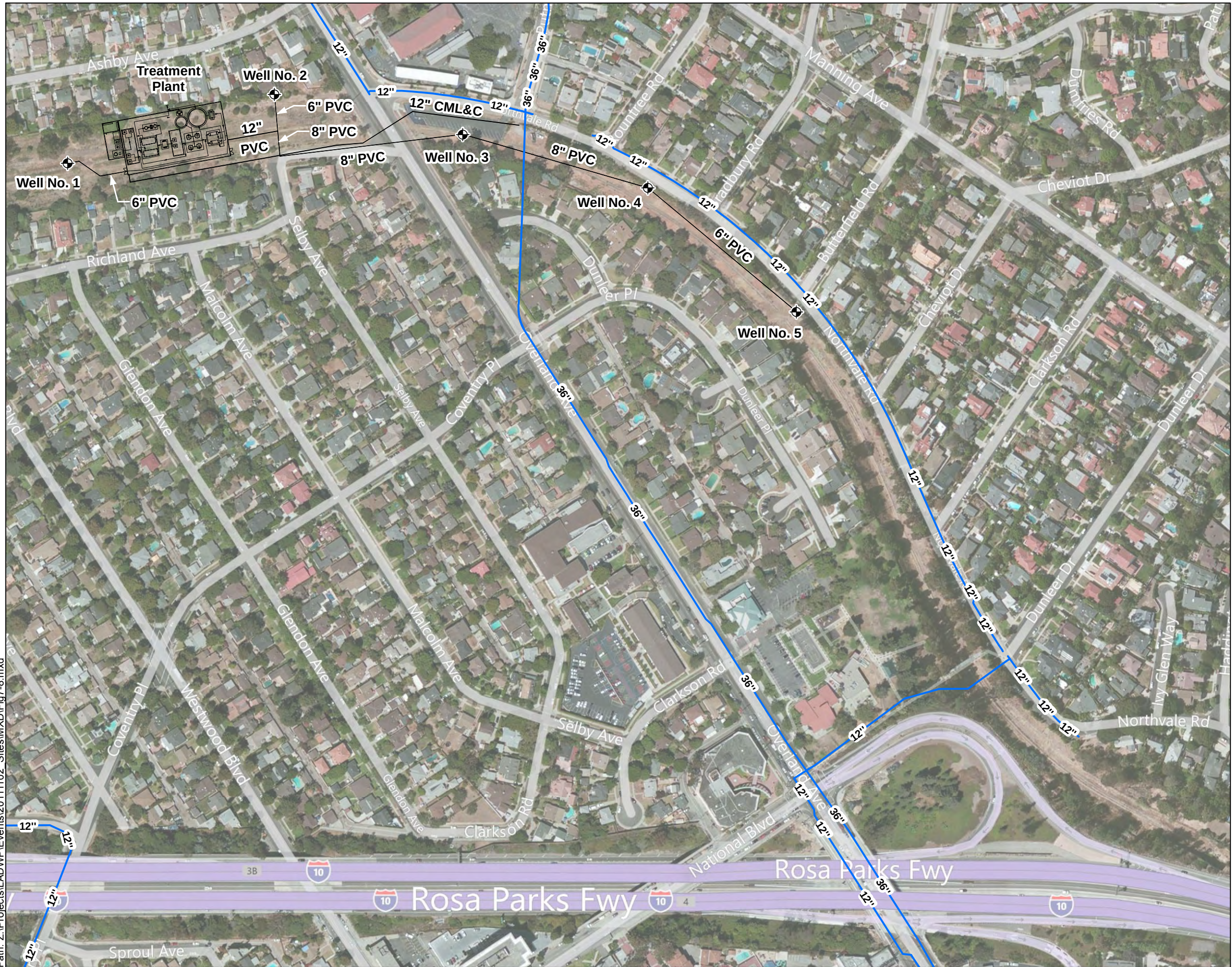
7.3 Santa Monica Basin/Coastal Subbasin

Three alternative sites were identified in the Santa Monica Basin/Coastal Subbasin:

- Venice Reservoir Park;
- Penmar and Lake Street; and
- Bluff Creek Drive.

These alternatives are discussed herein.

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Legend

- Proposed Well Location
- LADWP Pipeline $\geq 12"$

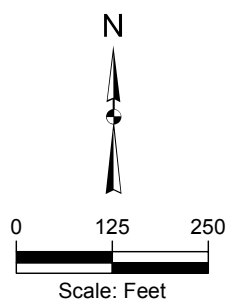


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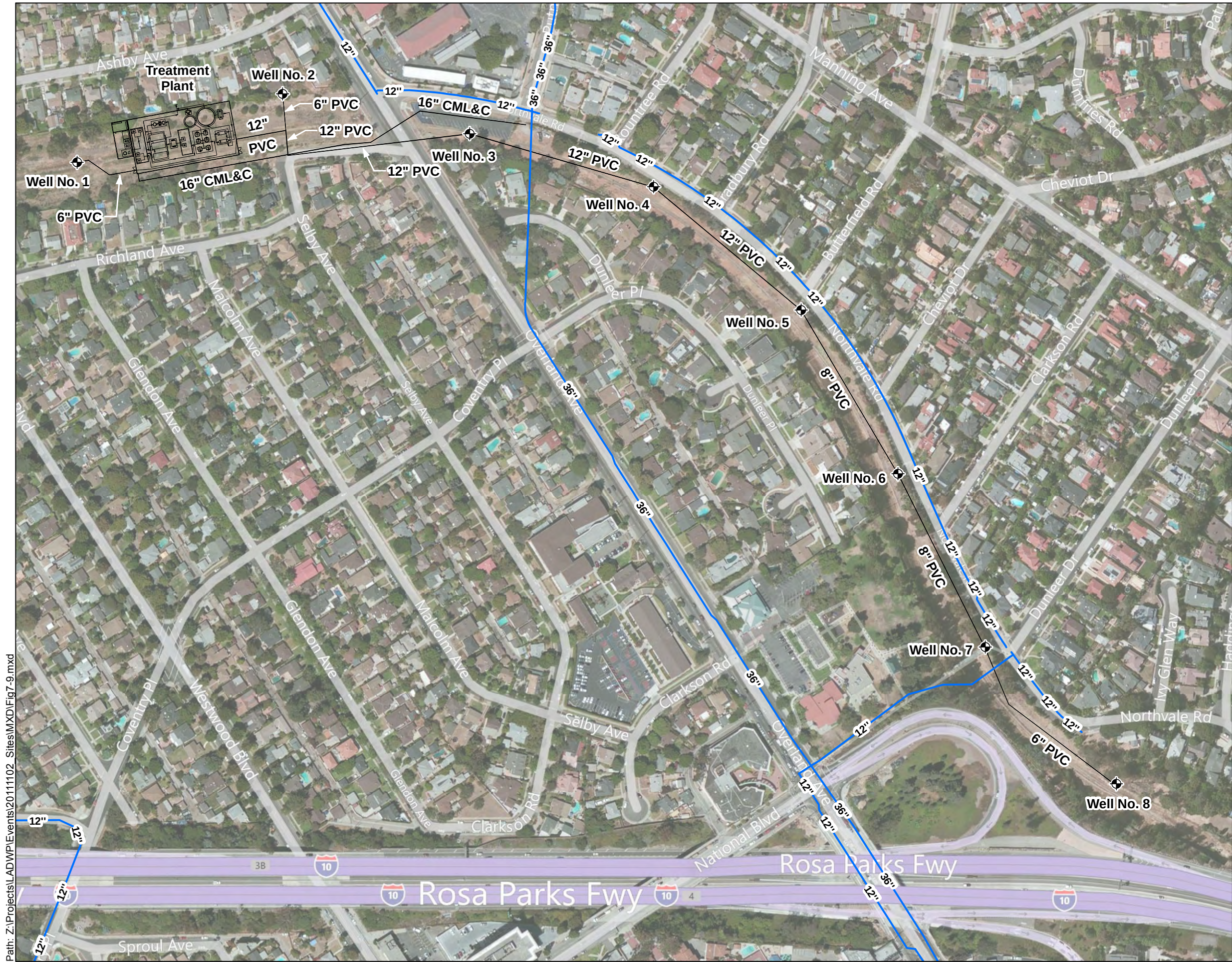
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Crestal Subbasin Northvale Road Alternative 4A Site Layout (10-Month)

K/J 1179008*00
December 2011

Figure 7-8



Path: Z:\Projects\LADWP\Events\20111102_Sites\MXD\Fig7-9.mxd

- Legend**
- Proposed Well Location
 - LADWP Pipeline ≥ 12"

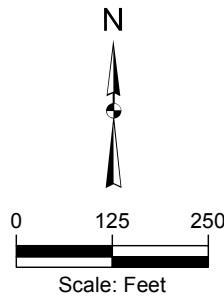


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**Crestal Subbasin Northvale Road
Alternative 4B Site Layout (6-Month)**

K/J 1179008*00
December 2011

Figure 7-9

Table 7-9: Summary of Northvale Road (Alternative 4) Capital Costs

Description	4A – 10 month 2,000 AF/YR	4B – 6 month 2,000 AF/YR
Wells (5 at 350 gpm)/(8 at 360 gpm)	\$2,604,000	\$4,166,000
Off-Site Pipelines	\$266,000	\$474,000
Site Improvements	\$236,000	\$236,000
Pressure Filters (Fe & Mn Removal)	\$949,000	\$1,213,000
GAC (4 vessels)/(6 vessels)	\$1,175,000	\$1,691,000
RO System (1.3 mgd)/(2.1 mgd)	\$2,190,000	\$2,624,000
Chemical Building (2,600 sq ft)	\$823,000	\$823,000
Clearwell & Pump Station	<u>\$382,000</u>	<u>\$446,000</u>
Subtotal	\$8,625,000	\$11,673,000
Contingency (20%)	\$1,725,000	\$2,335,000
Engineering & Admin (20%)	\$1,725,000	\$2,335,000
Sewer Connection	\$1,040,000	\$1,740,000
Property Acquisition	<u>\$1,400,000</u>	<u>\$1,700,000</u>
Total	\$14,520,000	\$19,780,000
Unit Cost	\$472/AF	\$643/AF

Table 7-10: Summary of Northvale Road (Alternative 4) O&M Costs

Description	4A – 10 month 2,000 AF	4B – 6 month 2,000 AF
Well Pumps	\$96,000	\$111,000
Treatment Chemicals	\$254,000	\$254,000
Pressure Filter Media Replacement	\$4,000	\$4,000
GAC Media Replacement	\$144,000	\$216,000
RO Membrane Replacement	\$19,000	\$28,000
Process Pumping	\$94,000	\$94,000
Distribution Pumping	\$249,000	\$250,000
Maintenance (0.5% of capital/year)	\$52,000	\$71,000
Operator Labor (\$100,000/FTE)	\$50,000	\$30,000
Sewer Disposal Fee	<u>\$355,000</u>	<u>\$351,000</u>
Total	\$1,317,000	\$1,409,000
Unit Cost	\$659/AF	\$705/AF

Table 7-11: Summary of Water Supply Costs for Crestal Subbasin Alternatives

Alternative No.	Site Name	Finished Water (AF/yr)	10-Month Operation		
			Capital	O&M	Total
2A	Cheviot Hills Park	2,000	\$483/AF	\$589/AF	\$1,072/AF
3A	Hillcrest Country Club	2,000	\$488/AF	\$572/AF	\$1,060/AF
4A	Northvale Road	2,000	\$472/AF	\$659/AF	\$1,131/AF

Alternative No.	Site Name	Finished Water (AF/yr)	6-Month Operation		
			Capital	O&M	Total
2B	Cheviot Hills Park	2,000	\$658AF	\$630/AF	\$1,288/AF
3B	Hillcrest Country Club	2,000	\$663/AF	\$613/AF	\$1,276/AF
4B	Northvale Road	2,000	\$643/AF	\$705/AF	\$1,348/AF

7.3.1 Venice Reservoir Park

The Venice Reservoir Park site is located within the Venice Reservoir Site in the community of Mar Vista (see Figure 7-1). Venice Reservoir was built atop Mar Vista Hill in the late 1940's by the LADWP. However, the reservoir was later decommissioned, and three baseball diamonds were added subsequently to the Venice Reservoir Site. The site is bordered by South Centinela Avenue to the west; local neighborhoods to the south; Grand View Boulevard to the east and northeast; and Stanwood Drive to the northwest. The east roughly two-thirds of the property is used as little league baseball fields and open space park area, while the west roughly one-third of the property is used as a community garden with numerous small plots available to the public. The potential well depth is estimated to be 500 feet and slightly greater than the other six alternative sites. As a deeper aquifer, this alternative requires fewer wells than the other alternatives. It is assumed that LADWP would not need to perform property acquisition at for this site.

The wells were located using a minimum spacing of 420 feet to reduce pumping interference and excessive drawdown. The specific placement of each well within the park was selected to reduce impact to the park features and to allow ease of access for construction and maintenance. The well collection pipelines were also aligned to minimize impact to the park features by keeping to the park perimeter or to low-use areas within the park interior. The pipelines were laid out to reduce the length required while considering park facilities and capital cost. The treatment facility has been sited in the southeast corner of the park outside of the baseball field boundaries and readily accessible from Grand View Boulevard. Treatment would consist of an RO system and a 3,800 square-foot chemical building. The treatment train for this

alternative is shown in Figure 6-3. Ancillary facility features include a clearwell tank, pump station, and off-site pipelines. Additional elements of this alternative include site improvements and a sewer connection. Again, property acquisition costs are not included as the site is an LADWP property. LADWP has an existing 20-inch diameter pipeline in Palms Boulevard which serves the 426 pressure zone. Distribution pumps located on top of the clearwell tank would lift treated water from the clearwell to the 426 pressure zone. A CML&C pipeline would be used to convey treated water from the treatment plant to LADWP's existing distribution pipeline via Grand View Boulevard.

Alternative 5A: 10-Month Operational Scenario. The layout for the 10-month operational scenario is shown on Figure 7-10. This alternative (5A) consists of 4 wells at 450 gpm connected by 6 - 8-inch PVC piping. Water would be collected and sent to a centralized on-site treatment plant. Specifically, the treatment plant would be equipped with a 1.8 mgd RO system. This amount assumes a 17% loss and requires 1,794 gpm inflow (1,489 gpm outflow). Two 150 HP distribution pumps in a 1 + 1 spare configuration would discharge to a 12-inch CML&C pipeline conveys treated water from the treatment plant to LADWP's existing 20-inch diameter pipeline in Palms Boulevard via Grand View Boulevard.

Alternative 5B: 6-Month Operational Scenario. The layout for the 6-month operational scenario is shown on Figure 7-11. This alternative (5B) consists of 6 wells at 500 gpm connected by 6 - 12-inch PVC piping. Water would be collected and sent to a centralized on-site treatment plant. Specifically, the treatment plant would be equipped with a 2.9 mgd RO system. The amount of finished water would be 2,000 AF/yr. This amount assumes a 17% loss and requires 2,995 gpm inflow (2,486 gpm outflow). Two 250 HP distribution pumps in a 1 + 1 spare configuration would discharge to a 16-inch CML&C pipeline conveys treated water from the treatment plant to LADWP's existing 20-inch diameter pipeline in Palms Boulevard via Grand View Boulevard.

Capital costs are summarized in Table 7-12, and supporting documentation is provided in Appendix E. The 10-month scenario has an estimated capital cost of \$10.1 million, whereas the 6-month scenario has an estimated capital cost of \$13.6 million. Amortized over 30 years at 5% interest, the capital costs for the water supply associated with the 10-month and 6-month scenarios are \$327/AF and \$443/AF, respectively.

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Legend

- Proposed Well Location
- LADWP Pipeline $\geq 12"$

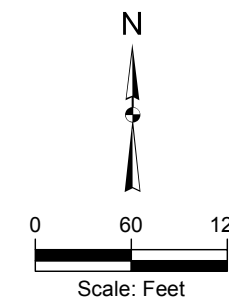


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Coastal Subbasin Venice Reservoir Alternative 5A Site Layout (10-Month)

K/J 1179008*00
December 2011

Figure 7-10

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Legend

- Proposed Well Location
- LADWP Pipeline $\geq 12''$

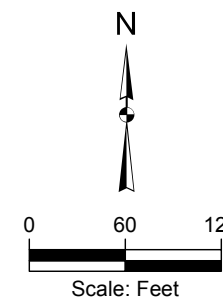


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Coastal Subbasin Venice Reservoir Alternative 5B Site Layout (6-Month)

K/J 1179008*00
December 2011

Figure 7-11

Table 7-12: Summary of Venice Reservoir (Alternative 5) Capital Costs

Description	5A – 10 month 2,000 AF/YR	5B – 6 month 2,000 AF/YR
Wells (4 at 450 gpm)/(6 at 500 gpm)	\$2,188,000	\$3,282,000
Off-Site Pipelines	\$293,000	\$466,000
Site Improvements	\$174,000	\$174,000
RO System (1.8 mgd)/(2.9 mgd)	\$2,500,000	\$3,121,000
Chemical Building (3,800 sq ft)	\$823,000	\$823,000
Clearwell & Pump Station	\$296,000	\$332,000
Subtotal	<u>\$6,274,000</u>	<u>\$8,198,000</u>
Contingency (20%)	\$1,255,000	\$1,640,000
Engineering & Admin (20%)	\$1,255,000	\$1,640,000
Sewer Connection	\$1,280,000	\$2,130,000
Property Acquisition	\$0	\$0
Total	\$10,060,000	\$13,610,000
Unit Cost	\$327/AF	\$443/AF

O&M costs are summarized in Table 7-13, and supporting documentation is provided in Appendix E. The 10-month scenario has an estimated annual O&M cost of \$1.12 million or \$562/AF, whereas the 6-month scenario has an estimated annual O&M cost of \$1.14 million or \$572/AF.

Costs for the water supply associated with this alternative are compared against other alternatives in the Coastal Subbasin in Section 7.3.4. Total costs for the 10-month scenario are \$889/AF, and costs for the 6-month scenario are \$1,015/AF.

7.3.2 Penmar and Lake Street

The Penmar and Lake Street site is located across the central portion of the Penmar Recreation Center from Rose Avenue to Lake Street, and then southwestward along Lake Street (see Figure 7-1). The perimeter of the site is located southwest of Penmar Municipal Golf Course in the City of Venice. Penmar Recreation Center is operated by the City of Los Angeles Department of Recreation and Parks. Ancillary park features include an auditorium, baseball diamond, basketball courts, children's play area, handball courts, indoor gym, picnic tables, and tennis courts. It is assumed that LADWP would need to perform property acquisition at market value.

Table 7-13: Summary of Venice Reservoir (Alternative 5) O&M Costs

Description	5A – 10 month 2,000 AF	5B – 6 month 2,000 AF
Well Pumps	\$106,000	\$120,000
Treatment Chemicals	\$242,000	\$245,000
RO Membrane Replacement	\$26,000	\$38,000
Process Pumping	\$141,000	\$141,000
Distribution Pumping	\$86,000	\$85,000
Maintenance (0.5% of capital/year)	\$38,000	\$50,000
Operator Labor (\$100,000/FTE)	\$50,000	\$30,000
Sewer Disposal Fee	<u>\$434,000</u>	<u>\$434,000</u>
Total	\$1,123,000	\$1,143,000
Unit Cost	\$562/AF	\$572/AF

The site is somewhat unique in that several wells are located within a park and golf course and the treatment plant is some distance away on an empty parcel, with two wells located on an adjacent empty parcel. The wells were located using a minimum spacing of 540 feet to reduce pumping interference and excessive drawdown. The specific placement of each well within the park and golf course was selected to reduce impact to the park and golf course features and to allow ease of access for construction and maintenance. The well collection pipelines were also aligned to minimize impact to the park and golf course features by keeping to the park perimeter and outside of the greens and limiting disturbance of fairways within the park and golf course interiors. The pipelines were laid out to reduce the length required while considering park/golf course facilities and capital cost. Two wells and the treatment facility have been sited northeast of the intersection of Lake Street and Valita Road on a vacant industrial parcel. Treatment would consist of an RO system and a 3,800 square-foot chemical building. The treatment train for this alternative is shown in Figure 6-3. Ancillary facility features include a clearwell tank, pump station, and off-site pipelines. Additional elements of this alternative include site improvements, a sewer connection, and property acquisition. LADWP has an existing 20-inch diameter pipeline along Lake Street Road which serves the 205 pressure zone. Distribution pumps located on top of the clearwell tank would lift treated water from the clearwell to the 205 pressure zone. A CML&C pipeline would be used to convey treated water from the treatment plant to LADWP's existing distribution pipeline.

Alternative 6A: 10-Month Operational Scenario. The layout for the 10-month operational scenario is shown on Figure 7-12. This alternative (6A) consists of 5 wells at 360 gpm connected by 6 - 12-inch PVC piping. Water would be collected and sent to a centralized on-site treatment plant. Specifically, the treatment plant would be equipped with a 1.8 mgd RO system. The amount of finished water would be 2,000 AF/yr. This amount assumes a 17% loss

and requires 1,794 gpm inflow (1,489 gpm outflow). Two 100 HP distribution pumps in a 1 + 1 spare configuration would discharge to a 12-inch CML&C pipeline conveys treated water from the treatment plant to LADWP's existing 20-inch diameter pipeline in Lake Street.

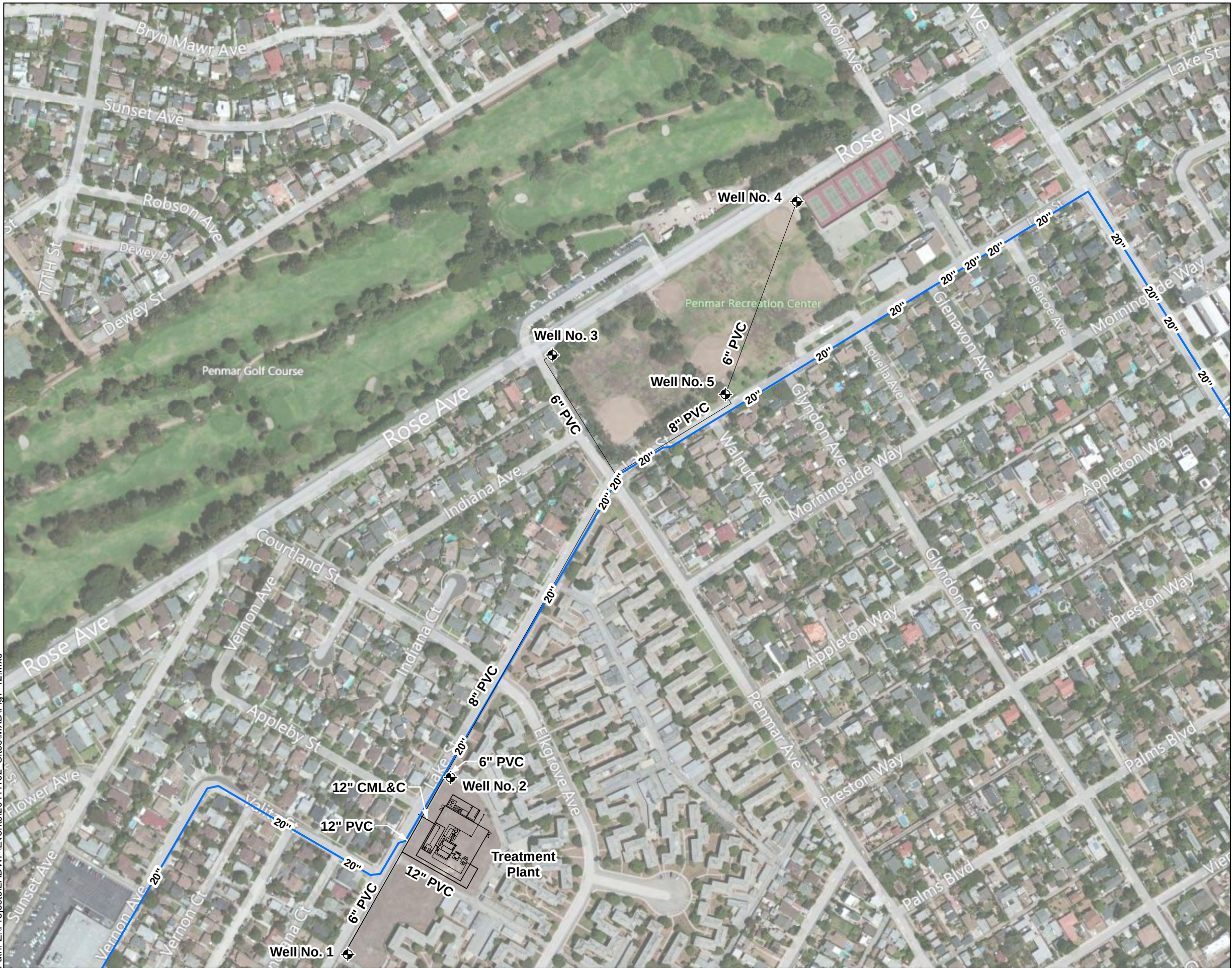
Alternative 6B: 6-Month Operational Scenario. The layout for the 6-month operational scenario is shown on Figure 7-13. This alternative (6B) consists of 7 wells at 430 gpm connected by 6 - 16-inch PVC piping. Water would be collected and sent to a centralized on-site treatment plant. Specifically, the treatment plant would be equipped with a 2.9 mgd RO system. The amount of finished water would be 2,000 AF/yr. This amount assumes a 17% loss and requires 2,995 gpm inflow (2,486 gpm outflow). Two 200 HP distribution pumps in a 1 + 1 spare configuration would discharge to a 16-inch CML&C pipeline conveys treated water from the treatment plant to LADWP's existing 20-inch diameter pipeline in Lake Street.

Capital costs are summarized in Table 7-14, and supporting documentation is provided in Appendix E. The 10-month scenario has an estimated capital cost of \$12.4 million, whereas the 6-month scenario has an estimated capital cost of \$16.0 million. Amortized over 30 years at 5% interest, the capital costs for the water supply associated with the 10-month and 6-month scenarios are \$404/AF and \$521/AF, respectively.

O&M costs are summarized in Table 7-15, and supporting documentation is provided in Appendix E. The 10-month scenario has an estimated annual O&M cost of \$1.04 million or \$520/AF, whereas the 6-month scenario has an estimated annual O&M cost of \$1.06 million or \$530/AF.

Costs for the water supply associated with this alternative are compared against other alternatives in the Coastal Subbasin in Section 7.3.4. Total costs for the 10-month scenario are \$924/AF, and costs for the 6-month scenario are \$1,051/AF.

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Legend

- Proposed Well Location
- LADWP Pipeline $\geq 12"$

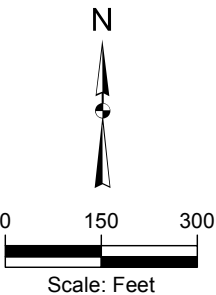


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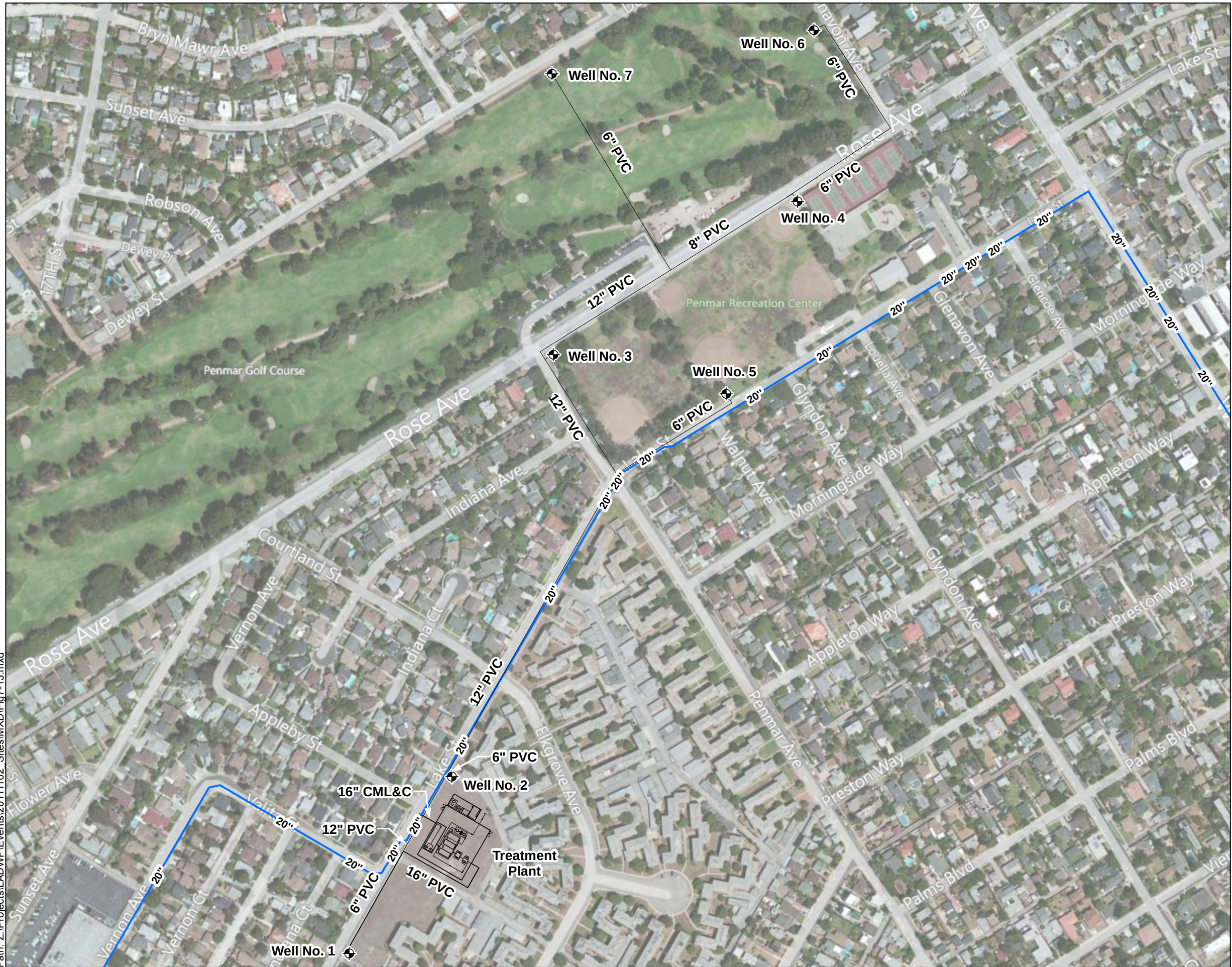
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Coastal Subbasin Penmar and Lake Street Alternative 6A Site Layout (10-Month)

K/J 1179008*00
December 2011

Figure 7-12

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Legend

- Proposed Well Location
- LADWP Pipeline ≥ 12 "

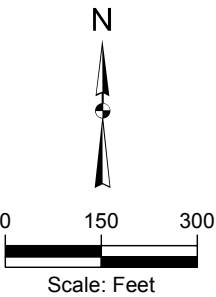


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Coastal Subbasin Penmar and Lake Street Alternative 6B Site Layout (6-Month)

K/J 1179008*00
December 2011

Figure 7-13

Table 7-14: Summary of Penmar and Lake Street (Alternative 6) Capital Costs

Description	6A – 10 month 2,000 AF/YR	6B – 6 month 2,000 AF/YR
Wells (4 at 450 gpm)/(6 at 500 gpm)	\$2,604,000	\$3,660,000
Off-Site Pipelines	\$281,000	\$466,000
Site Improvements	\$176,000	\$176,000
RO System (1.8 mgd)/(2.9 mgd)	\$2,500,000	\$3,121,000
Chemical Building (3,800 sq ft)	\$823,000	\$823,000
Clearwell & Pump Station	<u>\$282,000</u>	<u>\$317,000</u>
Subtotal	\$6,666,000	\$8,563,000
Contingency (20%)	\$1,333,000	\$1,713,000
Engineering & Admin (20%)	\$1,333,000	\$1,713,000
Sewer Connection	\$1,280,000	\$2,130,000
Property Acquisition	<u>\$1,800,000</u>	<u>\$1,900,000</u>
Total	\$12,410,000	\$16,020,000
Unit Cost	\$404/AF	\$521/AF

Table 7-15: Summary of Penmar and Lake Street (Alternative 6) O&M Costs

Description	6A – 10 month 2,000 AF	6B – 6 month 2,000 AF
Well Pumps	\$42,000	\$54,000
Treatment Chemicals	\$242,000	\$245,000
RO Membrane Replacement	\$26,000	\$38,000
Process Pumping	\$141,000	\$141,000
Distribution Pumping	\$64,000	\$64,000
Maintenance (0.5% of capital/year)	\$40,000	\$52,000
Operator Labor (\$100,000/FTE)	\$50,000	\$30,000
Sewer Disposal Fee	<u>\$434,000</u>	<u>\$435,000</u>
Total	\$1,039,000	\$1,059,000
Unit Cost	\$520/AF	\$530/AF

7.3.3 Bluff Creek Drive

The Bluff Creek Drive site is located along the south side of Bluff Creek Drive between Campus Center Drive to the east, a residential neighborhood to the south, and McConnell Avenue to the west (see Figure 7-1). The site appears to be a linear park consisting of two landscaped trails for use by pedestrians, bicycles, and horses. A portion of the site extends into an active commercial/and industrial development to the north of Bluff Creek Drive. It is assumed that LADWP would need to perform property acquisition at market value.

The wells were located using a minimum spacing of 625 feet to reduce pumping interference and excessive drawdown. The specific placement of each well along an open drainage swale and along the perimeter of an existing commercial/industrial parcel was selected to reduce impact to the landscaped park and trails and to allow ease of access for construction and maintenance. The well collection pipelines were also aligned to minimize impact to the park and parcels by staying between the trails and keeping to the perimeter of the commercial/industrial parcels. The pipelines were laid out to reduce the length required while considering park facilities and capital cost. The treatment facility has been sited toward the west end of the site at the projected intersection of Bluff Creek Drive and McConnell Avenue. Treatment would consist of an RO system and a 3,800 square-foot chemical building. The treatment train for this alternative is shown in Figure 6-3. Ancillary facility features include a clearwell tank, pump station, and off-site pipelines. Additional elements of this alternative include site improvements, a sewer connection, and property acquisition. LADWP has an existing 26-inch diameter pipeline along Centinela Avenue which serves the 205 pressure zone. Distribution pumps located on top of the clearwell tank would lift treated water from the clearwell to the 205 pressure zone. A CML&C pipeline would be used to connect the treatment plant to LADWP's existing distribution pipeline via West Lawn Avenue and West Jefferson Boulevard.

Alternative 7A: 10-Month Operational Scenario. The layout for the 10-month operational scenario is shown on Figure 7-14. This alternative (7A) consists of 5 wells at 360 gpm connected by 6 - 12-inch PVC piping. Water would be collected and sent to a centralized on-site treatment plant. Specifically, the treatment plant would be equipped with a 1.8 mgd RO system. This amount assumes a 17% loss and requires 1,794 gpm inflow (1,489 gpm outflow). Two 125 HP distribution pumps in a 1 + 1 spare configuration would discharge to a 12-inch CML&C pipeline conveys treated water from the treatment plant to LADWP's existing 26-inch diameter pipeline in Centinela Avenue via West Lawn Avenue and West Jefferson Boulevard.

Alternative 7B: 6-Month Operational Scenario. The layout for the 6-month operational scenario is shown on Figure 7-15. This alternative (7B) consists of 8 wells at 375 gpm connected by 6 - 12-inch PVC piping. Water would be collected and sent to a centralized on-site treatment plant. Specifically, the treatment plant would be equipped with a 2.9 mgd RO system. The amount of finished water would be 2,000 AF/yr. This amount assumes a 17% loss and requires 2,995 gpm inflow (2,486 gpm outflow). Two 200 HP distribution pumps in a 1 + 1 spare configuration would discharge to a 16-inch CML&C pipeline conveys treated water from the treatment plant to LADWP's existing 26-inch diameter pipeline in Centinela Avenue via West Lawn Avenue and West Jefferson Boulevard.



Legend

◆ Proposed Well Location

— LADWP Pipeline ≥ 12"

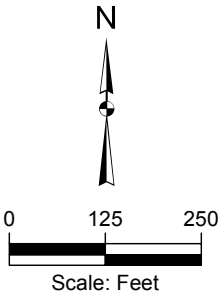


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**Coastal Subbasin Bluff Creek Drive
Alternative 7A Site Layout (10-Month)**

K/J 1179008*00
December 2011

Figure 7-14



Legend

◆ Proposed Well Location

— LADWP Pipeline ≥ 12"

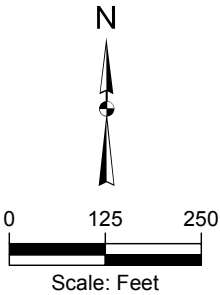


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**Coastal Subbasin Bluff Creek Drive
Alternative 7B Site Layout (6-Month)**

K/J 1179008*00
December 2011

Figure 7-15

Capital costs are summarized in Table 7-16, and supporting documentation is provided in Appendix E. The 10-month scenario has an estimated capital cost of \$12.6 million, whereas the 6-month scenario has an estimated capital cost of \$17.3 million. Amortized over 30 years at 5% interest, the capital costs for the water supply associated with the 10-month and 6-month scenarios are \$410/AF and \$561/AF, respectively.

Table 7-16: Summary of Bluff Creek Drive (Alternative 7) Capital Costs

Description	7A – 10 month 2,000 AF/YR	7B – 6 month 2,000 F/YR
Wells (5 at 360 gpm)/(8 at 375 gpm)	\$2,604,000	\$4,166,000
Off-Site Pipelines	\$842,000	\$1,208,000
Site Improvements	\$174,000	\$174,000
RO System (1.8 mgd)/(2.9 mgd)	\$2,500,000	\$3,121,000
Chemical Building (3,800 sq ft)	\$823,000	\$823,000
Clearwell & Pump Station	<u>\$289,000</u>	<u>\$317,000</u>
Subtotal	\$7,232,000	\$9,809,000
Contingency (20%)	\$1,446,000	\$1,962,000
Engineering & Admin (20%)	\$1,446,000	\$1,962,000
Sewer Connection	\$1,280,000	\$2,130,000
Property Acquisition	<u>\$1,200,000</u>	<u>\$1,400,000</u>
Total	\$12,600,000	\$17,260,000
Unit Cost	\$410/AF	\$561/AF

O&M costs are summarized in Table 7-17, and supporting documentation is provided in Appendix E. The 10-month scenario has an estimated annual O&M cost of \$1.06 million or \$530/AF, whereas the 6-month scenario has an estimated annual O&M cost of \$1.07 million or \$536/AF.

Costs for the water supply associated with this alternative are compared against other alternatives in the Coastal Subbasin in Section 7.3.4. Total costs for the 10-month scenario are \$940/AF, and costs for the 6-month scenario are \$1,097/AF.

Table 7-17: Summary of Bluff Creek Drive (Alternative 7) O&M Costs

Description	7A – 10 month 2,000 AF	7B – 6 month 2,000 AF
Well Pumps	\$46,000	\$52,000
Treatment Chemicals	\$242,000	\$245,000
RO Membrane Replacement	\$26,000	\$38,000
Process Pumping	\$141,000	\$141,000
Distribution Pumping	\$76,000	\$73,000
Maintenance (0.5% of capital/year)	\$44,000	\$59,000
Operator Labor (\$100,000/FTE)	\$50,000	\$30,000
Sewer Disposal Fee	<u>\$434,000</u>	<u>\$434,000</u>
Total	\$1,059,000	\$1,072,000
Unit Cost	\$530/AF	\$536/AF

7.3.4 Comparison of Coastal Subbasin Alternatives

A comparison of total unit costs for the Coastal Subbasin alternatives are shown below in Table 7-18.

7.4 Comparison of All Alternatives Using Estimated Costs

Table 7-19 provides a comparison and ranking of all alternatives based on estimated probable costs. The alternatives are listed in order of increasing total cost per acre foot.

Table 7-18: Summary of Water Supply Costs for Crestal Subbasin Alternatives

Alternative No.	Site Name	Finished Water (AF/yr)	10-Month Operation		
			Capital	O&M	Total
5A	Venice Reservoir	2,000	\$327/AF	\$562/AF	\$889/AF
6A	Penmar & Lake Street	2,000	\$404/AF	\$520/AF	\$924/AF
7A	Bluff Creek Drive	2,000	\$410/AF	\$530/AF	\$940/AF
Alternative No.	Site Name	Finished Water (AF/yr)	6-Month Operation		
			Capital	O&M	Total
5B	Venice Reservoir	2,000	\$443AF	\$572/AF	\$1,015AF
6B	Penmar & Lake Street	2,000	\$521/AF	\$530/AF	\$1,051/AF
7B	Bluff Creek Drive	2,000	\$561/AF	\$536/AF	\$1,097/AF

Table 7-19: Summary of Alternatives Ranked on Estimated Costs

Alternative No.	Basin/Site Name	Finished Water (AF/yr)	10 Month Operation		
			Capital	O&M	Total
1A	Hollywood – Pan Pacific	3,000	\$232/AF	\$201/AF	\$433/AF
5A	Coastal - Venice Reservoir	2,000	\$327/AF	\$562/AF	\$889/AF
6A	Coastal - Penmar & Lake St	2,000	\$404/AF	\$520/AF	\$924/AF
7A	Coastal - Bluff Creek Drive	2,000	\$410/AF	\$530/AF	\$940/AF
3A	Crestal - Hillcrest Country Club	2,000	\$488/AF	\$572/AF	\$1,060/AF
2A	Crestal - Cheviot Hills Park	2,000	\$483/AF	\$589/AF	\$1,072/AF
4A	Crestal - Northvale Road	2,000	\$472/AF	\$659/AF	\$1,131/AF
Alternative No.	Basin/Site Name	Finished Water (AF/yr)	6 Month Operation		
			Capital	O&M	Total
1B	Hollywood – Pan Pacific	2,500	\$370/AF	\$244/AF	\$614/AF
5B	Coastal - Venice Reservoir	2,000	\$443AF	\$572/AF	\$1,015AF
6B	Coastal - Penmar & Lake St	2,000	\$521/AF	\$530/AF	\$1,051/AF
7B	Coastal - Bluff Creek Drive	2,000	\$561/AF	\$536/AF	\$1,097/AF
3B	Crestal - Hillcrest Country Club	2,000	\$663/AF	\$613/AF	\$1,276/AF
2B	Crestal - Cheviot Hills Park	2,000	\$658AF	\$630/AF	\$1,288/AF
4B	Crestal - Northvale Road	2,000	\$643/AF	\$705/AF	\$1,348/AF

Section 8: Evaluation of Non-Economic Factors

A non-economic evaluation was conducted to prioritize and rank the alternatives. There are a number of non-economic factors used to evaluate the alternatives, including:

- Water quality data availability (uncertainty);
- Construction impacts;
- Tree removal;
- Access;
- Security;
- Aesthetics;
- Community impacts; and
- Environmental impacts.

8.1 Description of Non-Economic Factors

A definition of each criteria and how they apply to the project alternatives is presented herein, followed by a summary analysis of these issues.

8.1.1 Water Quality Data Availability

The availability of water quality data for a specific basin or subbasin is an important consideration for the type and level of treatment required to supply potable groundwater. The lack of available water quality raises uncertainty about the proposed treatment, making the capital and O&M cost estimates less reliable and a specific alternative, other considerations equal, less desirable.

For the three basins/subbasins under consideration, the Hollywood Basin has considerably more water quality data available than the Coastal Subbasin which, in turn, has more water quality data than the Crestal Subbasin. Since there are no wells in the Crestal Subbasin, this study assumes that the water quality is similar to the adjacent Charnock Subbasin, which presents a very high level of uncertainty.

8.1.2 Construction Impacts

Construction impacts include excessive construction-related activities and associated impacts. Examples include over excavation and re-compaction of sub grade or considerable traffic control, noise, staging, and storage issues.

Certain alternatives have substantially greater construction impacts due to the location and type of land use. Several alternatives are in active parks or golf courses. Other alternatives are

largely in drainage right of ways or old abandoned railroad right of ways. The locations of the wells and the treatment plants are both taken into consideration in the rankings provided.

8.1.3 Tree Removal

Tree removal is perceived as negative, especially the removal of large mature trees. The ranking takes into consideration the need to remove or dramatically trim any trees for well, pipeline, and treatment plant construction.

Based on recent aerial photography, certain alternatives are favorable in that they would not appear to require the removal of any tree. Other alternatives are slightly less favorable in that they would require the removal of several small trees or a single large tree. A negative ranking would be applied if an alternative required the removal of several large trees or numerous small trees.

8.1.4 Access

Access relates to: (1) the ease of entering and leaving the site for the operations staff that would be required to visit each site daily with passenger-sized vehicles or pick-up trucks, (2) the ease of entering and maneuvering heavy equipment (such as a boom truck) in order to perform routine or emergency maintenance on treatment plant equipment and/or wells, and (3) the ease of access and egress for chemical and material/media deliveries for the treatment plants.

Certain sites have been placed in parks or golf courses or other public open space with limited access by paved roads to the wells and treatment plants. Sites that would require the construction of new street turn-outs and paved access roads across currently open space are considered more negative than sites adjacent to paved streets. Sites that require access to wells along secure drainage right of ways or abandoned railroad right of ways are more negative than wells that are near paved streets.

8.1.5 Security

Security relates to the ability for the public to access the site. Public access raises concerns regarding potential vandalism, safety, and even terrorism resulting from intentional contamination of the water supply. In effect, a secure site scores higher than a less secure site with more public access. At the level of analysis for this feasibility study, the social-economic standing of the community surrounding a particular alternative was not taken into consideration.

The majority of the sites are readily accessible to the public, and those that are slightly more secluded offer security challenges due to limited visibility by the public. Since security can be built into the design for any and all of the sites under consideration, this criteria was given a neutral ranking for all 14 alternatives.

8.1.6 Aesthetics

Aesthetics is perceived as a positive or negative benefit if the alternative either improves or degrades the aesthetics of the site, such as enhancing or removal of landscaping. In most cases the construction of a new water treatment plant with buildings, walls, fencing, and exposed treatment vessels, tanks, and piping would have a negative impact on aesthetics. Therefore, the treatment plant sites that are more remote, are shielded by existing mature trees, or are located in more industrial areas are ranked more favorably.

8.1.7 Community Impacts

Community impacts include the aggregate of multiple other criteria and their overall impact on the community of residents, businesses, visitors, or other stakeholders of the area adjacent to the facilities, largely the treatment plants, but including the construction, access, and maintenance of the wells, pipelines, and treatment facilities. Any number of negative community impacts might be offset by ancillary benefits to the community as a result of the construction of the alternative, such as new landscaping or hardscape that improves the aesthetics and/or functionality of the adjacent areas.

The type and magnitude of community improvements that may be requested of LADWP or offered by LADWP to offset certain unique or aggregate impacts, is beyond the scope of this feasibility study.

8.1.8 Environmental Impacts

Environmental impacts include those impacts that are detrimental or negative to the environment. In addition, this criteria takes into consideration required environmental documentation and regulatory compliance per the California Environmental Quality Act (CEQA). Several of the criteria have potential environmental impacts such as construction impacts (traffic, noise, dust, and related issues), tree removal, long-term access, and potentially aesthetics, as well as the aggregate of multiple other criteria.

Although the evaluation of the biology of the individual sites is beyond the scope of this study, certain alternatives by their location within or adjacent to dense vegetation have a greater likelihood of significant environmental impacts, and are ranked more negatively.

8.2 Summary Analysis of Non-Economic Factors

A rating of positive (+), neutral (0), or negative (-) was assigned for each of the alternatives for each of the evaluation criteria considered as follows:

- Positive (+) = 3 points;
- Neutral (0) = 2 points; and
- Negative (-) = 1 point.

Table 8-1 summarizes the findings and each of the alternatives is briefly described with an emphasis on positive or negative, rather than neutral rankings.

Table 0-1: Non-Economic Ranking of Alternative

Criteria	1A	1B	2A	2B	3A	3B	4A	4B	5A	5B	6A	6B	7A	7B
Water Quality Availability	+	+	-	-	-	-	-	-	0	0	0	0	0	0
Construction Impacts	0	-	0	-	-	-	-	-	0	0	0	0	0	0
Tree Removal	0	0	0	0	0	0	0	0	+	+	+	+	+	+
Access	-	-	+	+	-	-	+	0	+	+	+	+	0	0
Security	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aesthetics	0	0	0	0	+	+	0	0	-	-	0	0	+	+
Community Impacts	0	0	+	0	+	+	0	0	0	0	+	+	+	+
Environmental Impacts	0	0	0	0	0	0	-	-	+	+	+	+	0	0
Score:	16	15	17	15	15	15	14	13	18	18	20	20	19	19

8.2.1 Pan Pacific Park

The Pan Pacific Park alternatives are ranked as the third lowest of the seven sites evaluated in this study. The majority of the non-economic rankings are neutral, with the exception that the availability of water quality data is positive and the limited access is negative. Alternative 1B, which includes the construction of nine wells (and not just six wells) in the existing park, is ranked negative for its construction impacts.

8.2.2 Cheviot Hills Park

The Cheviot Hills Park site received the median ranking of the seven alternative sites, although the ranking of 16 for both Alternatives 2A and 2B were both below the average ranking. For Alternative 2A with a partially secluded treatment plant site hidden on three sides by mature trees and five wells outside of active parks use areas, a positive community impact ranking was assigned. However, Alternative 2B with three additional wells and greater disruption of the park during construction received a negative ranking for construction impacts. Both alternatives are positive regarding access, but negative regarding the lack of water quality data.

8.2.3 Hillcrest Country Club

The Hillcrest Country Club site received the second lowest non-economic ranking of the seven sites due to the lack of water quality data, construction impacts, and limited access. Since the treatment plant is located within a secluded area of the existing golf course, the two alternatives (3A and 3B) received positive rankings for aesthetics and community impacts.

8.2.4 Northvale Road

The Northvale Road site is entirely on an old abandoned railroad right of way with the exception of the well collection pipeline crossing a public street. However, the entire right-of-way is lined with residential properties on both sides, thus making this the lowest ranked set of alternatives. Construction of the wells, pipelines, and treatment plant in close proximity to residents would be challenging. The treatment plant would be highly exposed to residential homes on all sides. There is also both a significant potential for environmental impacts and a higher likelihood for contaminated soils and/or aquifer due to the past use as a railroad corridor.

The Northvale Road site may be the only site of the seven sites under consideration where the non-economic issues are sufficiently substantial as to place the project in question as to its viability as a public water supply project site.

8.2.5 Venice Reservoir

The Venice Reservoir site is the only property currently owned by LADWP. The east two-thirds of the property is used as baseball fields and open space park area, while the west one-third of the property is used as a community garden with numerous small plots available to the public. The potential well depth is estimated to be 500 feet and slightly greater than the remaining six sites. As a deeper aquifer, Alternative 5A only requires four wells and Alternative 5B only requires six wells. The proposed treatment plant site is in the southeast corner for the site outside the baseball field boundaries and readily accessible from the adjacent public street. The overall non-economic ranking was the third best of the seven sites with aesthetics as the only negative ranking.

8.2.6 Penmar and Lake Street

The Penmar and Lake Street site is somewhat unique in that Alternative 6A locates several wells within a park and the treatment plant some distance away on an empty parcel, with two of the proposed five wells on or adjacent to the empty parcel. Alternative 6B locates an additional two wells within an adjacent golf course outside the fairways and along public streets with excellent access. It appears that no trees need to be removed for construction.

This site received positive rankings for tree removal, access, community impacts, and environmental issues. The remaining rankings are neutral, with no negative rankings assigned. This site and its two alternatives (6A and 6B) received the highest non-economic rankings of all seven sites.

8.2.7 Bluff Creek Drive

The Bluff Creek Drive site is unique in that it is located in and adjacent to an active commercial/ industrial development. The five wells for Alternative 7A and six of the eight wells for Alternative 7B are located along an open drainage swale that has been landscaped as park with trails. The treatment plant is located adjacent to a public street on a relatively narrow strip of land that otherwise may have limited use. Positive rankings were assigned for aesthetics and community impacts, as well as tree removal. The remaining rankings are all neutral and no rankings are negative. As such, this site received the second highest non-economic ranking of the seven sites.

Section 9: Results Screening and Ranking of Alternatives

The 14 alternatives developed in this study are screened and ranked in this section based on a combination of cost estimates and non-economic criteria. The estimates of probable costs presented in Section 7 are summarized below, followed by highlights of the non-economic analysis presented in Section 8.

9.1 Rankings Based on Cost Estimates

As described in Section 7, 14 alternatives were developed along with estimates of probable cost for each. The cost estimates include planning-level capital and O&M costs for wells, treatment facilities, pump stations, ancillary features, as well as an estimate of pipeline requirements. These conceptual estimates were prepared to have level of accuracy of -30 percent to +50 percent. Specifically, the following costs were developed for each alternative:

- Capital costs include the cost for new wells, pipelines, site improvements, the treatment facility, pump stations, contingency, engineering & administration fees, sewer connection, and property acquisition.
- O&M costs include the cost of well and treatment, process operations, chemical and distribution pumping, treatment chemicals replenishment, treatment facility media/membrane replacement (where applicable), equipment maintenance and replacement, operator labor, and sewer disposal fees.

The capital costs of the 14 alternatives range from \$10.1 to \$15.0 million for the “A” scenarios operating over 10 months per year and \$13.6 to \$20.4 million for the “B” scenarios operating over 6 months per year. As Alternatives 1A and 1B are comprised of larger capacity projects than the remaining alternatives, unit cost of production is used to compare the alternatives. On an amortized unit cost basis, the alternatives range from \$232/AF to \$488/AF for the 10-month scenarios and \$370/AF to \$663/AF for the 6-month scenarios.

The annual O&M costs range from \$604,000 to \$1,317,000 for the 10-month scenarios and \$611,000 to \$1,409,000 for the 6-month scenarios. Again, Alternatives 1A and 1B produce a greater volume of product water, so unit cost of production is used to compare alternatives. These costs equate to \$201/AF to \$659/AF for the 10-month scenarios and \$562/AF to \$705/AF for the 6-month scenarios.

On a total unit cost basis, the 14 alternatives range from \$433/AF to \$1,131/AF for the 10-month scenarios and \$614/AF to \$1,348 for the 6-month scenarios.

9.1.1 Lowest Cost Alternatives

The lowest cost project on a total unit cost basis of \$433/AF is Alternative 1A, the Hollywood Basin Pan Pacific Park site designed to produce 3,000 AF/yr over 10 months of operation using six wells and a Green Sand – GAC – Chloramination treatment process train. The second lowest cost project with a total unit cost of \$614/AF is Alternative 1B, the Hollywood Basin Pan Pacific Park site designed to produce 2,500 AF/yr over 6 months of operation using nine wells and a green sand – GAC – Chloramination treatment process train. However, these two

projects are mutually exclusive and one project would need to be selected over the other. The non-economic analysis is described below.

After the Pan Pacific Park Project in the Hollywood Basin (as 3,000 AF/year over 10 months or 2,500 AF/year over 6 months), then the next lowest cost project (on a unit cost basis) is Alternative 5A, the Santa Monica Basin, Coastal Subbasin, Venice Reservoir Park Project at \$889/AF. This project is designed to produce 2,000 AF/yr over 10 months of operation using four wells and a Green Sand – GAC- RO – Chloramination treatment process train.

Should LADWP prefer to develop a project that produces 2,000 AF/yr over 6 months of operation, then the next lowest cost project (on a unit cost basis) is Alternative 5B, the Santa Monica Basin, Coastal Subbasin, and Venice Reservoir Park Project at \$1,015 per AF. This project is designed to produce 2,000 AF/yr over 6 months of operation using six wells and a Green Sand – GAC- RO – Chloramination treatment process train.

9.2 Non-Economic Screening

The non-economic evaluation presented in Section 8, looked at numerous non-economic factors including: water quality availability (uncertainty), construction impacts, tree removal, access, security, aesthetics, community impacts, and environmental impacts. The ranking of these factors for each alternative resulted in one site, the Northvale Road site in the Santa Monica Basin, Crestal Subbasin (Alternatives 4A and 4B), as being sufficiently substantial as to place the project in question as to its viability as a public water supply project site. One of the concerns includes the potential for contamination in the surface and/or subsurface soils due to the previous use as a railroad transportation corridor.

Since Alternative 4A and 4B are the most expensive alternatives (on a unit cost basis) for the 10-month and 6-month operating scenarios, respectively, removing this site from further consideration has no impact on the recommended projects.

The lowest unit cost site, Pan Pacific Park in the Hollywood Basin is ranked low with negative rankings for construction impacts and access, with neutral rankings for tree removal, security, aesthetics, community impacts, and environmental impacts. Alternative 1B, with nine proposed wells, associated well collection pipelines, and a treatment plant in the park, is slightly more intrusive than Alternative 1A with only six wells and associated well collection pipelines. While the negative ranking does not eliminate the project from consideration, it does indicate that mitigation of the impacts and public participation and coordination will be important for a successful project.

After the Pan Pacific Park site, the next lowest cost site is the Venice Reservoir Park site in the Santa Monica Basin, Coastal Subbasin. This project received a relatively high non-economic ranking with aesthetics as the only negative criteria and neutral rankings for water quality data, construction impacts, security, and community impacts.

Section 10: Conclusions and Recommendations

10.1 Summary

The purpose of this study was to evaluate the feasibility of developing the Santa Monica and Hollywood groundwater basins as potable groundwater supply sources for the City of Los Angeles.

For each groundwater basin, the study included:

- Hydrogeologic characterization, including an estimation of groundwater quantity available and review of safe yield estimates;
- Evaluation of basin governance, including interviews with stakeholder agencies and quantification of groundwater production by other entities;
- Review of groundwater quality;
- Review of existing facilities and groundwater production in the study area;
- Development of treatment scenarios needed to produce potable water; and
- Identification and development of alternatives, including preliminary siting of wells, pipelines, and treatment facilities.

As described in Section 7, seven viable sites and 14 alternatives were identified in the study area as follows:

- Hollywood Basin
 - Pan Pacific
 - o Alternative 1A – 6 wells and 3,000 AF/yr
 - o Alternative 1B – 9 wells and 2,500 AF/yr
- Santa Monica Basin – Crestal Subbasin
 - Cheviot Hills Park
 - o Alternative 2A – 5 wells and 2,000 AF/yr
 - o Alternative 2B – 8 wells and 2,000 AF/yr
 - Hillcrest Country Club
 - o Alternative 3A – 5 wells and 2,000 AF/yr
 - o Alternative 3B – 8 wells and 2,000 AF/yr
 - Northvale Road
 - o Alternative 4A – 5 wells and 2,000 AF/yr
 - o Alternative 4B – 8 wells and 2,000 AF/yr
- Santa Monica Basin – Coastal Subbasin
 - Venice Reservoir Park
 - o Alternative 5A – 4 wells and 2,000 AF/yr

- o Alternative 5B – 6 wells and 2,000 AF/yr
- Penmar and Lake Street
 - o Alternative 6A – 5 wells and 2,000 AF/yr
 - o Alternative 6B – 7 wells and 2,000 AF/yr
- Bluff Creek Drive
 - o Alternative 7A – 5 wells and 2,000 AF/yr
 - o Alternative 7B – 8 wells and 2,000 AF/yr

The purpose of a 10-month versus a 6-month operational scenario is to address the seasonality of demand and the added benefit of emergency supply. The 6-month scenario provides a greater production capacity, but at a higher cost.

These sites were identified primarily by the results of the hydrogeologic and water quality characterization previously discussed. This identification was then supplemented by a review of available open space. Specifically, vacant properties greater than or equal to 0.5 acres in size as well appropriate multi-use properties (parks, golf courses, and other open space) that are of sufficient size for the construction of groundwater production wells and treatment facilities were considered. Furthermore, property owned by the City of Los Angeles was identified. For each site, the location, size, property features, slope, proximity to LADWP distribution pipelines, and proximity to available utilities (e.g., power, storm drain, and sewer) was evaluated.

Wells were spaced appropriately using hydrogeologic data so as to minimize well interference. Next, treatment scenarios previously described were applied on a basin/subbasin-specific basis. A pipeline collection system was then sized and conceptually developed for each group of wells to feed a regional treatment facility. Finally, pump stations and pipeline facilities to deliver the treated groundwater to the nearest appropriate LADWP distribution pipeline were identified for each alternative.

10.2 Conclusions

As a result of the study, it was determined that the development of a new potable water supply of up to 3,000 AF/yr from the Hollywood Basin and up to 2,000 AF/yr from the Santa Monica Basin (Crestal or Coastal subbasins) is viable and technically feasible. The political and legal merits, including the determination of water rights, for developing these supplies is outside the scope of this study.

The lowest cost project on a total unit cost basis of \$433/AF is Alternative 1A, the Hollywood Basin Pan Pacific Park site designed to produce 3,000 AF/yr over 10 months of operation using six wells and a Green Sand – GAC – Chloramination treatment process train. The second lowest cost project with a total unit cost of \$614/AF is Alternative 1B, the Hollywood Basin Pan Pacific Park site designed to produce 2,500 AF/yr over 6 months of operation using nine wells and a green sand – GAC – Chloramination treatment process train. However, these two projects are mutually exclusive and one project would need to be selected over the other. The non-economic analysis suggests that Alternative 1A would be less intrusive and disruptive than Alternative 1B, due to the construction of three fewer wells and associated collection pipelines within the existing park.

After the Pan Pacific Park Project in the Hollywood Basin, the next lowest cost project (on a unit cost basis) is Alternative 5A, the Santa Monica Basin, Coastal Subbasin, and Venice Reservoir Park Project at a total unit cost of \$889/AF. This project is designed to produce 2,000 AF/yr over 10 months of operation using four wells and a Green Sand – GAC- RO – Chloramination treatment process train. This project was ranked relatively high in the non-economic ranking with the greatest concern being aesthetics.

LADWP has expressed interest in potentially developing a potable groundwater supply in the No Man's Land area in the north end of the Central Basin (just south of the Hollywood Basin). LADWP suggested that property at its Western District Headquarters at 5898 West Venice Boulevard, Los Angeles, CA 90019, could serve as a demonstration project for a well or wells and treatment using a package (potentially leased) treatment facility. Evaluation of this option is outside the scope of the current study.

10.3 Recommendation

Based on the findings of this study, Kennedy/Jenks recommends Alternative 1A and Alternative 5A for further study and potential implementation.

Alternative 1A involves the development of 3,000 AF/yr from the Hollywood Basin at the Pan Pacific Park site with 6 wells and a 10-month pumping operation using a Green Sand – GAC – Chloramination treatment process train. The production from this site would be pumped into LADWP's 579 Zone. The capital cost is estimated to be \$10.7 million. The total unit cost is estimated to be \$433/AF. This cost is approximately half of the current cost of purchasing treated imported water from MWD.

Alternative 5A involves the development of 2,000 AF/yr from the Santa Monica Basin at the LADWP-owned Venice Reservoir Park site with 4 wells and a 10-month pumping operation using Green Sand – GAC – RO- Chloramination treatment process train. The production from this site would be pumped into LADWP's 426 Zone. The capital cost is estimated to be \$10.1 million. The total unit cost is estimated to be \$889/AF. This cost is essentially equal to the current cost of purchasing treated imported water from MWD. However, MWD has stated their intention to increase its water rates approximately 7 to 8 percent per year over the next five years, which suggests a purchased water cost of roughly \$1,150/AF by 2017.

If a project is selected for implementation, additional study will be needed. One option is to construct a test well to allow site specific water quality sampling as well as confirmation of depth to bedrock and soil conditions. Furthermore, a CDPH-mandated drinking water source water assessment would be required to permit the source. This assessment would serve to further characterize potential contaminating activities for the selected alternative.

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