WATER RESOURCE RELIABILITY PROGRAM
RECYCLED WATER INJECTION WELL STUDY

Prepared for

OCEANO COMMUNITY SERVICES DISTRICT
AND
CANNON CORPORATON

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EXECUTIVE SUMMARY

This Recycled Water Injection Well Study evaluates sites within the Oceano Community Services District service area for recharging groundwater with recycled water using injection wells and recharge basins. The intent of the study is to augment the existing work efforts of regional partners toward groundwater basin sustainability by focusing on potential sites for injection wells or other recharge options within Oceano.

Five sites were evaluated for use as either an injection well (three sites) or recharge basin (two sites) as follows:

- Site A - Oceano CSD Water Yard Injection
- Site B - South Elm Street Injection
- Site C - South Elm Street Basin
- Site D - Arroyo Grande Creek Area Injection
- Site E - Arroyo Grande Creek Area Basin

Evaluation criteria used for the sites incorporate the following hydrogeologic and engineering/cost criteria:

- Recharge capacity
- Travel time
- Sustainable yield benefit
- Seawater intrusion mitigation
- Water quality benefit
- Environmental benefit/Impact
- Facility requirements/constructability
- Recharge source distribution
- Operations and maintenance
- Land acquisition requirements
- Permitting Requirements

Results of the Recycled Water Injection Well Study are presented as a matrix comparing the hydrogeologic criteria and the engineering/cost criteria, with an overall site ranking. Tables ES-1 and ES-2 show the final site rankings.

Table ES-1 – Combined Hydrogeologic Evaluation Criteria Ranking

Hydrogeologic Evaluation Criteria	Site Ranking (1 = highest)				
	Site A	Site B	Site C	Site D	Site E
	Water Yard Injection	S. Elm Injection	S. Elm Basin	Creek Area Injection	Creek Area Basin
Recharge Capacity	1	2	3	5	4
Sustainable Yield Benefit	3	1	1	2	2
Seawater Intrusion Mitigation	1	2	2	3	3
Water Quality Benefit	4	2	3	Not ranked	1
Environmental Benefit	1	4	5	2	3
Unweighted Average Rank[1]	2	2.2	2.8	3	2.6
Recharge Capacity Multiplier[2]	1	2	4.5	9.6	6.1
Final Average Rank	2	4.4	12.6	28.8	15.9
Weighted Hydrogeologic Rank	**1**	**2**	**3**	**5**	**4**

[1] average rank prior to adjusting for recharge capacity
[2] equal to the highest recharge capacity devided by the individual site recharge capacity

Table ES-2 – Cost-Benefit Summary and Overall Site Ranking

Description	Cost				
	Site A	Site B	Site C	Site D	Site E
	Water Yard Injection	S. Elm Injection	S. Elm Basin	Creek Area Injection	Creek Area Basin
Recharge Facilities	$1,200,000	$1,140,000	$70,000	$1,200,000	$360,000
Recharge Source Distribution	$355,000	$724,000	$560,000	$448,000	$504,000
O&M over 30 years	$1,200,000	$1,200,000	$240,000	$1,200,000	$1,350,000
Land Acquisition	$0	$100,000	$0	$100,000	$2,800,000
Total cost	$2,755,000	$3,164,000	$870,000	$2,948,000	$5,014,000
Total cost with 5% APR financing	$5,328,000	$6,120,000	$1,692,000	$5,688,000	$9,684,000
	Cost-Benefit				
Recharge Capacity (AFY)[1]	700	340	150	70	110
Recharge over 30 years (AF)	21000	10200	4500	2100	3300
Cost of recharge ($/AF)[2]	$250	$600	$370	$2,710	$2,940
Cost of recycled water ($/AF)[3]	$2,100	$2,100	$2,100	$2,100	$2,100
Total cost of GRRP site ($/AF)	$2,350	$2,700	$2,480	$4,810	$5,030
	Overall Ranking (1 = highest)				
Cost Rank	1	3	2	4	5
Weighted Hydrogeologic Rank	1	2	3	5	4
Overall Site Rank	**1**	**2**		**3**	

APR = Annual Percentage rate; AFY = Acre-Feet per Year
[1] average rank prior to adjusting for recharge capacity
[2] equal to the highest recharge capacity divided by the individual site recharge capacity
[3] $2,100 unit cost for Phase 2 Advanced Treatment Plant water before injection (WSC, 2017), with similar unit cost for a disinfected tertiary treated wastewater/municipal supply/ATP water blend approved for recharge basins.

1.0 INTRODUCTION

Oceano Community Services District (OCSD) is a member of the Regional Water Management Group that provides collaborative efforts to manage water resources through the Integrated Regional Water Management (IRWM) Program. OCSD has sponsored a planning study as part of the 2014 IRWM Plan, entitled the Water Resources Reliability Program (WRRP), which includes the Recycled Water Injection Well Study.

Recycled water injection has been evaluated on a regional basis as part of the Regional Groundwater Sustainability Project (RGSP), now called Central Coast Blue, through efforts led by other Regional Water Management Group partners. This Recycled Water Injection Well Study evaluates five Groundwater Replenishment Reuse Project (GRRP) sites within the OCSD service area for recharging groundwater with recycled water through injection wells or recharge basins. The intent of the site evaluations is to augment the existing work efforts of regional partners toward basin sustainability by focusing on potential sites for injection wells or other recharge options within Oceano.

Cleath-Harris Geologists (CHG) was subcontracted by Cannon Corporation to assist with the Recycled Water Injection Study, which is Task 1 of the WRRP. CHG previously assisted with the regional evaluation of recycled water injection, including the development of a three-dimensional numerical groundwater flow model. The flow model, which was Phase 1A of the Santa Maria Groundwater Basin model under the RGSP, has been used for the current study. A Phase 1B flow model is in development by others, and will provide expanded regional coverage. This report presents the findings of the Recycled Water Injection Well Study.

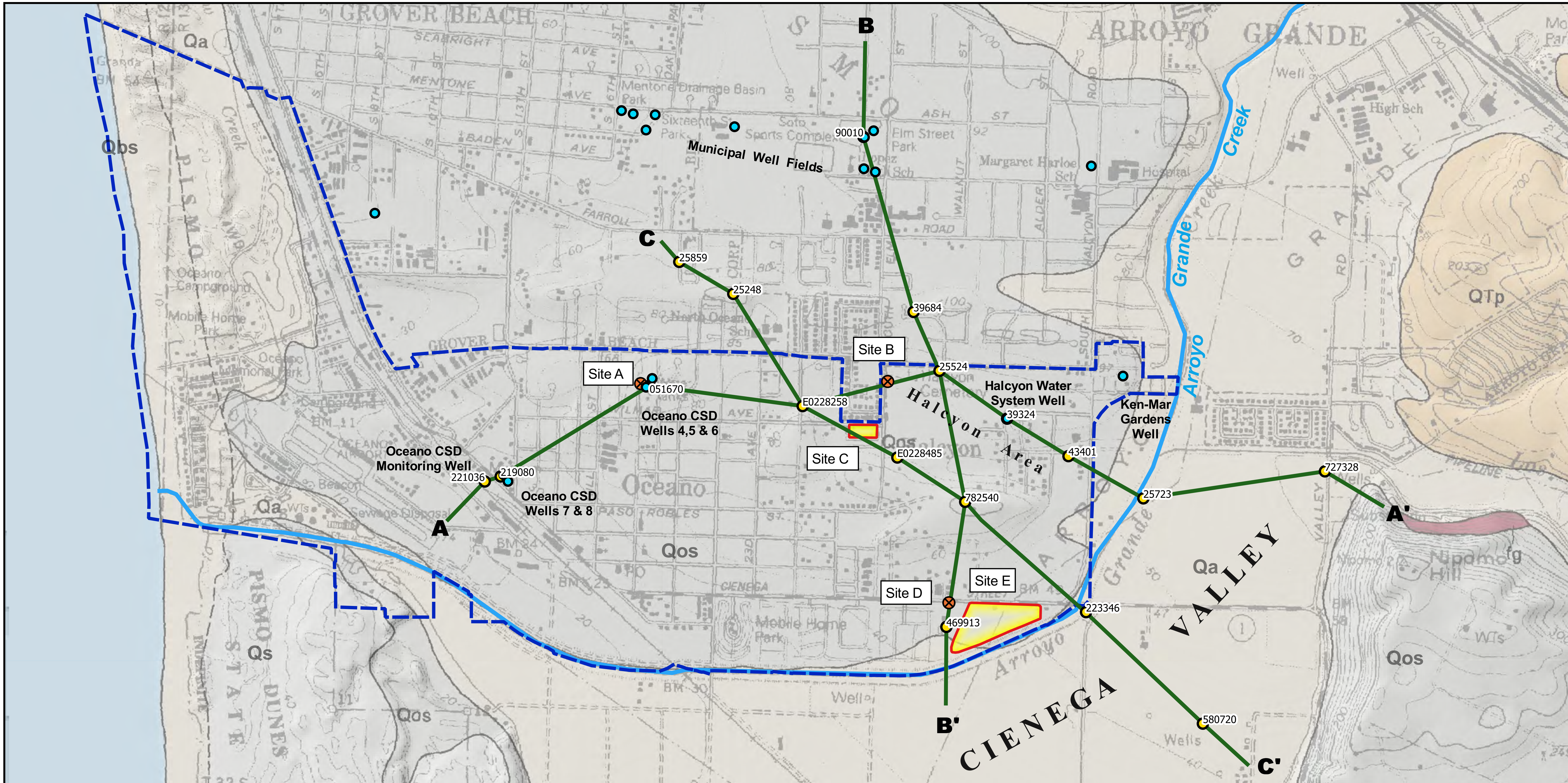
Three sites were originally identified by OCSD for GRRP consideration: OCSD Water Yard, Halcyon Area, and Arroyo Grande Creek Area. The OCSD Water Yard was evaluated for an injection well. The Halcyon Area was evaluated for both an injection well and a recharge basin (using an existing basin immediately adjacent to the Halcyon Area). The Arroyo Grande Creek Area was also evaluated for both an injection well and a recharge basin, resulting in a total of five sites being evaluated for the Recycled Water Injection Well Study (Figure 1).

2.0 REVIEW OF PRIOR WORK

Several recycled water projects and studies have been performed over the last decade in the Northern Cities Management Area (NCMA) of the Santa Maria Valley Groundwater Basin. Recent studies with information pertinent to the Recycled Water Injection Study are summarized below.

2.1 Regional Recycled Water Strategic Plan (November 2014)

Cannon Corporation produced the San Luis Obispo County Regional Recycled Water Strategic Plan (RRWSP) for the County of San Luis Obispo. This plan was an update to the IRWM



Explanation

- Cross-section Wells
- Public Supply Wells
- Cross Sections
- OCSD Boundary
- GRRP Basin Sites
- GRRP Injection Well Sites

Geology

- Qa - Alluvium
- QTp - Paso Robles Formation
- fg - Franciscan Assemblage
- Qs - Dune Sand
- Qbs - Beach Sand
- Qos - Older Dune Sand

Basemap: Dibblee, T.W. Geologic map of the Oceano quadrangle, San Luis Obispo County, California

0 1250 2500 3750 ft

NORTH

Coordinate System: State Plane California Zone V
Vertical Datum: NAD 1983

Figure 1
Area Geology and GRRP Sites
Recycled Water Injection Well Study
Oceano CSD / Cannon

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Program, with the Northern Cities area being one of the four study areas covered. Northern Cities stakeholders include Arroyo Grande, Grover Beach, Pismo Beach, OCSD, and South San Luis Obispo County Sanitation District (SSLOCSD). The RRWSP included a review of recycled water studies and compilation of technical data and costs from the various reports, which were used to compare cost and benefit for a wide range of recycled project concepts. Other evaluation criteria besides costs were discussed for projects, including regulatory and design criteria, reliability, drought resistance, and public acceptance.

2.2 Recycled Water Facilities Planning Study (April 2015)

Water Systems Consulting (WSC) completed the Recycled Water Facilities Planning Study (RWFPS) for the City of Pismo Beach, and estimated that approximately 930 acre-feet per year (AFY) of recycled water was available for groundwater recharge from the City of Pismo Beach's wastewater treatment plant. The estimated 930 AFY of recycled water was based on the average effluent flows after an advanced treatment process that included Microfiltration/Ultra-Filtration, Reverse Osmosis and Ultraviolet/Advanced Oxidation. The RWFPS focused on use of the recycled water to benefit the City of Pismo Beach and the other Northern Cities Management Area (NCMA) agencies, including OCSD.

CHG prepared a Preliminary Hydrogeologic Assessment as part of the evaluation of groundwater recharge options for the RWFPS, and concluded that injection wells were the most effective method of using recycled water for recharging the groundwater basin to prevent seawater intrusion and increase groundwater yield within the project area. The Preliminary Hydrogeologic Assessment also developed conceptual design criteria for both inland and coastal injection wells. It was estimated that a minimum setback of 200 feet is required to achieve a minimum 8-month subsurface residency time for recycled water between injection wells and pumping wells.

For inland injection, each well was assumed to be capable of injecting 200-300 AFY based on the transmissivity of the aquifers. The wells would be designed to inject into the main aquifer zones with total depths ranging from 400-600 feet. The total available injection capacity in the area where the municipal/public water supply wells are located was estimated at 1,000 to 1,500 AFY, assuming active municipal pumping of similar quantities to regulate groundwater pressure heads. An estimated 75 percent of the water injected could be recovered by municipal wells for beneficial use.

For coastal injection, the wells would be designed to pump into the aquifer zones which have exhibited seawater intrusion. A steady state groundwater flow model was constructed to conduct preliminary analysis for the seawater intrusion barrier wells. Based on model results, it was determined that three (3) injections wells at 4,000-foot spacing would be sufficient to create a seawater intrusion barrier by injecting a combined 350 AFY. Up to an estimated 1,100 AFY of injection capacity would be possible with coastal injection, assuming active pumping at the nearest municipal wells of at least 800 AFY to regulate groundwater pressure heads. An estimated 70 percent of the water injected could be recovered by municipal wells for beneficial use.

Two monitoring wells were included with each injection well to satisfy Groundwater Recharge Regulations. Monitoring wells would be equipped with water level and water quality monitoring equipment. Maintenance of the injection wells would involve monitoring injection pressures, frequent inspections and clean out of the well casings, including removing microbial build-up once every two years.

2.3 Santa Maria Groundwater Basin Characterization (December 2015)

The Santa Maria Groundwater Basin Characterization (SMGBC) study was prepared by Fugro Consultants for the County of San Luis Obispo. The study compiled a well log database, characterized the hydrogeologic framework with well log cross sections, and determined the hydrogeologic parameters for the San Luis Obispo County portion of the Santa Maria Groundwater Basin. This study described enhanced recharge options and stated that the highly permeable Paso Robles Formation/alluvium aquifers would be preferred over the less permeable Careaga Formation in the Tri-Cities Mesa aquifers as a target for injection of water. Recharge basins were also not considered favorable in the southern portion of the Tri-Cities Mesa area due to the presence of clay layers.

The study addressed the offshore geology and seawater intrusion, stating that there was limited offshore geologic information, that there were no documented offshore geologic features restricting groundwater flow, that the groundwater-bearing geologic formations extend several miles offshore, and that the current drought has not resulted in seawater intrusion.

2.4 Groundwater Flow Analysis (February 2017)

CHG prepared the Groundwater Flow Analysis, Regional Groundwater Sustainability Project, Arroyo Grande/Tri-cities Mesa Area report for the City of Pismo Beach and Water Systems Consulting. The analysis consisted of development of a numerical flow model which was used to evaluate recycled water injection scenarios. The conceptual model defined during model development identified three potential target aquifers for injection, two within the Paso Robles Formation, with the third being the Careaga Formation. Two injection well field configurations, one linear and the other an alternative "tee" layout, were evaluated to investigate the potential for protecting the groundwater basin from seawater intrusion and improve water supply reliability. A dispersed well field option was initially considered but was found to have significantly increased monitoring requirements.

The linear well layout consisted of five coastal wells injecting into either the Paso Robles or Careaga aquifer zones. The alternative "tee" layout investigated the effects of coastal and inland injection, with three coastal wells and two inland wells injecting into a combination of Paso Robles and Careaga Formation aquifers. A fixed recycled water supply of 1,000 AFY was assumed for injection, and paired with municipal pumping scenarios ranging from Baseline pumping (2,338 AFY) to full Allocation pumping (4,000 AFY). The direction of groundwater flow across the shoreline boundary was used to evaluate seawater intrusion potential, while a water balance was used to evaluate changes in groundwater storage and sustainable yield. Particle tracking was used to evaluate subsurface travel time distances.

Results of the Groundwater Flow Analysis indicated Baseline pumping with no injection creates conditions for seawater intrusion. Both coastal and "tee" injection well scenarios provide protection against intrusion under Baseline pumping, with no depletion of groundwater storage. Paso Robles Formation injection scenarios achieve seawater intrusion mitigation results similar to scenarios using Careaga Formation injection. When production is increased to Allocation pumping, the coastal injection well layout maintains protection against intrusion, but full Allocation pumping is not sustainable due to depletion of groundwater in storage inland of the coast. Municipal purveyor production with 1,000 AFY linear injection could increase by an estimated 1,300 AFY over Baseline pumping without seawater intrusion or storage depletions.

Average groundwater flow velocity moving away from injection well sites was estimated using the model at 60 feet per year in the Careaga Formation and 140 feet per year in the Paso Robles Formation. Travel time from injection wells to proximate municipal pumping wells was more than two years for all analyzed injection scenarios.

2.5 Recycled Water Facilities Planning Study (June 2017)

The Recycled Water Facilities Planning Study was prepared by Water Systems Consulting for the SSLOCSD and the City of Arroyo Grande. The study was performed for RGSP/Central Coast Blue and analyzes recycled water projects using the combined flows of the SSLOCSD and the City of Pismo Beach Wastewater Treatment Plant (Pismo WWTP).

Wastewater currently discharged to the ocean from the SSLOCSD facility and the Pismo WWTP will require advanced water purification for groundwater recharge through recycled water injection. The study evaluated two alternatives for siting an Advanced Treatment Plant (ATP) for recycled water, one located onsite (SSLOCSD facilities) and the other located off-site. A hybrid approach of groundwater recharge using injection wells and direct agricultural reuse was also considered for both ATP site alternatives. The project alternatives were further divided into two phases, with Phase 1 being the ATP for Pismo WWTP flows and Phase 2 the full capacity APT for both Pismo and SSLOCSD flows.

The alternatives were ranked for qualitative components and for quantitative costs. Qualitative components included 10 categories, with each alternative/hybrid option receiving a high (3), medium (2), or low (1) score, which were then weighted and summed to provide numerical rankings. Estimated costs for the infrastructure, operations and maintenance, and financing of the alternatives were reduced to a unit cost per acre-foot of ATP recycled water, both before and after injection. The alternatives were not evaluated solely upon their qualitative or quantitative scores, but were evaluated based on both findings. The study selected the onsite ATP as the preferred alternative, based on a lower unit cost for recycled water and input from RGSP/Central Coast Blue stakeholders.

3.0 EVALUATION CRITERIA

Evaluation criteria selected for Oceano groundwater recharge sites, whether through injection wells or percolation basins, include hydrogeologic and engineering/planning criteria, as discussed below.

3.1 Hydrogeologic Evaluation Criteria

Hydrogeologic evaluation criteria are associated with subsurface conditions and sustainable basin management. Specific criteria considered for this study include:

- Recharge capacity
- Travel time
- Sustainable yield benefit
- Seawater intrusion mitigation
- Water quality benefit
- Environmental benefit/Impact

<u>Recharge Capacity</u>

Recharge capacity is the estimated amount of recycled water that could be injected or percolated into the ground at a site. Screening level parameters for evaluating recharge capacity include the specific capacity of existing wells and groundwater mounding potential beneath recharge basins. These parameters constrain the ability of facilities to put recycled water into the ground.

Specific capacity is a measure of well-specific aquifer characteristics, and is typically reported in gallons per minute per foot of water level drawdown (gpm/ft). Specific capacity can vary significantly at a well based on the aquifer transmissivity, pumping rate and duration of pumping. Specific injectivity, also referred to as injectivity index, is a similar measure used for injection wells and is represented by the injection rate per change in receiving reservoir pressure.

Low-pressure injection is assumed for sizing groundwater recharge facilities. The capacity of an injection well is based on its ability to receive water under atmospheric pressure with the injected water level maintained at ground surface. This capacity would then be maintained throughout a service cycle by increasing delivery pressure (if necessary) until a predetermined system pressure is reached, after which a backflush cleaning can be performed.

Groundwater mounding potential has been evaluated using a MODFLOW numerical flow model developed for each recharge basin site (Harbaugh, 2005). The groundwater mounding analysis incorporates shallow clay layers which are not included in the Phase 1A model. The recharge capacity of a basin is constrained by the allowable height of the groundwater mound developed on these shallow clay horizons.

Travel Time

Subsurface residency requirements for indirect potable reuse, or the "response retention time", for recycled water is 2 months using an added tracer, 4 months using a calibrated numerical flow model, or 8 months for calculations using analytical method such as Darcy's Law (Title 22 CCR, Section 60320.224). The minimum setback from other wells to meet "response retention time" has been estimated for each site using particle tracking in the numerical flow model and is conservatively based on 8 months travel time from the injection well. Travel time is considered when locating monitoring wells sites, but it is not used as an evaluation criteria for ranking Oceano GRRP sites.

Sustainable Yield Benefit

The sustainable yield benefit is a hydrogeologic criteria that evaluates the relative benefit from GRRP activities to the yields of wells in various defined areas. A water balance from the Phase 1A model, based on GRRP operation over an 8-year balanced hydrologic period, has been used to compare groundwater inflows and outflows, with the net difference equal to the estimated change in groundwater storage.

Seawater Intrusion Mitigation

The Groundwater Flow Analysis (CHG, 2017) included an estimate of seawater intrusion potential using an Equivalent Freshwater Head (EFH) boundary at the coastline in the Phase 1A flow model. The EFH approach is based on the Ghyben-Herzberg relation, which states that for every foot of fresh water above sea level, the seawater/fresh water interface will be displaced 40 feet below sea level (Freeze and Cherry, 1979). By setting the ocean boundary at the EFH required to displace seawater from the aquifer, the direction of flow across the boundary can be used as a indicator of seawater intrusion potential.

The RSGP/Central Coast Blue project involves a regional strategy that includes multiple injection well sites, whereas only a few GRRP sites are being evaluating herein for the WRRP. The regional well field design is expected to be refined using the Phase 1B model currently under development, and well field layout may also be adjusted following a pilot program of injection well construction and testing. Seawater intrusion mitigation for the Oceano GRRP sites has been ranked based on a comparison of groundwater flow across ocean boundary when adding each injection well site to the linear array coastal injection wells in the Phase 1A model.

Prior investigations have shown historical evidence of seawater intrusion in Paso Robles Formation aquifers along the coast near Oceano during 2009-2010, with no indication of intrusion in wells screened in the underlying Careaga Formation (GSI, 2018). Phase 1A model results indicated Paso Robles Formation injection scenarios achieve seawater intrusion mitigation results similar to scenarios using Careaga Formation injection. Therefore, coastal linear injection into the Paso Robles Formation is the baseline scenario used to evaluate seawater intrusion mitigation for the WRRP.

Water Quality Benefit

Effluent water quality may differ between sources (SSLOCSD versus Pismo WWTP), but the recycled water quality from the Advanced Treatment Plant (ATP) should be the same from one injection site to another, therefore, no significant differences in water quality deliveries to injection sites is anticipated. Recycled water quality for recharge basins may include a blend of disinfected tertiary treated wastewater with a diluent water (such as ATP water or municipal supply water) per Recycled Water Criteria, and prior comparison of potential water quality benefit ranked injection wells above recharge basins (WSC, 2017).

Water quality benefit for this study considers the receiving water quality at each Oceano GRRP location. The water quality benefit is ranked based on differences between the recharge source water and the receiving water, with a greater difference providing a greater benefit.

Environmental Benefit/Impact

Arroyo Grande Creek is a losing stream between Highway 101 and the 22nd Street Bridge, and then becomes a gaining stream as it nears the ocean. The reach with highest infiltration rate is between the Fred Grieb Bridge (Fair Oaks Avenue) and the Highway 1 Bridge, based on flow measurements from June 1984 (Todd, 2007; Hoover, 1985).

Potential juvenile habitat for red-legged frog was identified during a 1999 survey for the reach downstream of the Arroyo Grande Creek confluence with Los Berros Creek through the 22nd Street Bridge. Portions of the Arroyo Grande stream channel downstream of the 22nd Street bridge also have potential breeding, tadpole, and juvenile rearing habitat for red-legged frog, if water levels were sufficient and remained long enough. There is usually permanent surface water at the 22nd Street bridge, but areas downstream of Highway 1 generally go dry during the summer (Stetson, 2004).

There is a potential for environmental benefit from GRRP operations with respect to stream flow in Arroyo Grande Creek. A GRRP location near Arroyo Grande Creek could provide local recharge to replenish groundwater in storage, reducing the higher stream seepage rates beneath Arroyo Grande Creek and increasing surface flow.

There is also a potential for adverse environmental impacts resulting from GRRP operations, such as increased flooding and liquefaction potential. An Environmental Impacts Report is being planned that would evaluate regional and specific project configurations and impact thresholds. Relative impacts of flooding and liquefaction potential are considered for this study.

3.2 Engineering and Cost Evaluation Criteria

Engineering and Cost evaluation criteria are associated with infrastructure, operations and maintenance (O&M), land acquisition, and regulations. The RGSP/Central Coast Blue project is considered a GRRP under Title 22 CCR, Section 60301.390. Specific engineering and cost evaluation criteria considered for this study include:

- Facility requirements/constructability
- Recharge source distribution
- Operations and maintenance
- Land acquisition requirements
- Permitting Requirements

<u>Facility requirements/constructability</u>

Injection well sites require sufficient area for access during construction, operations, and maintenance. For injection or monitoring well construction, an area of 40 feet by 80 feet would be appropriate. For the completed injection well, an area of 15 feet by 25 feet would be sufficient for the well head facilities enclosure, with additional adjacent area for accessing the well during maintenance. Vehicle access to monitoring well locations should also be available. Electric power service is needed at injection well sites for telemetry and flow controls, and a sewer connection or detention basin is recommended for discharging backwash during well cleaning.

Recharge basin facilities require much greater areas than injection well sites. Both injection wells and recharge basins are GRRP sites covered by the Recycled Water Criteria. A minimum of two groundwater monitoring wells are required hydraulically downgradient of a GRRP location such that at least one well is located no less than 2 weeks but no more than 6 months of travel through the saturated zone affected by the GRRP, and at least 30 days upgradient of the nearest drinking water well. In addition, at least one monitoring well will be located between the GRRP and the nearest hydraulically downgradient drinking water well (Title 22 CCR, Section 60320.126). Additional monitoring wells would be required where groundwater recharge or future municipal pumping results in significant changes to the existing hydraulic gradient.

Facility requirements/constructability criteria will evaluate sites based on ability to provide the minimum area requirements for construction and O&M, and on the feasibility of monitoring well constructions within the required parameters.

<u>Recharge Source Distribution</u>

The distance along public right-of-way from the ATP to the Oceano GRRP sites was estimated for pipeline costing. The assumed location of the ATP is at the existing SSLOCSD property. The pipeline supplying ATP recycled water to injection wells is assumed to be independent from the pipeline delivering recycled water to recharge basins, where 100 percent advanced treatment is not required. Pipeline sizing would depend on projected flow rates, and whether there are other facilities that will be receiving recycled water deliveries. For the site evaluations, pipeline sizing and costing assumes each site is independent and operating at its maximum capacity.

Operations and Maintenance Requirements

Injection pressures would be expected to range from atmospheric pressure up to 10 pounds per square inch (psi) during operation. Start-up procedures and flow controls would be designed to avoid air-entrainment from cascading water within the well casing, which can lead to injection zone plugging. Other sources of plugging typically include slime-forming bacteria and particle deposition (Bouwer et al, 2008).

Maintenance of injection wells would involve monitoring injection pressures with frequent inspections and cleanings. Full well rehabilitation may be required every few years. Routine backwashing is beneficial to remove particle and scale plugging. The backwashing schedule would be developed through monitoring specific (injection) capacity declines at the specific site. Maintenance schedules vary between injection wells, depending on the method used, well construction, water levels, and well performance.

Recharge basin operations may vary between the existing basin (S. Elm Street) and a new GRRP basin (Highway 1). The Elm Street basin is an existing stormwater detention facility, and would need to continue to provide seasonal flood control protection. The GRRP-specific recharge basin along Highway 1 could be managed exclusively for recharge operations. Periodic cleaning would be needed at both recharge basins, based on the degree of plugging experienced. Site evaluations include the estimated costs for O&M.

Land Acquisition Requirements

Land acquisition criteria evaluate the overall cost of acquiring property for each GPPR location. Many of the monitoring wells are assumed to be positioned on existing public parcels or right-of-way and would not require separate land acquisition.

Permitting Requirements

Some of the permitting requirements are incorporated into the site evaluations, but are not a separate evaluation criteria. GRRP requirements for recycled water treatment, monitoring wells, and response retention time are included in Recycled Water Criteria (CCR Title 22, Division 4, Chapter 3). The GRRP regulations apply to all sites, although the requirements for injection wells are not the same as for recharge basins.

Unless highly purified water from the ATP is used exclusively, Recycled Water Criteria for surface recharge basins place initial limits of no more than 20 percent disinfected tertiary treated wastewater for GRRP operations. The other source of recharge water (diluent water) may be municipal supply water or a source meeting additional water quality criteria.

4.0 INJECTION WELL/RECHARGE BASIN SITE EVALUATIONS

Five sites have been evaluated for RGSP/Central Coast Blue use as either an injection well (three sites) or recharge basin (two sites), as follows:

- Site A - OCSD Water Yard Injection
- Site B - South Elm Street Injection
- Site C - South Elm Street Basin
- Site D - Arroyo Grande Creek Area Injection
- Site E - Arroyo Grande Creek Area Basin

4.1 Geologic Cross-Sections

The Oceano GRRP sites are shown in Figure 1, along with area geology. Geologic cross-sections through the sites are shown in Figures 2, 3, and 4. The WRRP project area is within the Northern Cities Management Area of the Santa Maria Valley Groundwater Basin (Department of Water Resources Basin 3-12).

Most of the sites evaluated for GRRP overlie older (late Pleistocene) dune sands, with Site E interpreted from soil maps to overlie Arroyo Grande Creek alluvial deposits (Appendix A). The older dune sands range from approximately 20 to 80 feet thick, and are mostly unsaturated. Arroyo Grande Creek alluvial deposits reach up to 100 feet thick and are mostly saturated. Beneath the older dune sands and alluvial deposits are sand and gravel aquifers of the Paso Robles Formation, with interbedded clay units. The Paso Robles Formation deposits reach up to approximately 250 feet thick on the north and west ends of the cross-sections, becoming less than 100 feet thick approaching the alluvial creek valley. Beneath the Paso Robles Formation are marine sandstones of the Careaga Formation, which are generally 300 to 400 feet thick and often include sea shells. The base of permeable sediments is drawn at the base of the Careaga Formation, and is generally rising to the east and southeast beneath the Oceano GRRP sites (Figures 2, 3, and 4).

4.2 Recharge Capacity

Recharge capacity is the estimated amount of recycled water that can be injected or percolated into the ground at a site. Table 1 presents a summary of the recharge capacities for each site. Details for each site are discussed separately below.

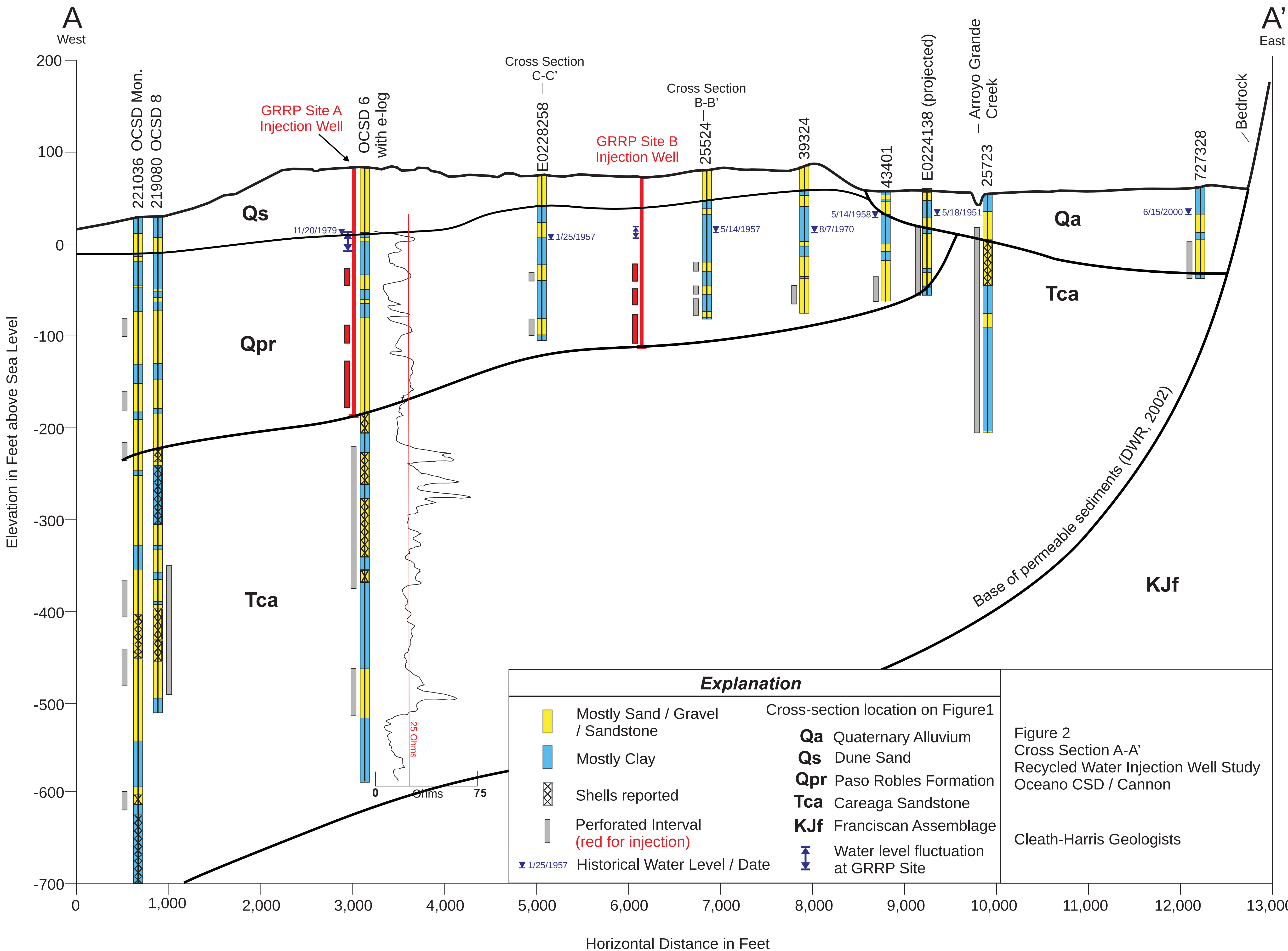
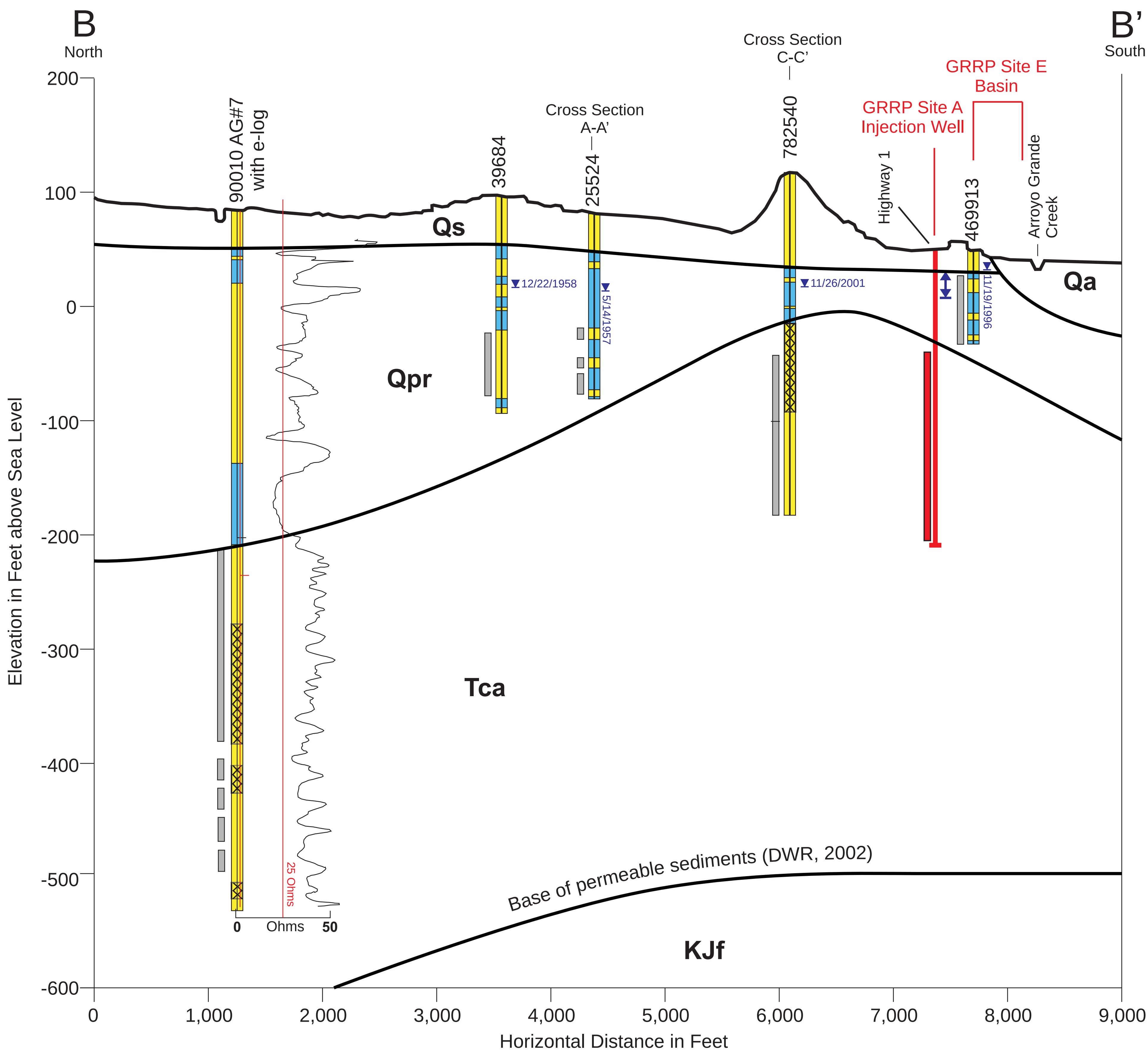


Figure 2
Cross Section A-A'
Recycled Water Injection Well Study
Oceano CSD / Cannon



Explanation

Mostly Sand / Gravel / Sandstone

Mostly Clay

Shells reported

Perforated Interval (red for injection)

11/26/2001 Historical Water Level / Date

Cross-section location on Figure1

Qa Quaternary Alluvium

Qs Dune Sand

Qpr Paso Robles Formation

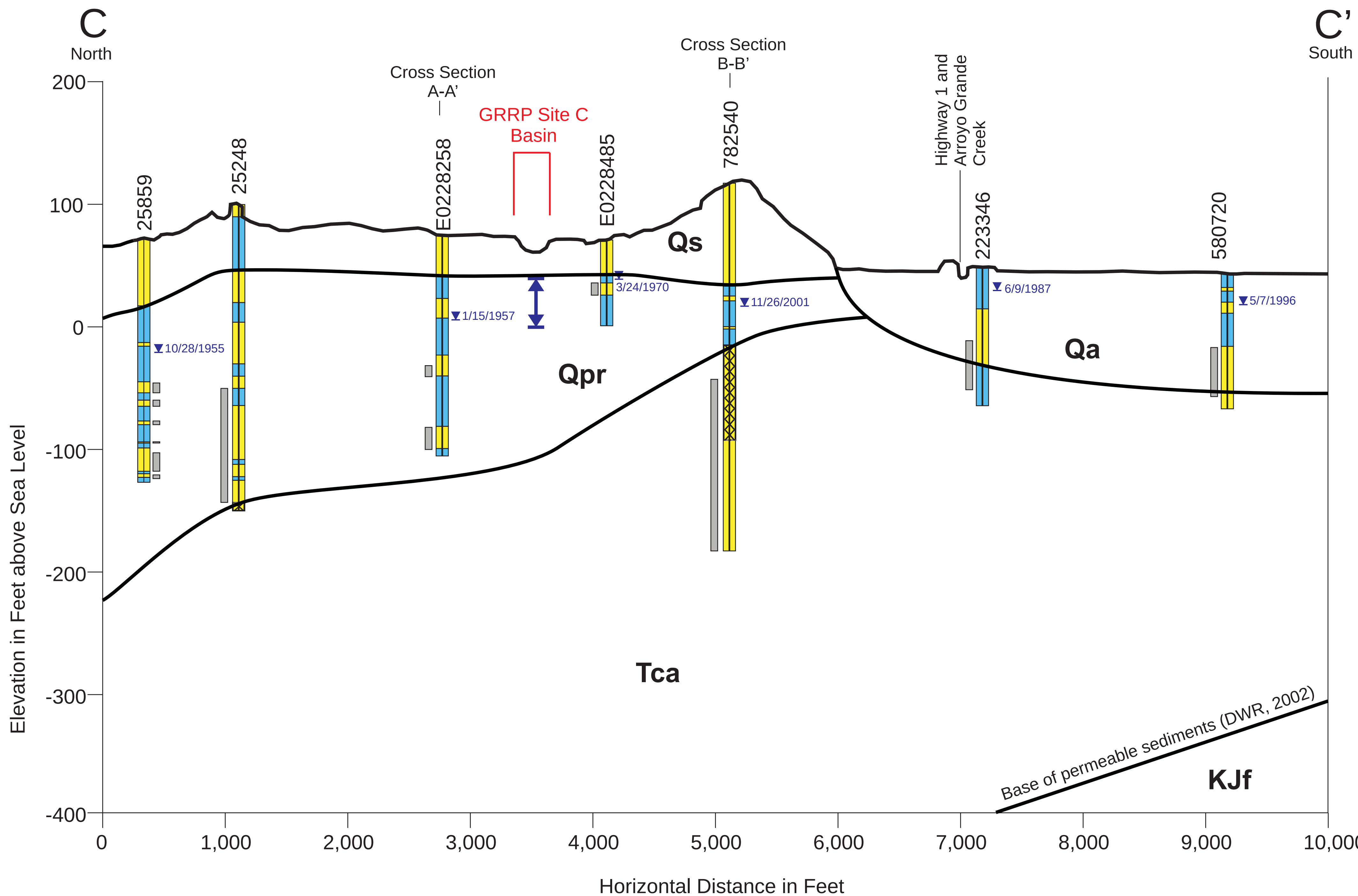
Tca Careaga Sandstone

KJf Franciscan Assemblage

Water level fluctuation at GRRP Site

Figure 3
Cross Section B-B'
Recycled Water Injection Well Study
Oceano CSD / Cannon

Cleath-Harris Geologists



Explanation

- Mostly Sand / Gravel / Sandstone
- Mostly Clay
- Shells reported
- Perforated Interval
- 1/25/1957 Historical Water Level / Date

Cross-section location on Figure1

- **Qa** Quaternary Alluvium
- **Qs** Dune Sand
- **Qpr** Paso Robles Formation
- **Tca** Careaga Sandstone
- **KJf** Franciscan Assemblage
- Water level fluctuation at GRRP Site

Figure 4
Cross Section C-C'
Recycled Water Injection Well Study
Oceano CSD / Cannon

Cleath-Harris Geologists

Table 1 - Estimated Site Recharge Capacities

Site ID	Description	Aquifer	Estimated Recharge Capacity (AFY)	Ranking (1 = highest)
Site A	Water Yard Injection	Paso Robles	700	1
		Careaga	140	none[1]
Site B	S. Elm Street Injection	Paso Robles	340	2
Site C	S. Elm Street Basin	Paso Robles	150[2]	3
Site D	Arroyo Grande Creek Area Injection	Careaga	70	5
Site E	Arroyo Grande Creek Area Basin	Alluvium/Paso Robles	110[3]	4

NOTES:

AFY = acre-feet per year

[1] Careaga injection at Site A not used for benefits analysis due to reduced capacity compared to Paso Robles injection at same site.

[2] Estimated total recharge capacity of 200 AFY reduced by 50 AFY for flood control.

[3] Maximum estimated capacity with 9 acres of basin area

4.1.1 Site A - OCSD Water Yard

The OCSD Water Yard (Water Yard) is located on 19th Street between Wilmar Avenue and The Pike (Figure 5). The parcel (APN 062-261-080) is 170 feet deep with 200 feet of 19th Street frontage. There are three existing wells (Wells 4, 5, and 6) and one destroyed well (Well 3) at the site. Wells 4 and 5 are completed in the Paso Robles Formation, and Well 6 is completed in the Careaga Formation.

The Water Yard site has been evaluated for an injection well. The existing supply wells may be destroyed, used for Aquifer Storage and Recovery, or used for monitoring purposes. Aquifers present beneath the site include the Paso Robles Formation and Careaga Formation (Figure 2).

Water Levels

Semi-annual water level records are available at Well 4 since 1965 and at Well 6 since 1979. Water level fluctuations at Well 4 (Paso Robles Formation) between 1965 and 2015 ranged from approximately 67 to 93 feet depth (averaging 77 feet depth), or between 17 feet and -8 feet above sea level (averaging 8 feet above sea level). Water level fluctuations at Well 6 (Careaga Formation) range from approximately 65 to 94 feet depth (averaging 79 feet deep), or 21 to -8 feet above sea level (averaging 8 feet above sea level). Reservoir pressures (groundwater elevations) for injection purposes are similar between the two formations. The general direction of groundwater flow appears to be to the southwest during the fall, and variable (southeast to southwest) during the spring based on water level contour maps for a drought year (2015) and a wet year (2017) shown in Appendix B.

Explanation

- Injection Well Location
- Public Supply Well
- Monitoring Well
- GRRP Site Parcel Boundary
- Construction Area
- Injection Facilities Area

0 25 50 75 100 ft

NORTH

Coordinate System: State Plane California Zone V
Vertical Datum: NAD 1983

Figure 5
Site A - Water Yard Injection
Recycled Water Injection Well Study
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Recharge Capacity

The specific capacity of Well #4 (Paso Robles Formation) during the first five years of production (1952-1957) ranged between 6.8 and 29 gpm/ft, averaging 15 gpm/ft. By comparison, the specific capacity of Well 6 (Careaga Formation) following construction was 3 gpm/ft; there is significantly greater specific capacity (and anticipated injectivity potential) in the Paso Robles Formation, compared to the Careaga Formation.

Assuming a 15 gpm/ft injectivity index with 77 feet added pressure head during injection, there would potentially be up to 1.66 million gallons per day (mgd) recharge capacity into the Paso Robles Formation at the Water Yard, compared to 0.33 mgd injection capacity into the Careaga Formation. These rates are maximum daily injection capacity and not likely to be sustainable over time. There are operational considerations and uncertainty in projecting long term performance based on short-term pumping tests. For planning purposes, the maximum injection rate has been reduced by 50 percent to account for uncertainty (a 2:1 safety factor), along with an additional 25 percent reduction for O&M (includes declines in injection capacity due to plugging between maintenance events). The resulting sustainable recharge capacity for the Paso Robles Formation at Site A, provided regional pumping manages basin storage, is 0.62 mgd, or approximately 700 AFY. Recharge capacity for injection into the Careaga Formation at Site A, by comparison, is estimated at 140 AFY.

4.1.2 Site B - South Elm Street Injection

The South Elm Street Injection site (Site B) is located on the east side of South Elm Street, approximately 250 feet south of The Pike (Figure 6). A nominal 40-foot x 80-foot area adjacent to County right-of-way would provide enough room for injection well construction and operation. The underlying parcel (APN 062-261-080) is approximately 3 acres, with 300 feet of South Elm Street frontage, and includes agriculture and the Halcyon Cemetery. The closest active well is approximately 800 feet east-northeast and was drilled as an irrigation well, but may also serve domestic uses. The Halcyon Water Company supply well is 1,500 feet east-southeast of Site B (Figure 1).

Site B was selected as the Halcyon area site for injection well evaluation. As shown in the geologic cross-sections (Figures 2, 3, and 4), the base of the Paso Robles Formation is rising toward the southeast. Site B, located at the northwest corner of the Halcyon area, is interpreted to overlie the deepest available sediments of the Paso Robles Formation, which would be expected to provide greater recharge capacity, compared to other areas in Halcyon.

Water Levels

Water level fluctuations at Site B, based on Fall 2015 (drought) and Spring 2017 (wet year) water level contour maps shown in Appendix B, indicate a range of approximately 12 feet to 3 feet above sea level (assume 7 feet average elevation). Assuming an approximate site elevation

Explanation

- Injection Well Location
- Monitoring Well
- OCSD Boundary
- GRRP Site Parcel Boundary
- Construction Area
- Injection Facilities Area

0 100 200 300 ft

NORTH

Coordinate System: State Plane California Zone V
Vertical Datum: NAD 1983

Figure 6
Site B - South Elm Street Injection
Recycled Water Injection Well Study
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of 72 feet, depth to water would average 65 feet. The general direction of groundwater flow is to the south and southwest, based on water level contour maps shown in Appendix B.

Recharge Capacity

The specific capacity of an irrigation well approximately 1,800 feet west-southwest was reported at 8.6 gpm/ft (Well E0228258, Figure 3). This well was 180 feet deep, with 27 feet of screen opposite gravel zones. A similar or greater capacity for injection at Site B is expected.

Using an 8.6 gpm/ft injectivity index with 65 feet added pressure head during injection, there would potentially be up to 0.8 mgd recharge capacity into the Paso Robles Formation at Site B. This rate is the estimated maximum daily injection capacity and not likely to be sustainable over time. There are operational considerations and uncertainty in projecting long term performance based on short-term pumping tests. For planning purposes, the maximum injection rate has been reduced by 50 percent to account for uncertainty, along with an additional 25 percent reduction for operations and maintenance. The resulting sustainable recharge capacity for the Paso Robles Formation at Site B, provided regional pumping manages basin storage, is 0.3 mgd, or approximately 340 AFY.

4.1.3 Site C - South Elm Street Basin

The South Elm Street Basin (Site C) is an existing flood control basin located on the west side of South Elm Street, approximately 800 feet south of The Pike (site detail in Figure 7). The basin is owned by the City of Arroyo Grande, but is within the OCSD service area boundary.

Site C (APN 062-074-012) is approximately 2.5 acres, although the basin footprint is closer to 1.5 acres. The basin holding capacity is listed at 5.1 acre-feet and receives stormwater runoff from a tributary watershed area of 65.7 acres, or approximately one tenth of the 640-acre Fair Oaks Drainage Watershed within the City of Arroyo Grande (City of Arroyo Grande, 2010).

The basin is underlain by permeable dune sands to an estimated depth of approximately 20-25 feet, followed by clays, sands, and gravel of the Paso Robles Formation (Cross-Section C-C', Figure 4).

Water Levels

Water level fluctuations at Site C, based on Fall 2015 (drought) and Spring 2017 (wet year) water level contour maps shown in Appendix B, indicate a range of approximately 10 feet to 0 feet above sea level. Well completion reports across Elm Street from the basin indicate that the first sand and gravel aquifer zone in the Paso Robles Formation was saturated under historical conditions (water level of approximately 40 feet above sea level). As a conservative measure, the mounding analysis assumes the shallow aquifer is saturated during basin recharge operations.

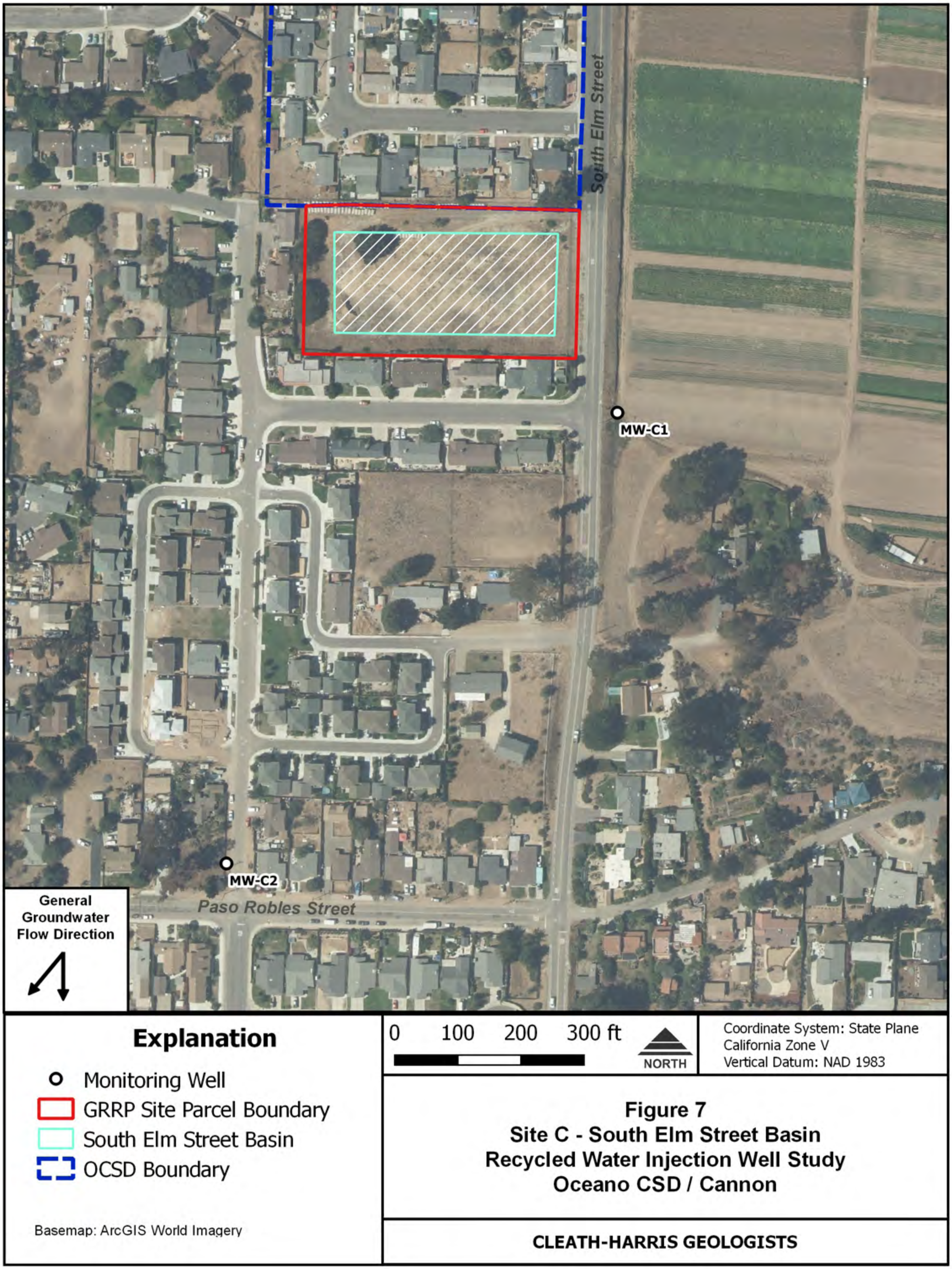

Figure 7
Site C - South Elm Street Basin
Recycled Water Injection Well Study
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Assuming an approximate basin bottom elevation of 61 feet, depth to water would average 21 feet. The general direction of groundwater flow is to the south and southwest, based on water level contour maps for a drought year (2015) and a wet year (2017) shown in Appendix B.

Recharge Capacity

A MODFLOW numerical groundwater flow model was constructed for the S. Elm Street basin to quantify the recharge capacity of the basin and the travel time distances of recycled water moving away from the basin. The local groundwater mounding model incorporates the older dune sand and shallow clay lenses interpreted to be beneath the site (cross-section B-B'; Figure 3). Hydraulic conductivity for the older dune sand (Oceano sand) is estimated at 26 feet per day (reported at 92 micrometers per second; Appendix A). The resulting capacity for the S. Elm Street basin to percolate water without the groundwater mound rising above the basin floor is 200 AFY. The initial water level assumption (21 feet depth) is 30-40 feet above the regional contoured groundwater levels and provides a safety factor.

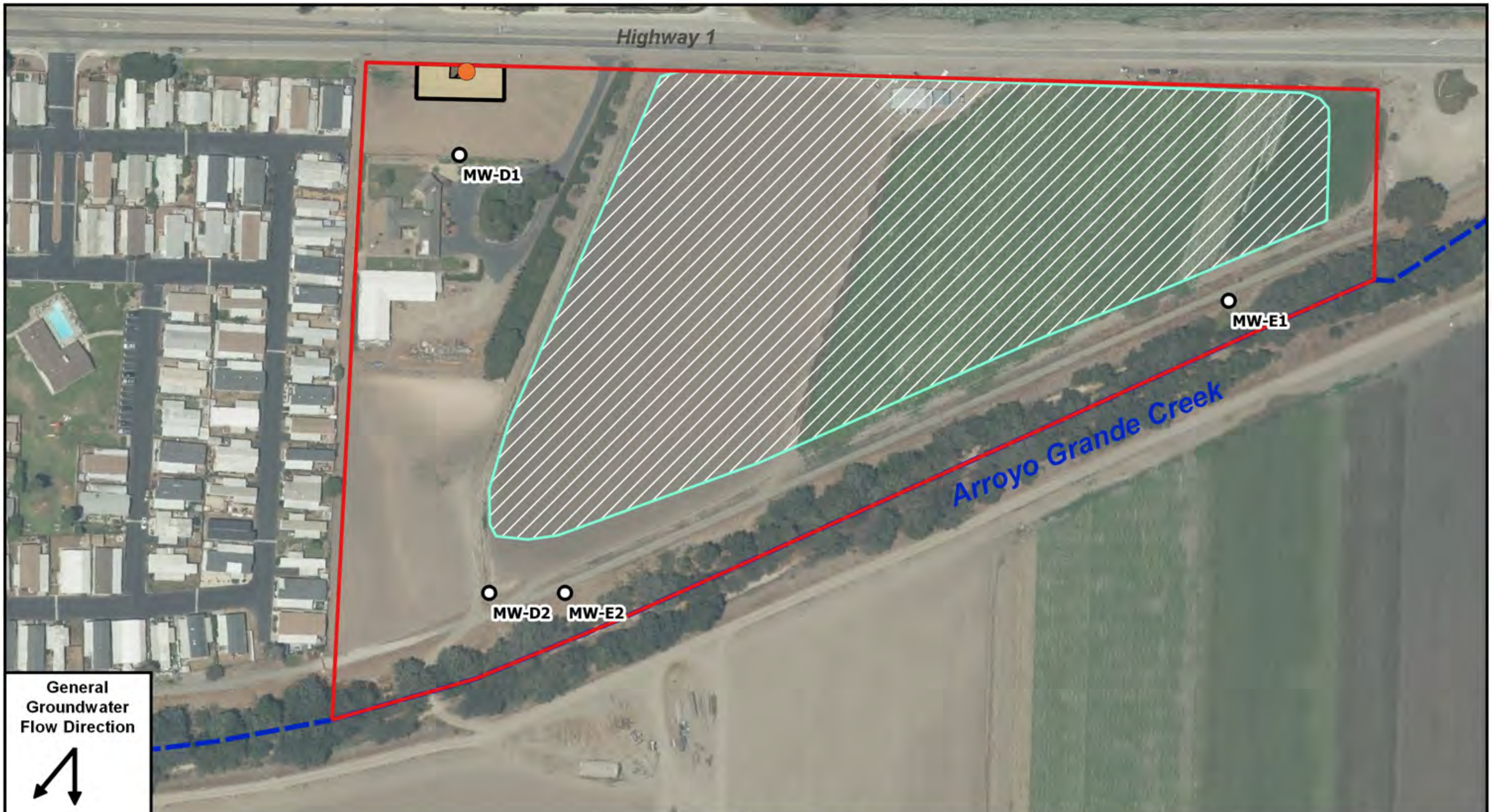
An estimate of the average annual stormwater runoff to the basin was performed using the US EPA National Stormwater Calculator (Rossman, L.A., and Bernagros, J.T., 2018). The calculator incorporates local soils, topography, precipitation, and evapotranspiration. Based on the results of the runoff evaluation, an estimated average annual runoff of 50 AFY flows into the S. Elm Street Basin (Appendix C). Therefore, to maintain flood control capacity, recharge operations would be limited to 150 AFY. No further reduction in capacity due to operations and maintenance is applied, since the flood control capacity reduction provides the equivalent of 3 months with no GRRP activities when drying/cleaning may be scheduled (weather permitting).

4.1.4 Site D - Arroyo Grande Creek Area Injection

The Arroyo Grande Creek Area Injection site (Site D) is located on the south side of Highway 1 approximately 1,500 feet west of the Halcyon Avenue intersection (Figure 8). This site lies just outside the 100-year floodpain of Arroyo Grande Creek (Appendix D) . A nominal 40-foot x 80-foot area adjacent to County right-of-way would provide enough room for injection well construction and operation. The underlying parcel (APN 075-032-011) is approximately 18.8 acres of mostly irrigated farm land, with 950 feet of Highway 1 frontage and 1,500 feet of Arroyo Grande Creek frontage. There is a residence with a domestic well on the west side of the parcel, although OCSD water service to the property is assumed under GRRP operations.

Water Levels

Water level fluctuations at Site D, based on Fall 2015 (drought) and Spring 2017 (wet year) water level contour maps shown in Appendix B, indicate a range of approximately 10 feet to -3 feet above sea level, although a higher water level of approximately 30 feet above sea level was documented in the shallow on-site well (Figure 3). Assuming an average water level in the Careaga Formation of 14 feet above sea level, and an approximate site elevation of 50 feet, depth



Explanation

- Injection Well Location
- Monitoring Well
- OCSD Boundary
- GRRP Site Parcel Boundary
- Construction Area (Site D)
- Injection Facilities Area (Site D)
- Basin (Site E)

Basemap: ArcGIS World Imagery

0 100 200 300 ft

NORTH

Coordinate System: State Plane California Zone V
Vertical Datum: NAD 1983

Figure 8
Site D Injection and Site E Basin - Arroyo Grande Creek Area
Recycled Water Injection Well Study
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to water would average 36 feet. The general direction of groundwater flow appears to be to the south and southwest (Appendix B).

Recharge Capacity

Geologic cross-section B-B' (Figure 3) and C-C' (Figure 4) shows the Careaga Formation is anticipated at depths below approximately 100 feet near Arroyo Grande Creek, and would be the target injection aquifer for Site D. Specific capacities for wells in the Careaga Formation are reported between 2.3 and 13.1 gpm/ft, although all the wells with aquifer test data for the Careaga are over a mile away from the site. For planning purposes, a specific capacity of 3 gpm/ft is assumed, similar to Well #6 at the Water Yard (the closest Careaga Formation well with test data).

Using a 3 gpm/ft injectivity index with 36 feet added pressure head during injection, there would be up to an estimated 0.16 mgd recharge capacity into the Careaga Formation at Site D. As previously discussed, this rate would likely not be sustainable over time, and represents the maximum estimated daily injection capacity. There are operational considerations and uncertainty in projecting long term performance based on short-term pumping tests. For planning purposes, the maximum injection rate has been reduced by 50 percent to account for uncertainty, along with an additional 25 percent reduction for operations and maintenance. The resulting sustainable recharge capacity for the Careaga Formation at Site D is 0.06 mgd, or approximately 70 AFY.

4.1.5 Site E - Arroyo Grande Creek Area Recharge Basin

The Arroyo Grande Creek Area recharge basin (Site E) is located in an agricultural field along Arroyo Grande Creek approximately 450 feet downstream of the Highway 1 bridge (Figure 8). The underlying parcel (APN 075-032-011; same as Site D) is approximately 18.8 acres of mostly irrigated farm land, with 950 feet of Highway 1 frontage and 1,500 feet of Arroyo Grande Creek frontage. There is a residence with a domestic well on the west side of the parcel, although OCSD water service to the property is assumed under GRRP operations.

Site E is assumed to occupy the 14-acre portion of the property currently used for farming. With setbacks from the creek and other access considerations, a total recharge basin area of 9 acres was used to evaluate recharge capacity. The basin area is underlain by sandy loam soils associated with alluvial valley deposits on top of Paso Robles Formation sediments through a combined estimated depth of 100 feet, followed by Careaga Formation sands (cross-section B-B', Figure 3).

Water Levels

Water level fluctuations at Site E, based on Fall 2015 (drought) and Spring 2017 (wet year) water level contour maps shown in Appendix B, indicate a range of approximately 10 feet to -3 feet above sea level. Higher water levels of approximately 30 feet above sea level were documented in the on-site well (Figure 3) and at a well near the intersection of Halcyon Avenue and Highway 1 (Figure 4). Site E is also within the 100-year floodplain of Arroyo Grande Creek (Appendix D). As a conservative measure, the mounding analysis uses an initial water level of 30 feet above sea level. Assuming an approximate basin bottom elevation of 40 feet, average depth to water before recharge operations would be 10 feet. The direction of groundwater flow appears variable, but generally toward pumping depressions in the Cienega Valley to the south and southwest (Appendix B).

Recharge Capacity

A MODFLOW numerical groundwater flow model with particle tracking was constructed for the Arroyo Grande Creek Area basin to quantify the recharge capacity of the basin and the travel time distances of recycled water moving away from the basin. This local groundwater mounding model incorporates the alluvial and shallow clay lenses interpreted to be beneath the site (cross-section B-B'; Figure 3). Hydraulic conductivity of the shallow alluvial deposits are estimated at 16 feet per day (reported at 59 micrometers per second, Appendix A). The resulting recharge capacity of a 9-acre basin at Site E is estimated at 110 AFY. The initial water level assumption (10 feet depth) is 20-30 feet above the contoured groundwater levels and provides a safety factor. No reduction in capacity for O&M is applied, given that the size of the site will allow for subbasin rotation and drying/cleaning without the need to stop recharge operations.

Recycled water rising into Arroyo Grande Creek was also evaluated using the mounding model, with the Creek as a drain package. The invert of Arroyo Grande Creek is approximately 8 feet below the adjacent field elevation. An estimated 60 AFY of the total recharge capacity of 110 AFY (55 percent of the recharge) is simulated to rise into Arroyo Grande Creek and would augment surface flow.

4.3 Travel Time

Particle tracking with MODPATH was used to simulate groundwater movement away from the Oceano GRRP sites during recharge operations (Pollock, 2012). The minimum setback from other wells to meet "response retention time" has been estimated for each site using particle tracking in the numerical flow model and is conservatively based on 8 months travel time from the injection well. Table 2 presents estimated distances for recycled water travel from the GRRP sites.

Table 2 - Travel Time Distances

Site ID	Description	Aquifer	Simulated distance of recycled water particle travel over 8 months (feet)
Site A	Water Yard Injection	Paso Robles	190
Site B	S. Elm Street Injection	Paso Robles	270
Site C	S. Elm Street Basin	Dune Sand	340
Site D	Creek Area Injection	Careaga	180
Site E	AG Creek Area Basin	Alluvium	300

Recycled water particles would travel an estimated 340 feet through the older dune sand over 8 months of continuous recharge at Site C, 300 feet in the shallow alluvial deposits at Site E, 190 to 270 feet in the Paso Robles Formation at Sites A and B, and 180 feet in the Careaga Formation at Site D. The simulated distances for particle movement shown in Table 2 are applicable to the area immediately surrounding the GRRP sites, where local hydraulic gradients are highest. Groundwater velocities would decline with increasing distance from the GRRP sites.

4.4 Sustainable Yield Benefit

Sustainable yield benefit has also been evaluated using the Phase 1A basin model. Each site was assigned a recharge rate of 300 AFY, regardless of actual recharge capacity, in order to rank sustainable yield benefit independent of other factors.

The water balance for the model domain was extracted for various injection scenarios and compared to the Baseline (historical) pumping scenario with linear injection. The differences in the water balance show the effects of recharge at each site. Table 4 presents the changes to the water balance from adding a 300 AFY Oceano GRRP site to the 1,000 AFY linear injection scenario from the RGSP Phase 1A Model. Locations of the general head boundaries (GHBs) and Arroyo Grande Creek reaches in the Phase 1A Model are shown in Figure 9.

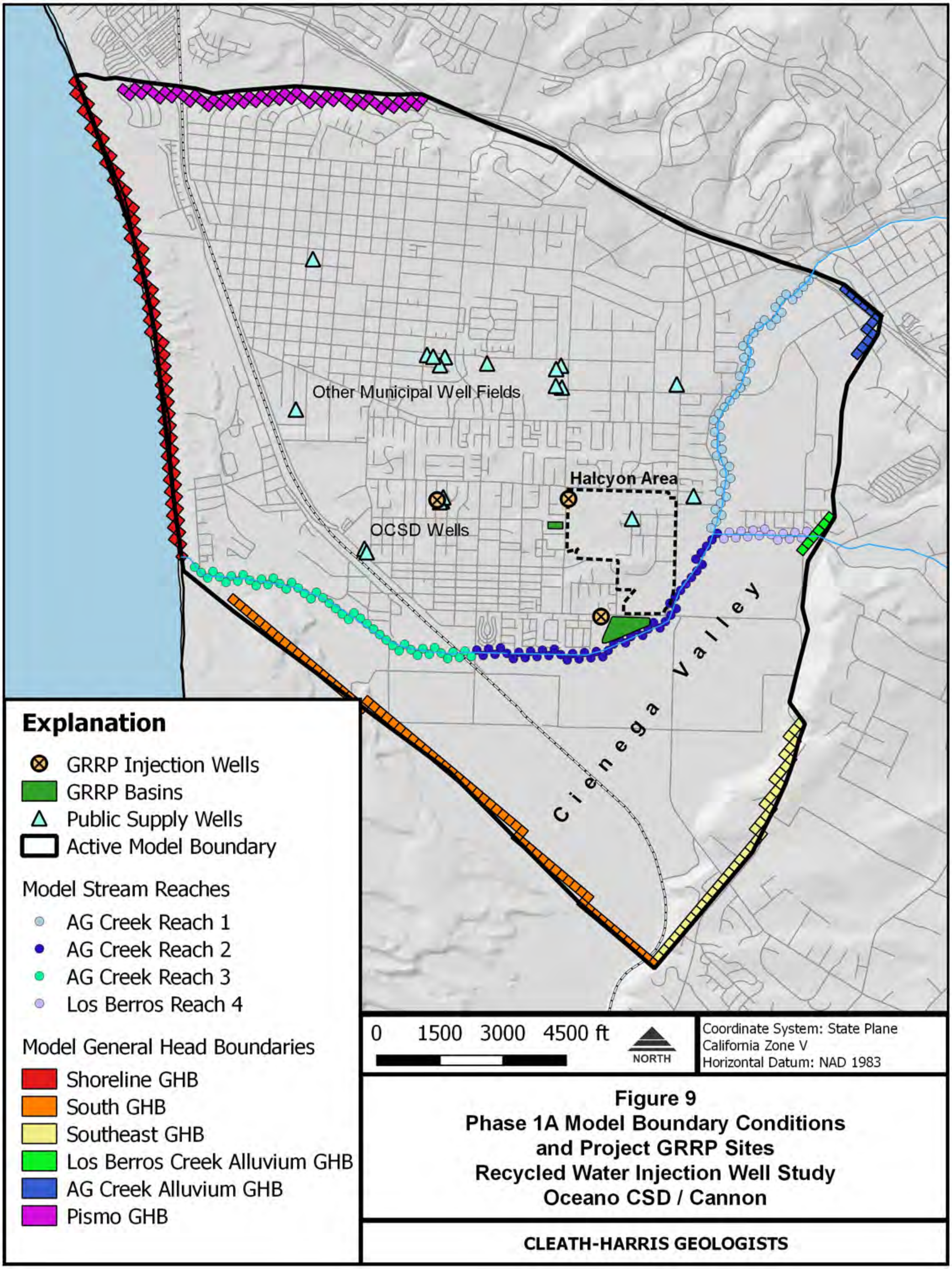

Figure 9
Phase 1A Model Boundary Conditions and Project GRRP Sites
Recycled Water Injection Well Study
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Table 3 –Changes to Water Balance from adding Oceano GRRP site

Budget Item	Changes to Water balance from adding Oceano GRRP Site to Linear Injection with Baseline Pumping Scenario (Phase 1A Model)				
	Site A	Site B	Site C	Site D	Site E
	Water Yard Injection	S. Elm Injection	S. Elm Basin	Creek Area Injection	Creek Area Basin
Municipal Wells	0	0	0	0	0
Agricultural Wells	0	0	0	0	0
Injection Wells	-300	-300	0	-300	0
Lagoon	10	6	6	3	3
Shoreline GHB (Coast)	9	6	6	4	3
Southern GHB	153	130	141	159	149
Southeast GHB	16	31	33	50	64
Los Berros Alluvium GHB	8	17	16	15	17
Arroyo Grande Creek GHB	2	5	4	3	3
Pismo GHB	40	36	31	20	16
AG Creek Reach 1	0	0	0	0	0
AG Creek Reach 2	0	0	0	0	0
AG Creek Reach 3	11	6	6	3	3
Los Berros Creek Reach 4	0	0	0	0	0
Precipitation Percolation	0	0	0	0	0
Basins	0	0	-300	0	-300
Storage	50	63	58	43	42
Net	0	0	0	0	0

All numbers are in acre-ft/year, GHB= General Head Boundary
A positive value represents increased flow out of the model domain into the respective budget item after adding the Oceano GRRP site
Water balance is for 8-year balanced hydrologic period in Phase 1A model

Less than 5 percent of the increased recharge to groundwater is simulated in the water balance to exit through the Shoreline boundary (coast), indicating a high potential for overall recharge recovery and increased sustainable yield. Changes to the water balance can be used to indicate where the opportunities for recharge water recovery are. For example, the greatest increase in basin outflow following GRRP recharge is through the Southern general head boundary (GHB), ranging from 130 AFY outflow with Site B injection to 159 AFY with Site D injection. OCSD Well 7 and Well 8, along with agricultural wells in the Cienega Valley, are between the GRRP sites and the South GHB, therefore, these facilities would have the greatest opportunity to recover recycled water and benefit from increased sustainable yield.

The second largest change in water balance is increased basin storage, followed by either outflow through the Pismo Marsh GHB (for Sites A, B) or the Southeast GHB (for Sites C, D, and E). Increases in basin storage benefits the wells closest to the recharge site, which would be

OCSD Wells 7 and 8 for Site A, Halcyon Area wells for Site B and C, and Cienega Valley wells for Sites D and E. The greatest opportunity to capture outflow to the Pismo Marsh would be by increased pumping at the other municipal well fields north and northwest of the Oceano GRRP sites, while the agricultural wells in the Cienega Valley provide the best option for capturing outflow to the Southeast GHB.

The distribution of outflow in the water balance shown in Table 4 does not represent the fate of particles recharged at GRRP sites, but shows the dynamic changes to groundwater flow caused by GRRP site recharge and associates water level changes. Sustainable yield benefits, along with one potential impact, are summarized in Table 5.

Table 4 – Sustainable Yield Benefit

Description	Wells / areas with potential yield benefit				
	Site A	Site B	Site C	Site D	Site E
	Water Yard Injection	S. Elm Injection	S. Elm Basin	Creek Area Injection	Creek Area Basin
Higher benefit potential	OCSD Wells[1]	Halcyon Area	Halcyon Area	Cienega Valley	Cienega Valley
Intermediate potential	Cienega Valley	OCSD Wells	OCSD Wells	Halcyon Area	Halcyon Area
	Other Municipal Well Fields	Cienega Valley	Cienega Valley	OCSD Wells	OCSD Wells
Lower potential	Halcyon Area	Other Municipal Well Fields	Other Municipal Well Fields	Other Municipal Well Fields	Other Municipal Well Fields
Increase in Storage (AFY)[2]	50	63	58	43	42
Loss of Production Wells	Yes[3]	No	No	No	No
Sustainable Yield Ranking (1 = highest)	3	1		2	

[1] OCSD Wells 7 and 8 only.
[2] Average annual storage increase over 8-year balanced hydrologic period (i.e. 400 acre-feet total storage increase from Site A injection).
[3] OCSD Wells 4, 5, and 6 would be taken off-line (unless pumped under ASR regulations).

Site B and C are given the highest sustainable yield benefit, because existing OCSD infrastructure (Wells 4, 5, and 6) at the Water Yard is preserved, and greater groundwater storage increases are possible. Site A is ranked last because of the loss of production wells at the Water Yard, although Well 4 and Well 5 were drilled in the 1950's and are due for replacement. Well 6 was completed in 1979 with galvanized steel screen and is approaching the end of its life cycle.

An alternative approach to Water Yard injection would be to operate the site for Aquifer Storage and Recovery operations. This would require additional analysis, but has the potential to preserve some of the production capacity of the existing wells. Injection would need to cease at least two months prior to production activities, and resumed when production stops. If no Aquifer Storage and Recovery is planned, replacing the lost production capacity at the Water Yard would require development of a new well site, which could involve land acquisition.

Municipal well fields north of the OCSD service area are given a lower potential for sustainable yield benefit, compared to the OCSD wells, Halcyon Area wells, and Cienega Valley wells. These municipal well fields are currently hydraulically upgradient from the GRRP sites. Increased pumping (together with a coastal seawater intrusion injection barrier) may change the hydraulic gradient and increase the potential yield benefit to the well fields from Oceano GRRP sites.

4.5 Seawater Intrusion Mitigation

Seawater intrusion mitigation has been evaluated using the Phase 1A basin model. Each site was assigned a recharge rate of 300 AFY, regardless of actual recharge capacity, in order to rank seawater intrusion mitigation independent of other factors. Model results are in Appendix E.

Overall differences in seawater intrusion mitigation, and the mitigation levels themselves, were relatively minor between the sites. The lack of substantial effect on seawater intrusion mitigation is interpreted to be because of the greater distance between Oceano GRRP sites and shoreline boundary, compared to other model boundaries. A linear coastal injection barrier is also being simulated in all scenarios, and the Oceano GRRP sites are inland of the injection barrier. Seawater intrusion benefit ranking is summarized in Table 3 below.

Table 5 - Seawater Intrusion Mitigation Benefit

Site ID	Description	Increased Shoreline Outflow (AFY)	Rank
Site A	Water Yard Injection	9	1
Site B	S. Elm Street Injection	6	2
Site C	S. Elm Street Basin	6	
Site D	Creek Area Injection	3	3
Site E	Creek Area Basin	3	

The seawater intrusion mitigation ranking is based on the amount of increased outflow to the ocean across the shoreline boundary (Table 5), and follows in the order of increasing distance from the coast.

4.6 Water Quality Benefit

The water quality benefit is ranked based on differences in quality between the recharge source water and the receiving water. A greater difference between recharge source and receiving water quality provides a greater benefit. Table 6 presents selected water quality information used for the evaluation.

Table 6 - Water Quality Information

<table>
<tr><th rowspan="2">Information Type</th><th rowspan="2">Area/Reference</th><th rowspan="2">Source/Use</th><th rowspan="2">Description</th><th rowspan="2">Sample Date</th><th>TDS</th><th>NO_3-N</th><th>Selenium</th></tr>
<tr><th colspan="2">mg/L</th><th>µg/L</th></tr>
<tr><td rowspan="5">Current Groundwater Quality</td><td rowspan="2">Water Yard (Site A)</td><td>Paso Robles</td><td>Well #4</td><td>8/2/2016</td><td>600</td><td>7.1</td><td>31</td></tr>
<tr><td>Careaga</td><td>Well #6</td><td>8/2/2016</td><td>650</td><td><0.4</td><td><5</td></tr>
<tr><td>Halcyon Area (Site B and C)</td><td>Paso Robles</td><td>Halcyon 1[1]</td><td>7/6/2016</td><td>990</td><td>14</td><td>58</td></tr>
<tr><td rowspan="2">Cienega Valley (Site D and E)</td><td>Alluvium/Paso Robles</td><td>8 wells[2]</td><td>Feb-Mar 2014</td><td>1530</td><td>43</td><td>no data</td></tr>
<tr><td>Careaga</td><td colspan="5">no data</td></tr>
<tr><td rowspan="2">Regulatory Guidelines</td><td>Title 22 CCR</td><td>MCL</td><td>Drinking Water</td><td>none</td><td>1000</td><td>10</td><td>50</td></tr>
<tr><td>Central Coast Basin Plan Objectives</td><td>Arroyo Grande sub-area</td><td>Groundwater</td><td>none</td><td>800</td><td>10</td><td>20[3]</td></tr>
<tr><td rowspan="2">Conceptual Goals</td><td>OCWD</td><td>Groundwater Injection</td><td>Finished Water Product</td><td>2017 Average</td><td>50</td><td>1</td><td><1</td></tr>
<tr><td>RRWSP</td><td>Agricultural Reuse</td><td>Recycled Water</td><td>none</td><td>500</td><td>5</td><td>20[3]</td></tr>
</table>

NOTES:
TDS = Total Dissolved Solids; NO_3-N = Nitrate as Nitrogen; CCR = California Code of Regulations; MCL = Maximum Contaminant Level; mg/L = milligrams per liter; µg/L = micrograms per liter
OCWD = Orange County Water District; RRWSP = Regional Recycled Water Sustainability Project
[1] raw water, prior to treatment
[2] average of 8 wells from Irrigated Lands Regulatory Program database (Geotracker)
[3] Central Coast Basin Plan objective for agricultural water quality - irrigation
[4] Reported as Total N

Three constituents were selected for the water quality benefits analysis: total dissolved solids (TDS), nitrate as nitrogen (NO_3-N), and selenium. TDS and NO_3-N represent salt and nutrient loads in the basin, while the trace element selenium is included due to locally elevated concentrations, compared to the drinking water standard. The conceptual goal for water quality used for injection from the future ATP is assumed to be similar to the water quality of finished product water used for injection by Orange County Water District (OCWD, 2018). Note that injection water quality is significantly less mineralized than the conceptual goal for agricultural reuse (Table 6).

Water used for recharge basins could be a blend of disinfected tertiary treated wastewater, municipal supply water, and highly purified water from the ATP. The blend ratio may change over time as water quality monitoring demonstrates the degree of protection required under the Recycled Water Criteria. For the purposes of this benefits analysis, surface water recharge would meet the conceptual goals for agricultural reuse water quality in Table 6.

Representative data for water quality in the Careaga Formation beneath the Cienega Valley are not available, therefore, Site E was not ranked for water quality benefit. The other sites were evaluated and ranked for each of the selected constituents separately, followed by a cumulative ranking. Tables 7 through 10 present the results of the water quality benefit evaluation.

Table 7 - Water Quality Benefit for Total Dissolved Solids

Site ID	Description	Aquifer	Discharge Water Quality	Receiving Water Quality	Difference	Rank 1 = highest
			Total Dissolved Solids (mg/L)			
Site A	Water Yard Injection	Paso Robles	50	600	550	3
Site B	S. Elm St. Injection	Paso Robles	50	990	940	2
Site C	S. Elm St. Basin	Paso Robles	500	990	490	4
Site D	Creek Area Injection	Careaga	50	*no data*	--	--
Site E	Creek Area Basin	Alluv./Paso Robles	500	1530	1030	1

mg/L = milligrams per liter

Table 8 - Water Quality Benefit for Nitrate as Nitrogen

Site ID	Description	Aquifer	Discharge Water Quality'	Receiving Water Quality	Difference	Rank 1 = highest
			Nitrate as Nitrogen (mg/L)			
Site A	Water Yard Injection	Paso Robles	1	7	6	4
Site B	S. Elm St. Injection	Paso Robles	1	14	13	2
Site C	S. Elm St. Basin	Paso Robles	5	14	9	3
Site D	Creek Area Injection	Careaga	1	*no data*	--	--
Site E	Creek Area Basin	Alluv./Paso Robles	5	43	38	1

mg/L = milligrams per liter

Table 9 - Water Quality Benefit for Selenium

Site ID	Description	Aquifer	Discharge Water Quality'	Receiving Water Quality	Difference	Rank 1 = highest
			(Selenium) µg/L			
Site A	Water Yard Injection	Paso Robles	0	31	31	3
Site B	S. Elm St. Injection	Paso Robles	0	58	58	1
Site C	S. Elm St. Basin	Paso Robles	20	58	38	2
Site D	Creek Area Injection	Careaga	0	*no data*	--	--
Site E	Creek Area Basin	Alluv./Paso Robles	20	*no data*	--	--

mg/L = milligrams per liter

Table 10 - Overall Water Quality Benefit Ranking

Site ID	Description	Rank 1 = highest
Site A	Water Yard Injection	4
Site B	S. Elm Street Injection	2
Site C	S. Elm Street Basin	3
Site D	Creek Area Injection	*not ranked*
Site E	Creek Area Basin	1

Based on the water quality benefit rankings for individual constituents (Tables 7, 8 and 9), GRRP Site E (Arroyo Grande Creek Area recharge basin) would provide the greatest overall water quality benefit for the ranked sites, although all sites provide significant water quality benefits. The water quality ranking does not account for recharge capacity.

4.7 Environmental Benefit/Impact

Potential environmental benefits are associated with increasing surface flow in Arroyo Grande Creek, while potential impacts relate to increasing liquefaction and flooding potential. The lower reaches of Arroyo Grande Creek have been identified as potential juvenile habitat for red-legged frog (Stetson, 2004). Flooding problems have been reported at many locations within Oceano during heavy precipitation events (RMC, 2004), and liquefaction has been documented in Oceano dune sands and artificial fill during the San Simeon Earthquake (Holtzer et al., 2004).

Arroyo Grande Creek Flow

The Phase 1A model includes Arroyo Grande Creek as a stream package, with flows entering the upstream reaches and providing seasonal recharge to the underlying aquifers. A review of the water balance results (Appendix E) agree with observations that Arroyo Grande Creek is a losing stream between Highway 101 and the 22nd Street Bridge, and then becomes a gaining stream as it nears the ocean (Todd, 2007; Hoover, 1985).

Model stream Reach 3 (Figure 9) runs from the 22nd Street Bridge to the Ocean, and was the only reach where flows are projected to increase in the Phase 1A Model following GRRP operations at Site A (Water Yard). The projected amount of increased flow is relatively minor, at less than 10 gallons per minute (11 AFY). This benefit would potentially be eliminated if production at OCSD Well 7 was resumed or production increased at Well 8. No other GRRP sites show a benefit to Arroyo Grande Creek flow in the Phase 1A model, although the model does not incorporate shallow clay horizons beneath recharge basin sites (Site B and Site E).

There is sufficient distance between the S. Elm Street recharge basin (Site B) and Arroyo Grande Creek for deep percolation to the Paso Robles aquifers simulated by the Phase 1A model. At the Arroyo Grande Creek recharge basin (Site E), however, the Phase 1A Model is not suitable for evaluating local effects on stream flow, therefore, recycled water flow rising into Arroyo Grande Creek was evaluated using the local mounding model, with the Creek as a drain package. For a maximum recharge basin area of approximately 9 acres, there would be an estimated recharge capacity of 110 AFY, of which 65 AFY (55 percent) was simulated to rise into Arroyo Grande Creek. The resulting surface flow benefit would be equivalent to approximately 40 gpm.

Flooding and Liquefaction Potential

Although the dune sands in Oceano are highly permeable, the Oceano Drainage and Flood Control Study (RMC, 2004) reported that increased hardscape from urban development has increased surface runoff to the point that local flooding issues exist. The Cienega Valley is also a floodplain for Arroyo Grande Creek, and while Lopez Reservoir provides flood control, there was a major flood event in 2001 due to levee system failure (Swanson, 2006).

The 2004 Liquefaction Study documented two earthquake hazards in Oceano, site amplification and liquefaction. Site amplification of ground shaking during an earthquake can occur where the seismic-wave velocity in shallow sediments is low. Liquefaction is a condition where saturated sands lose their strength during an earthquake and become fluid-like and mobile. Both of these conditions existing in some areas of Oceano (Holtzer et al., 2004).

An Environmental Impacts Report is planned that would evaluate these and other potential impacts based on specific project configurations and impacts thresholds. Relative impacts are considered for this planning study. Injection well GRRP sites have a lower potential for increasing the flooding and liquefaction potential than recharge basins. The injection wells discharge recycled water into aquifers below the dune sands, sealing off both the dune sands and the shallow clay horizons, where semi-perching conditions with local flooding can occur, and where liquefaction potential is greatest. The Arroyo Grande Creek recharge basin (Site E) has the greatest potential to increase flooding risk, due to shallow groundwater levels and less permeable soils, compared to the S. Elm Street basin (Site B). Site E is also within the 100-year floodplain of Arroyo Grande Creek and subject to potential flooding impacts (Appendix D).

Overall ranking for the sites in terms of environmental benefit / impacts is presented below in Table 11.

Table 11 - Environmental Benefit / Impact Ranking

Site ID	Description	Arroyo Grande Creek Flow Benefit	Flooding/Liquefaction Impact Potential[1]	Overall Rank 1 = highest
Site A	Water Yard Injection	2	1	1
Site B	S. Elm St. Injection	5	2	4
Site C	S. Elm St. Basin	4	4	5
Site D	Creek Area Injection	3	3	2
Site E	Creek Area Basin	1	5	3

[1] lower number has lower impact potential (higher ranking)

4.8 Facility Requirements/Constructability

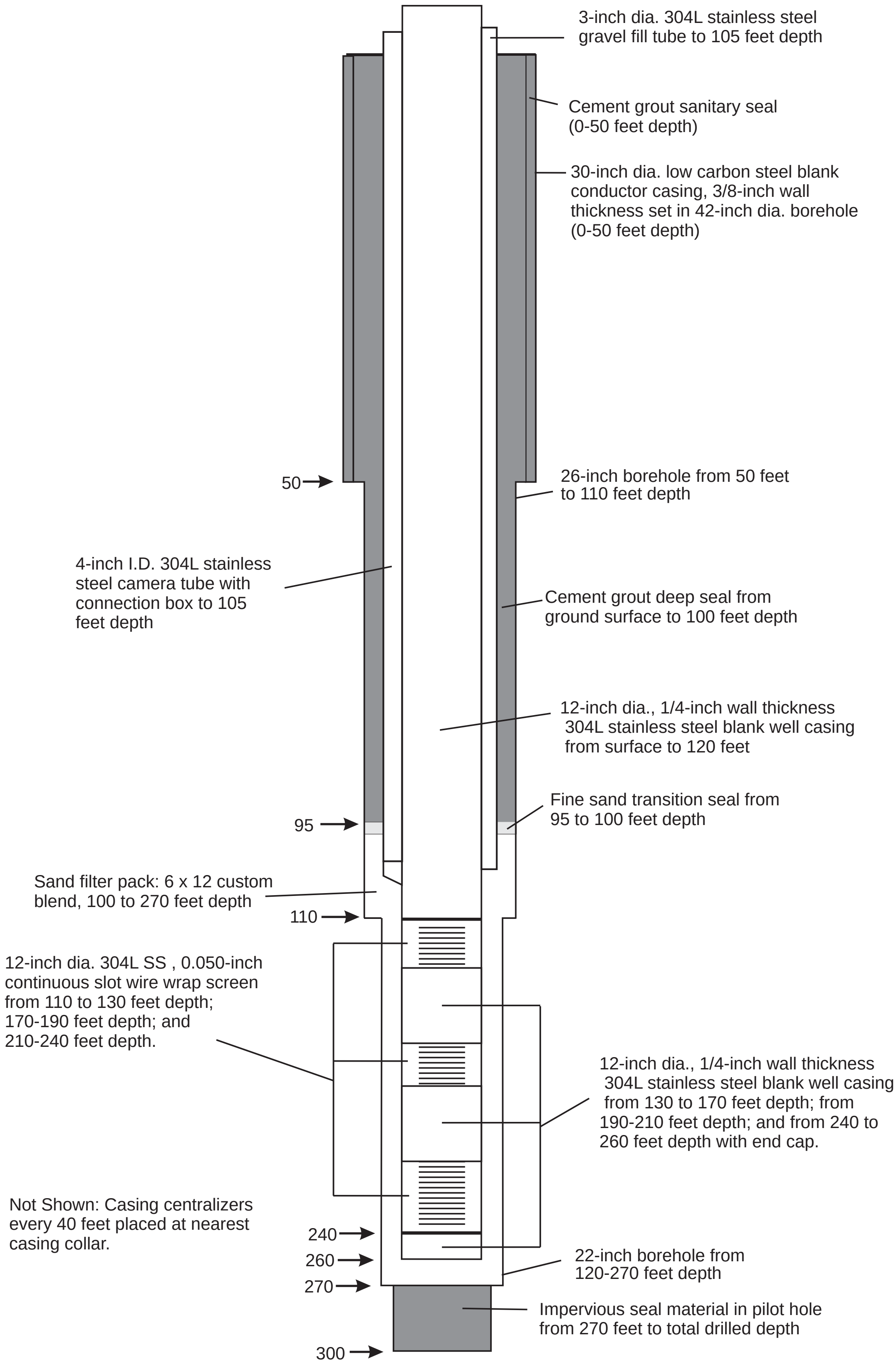
Facility requirements and constructability have been evaluated for adequate area and access, proximity to power and sewer, monitoring well locations, and costs.

4.5.1 Facilities

For injection or monitoring well construction, an area of 40 feet by 80 feet would be appropriate. For the completed injection well, an area of 15 feet by 25 feet would be sufficient for the well facilities enclosure, consisting of the well head, inflow piping and valving, backwash piping and discharge inlet (to sewer), flow controls, metering, and telemetry. An area adjacent to the injection well enclosure would be needed for temporary access during well rehabilitation or maintenance for a pump rig, compressor, pipe trailer, and vacuum truck. County road right-of-way (outside of travel lanes) may be suitable for temporary access, but otherwise the total recommended available area for accessing the well (including the well enclosure) would be 30 feet by 50 feet.

Monitoring wells may be located in vaults in County right-of-way (outside of travel lanes). Electric power service is needed at injection well sites for telemetry and flow controls, and a sewer connection is recommended for discharging backwash during well cleaning. An injection well design suitable for the Oceano GRRP sites is shown in Figure 10. The preliminary design shown in Figure 10 is for Site A (Water Yard), and depths and specific placement of well screen intervals will vary by site.

Figures 5 through 8 provide conceptual layouts for the temporary construction/access areas, permanent fenced enclosures, and monitoring well locations. All the injection sites and recharge



Drawing not to scale
Design for Site A

Figure 10
Preliminary Injection Well Design
Recycled Water Injection Well Study
Oceano CSD / Cannon

Cleath-Harris Geologists

basin sites have adequate area and access for facilities and construction. Electric power for controls and sewer service for backwash are also available or in close proximity to the sites.

Drinking water wells within the OCSD service area, for monitoring well siting purposes, are limited to the municipal wells (Wells 4, 5, 6, 7, and 8) and wells for the Halcyon and Ken-Mar Gardens water systems. Domestic wells for agricultural operations and residences are also present in the Cienega Valley hydraulically downgradient the of the OCSD service area. The direction of groundwater flow is estimated to be southwest to southeast for Site A, and southwest to south for the other Oceano GRRP sites, based on the drought year (2015) and wet year (2017) groundwater elevation contour maps shown in Appendix B.

The monitoring well locations are preliminary, and would require development of more detailed groundwater contour maps, confirmation of domestic well locations, and consultation with regulators prior to final siting. Two monitoring wells have been tentatively located for each of the GRRP location. Additional monitoring wells would be required where groundwater recharge or future municipal pumping results in significant changes to the existing hydraulic gradient. A third monitoring well for each site is assumed for cost purposes, but has not been sited.

Figure 11 presents a monitoring well design suitable for the Oceano GRRP sites. The Depths and specific placement of well screen intervals will vary by site. Monitoring wells are presented as nested well constructions to provide independent samples of each aquifer that will receive GRRP recharge water. The preliminary design shown in Figure 11 is for Site A (Water Yard), and depths, number, and specific placement of well screen intervals will vary by site.

<u>Site A - Water Yard</u>

Two wells (MW-A1 and MW-A2) are located hydraulically downgradient of the injection well site (Figure 5). MW-A1 would be constructed on OCSD property and is estimated to be approximately 5 months travel time (120 feet) from the injection well. MW-A2 is tentatively proposed in County right-of-way along 18th Street across from an existing landscape irrigation well at Oceano Elementary school, and upgradient of the nearest public drinking water supply well (Oceano Well 8; Figure 1). Both MW-A1 and MW-A2 monitoring wells would provide independent sampling of the Paso Robles Formation aquifer that will receive the GRRP's recharge water. Temporary use of private property during well construction would be necessary, but not a permanent easement. Overhead power lines are present, but there appears to be sufficient room to construct the well outside of the travel lane while maintaining a minimum 10-foot overhead clearance for the mast and rigging. Conversion of existing supply wells into monitoring wells at the Water Yard is also an option.

<u>Site B - S. Elm Street Injection</u>

Two wells (MW-B1 and MW-B2) are located hydraulically downgradient of the injection well site (Figure 6). MW-B1 would be located in County right-of-way a nominal 100 feet (3 months travel time) south of the injection well along S. Elm Street. MW-B2 would be in County right-

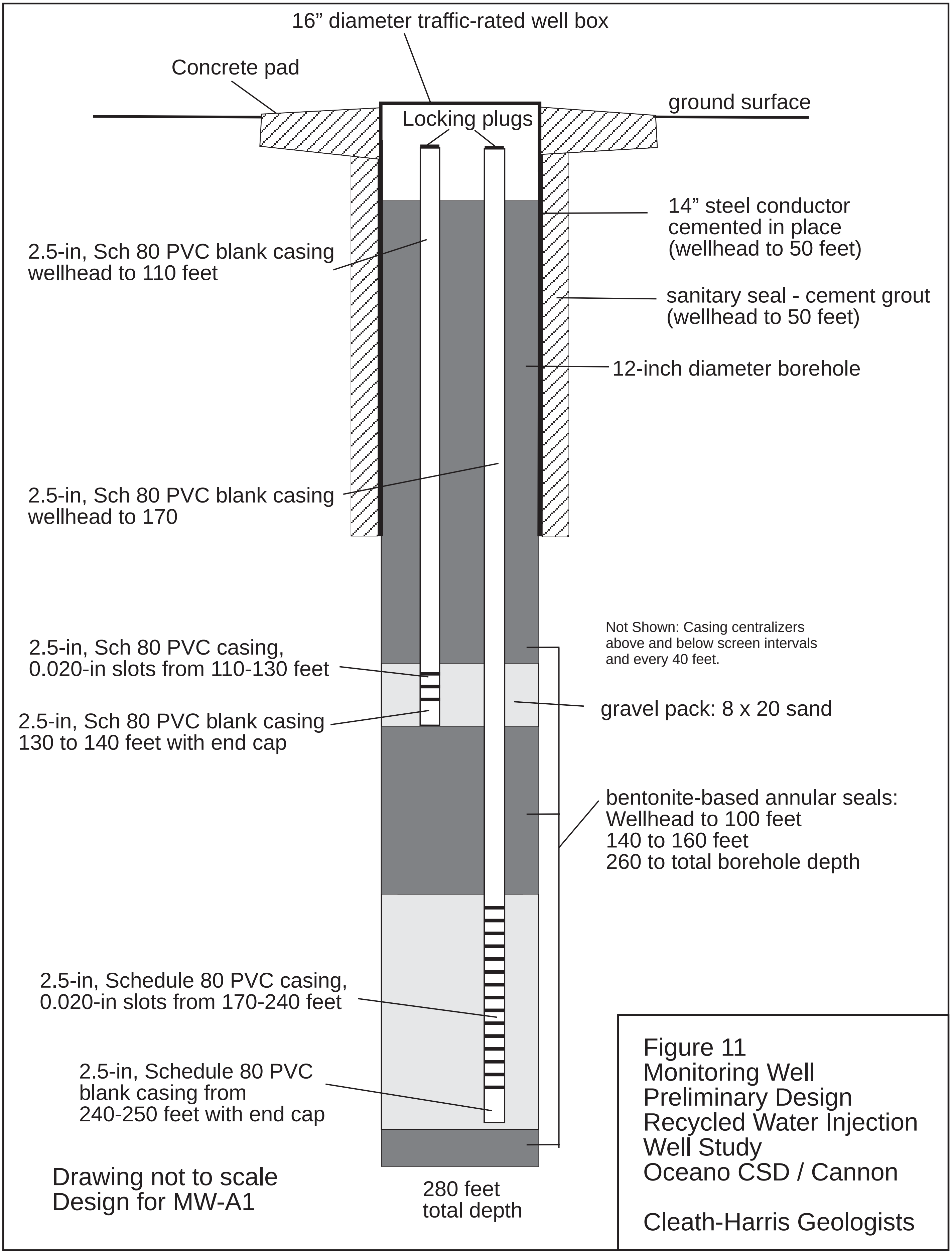


Figure 11
Monitoring Well
Preliminary Design
Recycled Water Injection
Well Study
Oceano CSD / Cannon

Cleath-Harris Geologists

of-way at the east end of Wilmar Avenue and is hydraulically upgradient of the closest public water supply wells (Oceano Well 4, Well 6 and Well 8; Figure 1). Temporary use of private property during well construction would be necessary, but not a permanent easement. Monitoring wells would provide independent sampling of the Paso Robles Formation aquifers that will receive GRRP recharge water. Shallow piezometers for water level monitoring in the dune sands beneath the site would also be recommended, and are included in the costs.

Site C - S. Elm Street Basin

Two wells (MW-C1 and MW-C2) are located hydraulically downgradient of the injection well site. MW-C1 is located in County right-of-way along S. Elm Street approximately 150 feet south of Site C and estimated to be between 3 and 4 months travel time from the recharge basin (Figure 7). MW-C2 is in County right-of-way along 25th Street and is upgradient of any drinking water wells outside the OCSD service area in the Cienega Valley. Both monitoring wells would provide independent sampling of the Paso Robles Formation aquifer that will receive GRRP's recharge water.

Site D - Arroyo Grande Creek Area Injection

Two wells (MW-D1 and MW-D2) are located on private property hydraulic downgradient of the injection well site. MW-D1 is estimated to be approximately 110 feet, or 5 months travel time from the injection well (Figure 8). MW-D2 is near Arroyo Grande Creek and upgradient of any drinking water wells outside the OCSD service area in the Cienega Valley. Both monitoring wells would provide independent sampling of the Careaga Formation aquifer that will receive GRRP recharge water.

Site E - Arroyo Grande Creek Area Basin

Two wells (MW-E1 and MW-E2) are located on private property hydraulically downgradient of the recharge basin site. MW-E1 and MW-E2 are estimated to be between 1 and 3 months travel time from the basin, and upgradient of any drinking water wells outside the OCSD service area in the Cienega Valley. Both monitoring wells would provide independent sampling of the alluvial and Paso Robles Formation aquifer that will receive GRRP recharge water. Shallow piezometers for water level monitoring in the alluvium beneath the site would also be recommended, and are included in the costs.

4.5.2 Site Constructability and Costs

There are considerable differences in the site layouts, existing facilities, and monitoring well locations for the different sites being evaluated. All sites are considered constructible, but vary in terms of relative difficulty and associated costs. For example, Site B is already a drainage basin, and would require less construction efforts than Site E.

Injection Well Construction Costs

Injection well costs were developed from the preliminary well design presented in Figure 10. The resulting estimated cost for a constructed, developed, and (pumping) tested injection well at Site A and Site D is $400,000 (total well depths of 270 feet). The estimated injection well construction cost would be $360,000, after adjusting casing schedules for an anticipated well depth of 190 feet.

Site improvements and appurtenances include well head injection piping, valves, flow controls, metering, telemetry, backwash piping and discharge inlet with sewer lateral, well pad, and removable fencing. Estimated costs for these items is based on a review of similar work for the Alamitos Barrier Improvement Project, and is estimated at $100,000 per injection well (OCWD, 2013).

Each injection well will have at least two monitoring wells with locations tentatively identified above. A third monitoring well is included for cost purposes, at a location to be determined in consultation with regulators. The estimated costs for each monitoring well is $90,000 (WSC, 2017).

The combined construction cost for each injection well, with surface facilities and three monitoring wells, is 770,000 for Site A and Site D, and $730,000 for Site B. With engineering design and construction monitoring, estimated at 20 percent of the construction value, and a 30 percent contingency, the final estimate injection well facilities cost is $1,200,000 for Site A and D, and $1,140,000 for Site B.

Recharge Basin Construction Costs

Recharge basin construction includes excavation/grading, berm construction, inlet facilities, and fencing. Estimated costs are based on the Paso Robles Groundwater Basin Supplemental Supply Options Feasibility Study (Carollo, 2017) which listed recharge basin capital costs at $15,000 per acre. With engineering, legal, administration, and contingency, recharge basin construction cost was estimated at $32,000 per acre. Site E is estimated to include up to 9 acres of recharge basin construction, at an estimated cost of $290,000. An additional $20,000 is estimated for an inlet structure, and the shallow piezometers are estimated to add $50,000 to site construction (based on 4 wells), for a total estimated construction cost of $360,000.

Site B is an existing 1.5-acre drainage basin with no associated capital construction cost, although some modifications may be needed, including a separate inlet structure for recycled water and shallow piezometers. A nominal $70,000 is estimated for Site B modifications.

4.9 Recharge Source Distribution

The Oceano GRRP would be part of a regional groundwater replenishment project, and recycled water pipeline routes and sizing would vary based on the final project layout. For the site evaluations, all piping is assumed to follow the same route from the ATP to the intersection of Highway 1 and 19th Street, therefore, the source distribution comparison begins at that location. Pipe sizing is based on less than 10 feet of headloss per 1,000 feet of pipe at peak operating capacity (WSC, 2017). The resulting distances, pipe size, cost per foot, and total cost are give in Table 12 below.

Table 12 - Recharge Source Distribution Costs

Site ID	Description	Nominal Peak Flow Rate[1] (gpm)	Pipeline Distance[2] (feet)	Pipe Diameter (inches)	Unit Cost per lineal foot[3]	Pipeline Cost
Site A	Water Yard Injection	875	2,500	10	$142	$355,000
Site B	S. Elm St. Injection	425	5,700	8	$127	$724,000
Site C	S. Elm St. Basin	200	5,000	6	$112	$560,000
Site D	Creek Area Injection	100	4,000	6	$112	$448,000
Site E	Creek Area Basin	140	4,500	6	$112	$504,000

gpm = gallons per minute
[1] based on twice the rated recharge capacity
[2] beginning at intersection of Highway 1 and 19th Street
[3] unit costs from WSC, 2017

4.10 Operations and Maintenance Requirements

The O&M criteria evaluation is based on estimated costs for each site. Injection well O&M costs for RSGP/Central Coast Blue have been estimated at $40,000 per well (WSC, 2017), and would apply to Site A, B, and D. Recharge basin O&M costs for the Paso Robles Supplemental Supply Option Study (Carollo, 2017) were estimated at $5,000 per acre, which converts to $7,500 per year for Site C, and $45,000 per year for Site E.

4.11 Land Acquisition Requirements

Land acquisition would not be required for Site A (OCSD property) or Site C (City of Arroyo Grande property). Monitoring wells for these sites are anticipated to be in County right-of-way.

The two properties where private land purchases would be needed are large acreage parcels. The entire injection well construction area of 40 feet by 80 feet (3,200 square feet) is recommended to be purchased for either Site B and Site D, rather than the slightly smaller size (30 feet by 50 feet) needed for ongoing operations. Depending on minimum costs for land acquisition, a larger area (i.e. half-acre) may be appropriate and could potentially include a monitoring well location. Both Site B and Site D would be adjacent to, and accessed directly from, the County right-of-way. Site E would require the largest land purchase, with close to 14 acres of the 18-acre parcel potentially needed for maximizing recharge basin operation.

The cost for injection well easements at Site B and Site D is estimated to be $100,000 for up to a half-acre of land at each site, based on a unit cost of $200,000 per acre (WSC, 2017). Land acquisition cost for approximately 14 acres at the Site E recharge basin is estimated to be $2,800,000.

5.0 OVERALL SITE RANKING AND COST COMPARISON

A combined site ranking for the hydrogeologic evaluation criteria and a cost-benefit analysis for the engineering evaluation criteria have been used to develop the overall Oceano GRRP site ranking. The hydrogeologic evaluation criteria rankings for individual criteria (except recharge capacity) were based on equal recharge for each site. Consideration for different recharge capacities is appropriate when combining the hydrogeologic rankings. Table 13 below summarizes the individual and combined hydrogeologic evaluation criteria ranking.

Table 13 – Combined Hydrogeologic Evaluation Criteria Ranking

Hydrogeologic Evaluation Criteria	Site Rank (1 = highest)				
	Site A	Site B	Site C	Site D	Site E
	Water Yard Injection	S. Elm Injection	S. Elm Basin	Creek Area Injection	Creek Area Basin
Recharge Capacity	1	2	3	5	4
Sustainable Yield Benefit	3	1	1	2	2
Seawater Intrusion Mitigation	1	2	2	3	3
Water Quality Benefit	4	2	3	Not ranked	1
Environmental Benefit	1	4	5	2	3
Unweighted Average Rank[1]	2	2.2	2.8	3	2.6
Recharge Capacity Multiplier[2]	1	2	4.5	9.6	6.1
Final Average Rank	2	4.4	12.6	28.8	15.9
Weighted Hydrogeologic Rank	**1**	**2**	**3**	**5**	**4**

[1] average rank prior to adjusting for recharge capacity
[2] equal to the highest recharge capacity devided by the individual site recharge capacity

Prior to adjustments for recharge capacity, the unweighted average rank shows Site B with the highest hydrogeologic benefit, with Site D having the lowest benefit. When the recharge capacity multiplier is applied, the weighted ranking places Site A (Water Yard injection) as the highest potential hydrogeologic benefit, with Site D (Arroyo Grande Creek Area injection) remaining as the lowest potential benefit.

The cost-benefit analysis combines the estimated costs for the various engineering criteria and divides by the recharge capacity, providing a relative cost comparison that can be used to develop the final, overall site ranking. The cost-benefit analysis and overal GRRP site rank is presented in Table 14.

Table 14 – Cost-Benefit Summary and Overall Site Ranking

Description	Cost				
	Site A	Site B	Site C	Site D	Site E
	Water Yard Injection	S. Elm Injection	S. Elm Basin	Creek Area Injection	Creek Area Basin
Recharge Facilities	$1,200,000	$1,140,000	$70,000	$1,200,000	$360,000
Recharge Source Distribution	$355,000	$724,000	$560,000	$448,000	$504,000
O&M over 30 years	$1,200,000	$1,200,000	$240,000	$1,200,000	$1,350,000
Land Acquisition	$0	$100,000	$0	$100,000	$2,800,000
Total cost	$2,755,000	$3,164,000	$870,000	$2,948,000	$5,014,000
Total cost with 5% APR financing	$5,328,000	$6,120,000	$1,692,000	$5,688,000	$9,684,000
	Cost-Benefit				
Recharge Capacity (AFY)[1]	700	340	150	70	110
Recharge over 30 years (AF)	21,000	10,200	4,500	2,100	3,300
Cost of recharge ($/AF)[2]	$250	$600	$370	$2,710	$2,940
Cost of recycled water ($/AF)[3]	$2,100	$2,100	$2,100	$2,100	$2,100
Total cost-benefit ratio ($/AF)	$2,350	$2,700	$2,480	$4,810	$5,030
	Overall Ranking (1 = highest)				
Cost Rank	1	3	2	4	5
Weighted Hydrogeologic Rank	1	2	3	5	4
Overall Site Rank	**1**	**2**		**3**	

[1] average rank prior to adjusting for recharge capacity
[2] equal to the highest recharge capacity divided by the individual site recharge capacity
[3] $2,100 unit cost for Phase 2 Advanced Treatment Plant water before injection (WSC, 2017), with similar unit cost for a disinfected tertiary treated wastewater/municipal supply/ATP water blend approved for recharge basins.

Project costs have been calculated based on a 30-year term with a 5 percent annual percentage rate financing. Recycled water unit costs for advanced treatment are based on the Phase 2 (combined SSLOCSD and Pismo WWTF) onsite groundwater recharge project from the Recycled Water Facilities Planning Study (WCS, 2017).

Site A (Water Yard injection) is the highest ranked GRRP site. However, there would be lost production capacity for the OCSD system from existing wells. Replacement costs for the two municipal wells shut down during injection activities (Well 4 and Well 6), with potential land acquisition and pipeline costs, could exceed $3,000,000. An alternative option would be to operate the site for Aquifer Storage and Recovery by alternating the injection and production activities.

The Water Yard (Site A) with recycled water injection has the greatest hydrogeologic benefit with the lowest cost-benefit ratio, and receives the highest overall ranking. Halcyon Area sites on S. Elm Street (Site B and Site C) are ranked second overall, with the injection well (Site B) having a higher hydrogeologic benefit and the recharge basin (Site C) having a lower cost-benefit ratio. Arroyo Grande Creek Area sites (Site D and Site E) received the lowest overall benefit rank.

6.0 CONCLUSIONS

Results of the Recycled Water Injection Well Study support the following conclusions:

- Significantly greater recharge capacity is possible using Paso Robles Formation injection wells, compared to Careaga Formation injection wells or recharge basins at the sites evaluated.

- Less than 5 percent of the increased groundwater recharge at GRRP sites is simulated in the Phase 1A model water balance to exit the groundwater basin through the Shoreline boundary (coast), indicating a high potential for overall recharge recovery and increased sustainable yield.

- The Water Yard (Site A) with recycled water injection has the greatest hydrogeologic benefit with the lowest cost-benefit ratio, and receives the highest overall ranking. Halcyon Area sites on S. Elm Street (Site B and Site C) are ranked second overall, with the injection well (Site B) having a higher hydrogeologic benefit and the recharge basin (Site C) having a lower cost-benefit ratio. Arroyo Grande Creek Area sites (Site D and Site E) received the lowest overall benefit rank.

- Municipal well fields north of the OCSD service area are given a lower potential for sustainable yield benefit, compared to the OCSD wells, Halcyon Area wells, and Cienega Valley wells. These municipal well fields are currently hydraulically upgradient from the GRRP sites. Increased pumping (together with a coastal seawater intrusion injection barrier) may change the hydraulic gradient and increase the potential yield benefit to the well fields from Oceano GRRP sites.

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APPENDICES

APPENDIX A

Soil Survey Information

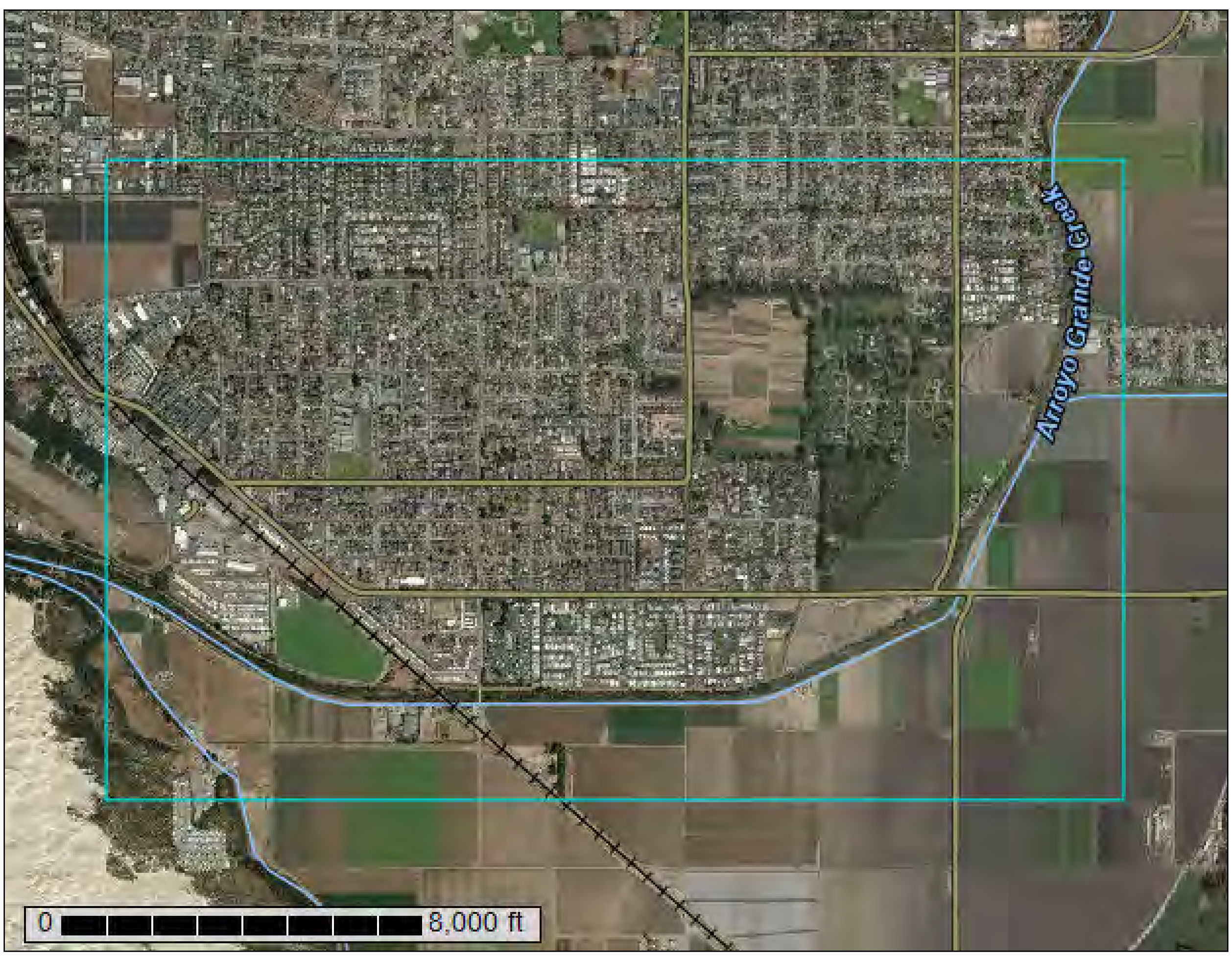
United States Department of Agriculture

NRCS

Natural Resources Conservation Service

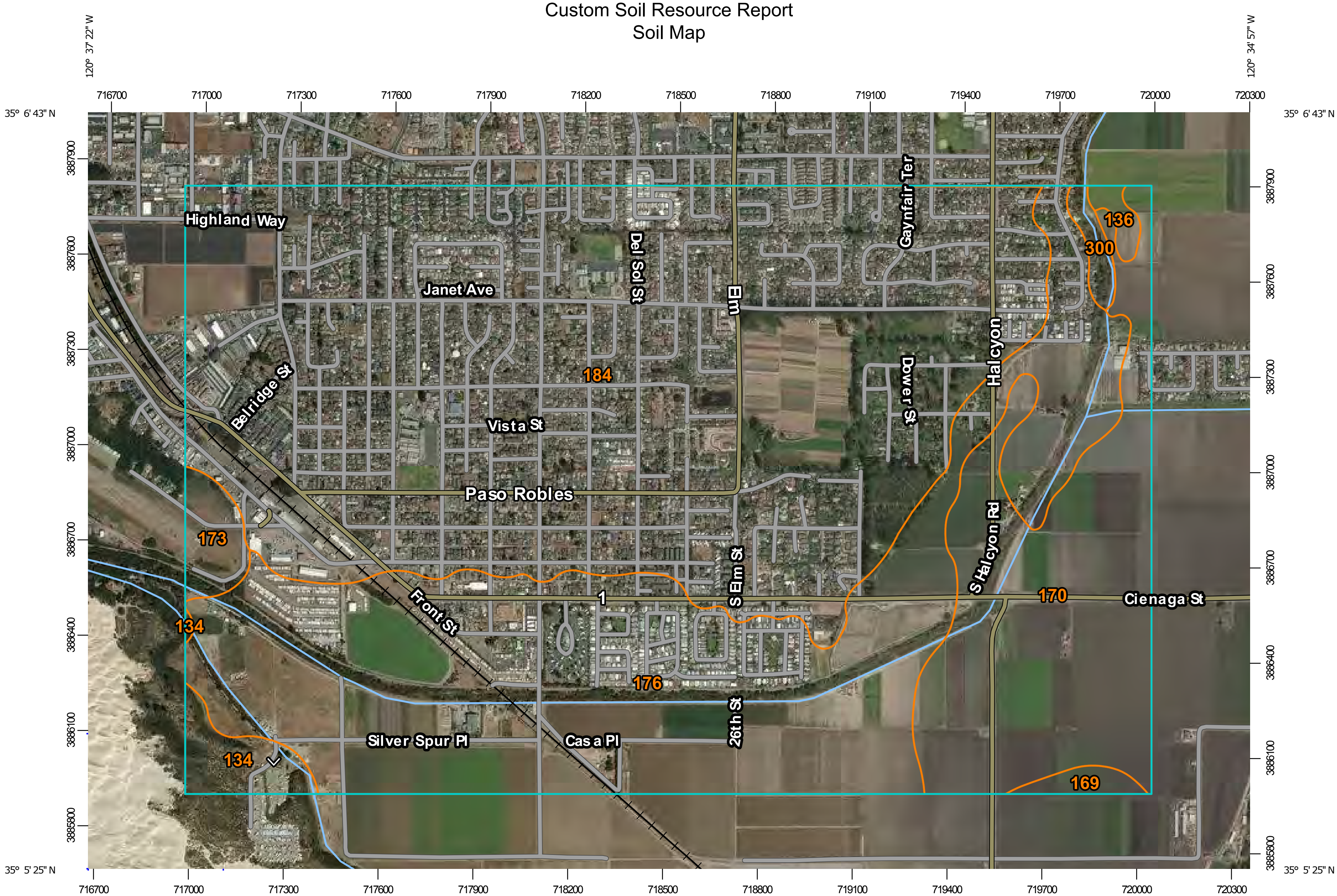
A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for San Luis Obispo County, California, Coastal Part



June 12, 2018

Soil Map



Map Scale: 1:16,800 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0, 200, 400, 800, 1200

Feet: 0, 500, 1000, 2000, 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
134	Dune land	19.8	1.4%
136	Elder sandy loam, 5 to 9 percent slopes	4.9	0.3%
169	Marimel sandy clay loam, occasionally flooded	6.4	0.4%
170	Marimel silty clay loam, drained	189.0	13.0%
173	Mocho fine sandy loam, 0 to 2 percent slopes, MLRA 14	16.3	1.1%
176	Mocho variant fine sandy loam	435.9	30.0%
184	Oceano sand, 0 to 9 percent slopes	773.0	53.2%
300	Corducci-Typic Xerofluvents, 0 to 5 percent slopes, occasionally flooded, MLRA 14	6.9	0.5%
Totals for Area of Interest		**1,452.0**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a

Table—Saturated Hydraulic Conductivity (Ksat), Standard Classes

Map unit symbol	Map unit name	Rating (micrometers per second)	Acres in AOI	Percent of AOI
134	Dune land	92.0000	19.8	1.4%
136	Elder sandy loam, 5 to 9 percent slopes	28.0000	4.9	0.3%
169	Marimel sandy clay loam, occasionally flooded	2.7000	6.4	0.4%
170	Marimel silty clay loam, drained	2.7000	189.0	13.0%
173	Mocho fine sandy loam, 0 to 2 percent slopes, MLRA 14	26.1263	16.3	1.1%
176	Mocho variant fine sandy loam	59.0184	435.9	30.0%
184	Oceano sand, 0 to 9 percent slopes	92.0000	773.0	53.2%
300	Corducci-Typic Xerofluvents, 0 to 5 percent slopes, occasionally flooded, MLRA 14	136.2200	6.9	0.5%
Totals for Area of Interest			**1,452.0**	**100.0%**

Rating Options—Saturated Hydraulic Conductivity (Ksat), Standard Classes

Units of Measure: micrometers per second

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

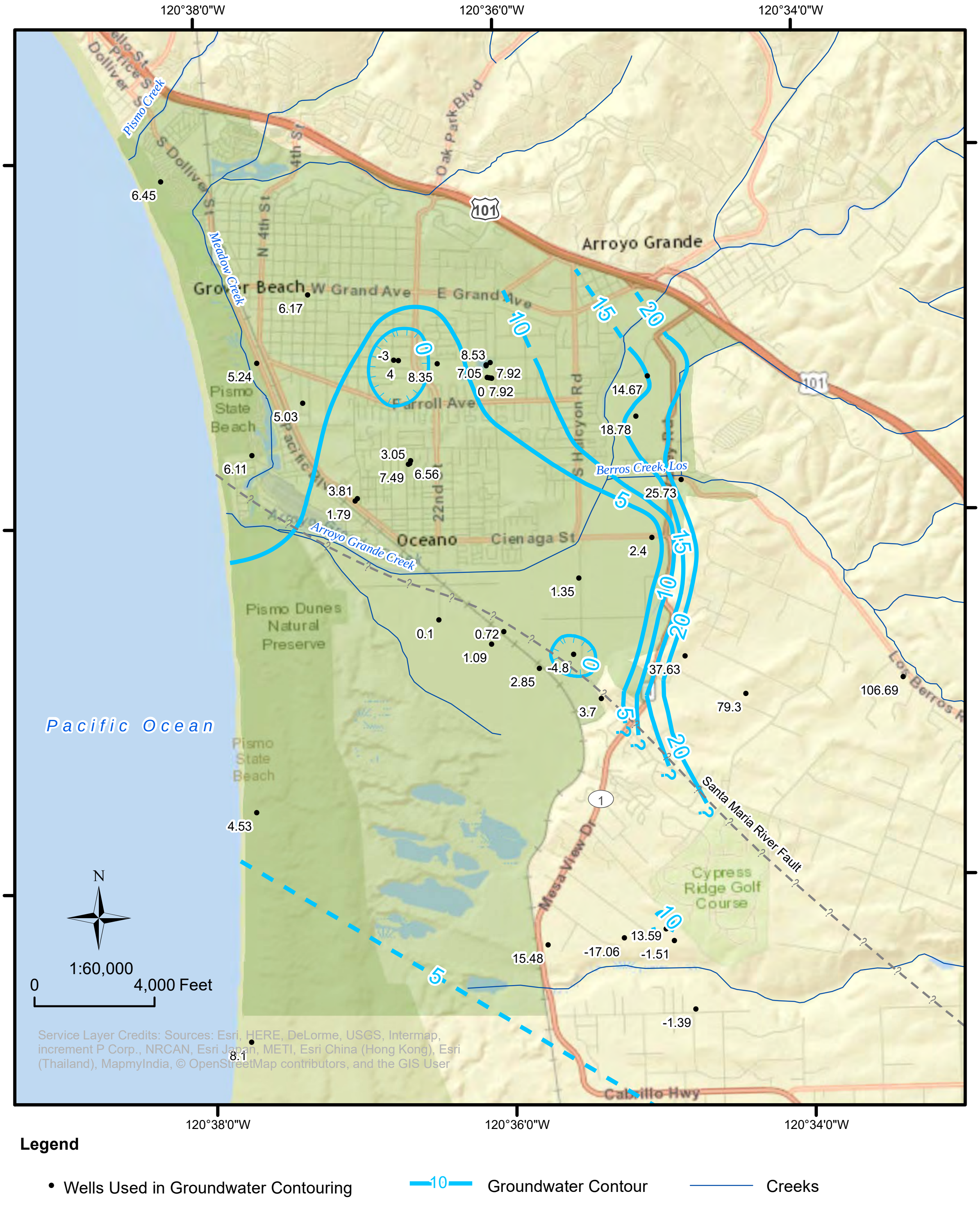
Tie-break Rule: Fastest

Interpret Nulls as Zero: No

Layer Options (Horizon Aggregation Method): All Layers (Weighted Average)

APPENDIX B

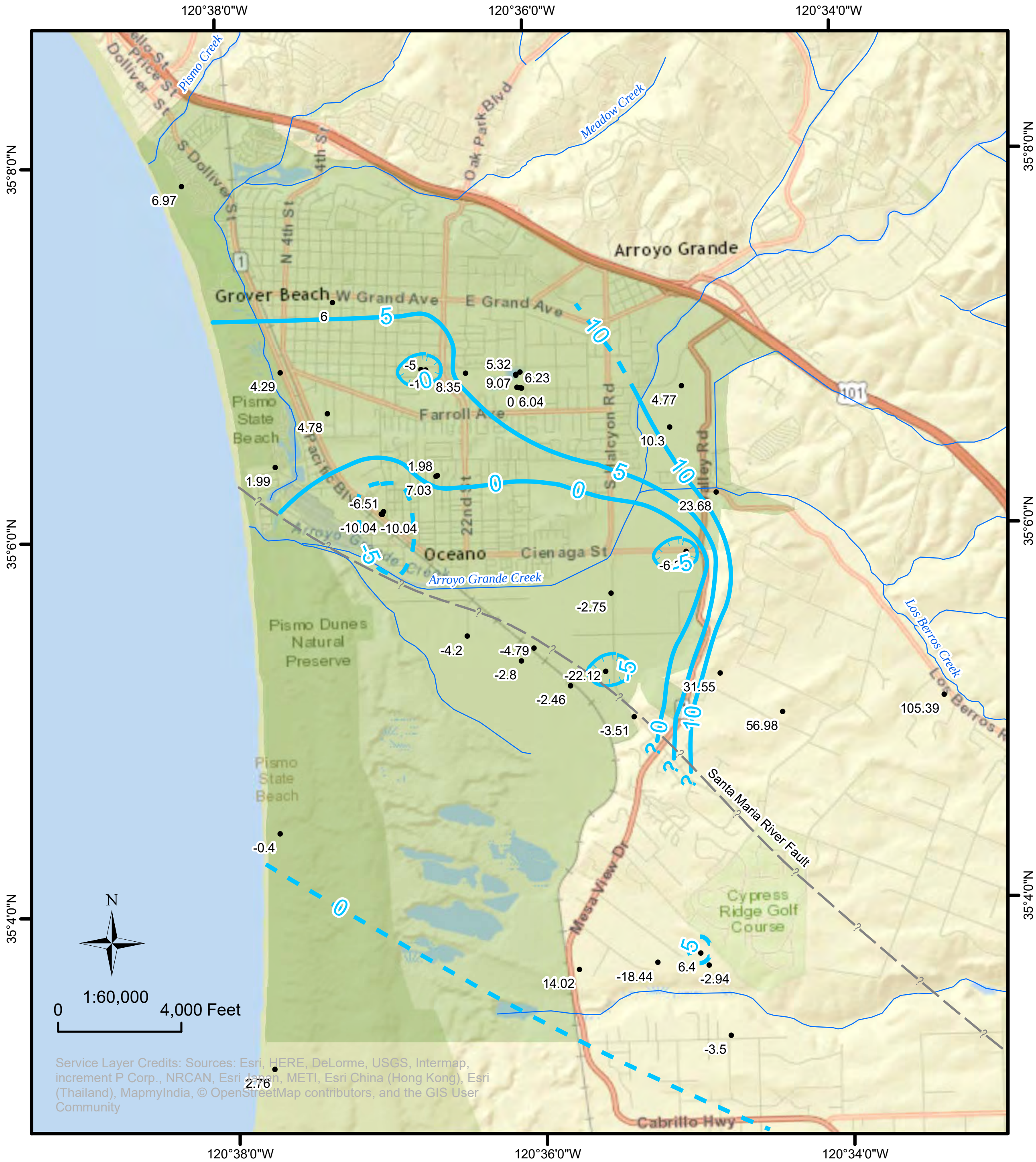
Groundwater Elevation Contour Maps



WATER LEVEL ELEVATION, APRIL 2015
Northern Cities Management Area
San Luis Obispo County, California

FIGURE 8

N:\Projects\04_2015\04_6215_0079_NCMA 2015 AGMR\Outputs\2016_04_22_NCMAAnnualReport\mxd\Figure 8_2015 April NCMA Contours-WLE.mxd, 4/22/2016, CDean



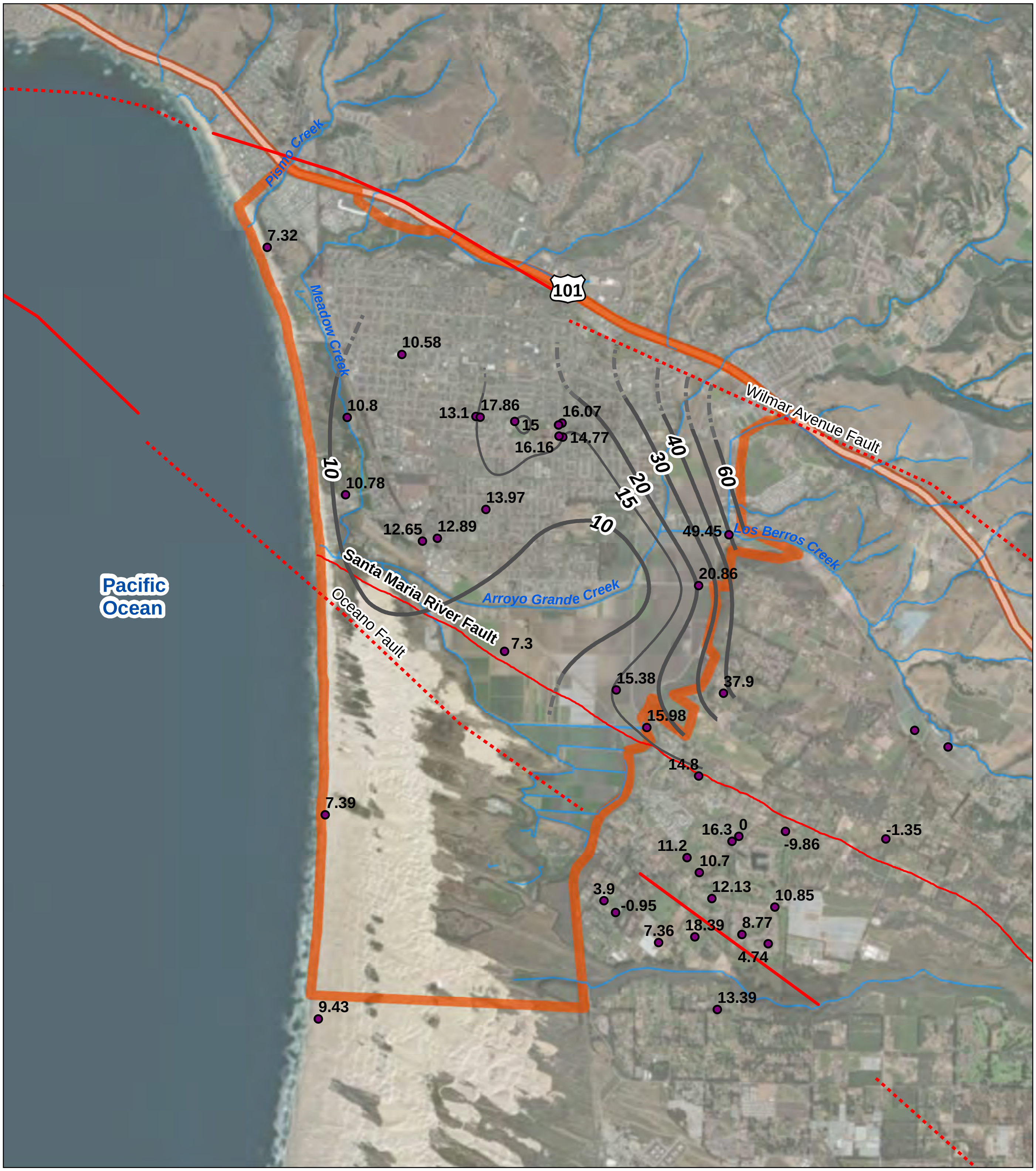
Legend

- Wells Used in Groundwater Contouring
- 10 Groundwater Contour
- Creeks

WATER LEVEL ELEVATIONS, OCTOBER 2015
Northern Cities Management Area
San Luis Obispo County, California

FIGURE 9

N:\Projects\04_2015\04_6215_0079_NCMA 2015 AGMR\Outputs\2016_04_22_NCMAnnualReport\mxd\Figure 9_2015 October NCMA Contours-WLE.mxd, 4/22/2016, CDean



LEGEND

- Wells Used in Groundwater Contouring
- Groundwater Contour (feet, NAVD88)
- Minor Groundwater Contour
- Northern Cities Management Area
- Streams
- Faults

N

0 1 Miles

FIGURE 8

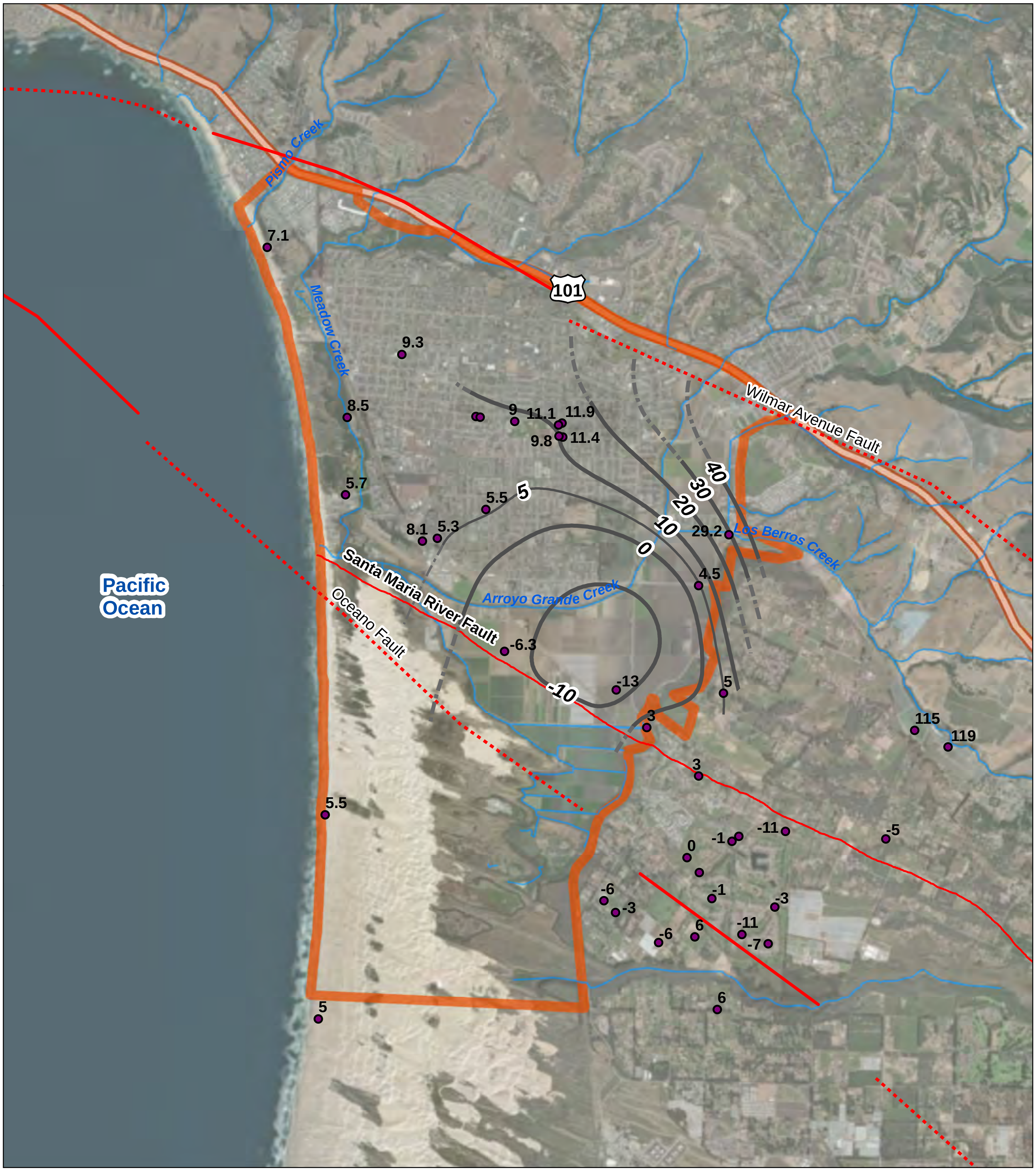
Groundwater Level Contours Spring 2017

Northern Cities Management Area
San Luis Obispo County, California

GSI Water Solutions, Inc.

Date: March 19, 2018
Data Sources: SLO County, NCMA and NMMA Agencies

Document Path: P:\Portland\672-Northern Cities Management Area\003-2017 Annual Report\Project_GIS\Project_mxds\Annual_Report\Figure_8_NCMA_Water_Level_Contours_April_2017.mxd



LEGEND

- Wells Used in Groundwater Contouring
- Groundwater Contour (feet, NAVD88)
- Minor Groundwater Contour
- Northern Cities Management Area
- Streams
- Faults

N

0 1
Miles

Date: March 19, 2018
Data Sources: SLO County, NCMA and NMMA Agencies

FIGURE 9

Groundwater Level Contours Fall 2017

Northern Cities Management Area
San Luis Obispo County, California

GSI Water Solutions, Inc.

Document Path: P:\Portland\672-Northern Cities Management Area\003-2017 Annual Report\Project_GIS\Project_mxds\Annual_Report\Figure_9_NCMA_Water_Level_Contours_Oct_2017.mxd

APPENDIX C

National Stormwater Calculator Results

National Stormwater Calculator Report

Site Description

S. Elm Street Basin

Parameter	Current Scenario	Baseline Scenario
Site Area (acres)	65.7	
Hydrologic Soil Group	A	
Hydraulic Conductivity (in/hr)	6	
Surface Slope (%)	5	
Precip. Data Source	PISMO BEACH	
Evap. Data Source	PISMO BEACH	
Climate Change Scenario	None	
% Forest	0	
% Meadow	0	
% Lawn	40	
% Desert	0	
% Impervious	60	
Years Analyzed	20	
Ignore Consecutive Wet Days	False	
Wet Day Threshold (inches)	0.10	

LID Control	Current Scenario	Baseline Scenario
Disconnection	0	
Rain Harvesting	0	
Rain Gardens	0	
Green Roofs	0	
Street Planters	0	
Infiltration Basins	0	
Porous Pavement	0	

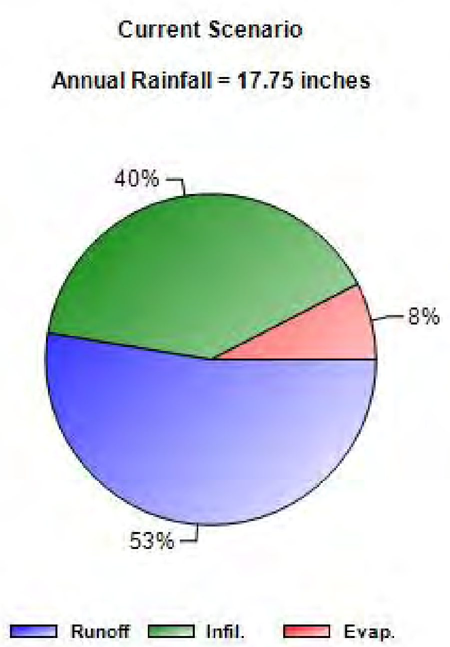
% of impervious area treated / % of treated area used for LID

National Stormwater Calculator Report

Summary Results

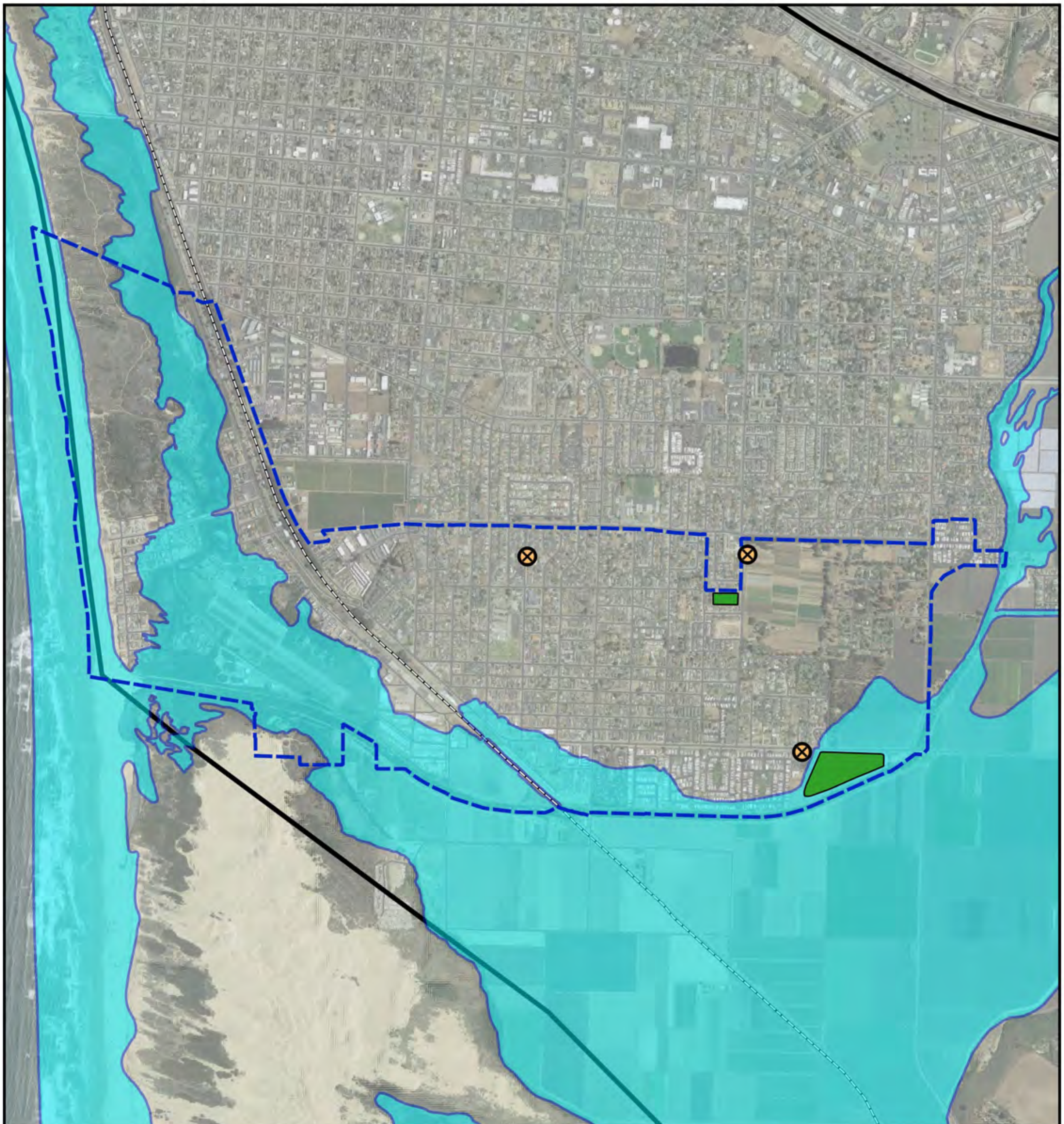
S. Elm Street Basin

Statistic	Current Scenario	Baseline Scenario
Average Annual Rainfall (inches)	17.75	
Average Annual Runoff (inches)	9.36	
Days per Year With Rainfall	30.98	
Days per Year with Runoff	22.48	
Percent of Wet Days Retained	27.42	
Smallest Rainfall w/ Runoff (inches)	0.18	
Largest Rainfall w/o Runoff (inches)	0.24	
Max. Rainfall Retained (inches)	1.07	



APPENDIX D

100-Year Flood Map



Explanation

- GRRP Injection Wells
- GRRP Basins
- Active Model Boundary
- Oceano CSD
- FEMA 100-year Flood Zone

0 1000 2000 3000 ft

NORTH

Coordinate System: State Plane
California Zone V
Horizontal Datum: NAD 1983

Appendix D
FEMA Flood Zone and Project GRRP Sites
Recycled Water Injection Well Study
Oceano CSD / Cannon

CLEATH-HARRIS GEOLOGISTS

APPENDIX E

Phase 1A Model Results

Scenario A			
Water Yard Injection			
Changes in Water Balance - SP 1 through 16			
Baseline linear injection and new Oceano injection			
Budget Item	Baseline Linear (Paso C)	Oceano Injection SITE A	Difference
	ACRE-FEET		
Well	-2896	-2596	-300
Lagoon	-54	-64	10
GHB_Shore	-75	-84	9
GHB_South	-2119	-2272	153
GHB_Southeast	227	211	16
GHB_AlluvLB	481	474	8
GHB_AlluvAG	334	332	2
GHB_PismoMarsh	-294	-335	40
Stream 1	995	995	0
Stream 2	710	710	0
Stream 3	477	466	11
Stream 4	135	135	0
Precip	1955	1955	0
Basins	278	278	0
Storage	-153	-204	50
NET	0	0	0

Scenario B			
S. Elm Street Injection			
Changes in Water Balance - SP 1 through 16			
Baseline linear injection and Oceano new injection			
Budget Item	Baseline Linear (Paso C)	Oceano Injection SITE B	Difference
	ACRE-FEET		
Well	-2896	-2596	-300
Lagoon	-54	-60	6
GHB_Shore	-75	-82	6
GHB_South	-2119	-2249	130
GHB_Southeast	227	196	31
GHB_AlluvLB	481	464	17
GHB_AlluvAG	334	330	5
GHB_PismoMarsh	-294	-330	36
Stream 1	995	995	0
Stream 2	710	710	0
Stream 3	477	471	6
Stream 4	135	135	0
Precip	1955	1955	0
Basins	278	278	0
Storage	-153	-216	63
NET	0	0	0

Scenario C

S. Elm Street Basin

Changes in Water Balance - SP 1 through 16			
Baseline linear injection and Oceano basin recharge			
Budget Item	Baseline Linear (Paso C)	Oceano Basin SITE C	Difference
	ACRE-FEET		
Well	-2896	-2896	0
Lagoon	-54	-60	6
GHB_Shore	-75	-81	6
GHB_South	-2119	-2260	141
GHB_Southeast	227	194	33
GHB_AlluvLB	481	466	16
GHB_AlluvAG	334	330	4
GHB_PismoMarsh	-294	-326	31
Stream 1	995	995	0
Stream 2	710	710	0
Stream 3	477	471	6
Stream 4	135	135	0
Precip	1955	1955	0
Basins	278	578	-300
Storage	-153	-211	58
NET	0	0	0

Scenario D

Arroyo Grande Creek Area Injection

Changes in Water Balance - SP 1 through 16			
Baseline linear injection and Oceano new injection			
Budget Item	Baseline Linear (Paso C)	Oceano Injection SITE D	Difference
	ACRE-FEET		
Well	-2896	-2596	-300
Lagoon	-54	-58	3
GHB_Shore	-75	-79	4
GHB_South	-2119	-2278	159
GHB_Southeast	227	177	50
GHB_AlluvLB	481	466	15
GHB_AlluvAG	334	331	3
GHB_PismoMarsh	-294	-314	20
Stream 1	995	995	0
Stream 2	710	710	0
Stream 3	477	474	3
Stream 4	135	135	0
Precip	1955	1955	0
Basins	278	278	0
Storage	-153	-196	43
NET	0	0	0

Scenario E			
Arroyo Grande Creek Area Basin			
Changes in Water Balance - SP 1 through 16			
Baseline linear injection and Oceano basin recharge			
Budget Item	Baseline Linear (Paso C)	Oceano Basin SITE E	Difference
	ACRE-FEET		
Well	-2896	-2896	0
Lagoon	-54	-57	3
GHB_Shore	-75	-79	3
GHB_South	-2119	-2268	149
GHB_Southeast	227	163	64
GHB_AlluvLB	481	464	17
GHB_AlluvAG	334	332	3
GHB_PismoMarsh	-294	-310	16
Stream 1	995	995	0
Stream 2	710	710	0
Stream 3	477	474	3
Stream 4	135	135	0
Precip	1955	1953	1
Basins	278	578	-300
Storage	-153	-194	41
NET	0	0	0