

APPENDIX C

Hydrologic Effects of Well Master Plan

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Subject: Hydrologic Effects of Well Master Plan

EXECUTIVE SUMMARY

Soquel Creek Water District (SqCWD) is undertaking studies to improve its water production and distribution system. The focus of these improvements is to provide redundancy and flexibility in SqCWD's system, while simultaneously redistributing pumping away from coastal areas. These studies constitute SqCWD's Well Master Plan (WMP). This letter addresses the anticipated hydrologic effects of implementing the WMP.

To achieve the goals of the studies, SqCWD identified five preferred well sites: O'Neill Ranch, Cunnison Lane, Granite Way, Austrian Way, and Polo Grounds Park. After constructing the proposed new wells and removing some of the existing impaired wells from service, SqCWD will redistribute its groundwater pumping to shift extractions away from the coast. This redistribution aims to achieve more uniform drawdown in the basin and reduce susceptibility to seawater intrusion. The redistribution scenarios are based on each well's production capacity, and will likely change over time in response to short-term hydrologic conditions and long-term water-level trends; flexibility is an important objective of installing the new wells.

Three potential effects are addressed for each new well site: damage to nearby wells from lowered water levels, unacceptable loss of well yield in nearby wells, and effects on streamflow in nearby creeks. Effects are rated using the following categories: beneficial effect, no effect, marginal effect, restrictive effect, and severe effect. The rating for both the water level and well yield effects on nearby

wells are based on the average effect to nearby wells. Using average effects is an appropriate benchmark because it would be unreasonable for the shallowest well in a basin to constrain the use of basin storage by all users. The effect ratings are developed to provide context for the analyses contained within this report. These may or may not be equivalent to the significance thresholds for effects incorporated into the final CEQA documentation.

Effects from pumping wells are based on the anticipated drawdown around the wells. A groundwater model was used to estimate future drawdown. The model applies an analytical solution to a multi-aquifer system. The model calculates drawdown within aquifer units while accounting for leakage between layers, consistent with the transmissivities of the individual aquifer units and the leakance values between units.

Both effects from individual wells and combined effects from both installing the planned well and redistributing pumping at existing wells are addressed. Results of the analyses are summarized below.

WATER LEVEL EFFECTS

Based on comparisons of the estimated drawdown around the proposed new wells and available information from nearby private and municipal wells, water level declines caused by pumping at the five preferred well sites will not increase the risk of damage at the average nearby well so the average water level effects are marginal. At locations where restrictive effects may occur from pumping at the new wells, the effects can be mitigated through redistributing pumping. Specific results for each well site include the following:

- Cunnison Lane and Granite Way Well Sites. The planned pumping at both the Cunnison Lane and Granite Way well sites will only marginally affect nearby wells. Additionally, the likely redistribution scenarios include decreased pumping at existing wells near the Cunnison Lane and Granite Way well sites. This redistribution will more than offset drawdown effects from the Cunnison Lane and Granite Way wells. Therefore, there is no restrictive water level effect from installing these two wells, and there is a beneficial combined effect from redistributing pumping.
- O'Neill Ranch Well Site. Operating the O'Neill Ranch well at its maximum seasonal rate will lower water levels at the City of Santa Cruz's (City) Live Oak wells, but water level effects will be marginal based on recent data. Additionally, the planned decrease in pumping at the Garnet well will offset any water level effects at the Live Oak wells. Pumping the O'Neill Ranch well will lower water levels at nearby private wells but water level effects will

be marginal for the average well. Pumping may also increase at the Main Street well during droughts, and the combined pumping at the O'Neill Ranch and Main Street wells is estimated to lower water levels at nearby private wells between 1-12 feet, but the effects of lowering water levels these amounts will be marginal. Therefore, there is no restrictive water level effect from the O'Neill Ranch well, and there is no restrictive combined effect from redistributing pumping in this area.

- Polo Grounds Well Site. Operating the Polo Grounds well at its maximum seasonal rate will lower water levels at the Central Water District's (CWD) wellfields, but water level effects will be marginal based on recent data. The planned pumping redistribution will further lower water levels in the CWD wells; however under average conditions water level effects will also be marginal. Redistributing pumping could initiate dewatering of a well screen at CWD well #10 if background water levels ever fall to levels observed at the end of the last extended drought. This is a potentially restrictive effect that could be mitigated by reducing pumping at the Polo Grounds well and/or the Aptos Jr. High well. Increases of pumping at the Polo Grounds well and Aptos Jr. High well are estimated to lower water levels at nearby private wells between 2-6 feet, but the effects of lowering water levels these amounts will be marginal.
- Austrian Way Well Site. Operating the Austrian Way well at its maximum seasonal rate will result in marginal effects at nearby wells. Pumping the Austrian Way well is estimated to lower water levels between 1-7 feet at nearby private wells, but effects of lowering water levels these amounts will be marginal. There are no other municipal wells in this area, so the planned pumping redistribution has no effect on nearby water levels. Therefore, there is no restrictive water level effect from the Austrian Way well, and there is no combined effect from redistributing pumping in this area.

WELL YIELD EFFECTS

Well yield effects due to lower water levels are less than restrictive for all private and municipal wells. At nearby wells, the simulated drawdown is a small percentage of the total operating head of the well pump and could increase pump operating time slightly. The nearby private wells are all domestic wells which typically operate only occasionally during the day, so a small increase in operating time can easily compensate for the minor loss of yield.

Pumping can also affect yields of nearby wells by altering the transport of contaminants at nearby regulated sites: a well that is impacted by regulated chemicals may have to be turned off or replaced. At regulated sites near the

O'Neill Ranch well site where contaminant levels are monitored, the transport of contaminants are only marginally affected by pumping the O'Neill Ranch well. At the Quik Stop site near the Cunnison Lane well site, likely decreases in pumping at the Rosedale and Tannery II wells will offset the effect on remediation wells from pumping the Cunnison Lane well, resulting in no adverse effect on yields of nearby private wells.

Lower water levels could potentially decrease the yield of the City's Live Oak wells due to the increased threat of seawater intrusion. This effect can be mitigated by redistributing pumping away from the Garnet well. Likely decreases in pumping at the Garnet well will offset the yield effect at the Live Oak wells caused by pumping the O'Neill Ranch well, resulting in no effect on yield.

STREAM EFFECTS

Stream effects are dependent on several site specific factors. These factors include the redistribution of pumping in nearby wells, the presence of baseflow in the creek during the dry season, the hydraulic connection between groundwater and the creek, the distance from the municipal well to the creek, and the ability of confining layers to spread the well's drawdown over a larger area. Particular results for each well site include the following:

- Cunnison Lane and Granite Way Well Sites. The likely redistribution scenarios include decreasing pumping at existing wells near the Cunnison Lane and Granite Way well sites. There will be a net decrease of groundwater pumping in the area and there will be no effect or a beneficial effect on streamflows in nearby creeks.
- Austrian Way Well Site. Water levels measured in the newly installed monitoring well at the site are 350 feet below ground surface, indicating a large vertical hydraulic separation between the shallow aquifer and the BC aquifer that will likely be pumped by a well at this location. This existing downward gradient implies that some leakage is already occurring, and pumping a well at the Austrian Way site will likely increase this leakage rate only minimally. Furthermore, streamflow depletion from pumping a well at this site will be slow and diffuse and decreases in pumping along Aptos Creek downstream of this site will mitigate the effects. The potential effects are marginal and should only be seen upstream of this site.

- O'Neill Ranch Well Site. The only nearby creek with the necessary conditions for baseflow depletion and fish habitats is Soquel Creek.¹ Due to its distance from Soquel Creek, the O'Neill Ranch well will have less effect on baseflows than the effects from the Main Street Well , which have thus far been below the detection threshold. The maximum possible effect on baseflows by the new O'Neill Ranch pumping and the pumping redistribution is estimated to be between 0.07 and 0.14 cubic feet per second. The actual effect will likely be less than this.
- Polo Grounds Well Site. Historical water levels indicate that a large vertical separation has existed between the Valencia Creek bed and the water table for the last 30 years. Therefore, there is no hydraulic connection between surface water and groundwater in the vicinity of this well and increased pumping in this area will have no effect on baseflow.

All of the potential effects are summarized on Table 1.

¹ Rodeo Gulch is near the well site. No flow records are available for Rodeo Gulch, but the small watershed area of only 3.4 square miles probably supports only a trickle of baseflow that likely disappears in dry years.

Table 1: Summary of Effects

		Proposed Municipal Wells				
		O'Neill Ranch	Cunnison Lane	Austrian Way	Granite Way	Polo Grounds
		Effects from pumping at capacity				
Private Wells	Water Level Effects	Marginal	Marginal	Marginal	Marginal	Marginal
	Yield Effects	Marginal	Restrictive based on possible dewatering of remediation wells at Quik Stop No. 78	Marginal	Marginal	Marginal
Municipal Wells	Nearby wellfields	City of Santa Cruz Live Oak	None	None	None	Central Water District Rob Roy and Cox
	Water Level Effects	Marginal	N/ A	N/ A	N/ A	Marginal
	Water Level Effects during drought	Marginal	N/ A	N/ A	N/ A	Restrictive based on water levels at the end of the last drought
	Yield Effects	Restrictive due to seawater intrusion risk	N/ A	N/ A	N/ A	Marginal
		Combined Effects				
Nearby redistribution of pumping		Main Street Well increases pumping in drought year. Garnet well decreases pumping.	Rosedale and Tannery II wells reduce pumping. Cunnison Lane well pumps less than capacity	No nearby District wells.	Aptos Creek well placed on standby.	Aptos Junior High well increases pumping. Bonita well decreases pumping.
Private Wells	Water Level Effects	Marginal	Beneficial	Marginal	Marginal	Marginal
	Yield Effects	Marginal	Beneficial	Marginal	Marginal	Marginal
Municipal Wells	Water Level Effects	Marginal	N/ A	N/ A	N/ A	Marginal
	Yield Effects	Marginal	N/ A	N/ A	N/ A	Marginal
Streamflow	Nearby stream with baseflow and steelhead habitat	Soquel Creek	Soquel Creek	Aptos Creek	Aptos Creek	Valencia Creek
	Effects on streamflow	Estimated maximum effect of 0.07-0.14 cfs	No decrease in streamflow due to net decrease in pumping in area	Detectable depletion most likely to occur in upper reaches of Aptos Creek	No decrease in streamflow due to net decrease in pumping in area	No effect on streamflow due to lack of hydraulic connection between stream and groundwater

Section 1 PURPOSE AND INTRODUCTION

Soquel Creek Water District (SqCWD) is undertaking studies to improve its water production and distribution system. The focus of these improvements is to provide redundancy and flexibility in SqCWD's system, while simultaneously redistributing pumping away from coastal areas. As part of these studies, SqCWD developed a Well Master Plan that identified potential new well sites. These sites were identified through a well selection process that is summarized in Attachment 1. The well selection process identified five preferred well sites: O'Neill Ranch, Cunnison Lane, Granite Way, Austrian Way, and Polo Grounds Park. Like SqCWD's existing production wells, these preferred well sites are located in the Soquel-Aptos groundwater basin, but are generally farther inland than existing wells. This letter discusses the hydrologic effects of developing the preferred well sites and redistributing SqCWD's pumping amongst the planned production well network.

The hydrologic effects fall under two categories. First, redistributed pumping may have drawdown and yield effects on nearby wells, including production wells of neighboring water districts, production wells of neighboring mutual water companies, and private wells. Second, redistributed pumping may have effects on stream baseflow. This letter evaluates these two categories of effects in two separate sections (Section 6 and Section 7).

GROUNDWATER MANAGEMENT PLAN CONSISTENCY

The WMP is designed to be consistent with the goals and objectives of the Soquel-Aptos Basin Groundwater Management Plan (GMP). SqCWD and CWD jointly developed the original plan in 1996 pursuant to AB3030 guidelines. The agencies recently updated the GMP to reflect new data and additional requirements imposed by SB1938 (SqCWD and CWD, 2007). The current plan articulates the following goals, objectives, and elements which are supported by the WMP:

GOALS SUPPORTED BY THE WMP

Goal 1: Provide adequate quantities of water for residential, commercial, institutional, agricultural, and fire suppression uses

OBJECTIVES SUPPORTED BY THE WMP

Objective 1-1: Pump within the sustainable yield of the basin

Objective 1-3: Manage groundwater storage for future beneficial uses and drought reserve

Objective 3-2: Avoid alteration of stream flows that would adversely affect the survival of populations of aquatic and riparian organisms

Objective 3-3: Protect the structure and hydraulic characteristics of the groundwater basin by avoiding withdrawals that cause subsidence

ELEMENTS SUPPORTED BY THE WMP

Element 8: Manage pumping to influence pumping depressions, provide adequate flow throughout the distribution system, avoid overdraft conditions, and prevent seawater intrusion.

LETTER OUTLINE

Section 2 of this letter presents our understanding of the hydrogeologic conditions and aquifer characteristics of the two principal geologic formations in the groundwater basin: the Purisima Formation and the Aromas Red Sands. Section 3 discusses the preferred well sites, and presents likely pumping distributions that meet the goals and objectives of the Soquel-Aptos Groundwater Management Plan (Soquel Creek Water District and Central Water District, 2007). Section 4 proposes a rating system for the analyses of well effects. Section 5 details the approach for conducting the analyses of well effects. Based on our conceptual model of the formations, we analyze the potential effects from SqCWD's proposed new wells and redistributed pumping on water levels and yield at nearby wells in Section 6, and categorize these effects based on the rating system. Finally, in Section 7 we evaluate available water level and stream flow data to analyze potential effects from the Well Master Plan on nearby streams.

Section 2

SOQUEL-APTOS BASIN CONCEPTUAL MODEL

GEOLOGY

Wells at the five preferred sites will extract groundwater from the Soquel-Aptos groundwater basin which comprises two main geologic formations: the consolidated Purisima Formation and the poorly consolidated Aromas Red Sands. The Pliocene to late Miocene Purisima Formation consists of grey to blue, moderately consolidated, fine to medium sandstones containing siltstone and claystone interbeds. A number of marker beds in the Purisima Formation have been correlated across central Santa Cruz County. These marker beds have been used to define the structure of the Purisima Formation. The Purisima Formation underlies the entire Soquel-Aptos area; however it is blanketed by the Aromas Red Sands in the eastern third of the Soquel-Aptos area (Figure 1). The Pleistocene age Aromas Red Sands are a sequence of brown to red, poorly consolidated, fine to coarse-grained sandstones containing lenses of silt and clay.

The Purisima Formation strikes generally northward in most of the groundwater basin east of the City of Santa Cruz (Hickey, 1968). The strike turns to north of northeast, however, near the Live Oak wellfield (Cloud, personal communication). The beds of the Purisima Formation dip to the east at approximately 4 degrees (Hickey, 1968). The formation is relatively undeformed in the Soquel-Aptos area: the beds appear to maintain a fairly even thickness, and are not significantly folded.

Johnson et al. (2004) divided the basin materials into a sequence of aquifers and aquitards based on geologic information from borehole logs. The lowest and oldest layer is an unnamed unit of Tertiary age referred to as the Tu aquifer. Overlying the Tu aquifer is a poorly defined fine-grained aquitard denoted as Tmp. It is unclear if this Tmp aquitard is part of the Purisima Formation or is part of an older unit such as the Santa Cruz Mudstone or Monterey Formation. Above the Tmp aquitard are a sequence of aquifers and aquitards comprising the Purisima Formation that are named in alphabetical order from lowest to highest: the AA aquifer, the A aquifer, the B aquitard, the BC aquifer, the D aquitard, the DEF aquifer, and the F aquifer.

The Aromas Red Sands (Qa) unconformably overlie the Purisima F aquifer. The Aromas Red Sands consist of interbedded sands, silts and clays, but the texture is generally coarser and less stratified than the Purisima Formation. The Aromas Red Sands is sometimes divided into an upper Aromas (Qua) and lower Aromas (Qla). The estimated surface projection of these hydrostratigraphic units is

shown on Figure 1. An east-west cross section of the hydrostratigraphic units is shown in Figure 2.

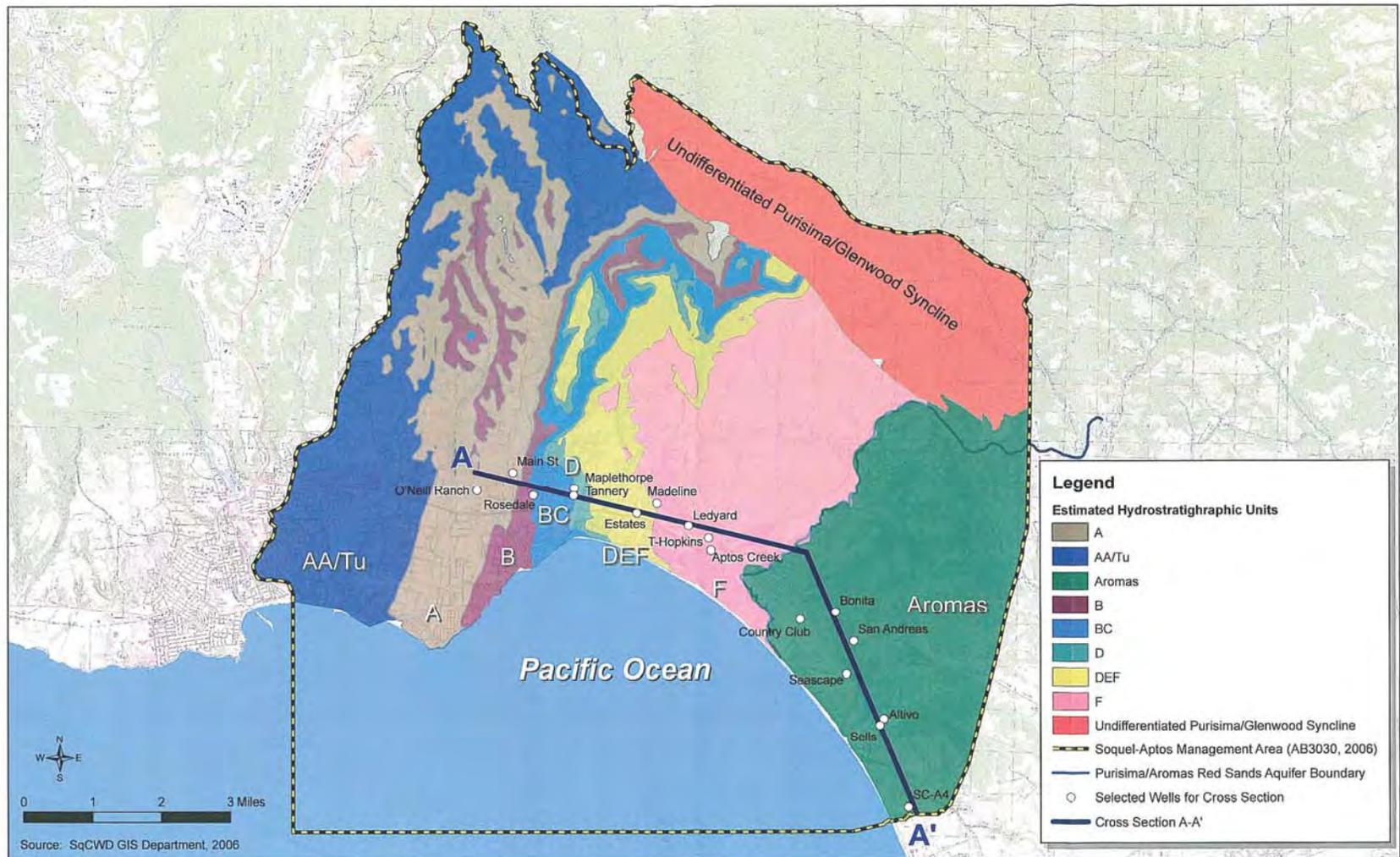
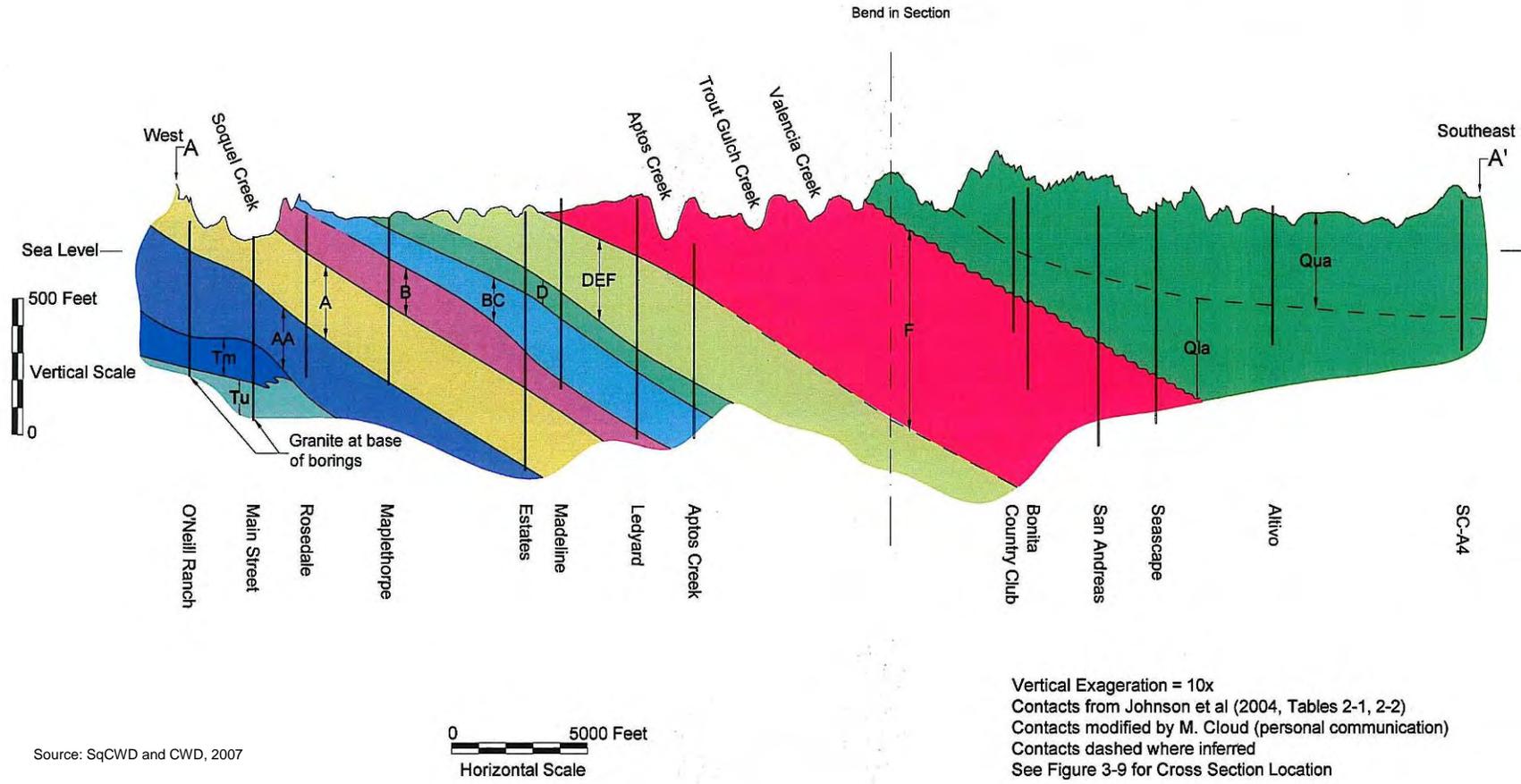


Figure 1. Outcrop Areas of Purisima Aquifer Units and the Aromas Red Sands



Source: SqCWD and CWD, 2007

Section line shown on Figure 1.

Figure 2. Hydrogeologic Cross Section A-A'

These hydrostratigraphic units are adopted as a convenience, but the boundaries between units generally do not represent sharp demarcations of water bearing and non-water bearing sediments. Aquifers contain sometimes significant amounts of claystone and siltstone beds; aquitards often have notable sandy layers embedded in them. This results in the opportunity for significant groundwater flow between aquifers, through the aquitards.

GROUNDWATER FLOW

Under pre-development conditions, groundwater likely flowed from the inland hills towards the ocean. This pattern has been disrupted by drawdown cones that develop around municipal, industrial, domestic, and agricultural wells. In places, these cones of depression have extended to the coastline.

Groundwater flow directions in the Soquel-Aptos area have been mapped in a number of previous studies. The U.S. Geological Survey published groundwater contour maps for April 1981 (Bloyd, 1981). This map shows the expected pattern of groundwater flowing from the eastern hills into the ravines and western lowlands. Additionally, the map shows groundwater flowing from the northwest towards the SqCWD and City wellfields. This is consistent with the City's Drinking Water Source Assessment and Protection (DWSAP) study (Johnson, 2003), which includes maps showing capture zones for the Live Oak wellfield. The DWSAP shows that the Live Oak wells generally capture water from west and slightly northwest of the wellfield.

The Addendum to Annual State of the Basin Report for Water Year 2007 (HydroMetrics LLC, 2009) showed water level contours for the Purisima A Unit in April 2007 (Figure 3) and October 2007 (Figure 4); and for the Purisima BC Unit in April 2007 (Figure 5) and October 2007 (Figure 6). The contours show that groundwater generally flows from the northern hills towards depressed water levels in the vicinity of the production wells; with groundwater in the western portion of the basin displaying an aspect of west to east flow as suggested by Bloyd (1981). The contours additionally suggest that a portion of the groundwater pumped by the SqCWD wells is derived from beneath Monterey Bay. This is the same general pattern of groundwater flow that has persisted for years.

The Addendum to Annual State of the Basin Report for Water Year 2007 also showed water level contours in the Aromas Red Sands in April 2007 (Figure 7) and October 2007 (Figure 8). Water levels in the Aromas Red Sands are characterized by a moderate seaward gradient in upland areas that transitions to

a relatively flat gradient throughout the coastal plain. Groundwater in the Aromas Red Sands generally flows from the hills towards the Pacific Ocean but appears to be almost entirely captured by municipal, private, and agricultural wells in the coastal plain area.

Johnson et al. (2004) estimated that the flow divide on the eastern end of the Soquel-Aptos groundwater basin is located 1-2 miles northeast of the Central Water District (CWD) wellfields (Figure 9). Southwest of the divide, groundwater recharge contributes to the yield of CWD and SqCWD wells. Additional pumping at CWD and SqCWD wells could shift the divide to the northeast, thereby expanding their capture zone into areas where groundwater normally flows toward the Pajaro Valley. Likewise, localized additional pumping in Pajaro Valley may shift the divide to the southwest, capturing water that currently flows towards CWD and SqCWD wells.

In addition to changes in the horizontal flow patterns, groundwater extraction has also altered vertical flow patterns. As noted above, the designation of aquifers and aquitards is a convenience, and there is flow between the various hydrostratigraphic units. This flow is suggested by the presence of vertical gradients in SqCWD's nested monitoring well clusters (Johnson et al., 2004). It is further corroborated by the volume of water extracted from the Purisima A aquifer, which is high in proportion to its outcrop area. This implies that much of the water extracted from that unit consists of groundwater that leaks into the A aquifer from the AA and BC aquifers.

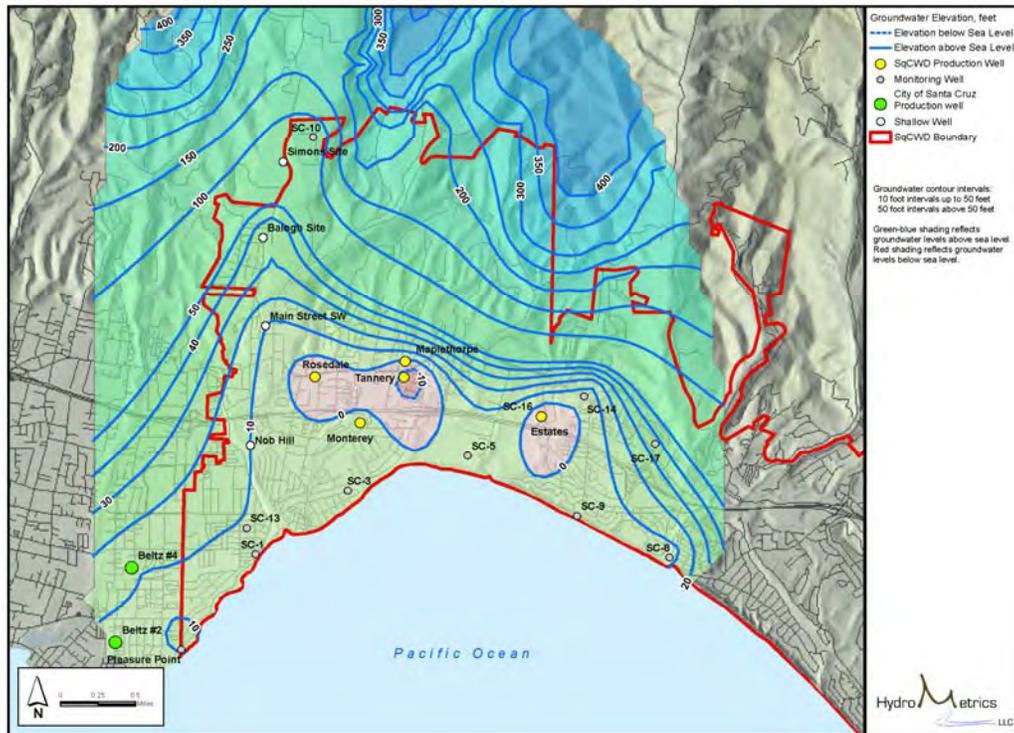


Figure 3. Water Level Contours, Purisima A-Unit, April 2007

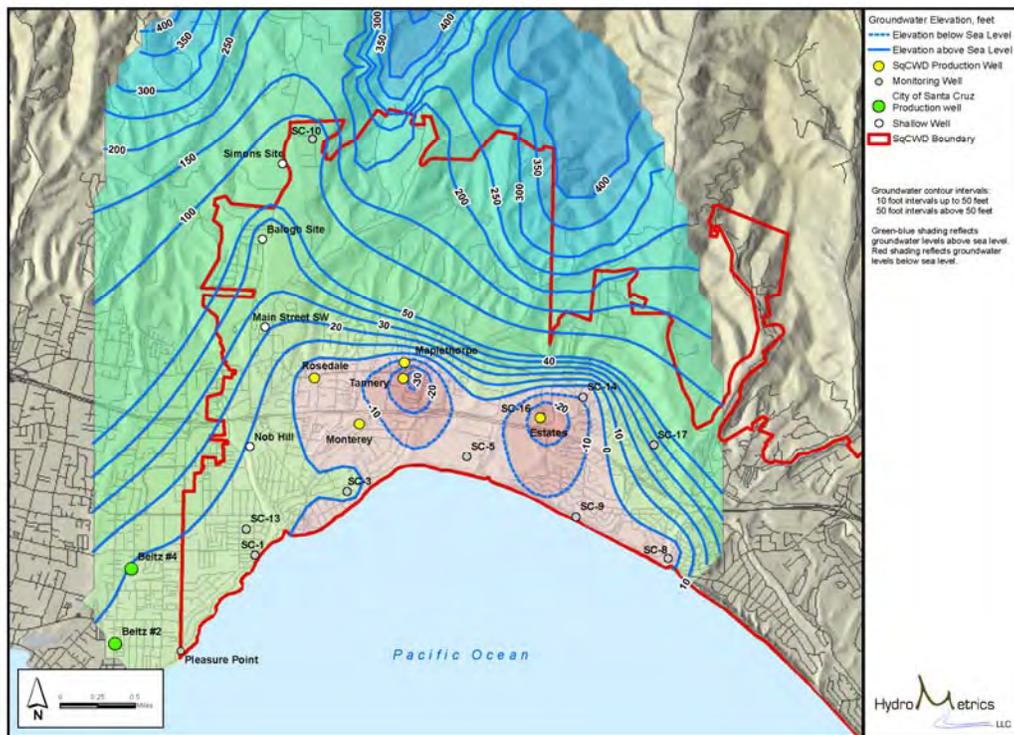


Figure 4. Water Level Contours, Purisima A-Unit, October 2007

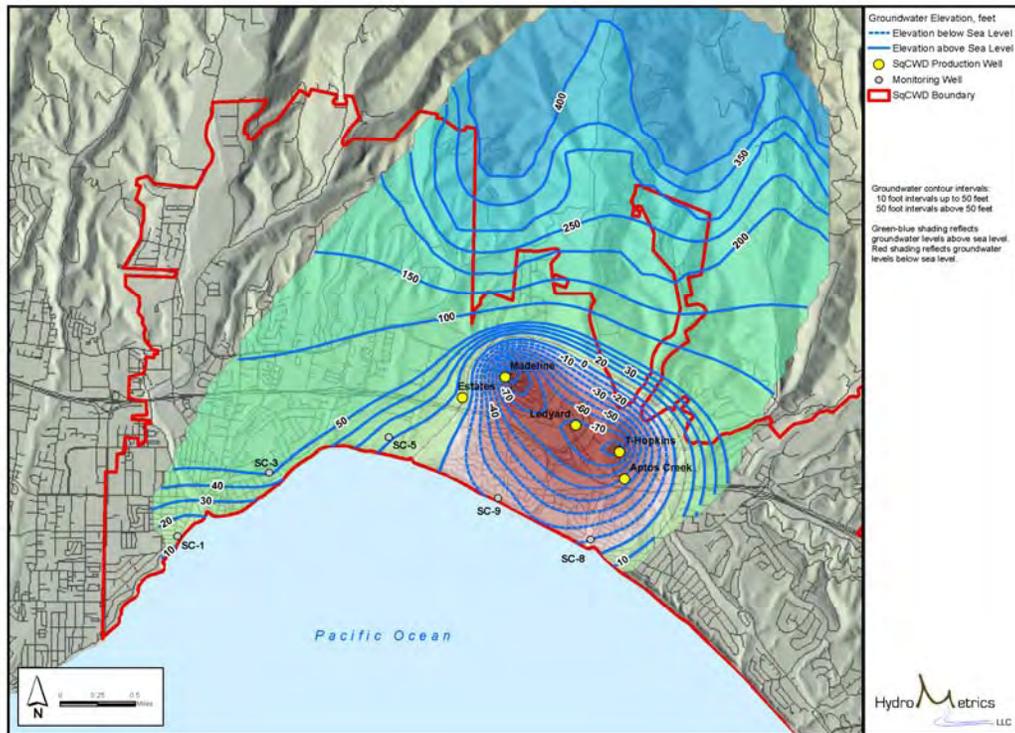


Figure 5. Water Level Contours, Purisima BC-Unit, April 2007

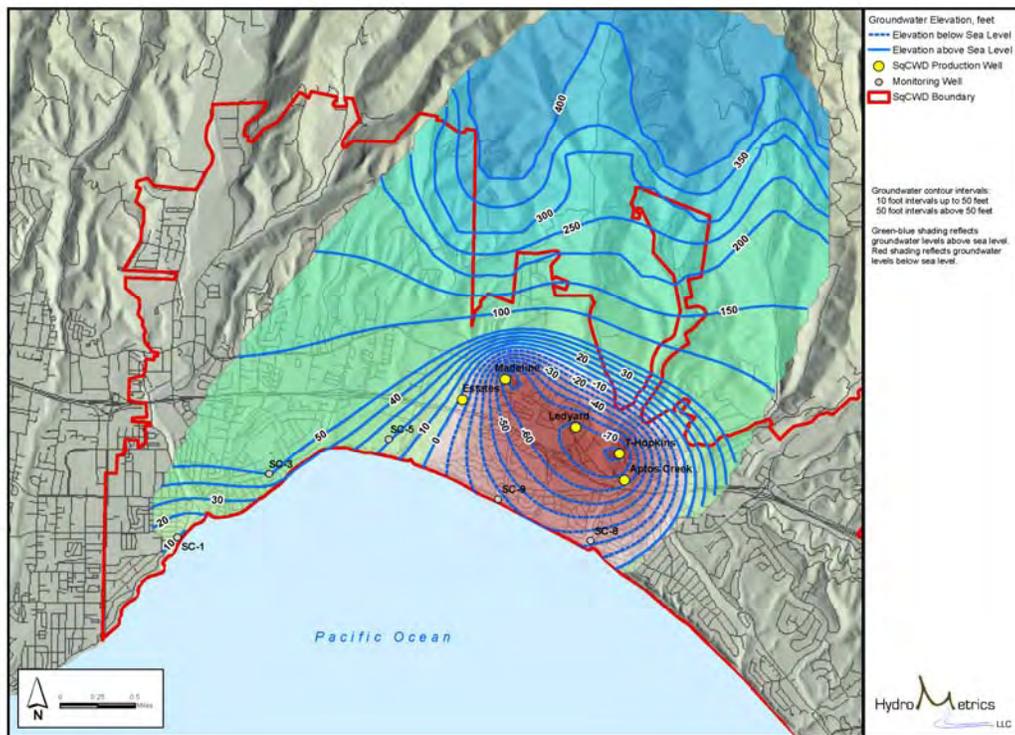


Figure 6. Water Level Contours in Purisima-BC Unit, October 2007

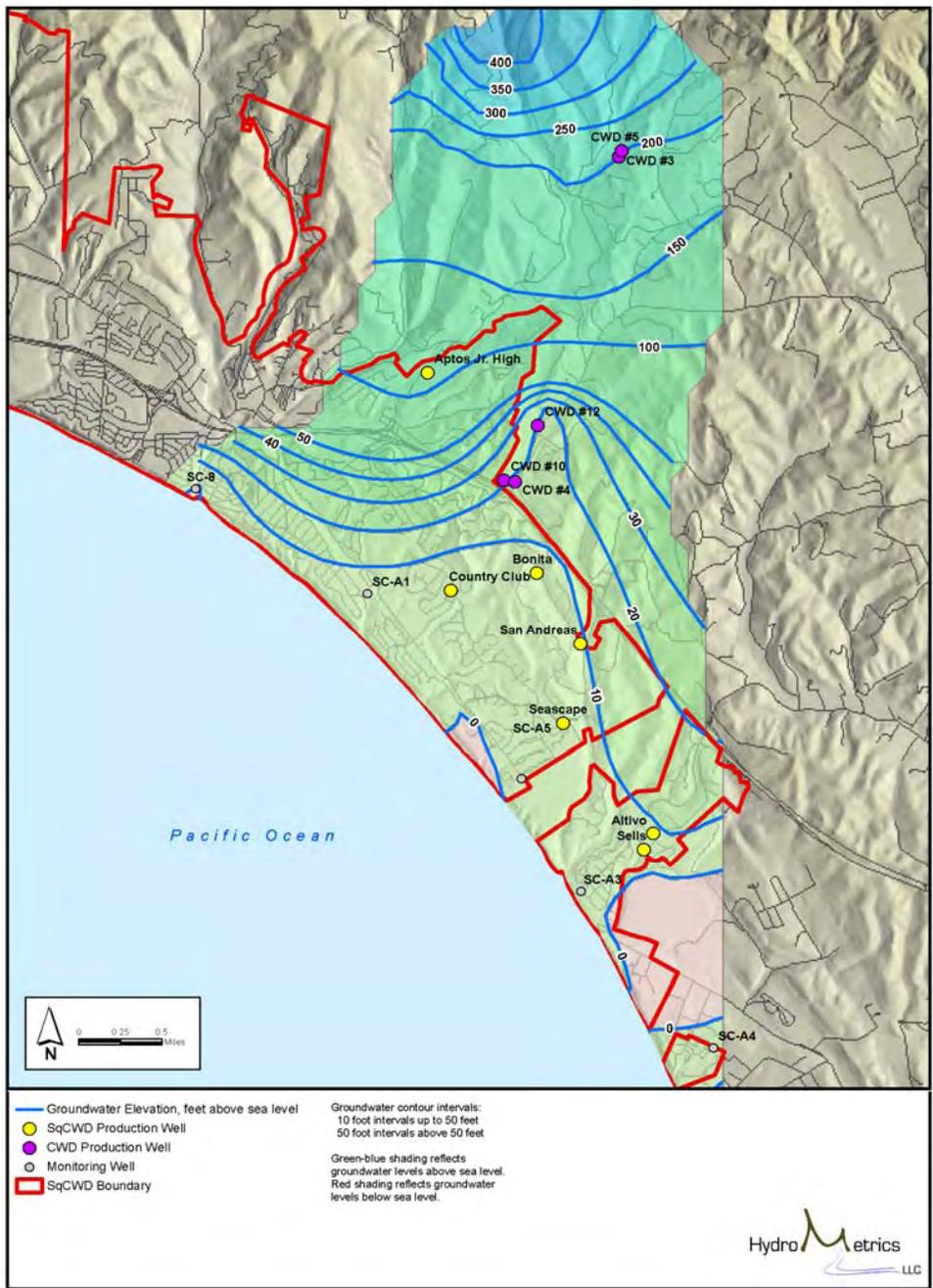


Figure 7. Water Level Contours, Aromas Red Sands, April 2007

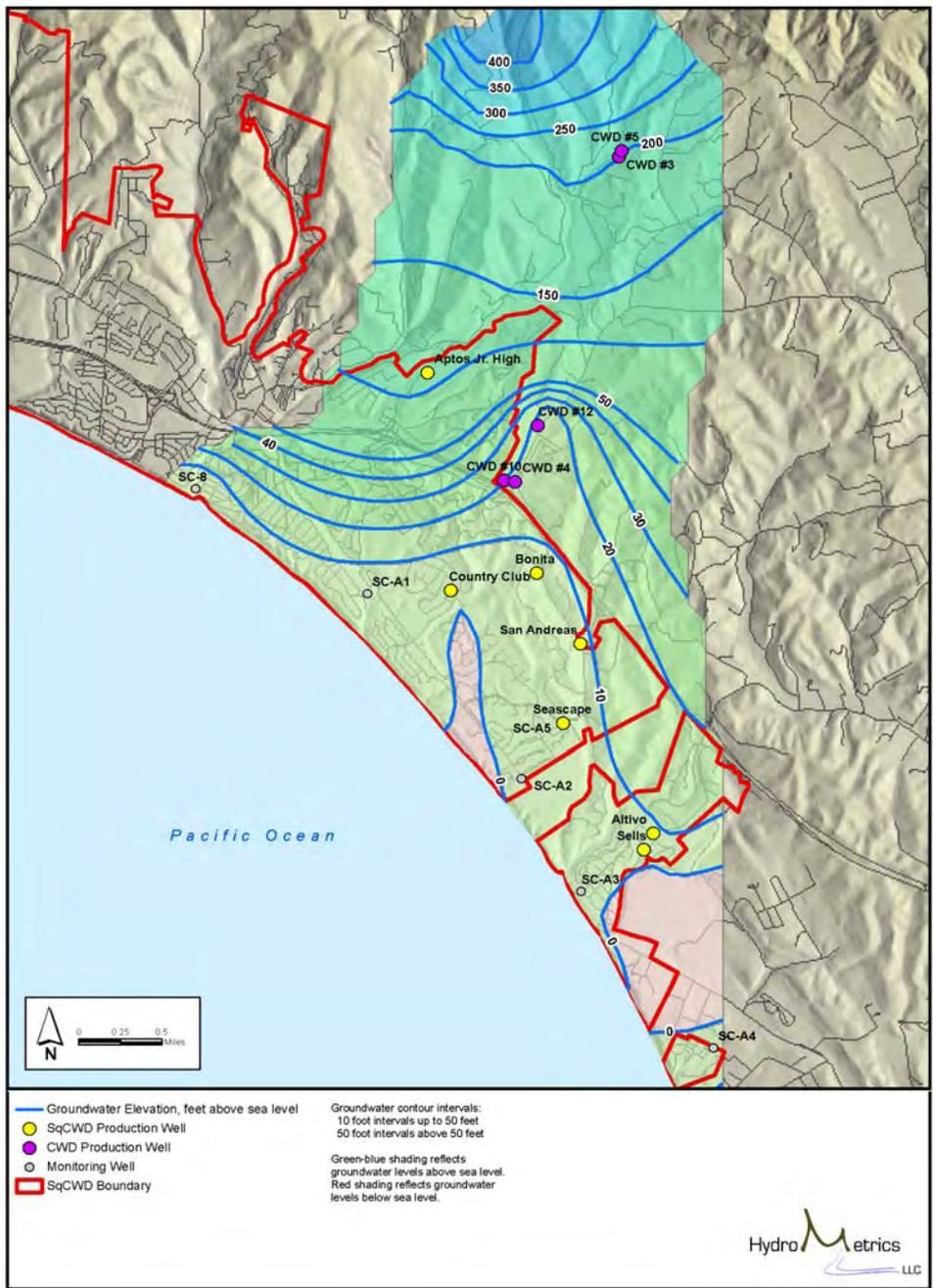


Figure 8. Water Level Contours, Aromas Red Sands, October 2007

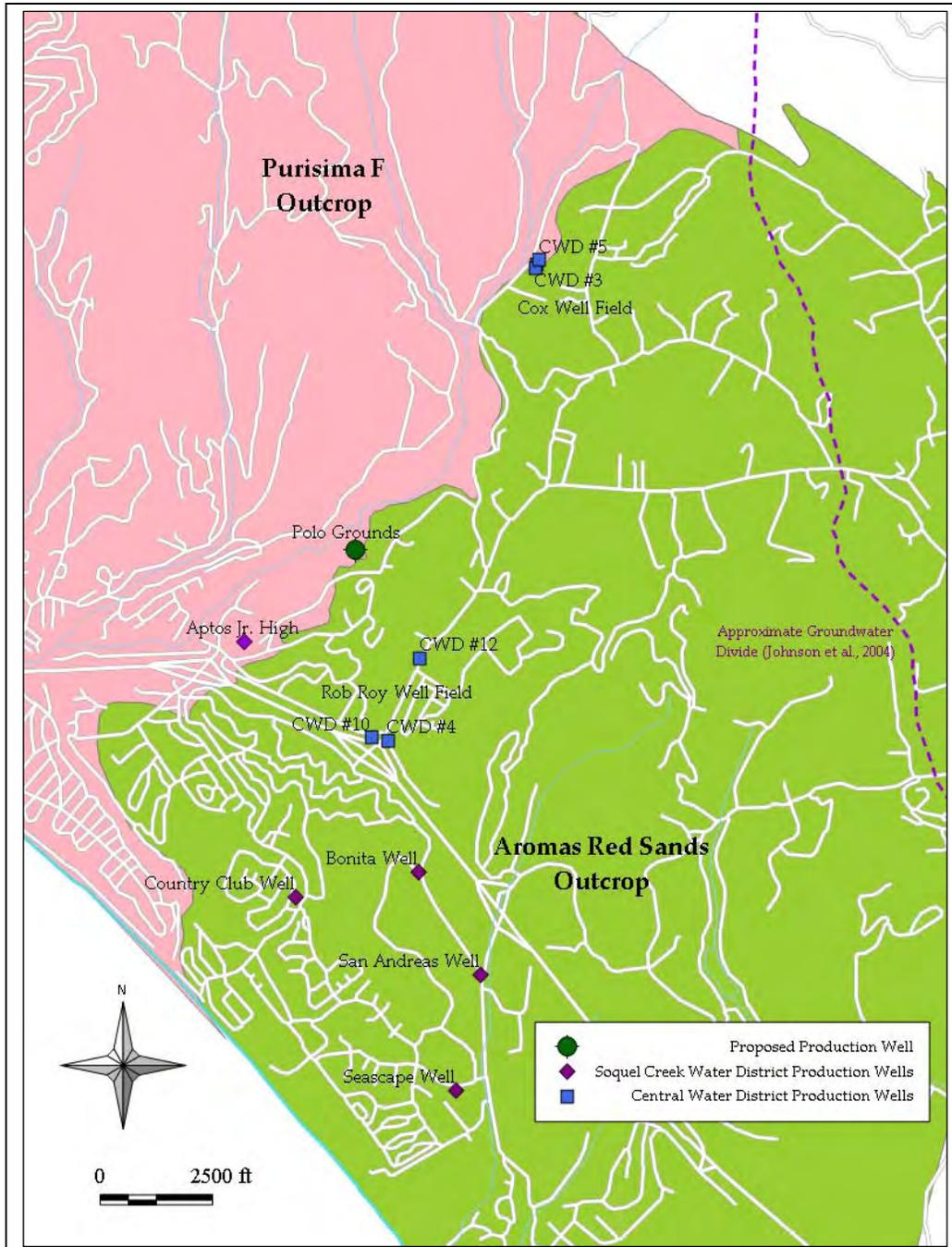


Figure 9. Central Water District Well Locations and Estimated Groundwater Divide

Section 3

DESCRIPTION OF NEW WELLS AND PUMPING REDISTRIBUTION

SqCWD has developed a Well Master Plan (WMP) to improve both redundancy and flexibility in SqCWD's water production and distribution system, while simultaneously redistributing pumping away from coastal areas. The WMP is based on current groundwater conditions, the reliability of the existing water system, and the findings of a source capacity assessment. The source capacity assessment was a study identifying which areas of the SqCWD distribution system may have insufficient supplies in the future (SqCWD, 2006). The assessment was performed on each of SqCWD's service areas independently, due to limited ability to transfer water between service areas. The adequacy of supply in each service area was assessed assuming the largest single source is out of service and other impaired wells are unavailable.

NEW WELL LOCATIONS

The preferred alternative identified in the WMP consists of developing new groundwater production wells at a minimum of four of five identified potential locations, destroying the deteriorating Monterey production well, and maintaining the Maplethorpe well as an inactive well. Other wells may also be placed on standby status after the proposed new well production is verified. One of the five proposed sites is the Polo Grounds site, which entails converting an existing irrigation well to a municipal well. The five potential locations for new municipal wells are shown on Figure 10. A description of the site selection process pursuant to the WMP is provided in Attachment 1.

WELL POTENTIAL PRODUCTION

The potential annual production of each existing and proposed well is based on each well's likely pumping rate. Table 2 shows the maximum instantaneous pumping rates used for planning purposes. These maximum pumping rates can be considered well capacities for the peak day demand analysis documented in the Well Master Plan.

However, the maximum pumping rates are not used in full when estimating potential annual production, because no well will pump 24 hours per day over many days. The maximum instantaneous rates are translated to annual production potential, by assuming each well operates 50% of the time over the year, as shown on Table 3.



Figure 10. Proposed Municipal Well Locations

PUMPING REDISTRIBUTION SCENARIOS

After constructing the proposed new wells and removing some of the existing impaired wells from service, SqCWD will redistribute its groundwater pumping

to shift extractions away from the coast. This redistribution aims to achieve more uniform drawdown in the basin and reduce susceptibility to seawater intrusion. The distribution of pumping among the active wells will likely change over time in response to short-term hydrologic conditions and long-term water-level trends; flexibility is an important objective of installing the new wells. At certain times, each of the new wells might be operated at its maximum sustainable pumping rate, resulting in the maximum drawdown at nearby wells. Most often, however, pumping will be distributed among all of the active wells to meet the goals of the groundwater management plan, subject to the constraints of meeting water demand within each of SqCWD's four service areas and the current limited capacity to transfer water between service areas.

Although the exact allocation of pumping among SqCWD's wells is not specified in the WMP, likely pumping distributions can be inferred from the WMP's objectives of achieving more uniform drawdown and reducing susceptibility to seawater intrusion. An evaluation of each well's depth, screened aquifer unit, maximum instantaneous pumping rate, and distance from the ocean boundary was used to develop several plausible pumping redistribution scenarios that would reduce susceptibility to seawater intrusion while meeting the demands within each of SqCWD's four service areas.

Table 3 shows the current pumping distribution, based on the average pumping in water years 2005 through 2008, and four hypothetical pumping redistribution scenarios. Scenarios 1 through 4 assume an annual production rate of 4,800 acre-feet/year; the pumping goal set by SqCWD (SqCWD and CWD, 2007). The pumping goal is divided into a goal of 3,000 acre-feet/year in the Purisima area (service areas I and II) and 1,800 acre-feet/year in the Aromas area (service areas III and IV) (SqCWD and CWD, 2007). Pumping 4,800 acre-feet/year meets the anticipated year 2050 demand with conservation and a supplemental water supply in place (ESA, 2006). Scenarios 1 through 4 are shown in the columns under the heading "BMO Pumping Condition."

The total pumping rate of 4,800 acre-feet/year will be sufficient during droughts as well as average years, because during drought years SqCWD plans to use proposed supplemental supply and mandatory drought restrictions to maintain the production rate. Slight redistributions in pumping may be necessary during droughts, and are discussed further in Section 5.

The four scenarios are based on the following general concepts.

- Scenario 1 uses all five proposed wells and assumes the existing transfer capacity between service areas is maintained. Pumping is distributed

evenly within service areas. This is considered the most likely pumping scenario.

- Scenario 2 uses four of the proposed wells, excluding the Cunnison Lane well from the system. The scenario assumes the existing transfer capacity between service areas is maintained. The Tannery II well pumps more than in Scenario 1 to make up for the excluded Cunnison Lane well. Pumping is less evenly distributed in Service Areas II and III than in Scenario 1. Scenario 2 includes the possibility of installing a higher capacity pump in the Country Club well, which leads to a larger transfer of water from Service Area III to Service Area IV.
- Scenario 3 uses four of the proposed wells, excluding the Austrian Way well from the system. The scenario assumes the existing transfer capacity between service areas is maintained. This existing capacity is used to pump more in Service Area I for transfer to Service Area II and the Estates well pumps more than in Scenario 1. Scenario 3 differs from other scenarios in that it includes the possibility that the Aptos Creek well remains online and the T. Hopkins well is placed on standby status to be used in emergencies for Service Area II. This scenario also includes a change in Service Area IV blending policy such that transfers from Service Area III to Service Area IV are no longer necessary.
- Scenario 4 uses all five proposed wells but assumes a total increase in transfer capacity of 200 gallons per minute (gpm) from Service Area II to Service Area III. Therefore, pumping is increased in Service Areas I and II and decreased in Service Areas III and IV when compared to Scenario 1. As a result, pumping is greater than the goal of 3,000 acre-feet/year established for the Purisima area.

PUMPING REDISTRIBUTION IN SERVICE AREA I

Two potential new well sites are proposed for Service Area I: the O'Neill Ranch site and the Cunnison Lane site. The Monterey well in this service area will be destroyed and the Maplethorpe well will be maintained as an inactive well. The addition of the O'Neill Ranch well allows for a reduction of pumping at the coastal Garnet well. Continued Garnet well pumping at reduced rates during non-drought years will maximize capture of water flowing towards the ocean while maintaining coastal groundwater levels that prevent seawater intrusion. Maximizing capture of offshore flow is a reasonable operational plan near the Garnet well because there is little offshore storage in this area. During drought years, pumping is shifted inland by reducing Garnet well pumping further and increasing Main Street well pumping.

The addition of the O'Neill Ranch well also allows for a reduction of pumping at the Rosedale and Tannery II wells in the middle of the Purisima A pumping trough. This redistribution spreads out pumping away from the coast. This should reduce maximum drawdowns and facilitate the maintenance of protective water levels at the coast.

The Cunnison Lane well is a possible second new well for Service Area I. Scenario 1 uses a well at this location to further reduce pumping at the nearby Rosedale and Tannery II wells. Scenario 3 uses a well at this location to also help meet demand in Service Area II. In Scenario 4, pumping at the Cunnison Lane well allows for decreased pumping in Service Areas III and IV, as this scenario assumes increased transfer capacity from Service Area I to Service Areas III and IV.

PUMPING REDISTRIBUTION IN SERVICE AREA II

Two potential new well sites are proposed for Service Area II: the Austrian Way site and the Granite Way site. Adding the Austrian Way well allows SqCWD to reduce pumping at the Estates well in Scenario 1. Reducing pumping from the Estates well is desirable because the pump in the Estates well has broken suction during prolonged pumping. The Estates well, however, is screened in the productive Unit A so it will likely continue to be a lead producer for Service Area II, even at reduced pumping rates. Pumping the Austrian Way well in Scenario 2 meets Service Area II demand without requiring the use of the Cunnison Lane well to transfer water from Service Area I. The Austrian Way well enables the greater transfer of water to Service Area III in Scenario 4.

A second possible well site in Service Area II is the Granite Way site. The addition of the Granite Way well allows SqCWD to stop all pumping at the Aptos Creek well under most scenarios. The Aptos Creek well will be placed on standby status under these scenarios. The Aptos Creek well has age and structural issues and is no longer reliable. However, it is possible that the Aptos Creek well will continue to perform adequately, so Scenario 3 shows continued use of this well and the nearby T. Hopkins well placed on standby status.

PUMPING REDISTRIBUTION IN SERVICE AREA III

One potential new municipal well site is proposed for Service Area III at Polo Grounds Park. In the redistribution scenarios, pumping increases in Service Area III occur at both the Polo Grounds well and the Aptos Jr. High well. The Polo Grounds well will be converted from park irrigation to municipal use. The

Aptos Jr. High well was reactivated for municipal production in 2007. These wells are primarily screened in the Purisima F Unit. These two wells allow for redistributing pumping from wells predominantly screened in the Aromas Red Sands to the Purisima F Unit. The Seascope well is located near historical observations of seawater intrusion in nearby monitoring well clusters SC-A2 and SC-A5 so all scenarios eliminate pumping in the Seascope well. However, this well will be placed on standby status for emergency purposes. The increased pumping at the Polo Grounds and Aptos Jr. High wells also facilitates decreasing pumping at the Bonita and San Andreas wells in the Aromas Red Sands.

Scenario 1 has a more even distribution of pumping between the Country Club, Bonita, and San Andreas wells than currently occurring. Most scenarios assume the Country Club well continues to pump at its current capacity, but Scenario 3 assumes that a larger pump is installed in the Country Club well and successfully produces at a higher rate. Scenario 4 has less pumping in Service Area III due to increased transfer capacity from Service Area II.

PUMPING REDISTRIBUTION IN SERVICE AREA IV

There are no new wells planned for Service Area IV. In scenarios 1, 2, and 4 pumping in Service Area IV is minimized by transferring water from Service Area III. This transfer water is used to reduce chromium VI levels in water delivered in Service Area IV. Scenario 3 accounts for a change in this policy such that the annual transfer of approximately 150 acre-feet/year is not required, and Service Area IV pumping meets Service Area IV demand. This would reduce pumping in Service Area III wells approximately 150 acre-feet/year, and would reduce the combined effect around the Polo Grounds well.

OPERATING PLANS AS WELLS ARE CONSTRUCTED

The columns under the heading “Operating Plan as Wells Come on Line” in Table 3 show how Scenario 1 would be implemented as each new well is added to the system. Wells are added to the system between 2010 and 2014. The total pumping during each of these years is 4,860 acre-feet/year: equivalent to recent annual pumping by SqCWD. The recent pumping of 4,860 acre-feet/year is approximately equal to the average projected demand for years 2010 through 2015, adjusted for planned conservation savings (Duncan, 2009).

GROUNDWATER LEVEL RESTORATION PLAN

Restoring groundwater levels in the Soquel-Aptos Basin will require SqCWD to pump less than 4,800 acre-feet/year for some number of years. The column under the heading “Minimum Pumping” in Table 3 shows how Scenario 1 would

be applied in restoration years. The production rate of 4,300 acre-feet/year assumes a supplemental water supply is available in excess of demand which can be used for restoring groundwater levels through in-lieu recharge (ESA, 2006). Total production may be required to be less than 4,300 acre-feet/year to fully restore groundwater levels.

MAXIMUM PUMPING CONDITION

The columns under the heading “Maximum Pumping Condition” in Table 3 compare Scenario 1 pumping and the no project alternative pumping, assuming a supplemental supply is not available. 5,675 acre-feet/year is the projected year 2050 demand using average growth assumptions and adjusted for conservation savings (Duncan, 2009). No mandatory drought reduction is applied because this condition may not occur during a drought. The column under the subheading “No Project Max” shows how the pumping will be distributed if no new wells are constructed. It is assumed that the total annual pumping of 5,675 acre-feet/year without the project includes 30 acre-feet/year pumped at the Polo Grounds well to irrigate the Polo Grounds park. The column under the subheading “Max Scenario 1” shows how the pumping will be distributed if Scenario 1 is implemented to meet the maximum pumping condition of 5,675 acre-feet/year.

Table 2. Yields of Existing and Proposed Municipal Wells Considered in the EIR

Well Name	Service Area	Instantaneous Yield Estimate (gpm)	Source of Yield Estimate
Cunnison Lane	I	538	Based on Rosedale, Tannery, Monterey and Maplethorpe
Garnet	I	712	Actual pumping rate on peak day in 2008
Main Street	I	1181	Actual pumping rate on peak day in 2008
Maplethorpe	I	0	Will be maintained as inactive
<i>Monterey</i>	I	0	Currently on emergency standby status
O'Neill Ranch	I	750	LSCE letter report (May 18, 2000; appendix to June 2001 O'Neill Ranch well neg dec) estimated yield comparable to Garnet Well (500-1000 gpm)
Rosedale	I	850	Actual pumping rate on peak day in 2008
Tannery II	I	960	Actual pumping rate on peak day in 2008
Aptos Creek	II	400	Actual pumping rate on peak day in 2008
Austrian Way tank site	II	250	HydroMetrics LLC memo (July 31, 2007) based on test boring correlated to Ledyard and Madeline
Estates	II	718	Actual pumping rate on peak day in 2008
Granite Way	II	245	Based on T. Hopkins well
Ledyard	II	178	Actual pumping rate on peak day in 2008
Madeline	II	221	Actual pumping rate on peak day in 2008
T. Hopkins	II	225	Actual pumping rate on peak day in 2008
Aptos Jr High	III	407	Actual pumping rate on peak day in 2008
Bonita	III	810	Actual pumping rate on peak day in 2008
Country Club	III	371	Actual pumping rate on peak day in 2008
Polo Grounds	III	500	LSCE letter report (March 18, 1983) estimated 900 gpm short-term but advised 500 gpm as probable long-term rate
San Andreas	III	992	Actual pumping rate on peak day in 2008
Seascape	III	772	Actual pumping rate on peak day in 2008
Altivo	IV	614	Actual pumping rate on peak day in 2008
Sells	IV	529	Actual pumping rate on peak day in 2008

Color Code:

Proposed for installation or conversion to municipal use

Proposed for abandonment

Table 3. SqCWD Existing Production Distribution and Examples of Redistribution Scenarios

Well Name ¹	Service Area	Instantaneous Pumping Rate (gpm)	Potential Production ² at 50% Operation (ac-ft/yr)	Actual WY 2005-2008		Basin Management Objective Pumping Condition with Supplemental Supply and Conservation				Operating Plan as Wells Come on Line Based on Scenario 1 No Supplemental Supply and 2005-2008 Demand					Minimum Pumping	Maximum Pumping Condition No Supplemental Supply No Drought Reduction	
				Average Annual Production ² (ac-ft/yr)	Percent of time Operating (%)	Scenario 1 (most likely)	Scenario 2	Scenario 3	Scenario 4	2010 Polo	2011 Oneill	2012 Granite	2013 Cunnison	2014 Austrian	Restoration 4,300 afy	No Project Max 5,675 afy	Max Scenario 1 5,675 afy
				Cunnison Lane	I	538	430	0	0%	180	0	215	285	0	0	0	180
Garnet	I	712	570	370	32%	200	200	200	200	370	200	200	200	200	200	370	200
Main Street	I	1181	950	720	38%	720	650	720	720	720	720	720	720	720	660	720	720
O'Neill Ranch	I	750	600	0	0%	600	500	600	600	0	600	600	600	600	600	0	600
Rosedale	I	850	690	490	36%	140	310	140	140	490	245	245	140	140	140	650	300
Maplethorpe	I	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0
Monterey	I	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0
Tannery II	I	960	770	430	28%	140	320	175	240	430	245	245	170	170	75	610	300
Aptos Creek	II	400	320	230	36%	0	0	230	0	170	170	0	0	0	0	230	0
Austrian Way tank site	II	250	200	0	0%	200	200	0	200	0	0	0	0	200	200	0	200
Estates	II	718	580	380	33%	285	380	380	430	380	380	380	380	285	260	545	450
Granite Way	II	245	200	0	0%	195	195	150	195	0	0	195	195	195	195	0	195
Ledyard	II	178	140	170	59%	100	140	100	100	170	170	145	145	100	70	170	100
Madeline	II	221	180	90	25%	90	0	90	90	90	90	90	90	90	90	90	90
T. Hopkins	II	225	180	150	41%	150	105	0	150	150	150	150	150	150	100	150	150
Aptos Jr High	III	407	330	70	11%	330	330	300	330	330	330	330	330	330	330	330	330
Bonita	III	810	650	570	44%	280	340	280	270	280	280	280	280	280	280	570	280
Country Club	III	371	300	270	45%	270	370	270	270	270	270	270	270	270	105	270	270
Polo Grounds	III	500	400	30	4%	400	400	300	400	400	400	400	400	400	400	30	400
San Andreas	III	992	800	620	39%	370	250	360	180	370	370	370	370	370	370	700	620
Seascape	III	772	620	30	2%	0	0	0	0	0	0	0	0	0	0	0	0
Altivo	IV	614	500	180	18%	150	110	150	0	180	180	180	180	160	125	180	180
Sells	IV	529	430	60	7%	0	0	140	0	60	60	60	60	20	0	60	60
Notes:		Subtotal Service Area I		2,010	1,980	1,980	2,050	2,185		2,010	2,010	2,010	2,010	2,010	1,775	2,350	2,350
¹ Wells proposed for installation shaded blue		Subtotal Service Area II		1,020	1,020	1,020	950	1,165		960	960	960	960	1,020	915	1,185	1,185
Wells proposed for abandonment shaded yellow		Subtotal Service Area III		1,590	1,650	1,690	1,510	1,450		1,650	1,650	1,650	1,650	1,650	1,485	1,900	1,900
² Annual production is rounded for clarity		Subtotal Service Area IV		240	150	110	290	0		240	240	240	240	180	125	240	240
		TOTAL (ac-ft/yr)		4,860	4,800	4,800	4,800	4,800		4,860	4,860	4,860	4,860	4,860	4,300	5,675	5,675
Scenario Definitions:		Total Aromas Area		1,830	1,800	1,800	1,800	1,450		1,890	1,890	1,890	1,890	1,830	1,610	2,140	2,140

Unless noted otherwise, all scenarios assume: 4,800 ac-ft/yr total production, existing transfer capacity between service areas.

Scenario 1: Most likely scenario. Use all five proposed wells and minimize intrusion by moving pumping inland and evenly distributing pumping near coast

Scenario 2: Use four proposed wells, excluding Cunnison Lane. Minimize intrusion but less evenly distribute pumping.

Scenario 3: Use four proposed wells, excluding Austrian Way. Minimize intrusion but changes service area IV blending policy where transfers from III to IV no longer necessary.

Scenario 4: Use all five proposed wells. Minimizes intrusion using increased transfer capacity between service areas II to III of 200 gpm (320 AFY)

2010 Like Scenario 1 in Aromas and begin reduction in Aptos Creek pumping

2011 Reduce Garnet to 200 afy and begin reduction in other SA I wells

2012 Eliminate Aptos Creek pumping

2013 Like Scenario 1 in SA I except slightly higher pumping at Tannery II

2012 Like Scenario 1 in SA II, pumping in SA IV remains slightly higher than Scenario 1

Future increases proportionally distributed amongst service areas

Section 4

RATING SYSTEM FOR EFFECTS AT NEARBY WELLS

To adequately analyze the effects on nearby wells from installing new wells and redistributing pumping, it is necessary to set standards for different levels of effects, specifically what might be considered restrictive, and what should be considered marginal. It is normal for wells pumping water from a groundwater basin to lower water levels in other wells in the same basin. Overlapping drawdown among two or more wells (well interference) is expected, and therefore is not ordinarily considered restrictive. Excessive well interference, however, can result in two types of restrictive effects: physical damage and loss of yield.

The first potentially restrictive effect is physical damage to a neighboring well. The effect of lowered water levels is potentially restrictive if the project causes static water levels at nearby wells to fall below the tops of the well screens, or if the project would cause pumping water levels currently above the tops of the well screens to fall below the tops of the well screens. Water levels that fall below the top of the screen invite corrosion of the screen and aeration of the well water, which can cause cavitation and damage to the pump bowls. These types of damage are difficult and expensive to repair. In practice, some wells have static water levels (when the pump is off) that are already below the top of the screen. In this case, a small amount of additional drawdown is of little consequence because the risk of screen collapse due to corrosion is already present. At some wells, pumping water levels (when the pump is on) are already below the top of the screen. Additional corrosion is not a restrictive effect in these situations because any potential corrosion has already been induced by the existing low water levels, and a small increment of additional drawdown would not substantially increase the aeration/cavitation risk. Accordingly, the effect of additional drawdown is considered restrictive only if it causes static or pumping water levels that are above the screen depths under existing conditions to fall below the tops of the screens with the project.

Water levels falling below the tops of the screens in a small number of wells do not necessarily result in a restrictive effect. When considering private wells in the basin, the appropriate benchmark is the **average** top-of-screen depth because it would be unreasonable for the shallowest well in a basin to constrain the use of basin storage by all users. Each nearby municipal well is considered because municipal wells are generally deeper than the average well and serve a large number of end-users.

The second potentially restrictive effect is a loss of yield in an affected well. The *California Groundwater Management Handbook* (Bachman et al., 2005) notes that

groundwater case law has generally adopted a threshold that “... material injury ... turns on the existence of an appreciable diminution in the quantity or quality of water...” A reasonable definition of “appreciable” in this context is if the project would render a nearby well incapable of meeting its:

1. Historically measured maximum daily production level;
2. Historically measured dry-season production levels; or
3. Historically measured annual production levels under drought conditions.

In practice, this could result if a substantial percentage of the well screen were dewatered or if groundwater flow patterns were altered such that seawater intrusion reached the affected well.

A restrictive effect is just one category in a rating system to describe the results of the pumping effects analysis. The categories for effects at nearby wells include

- beneficial effect, such as an increase in groundwater levels due to a reduction in groundwater pumping;
- no effect, or no change in groundwater levels or well yield;
- marginal effect, with a potential for measureable lowering of groundwater levels or slight decreases in well yield. However, these changes do not adversely affect nearby municipal wells or the average nearby private well;
- restrictive effect, as described above: a lowering of water levels such that there is an initial dewatering of a municipal well or of the average private well or a decrease in well yields of nearby wells;
- severe effect, in cases where effects on nearby wells make them unsuitable for production and it would be very difficult or not cost-effective to retrofit the well. This could happen if seawater intrusion reaches the well.

The rating system presented above is developed to provide context for the analyses contained within this report. These may or may not be equivalent to significance thresholds developed for the final CEQA documentation.

Section 5

PUMPING EFFECTS ANALYSIS APPROACH

Calculating the expected drawdown at nearby wells is sufficient to determine whether drawdown could cause physical damage to a well and also provides a basis for evaluating effects on yield at nearby wells. Customary practice in previous studies of drawdown around wells in the Soquel area has been to apply analytical equations that estimate drawdown in confined or leaky aquifers under conditions of constant pumping at the test well (Hopkins Groundwater Consultants 2004; Johnson 2001; Todd Engineers, 2001). These methods are useful for developing rough estimates of expected drawdown. The accuracy of these methods is generally limited by the simplifying assumptions originally used to derive the analytical equations. For example, the equations do not address a layered system of multiple leaky aquifers, conservation of mass, or geometrically complex recharge or barrier boundary conditions. Numerical groundwater models account for all of those issues, but can require significant effort to prepare.

A tool with an intermediate level of capabilities is the MLU (Multi-layer Unsteady) computer program, which applies an analytical solution to a multi-aquifer system in order to calculate drawdown within aquifer units, while accounting for leakage between layers (Hemker, 1999). This software can calculate drawdown in each Purisima unit and the Aromas Red Sands consistent with the transmissivities of the individual aquifer units, the leakance values between units, and a common drawdown value at the well. In light of this advantage and the ease of implementation, the MLU model was selected to evaluate drawdown effects.

DRAWDOWN EVALUATION APPROACH

Drawdowns from the proposed pumping were calculated with the MLU model after one-half year (182.5 days) of pumping, which is the assumed duration of the dry season. Drawdown and yield effects from the SqCWD's wells are greatest at the end of the dry season. Drawdown calculations over periods of longer than six months would be less realistic because recharge between late fall and mid spring helps groundwater levels recover every year. This is especially true in the CWD area which is predominately overlain by primary groundwater recharge zones as identified by the County of Santa Cruz (SqCWD and CWD, 2007).

As discussed in Section 3, each well is assumed to operate no more than 50% of the time, which is consistent with historical SqCWD practice. This assumption reflects seasonal and daily variations in well use. Data from 2005-2008 show that

61% of SqCWD production in service areas I and II and 63% of SqCWD production in service areas III and IV occurs in the dry season: from May through October. On the peak demand day, many of SqCWD's wells operate nearly 100% of the time. This elevated pumping during the dry season is balanced by decreased pumping during the wet season.

The drawdown calculations were designed to simulate the six months of dry-season production between May and October. Our analyses assume that future seasonal water demand patterns will be similar to present patterns: 61% of SqCWD's annual production in Service Areas I and II, and 63% of SqCWD's annual production in Service Areas III and IV will occur during the dry season. Different percentages are used for Service Areas I and II and Service Areas III and IV because there is currently limited transfer capacity between Service Areas I/II and III/IV. The drawdown calculations for the wells planned for Service Areas I and II are therefore based on a continuous pumping rate that, if maintained continuously for six months, sums to 61% of the well's average annual flow volume. This percentage applies to the O'Neill Ranch, Cunnison Lane, Austrian Way, and Granite Way wells. The drawdown calculations for the Polo Grounds well in service area III assumed a continuous pumping rate that, if maintained continuously for six months, sums to 63% of the well's average annual flow volume.

When evaluating SqCWD's proposed wells individually, the wells are assumed to have an annual flow volume equal to the value under "Potential Production at 50% Operation" shown in Table 3. Based on the dry-season pumping percentages discussed above, the continuous pumping rates used in the calculations are 61% of 750 gpm at the O'Neill Ranch well, 61% of 538 gpm at the Cunnison Lane well, 61% of 250 gpm at the Austrian Way well, and 61% of 245 gpm at the Granite Way well. The Polo Grounds well currently pumps 30 acre-feet in the dry season to irrigate the park fields (Branham, 2007). This is equivalent to a continuous rate of 37 gpm over the six month dry period. Therefore, the continuous pumping rate used at the Polo Grounds well is 63% of 500 gpm minus 37 gpm, to represent the increase in pumping at this well when converted to a municipal well.

BASIN MANAGEMENT OBJECTIVE PUMPING REDISTRIBUTION ANALYSIS

The effects of pumping SqCWD's proposed wells were evaluated both individually and in combination with existing wells, acknowledging the planned overall redistribution of pumping among SqCWD's proposed and existing wells. The pumping redistribution was based on Scenario 1: the most likely redistribution scenario for meeting the basin management objective (BMO) of pumping 4,800 acre-feet per year. The pumping in this scenario is compared to

the current distribution, represented by the average pumping for water years 2005 through 2008. The difference in pumping between these two distributions is shown in Table 4.

Table 4. Change in Pumping under Well Master Plan Scenario 1 around Proposed Wells

Proposed Well	Pumping Well	BMO Pumping Condition: Scenario 1 vs. 2005-2008 Pumping (ac-ft/yr)	Maximum Pumping Condition: Max Scenario 1 vs. No Project Max (ac-ft/yr)
O'Neill Ranch drought (private wells)	O'Neill Ranch	+600	+600
	Main Street	+100	+100
	Garnet	-270	-270
O'Neill Ranch non-drought (Live Oak)	O'Neill Ranch	+600	+600
	Main Street	0	0
	Garnet	-170	-170
Cunnison Lane	Cunnison Lane	+180	+230
	Rosedale	-350	-350
	Tannery II	-290	-310
Granite Way	Granite Way	+195	+195
	Aptos Creek	-230	-230
	T. Hopkins	0	0
Austrian Way	Austrian Way	+200	+200
Polo Grounds	Polo Grounds	+370	+370
	Aptos Jr. High	+260	0
	Bonita	-290	-290

	Country Club	0	0
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Table 4 shows each proposed well and the pumping wells in the area around each proposed well. The column labeled "BMO Pumping Condition" shows how pumping at each of these wells changes between current conditions and Scenario 1 at the pumping goal of 4,800 acre-feet/year. The combined drawdown effects in the areas around each proposed well are evaluated based on the changes listed in this column.

As mentioned in Section 3, the overall objective of pumping no more than 4,800 acre-feet per year will not change in a drought, and the pumping distribution around most of the proposed wells does not change in a drought. Therefore, separate drought year analyses are not performed around most of the proposed wells. Drought years will, however, result in a small pumping shift in the western end of Service Area I. This pumping shift will result in different effects in the western end of Service Area I during droughts and non-droughts. It is the intent of this analysis to evaluate the reasonable maximum effects from pumping. Nearby wells in the western end of Service Area I that are most affected during a drought are analyzed using the drought pumping distribution; nearby wells that are most affected during non-drought years are analyzed using non-drought pumping.

Pumping at the coastal Garnet well will be reduced and shifted inland to the Main Street well during a drought year. This shift in pumping means that drawdown effects at private wells near the Main Street and O'Neill Ranch wells will be greater during a drought year than a non-drought year. Therefore, the combined drawdown effects at these private wells are presented based on the drought year pumping distribution as shown in the first entry on Table 4. The Garnet well is closer to the City of Santa Cruz Live Oak wells than the Main Street well, so drawdown effects in the Live Oak area are greater during a non-drought year than a drought year. Therefore, combined drawdown effects at the Live Oak wells are presented based on the non-drought year pumping distribution as shown in the second entry on Table 4.

MAXIMUM PUMPING CONDITION REDISTRIBUTION ANALYSIS

As discussed in Section 3, pumping may exceed 4,800 acre-feet/year if no supplemental supply is available. In order to evaluate effects of the Well Master Plan under the maximum pumping condition, two pumping distributions meeting the condition are compared. The pumping distribution using current and proposed wells to meet the maximum pumping condition (Max Scenario 1 in Table 3) is compared to a pumping distribution using only current wells to meet

the condition (No Project Max in Table 3). The column in Table 4 labeled "Maximum Pumping Condition" shows how pumping at each listed well is different between the two distributions totaling 5,675 acre-feet/year each. In order to evaluate the combined pumping effects under the maximum pumping condition, the combined drawdown effects in the areas around each proposed well are evaluated based on the changes listed in this column.

Table 4 shows that around most wells, the change in pumping under the maximum pumping condition (last column of Table 3) would result in no greater drawdowns than the change in pumping under basin management objective pumping (third column of Table 3). As the bold box on Table 4 shows, the one exception is in the area around the Cunnison Lane well, where the Cunnison Lane well has more pumping under the maximum pumping condition than the basin management objective pumping condition. This increase is not offset by the decrease at the Tannery II well. Therefore, the combined drawdown effects will be shown for the maximum pumping condition only around the Cunnison Lane well and the combined drawdown effects will be shown for the basin management objective pumping amount around all other proposed wells. As a result, reasonable maximum effects from combined pumping are evaluated.

MODEL PARAMETERS

The aquifer properties required for the MLU model are transmissivity (T), vertical resistance (c), and storage (Sy/S) values. Transmissivity is the product of an aquifer's thickness and horizontal hydraulic conductivity. The leakance between hydrogeologic units is formulated in the MLU model as vertical resistance (c). Vertical resistance is the thickness of an aquitard divided by its vertical hydraulic conductivity.

Parameter values were based on several data sources. If nearby data showing the responses of an observation well to pumping exist, the MLU model was used to estimate aquifer properties based on those data. Published local values derived from aquifer tests or specific capacity data from nearby pumping wells were used if available. For other aquifers, or if local data and values are unavailable, published regional values were used in the MLU simulations. Table 5 shows the local data sources for hydraulic parameters used at different production wells. The calculation of specific parameter values or the published values used are included with the discussion of the analyses at each specific well.

Table 5. Available Local Data Sources for Hydraulic Parameter Values at Production Wells

Existing or Planned Production Well	Available Data	Source of Parameter Value
O' Neill Ranch	SC-18A, SC-18AA, SC-10AA Response to Main Street Well Pumping	MLU
Garnet	Opal Well Response to Main Street Well Pumping	MLU
Cunnison Lane	Tannery II Well Response to Tannery II Well Pumping	Johnson et al., 2004
Granite Way	T Hopkins Well specific capacity	Johnson et al., 2004
Austrian Way	Madeline Well Response to Madeline Well Pumping	Johnson et al., 2004
Polo Grounds	Polo Grounds specific capacity	LSCE, 1983
Polo Grounds	Huyck Well response to Aptos Jr. High Well pumping	MLU
Aptos Jr. High	Aptos Jr. High well specific capacity	Johnson et al., 2004
Aptos Jr. High	Huyck well response to Aptos Jr. High Well pumping	MLU

Regional values are based on data in Table 3-13 of the report by Johnson et al. (2004). Logarithmic averages of the parameters were calculated as baseline values. Johnson et al. did not provide an estimate of the vertical hydraulic conductivity for the aquitard above AA so the MLU results from the Main Street pumping test were used everywhere. Vertical hydraulic conductivity of the aquitard above the DEF aquifer was based on approximate anisotropy ratios of 10:1 to 100:1. The regional values used in our analyses are shown in Table 6, Table 7, and Table 8.

Table 6. Regional Values for Horizontal Hydraulic Conductivity (ft/d)

Aquifer Unit	Minimum	Maximum	Average
Lower Aromas	6	50	17.3
F	2	6	3.5
DEF	2	6	3.5
BC	1	3	1.7
A	7	18	11.2
AA	1	13 ¹	3.6
Tu	1	30 ¹	5.5

¹Based on MLU analysis of Main Street Pumping Well

Table 7. Regional Values for Vertical Hydraulic Conductivity (ft/d)

Aquitard Unit	Minimum	Maximum	Average
Above F	0.005	0.5	0.05
Above DEF	0.005	0.5	0.05
D	0.001	0.1	0.01
B	0.001	0.1	0.01
Above AA	0.004 ¹	0.8 ¹	0.06
Tmp	0.001	0.1	0.01

¹Based on MLU analysis of Main Street Pumping Well

Table 8. Regional Values for Storativity and Specific Yield

	Minimum	Maximum	Average
All Units Storativity	1 x 10 ⁻⁵	0.007	2.65 x 10 ⁻⁴
Purisima Specific Yield	0.01	0.1	0.03
Aromas Specific Yield	0.04	0.14	0.075

NEARBY WELL LOCATIONS USED IN THE ANALYSES

The County of Santa Cruz provided SqCWD with State of California Department of Water Resources (DWR) well logs and estimated locations for the wells. Additionally, SqCWD has locations of production wells of nearby public water agencies: the City of Santa Cruz and Central Water District. Those agencies provided screen interval information and water level data for their wells.

Drawdown effects were evaluated at any municipal or private production well within 1,000 meters of the proposed SqCWD wells. For effects to be analyzed, it is necessary to have well logs that included water level and screen interval information for each well. Drawdowns were also evaluated at the nearest well to the proposed site even if there is no water level or screen interval information for

that well. The DWR well logs and specific well locations are confidential so these private wells are assigned pseudonyms for inclusion in this letter. Estimated locations and specific distances from proposed wells are also not displayed due to confidentiality laws.

The County also has a database of private wells (Wolcott, 1999). This database includes some locations not included in the database of DWR well logs. Drawdown effects for wells in the County database are calculated for the non-duplicative wells nearest to the proposed municipal wells. However, these wells do not have screen interval information so the effects cannot be rated at these locations.

AVAILABLE WATER LEVELS AND DROUGHT YEAR EFFECTS

As discussed above and in Section 4, drawdown effects at nearby wells are rated based on groundwater levels. At the wells of nearby public water agencies such as the City of Santa Cruz and Central Water District, historical water level data are available that include data during drought years. Therefore, effects on these wells can be evaluated based on recent and drought year water levels. For private wells identified by DWR logs, there is typically only one water level measurement available. The measurement is taken when the well was constructed and the well log created. The effects on these wells are only evaluated based on this single measurement, and effects on drought year water levels cannot be presented.

Even though drought year water levels are not available for private wells, effects from any pumping increases anticipated during droughts are analyzed. The O'Neill Ranch well is the only proposed well where drought year pumping will be higher than non-drought year pumping in the surrounding area. Therefore, combined effects of pumping at private wells in the area surrounding the O'Neill Ranch well is based on drought year distribution. No other group of private wells has a separate drought and non-drought analyses.

Section 6

DRAWDOWN EFFECTS ANALYSES

Drawdown effects analyses are presented below in three parts for each of the planned production wells. The first part discusses model setup for simulating effects from pumping the planned well, including estimated aquifer parameters. The second part presents anticipated water level and yield effects at nearby wells from pumping the planned well. This second part addresses the issues of whether pumping the planned well will cause sufficient drawdown to result in physical damage to nearby wells. The second part also addresses potential loss of yield at the nearby wells from pumping the planned well. The third part presents the combined effects on nearby wells from both installing the planned well and redistributing pumping at existing wells.

O'NEILL RANCH WELL

MODEL SETUP

The MLU model was used to estimate aquifer properties based on spinner log and aquifer test data from the location nearest the O'Neill Ranch well: the Main Street well. The MLU model was also used to estimate aquifer properties based on aquifer test data from the Garnet well, because pumping changes at the Garnet well are part of the combined effects analysis.

PARAMETERS ESTIMATED FROM SPINNER LOG AND AQUIFER TESTS AT MAIN STREET WELL

A spinner log test and an aquifer test provide data from the Main Street well for estimating parameters at the Main Street and the O'Neill Ranch wells. Spinner log tests measure how flow rates vary throughout the depth of a well. Aquifer tests measure water level responses to pumping at observation wells.

Spinner logs measure the amount of flow contributed by each increment of well screen, thereby revealing the most productive depth intervals in a well. The technique assumes that there is generally no flow in the bottom of a well; farther up the well, water enters the well through various screens and the flow rate in the well increases.

Data from the spinner log test of the Main Street well in April 2005 indicate that a significant portion of this well's production is derived from the underlying Tu unit (Figure 11). The red line on this figure shows the relative flow rate in the Main Street well at different depths. A vertical red line signifies that the flow

rate is the same at all depths, and no water is entering the well. A red line that kicks significantly to the right of the chart indicates water entering the well.

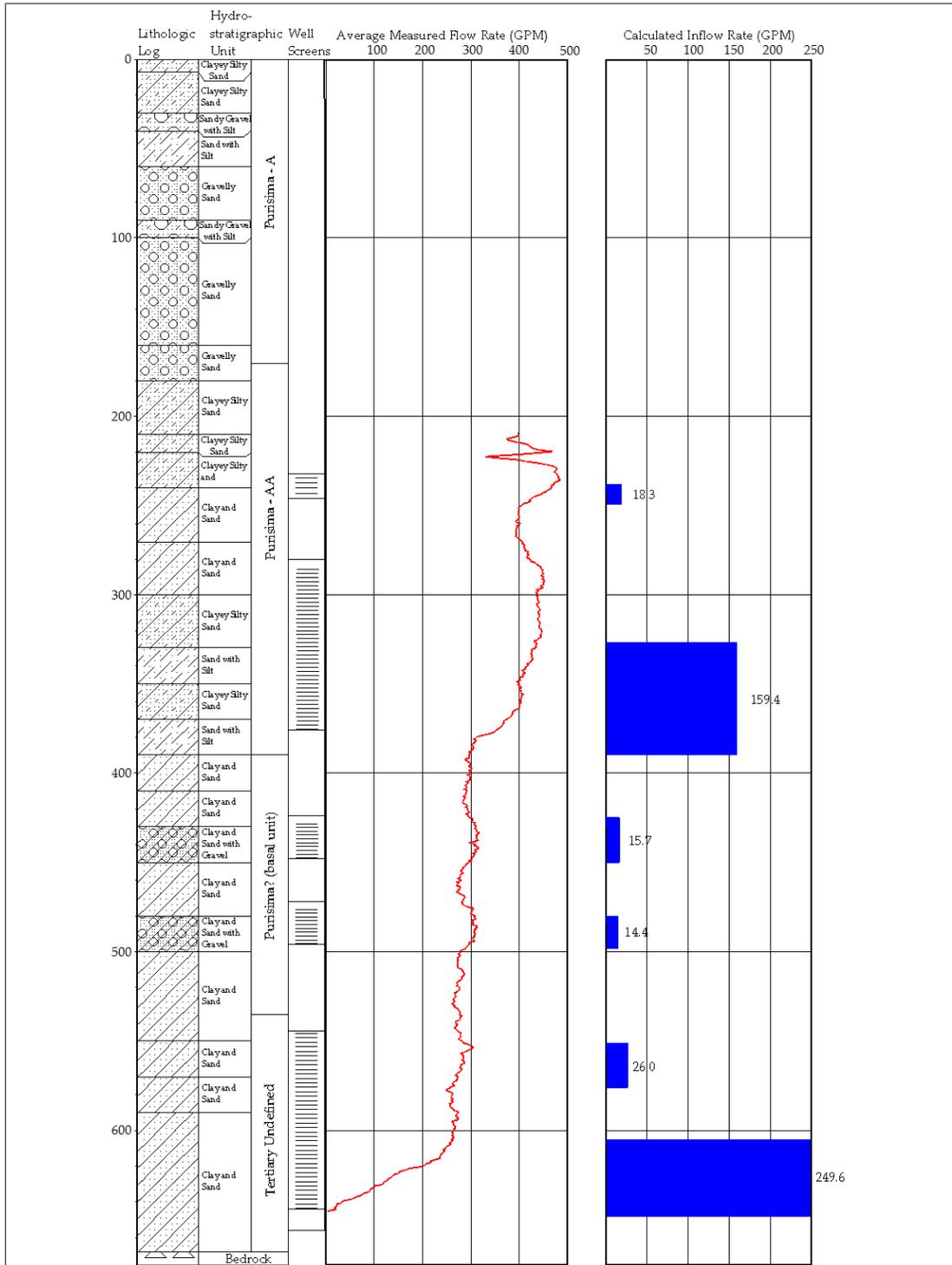


Figure 11 shows that 51.5% of the total flow enters through the bottom 20 feet of the well (HydroMetrics LLC, 2005). This 20 foot interval is screened in the lower part of the undefined Tertiary unit (Tu) that underlies the Purisima Formation. Johnson et al. (2004) identified this unit as either Santa Margarita or Lompico sandstones. Both the Santa Margarita Sandstone and Lompico Sandstone are relatively productive geologic units elsewhere along the Central California coast, and could reasonably be the source of water at the base of the Main Street well.

Including the small amount of flow that occurs in the upper part of the Tu unit and in the two screens in the overlying Tmp unit (identified as "Purisima? (basal unit)" on Figure 11) results in an estimated 63% of the flow pumped by the Main Street well coming from below the A and AA units. The remaining 37 percent of the flow occurs in the AA unit, mostly in the deepest portion of that unit (2nd screen interval from the top).

The aquifer test used to estimate aquifer properties for this area is the 1991 aquifer test at the Main Street well. The Main Street well is screened across the Tu and AA aquifers, and water levels were measured in both aquifers. In the lower Tu unit, water levels were measured at well 18AA, 39 feet away from the Main Street well. In the AA unit, water levels were measured at both wells 18A, 39 feet away and well 10AA, 6,905 feet away from the Main Street well.

The MLU model was set up with three layers; representing an overlying A unit, the intermediate AA unit and the deep Tu unit. The Tmp unit is represented by the vertical resistance between the AA and Tu units. Johnson et al. (2004) described the AA unit as having an aquitard at its top and this aquitard is represented by the vertical resistance between the A and AA units. This is the same layering that is used to subsequently simulate effects from pumping at the O'Neill Ranch well. Aquifer properties for the overlying A unit were fixed at average regional values shown in Table 6 and Table 8. Results from the MLU model were compared to data from all 3 observation wells, and parameters were optimized to reduce residual error. In addition, parameters were chosen such that the production distribution between AA and Tu units approximated the 37%/63% split between AA and Tu/Tmp units observed in the Main Street spinner log test.

Optimized aquifer parameters are shown in Table 9. These parameters simulate drawdowns at nearby wells 18A and 18AA very well (Figure 12), but simulated maximum drawdown at the more distant well 10AA is 0.0007 feet when drawdowns up to 2.5 feet are observed at this location.

Table 9. Parameters Matching Drawdowns at Wells 18A and 18AA

Model Layer	Aquifer / Aquitard	Unit	T (ft ² /d)	Sy/S	c (d)
1	Aquifer	A	1,100	0.03	
2	Aquitard	Above AA			91
	Aquifer	AA	1,184	4.4x 10 ⁻³	
3	Aquitard	Tmp			19,122
	Aquifer	Tu	2,107	9.9x 10 ⁻⁴	

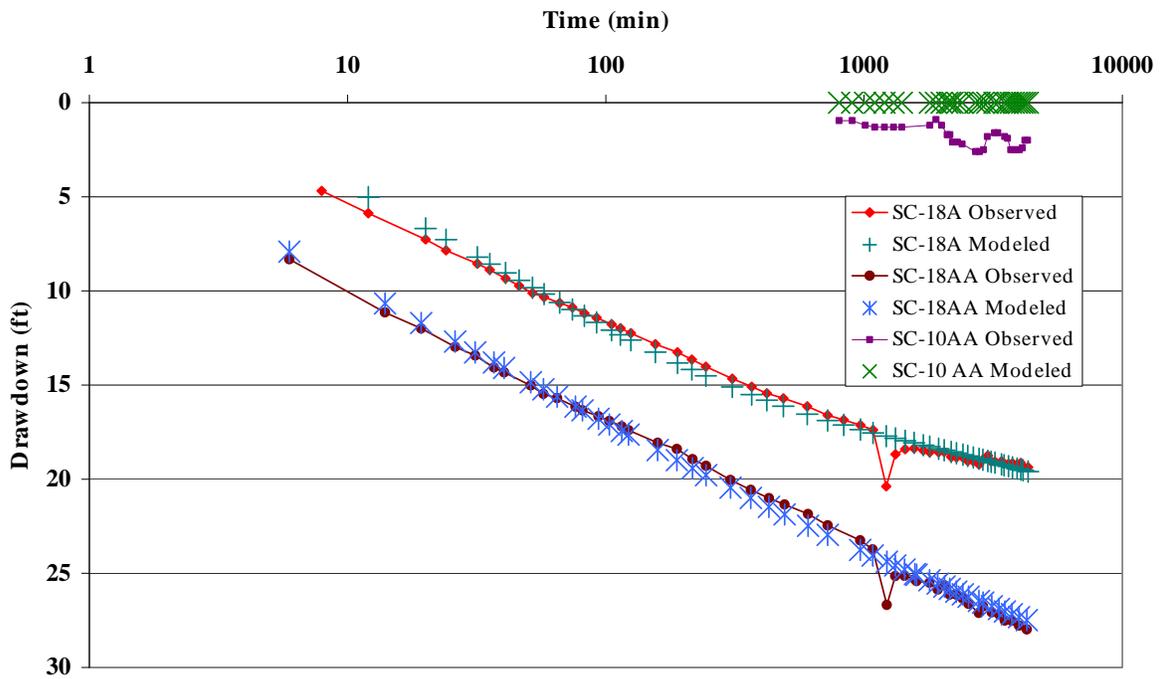


Figure 12. Drawdowns Matching Data at Wells 18A and 18AA

Adjusting parameters to simulate more drawdown at well 10AA makes it difficult to simulate the drawdown curves at wells 18AA and 18A. Table 10 shows the parameters that result in drawdowns matching data from Well 10AA (Figure 13). The most striking difference is that the vertical resistance to flow between the A and AA units is much larger in Table 10 than Table 9.

Table 10. Parameters Matching Drawdowns at Well 10AA

Model Layer	Aquifer / Aquitard	Unit	T (ft ² /d)	Sy/S	c (d)
1	Aquifer	A	1,100	0.03	
2	Aquitard	Above AA			19,751
	Aquifer	AA	1,948	8.8x10 ⁻⁵	
3	Aquitard	Tmp			6,688
	Aquifer	Tu	4,047	4.0x10 ⁻⁵	

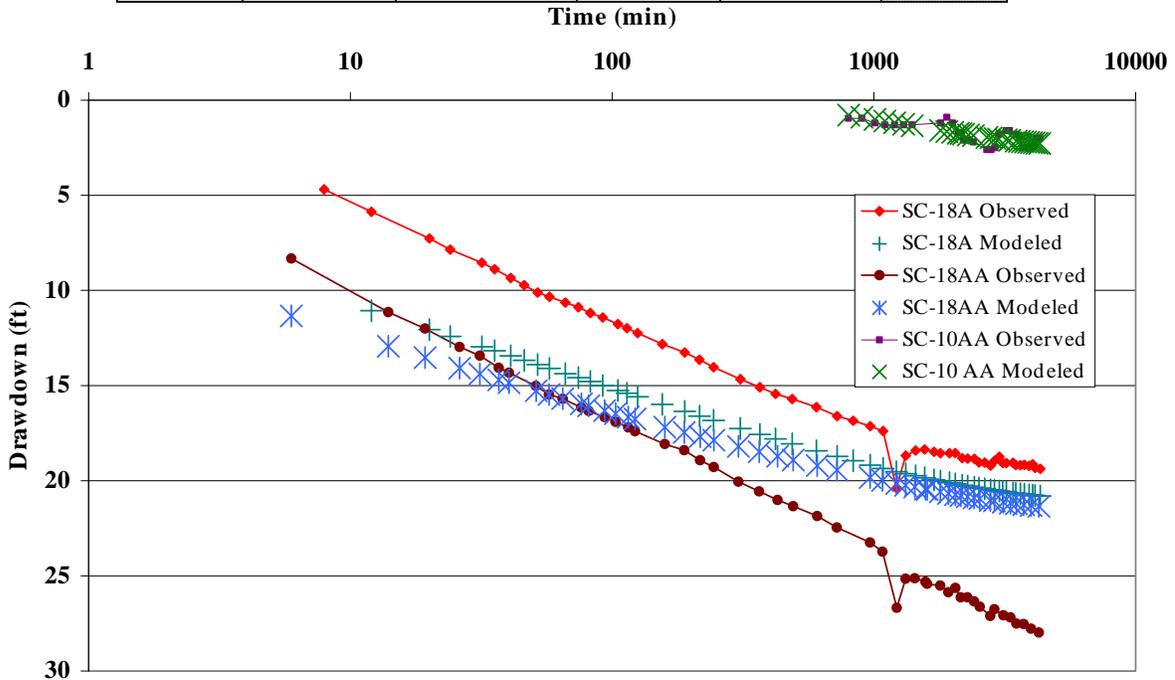


Figure 13: Drawdowns Matching Data at Well 10AA

Both sets of parameters are used in simulating the O'Neill Ranch well pumping effects and combined effects of redistributed pumping at the Main Street well, thereby providing a range of modeled drawdown effects at nearby wells. In order to translate parameter values from the Main Street well location to the O'Neill Ranch well location, horizontal (K_h) and vertical (K_v) hydraulic conductivities and specific storage (S_s) values for the AA and Tu units are calculated from the unit thicknesses (b and b') at the Main Street well (Table 11). Thicknesses are based on interpreted hydrostratigraphic contacts in Johnson et al. (2004). The thickness of the confining unit above the AA unit is assumed to be

1/3 of the AA unit thickness based on Figure 2-2 in Johnson et al. (2004). These conductivities and specific storage values are combined with unit thicknesses at the O'Neill Ranch well to provide parameters for MLU simulations of O'Neill Ranch well pumping.

Table 11: Hydraulic Properties Derived from the Main Street Well Aquifer Test

Observation Data	Aquifer / Aquitard	b (ft)	Kh (ft/d)	Ss (1/ft)	b' (ft)	Kv (ft)/d
Matching 18AA/18A	Above AA				73	0.8
	AA	147	8	3.0×10^{-5}		
	Tm				145	0.008
	Tu	133	16	7.4×10^{-6}		
Matching 10AA	Above AA				73	0.004
	AA	147	13	6.0×10^{-7}		
	Tm				145	0.02
	Tu	133	30	3.0×10^{-7}		

These optimized aquifer parameters do not match the properties derived by Johnson et al. (2004) using the Hantush-Jacob analytical solution. This is because Johnson et al. applied the Hantush-Jacob solution to observation data from each of the 3 monitoring wells separately. In each comparison, all of the aquifer test production was applied to the aquifer unit of the monitoring well. The MLU model has the advantage of distributing pumping amongst the screened units. If all of the pumping is applied to a single unit in MLU, the Hantush-Jacob results can be replicated.

PARAMETERS ESTIMATED FROM GARNET WELL AQUIFER TEST

The 1995 aquifer test at the Garnet Well is used to estimate aquifer properties for the area around the Garnet well. The well is screened across the A aquifer unit and the aquifer test measured water levels at the Opal 4 well, 30 feet away.

The MLU model was set up with four layers; representing an overlying unit, the pumped A unit, and the underlying AA unit and Tu units. The B unit is represented by the vertical resistance between the overlying unit and A unit. This is the same layering that is used to subsequently simulate effects from reducing pumping at the Garnet well. The overlying unit serves to provide an overlying source of water so properties for the overlying unit were set at the maximum horizontal hydraulic conductivity and average specific yield for the BC unit. Properties for the underlying units were fixed at average regional values documented by Johnson et al. (2004). Model results were compared to data from the Opal 4 well, and parameters for the A unit were optimized to reduce residual error.

Optimized aquifer parameters are shown in Table 12. These parameters simulate drawdowns at nearby Opal 4 very well as shown in Figure 14.

Table 12. Modeled Property Values at Garnet Well

Model Layer	Aquifer/Aquitard	Unit	T (ft ² /d)	Sy/S	c (d)
1	Aquifer	Overlying	156	0.03	
2	Aquitard	Above A			12
	Aquifer	A	1,346	1.3x 10 ⁻³	
3	Aquitard	Above AA			1,423
	Aquifer	AA	492	3.0 x 10 ⁻⁴	
4	Aquitard	Tm			817
	Aquifer	Tu	1,058	3.0 x 10 ⁻⁴	

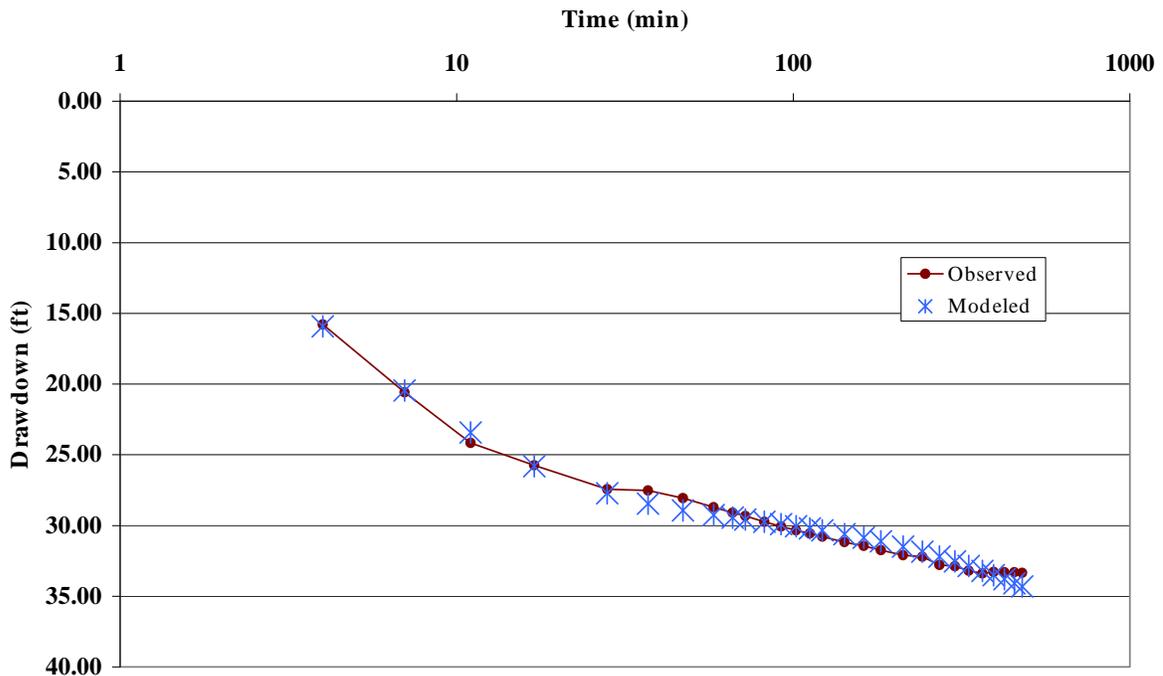


Figure 14. Drawdowns at Opal 4 Well During Garnet Well Aquifer Test

These optimized aquifer parameters do not match the properties derived by Johnson et al. (2004) using the Hantush-Jacob analytical solution. The assumptions underlying the Hantush-Jacob solution do not include the underlying layers modeled by MLU. Additionally, the Hantush-Jacob analytical solution does not simulate observed drawdowns with the parameter values documented in Johnson et al. (2004). There appears to be an error in the analysis documented by Johnson et al.

ESTIMATED WATER LEVEL AND YIELD EFFECTS FROM PUMPING THE O'NEILL RANCH WELL

Luhdorff & Scalmanini (2000) evaluated hydrogeologic conditions at the O'Neill Ranch well site and concluded that the new well might have a capacity similar to the Garnet well: 750 gallons per minute (gpm). Assuming the O'Neill Ranch well pumps 50 percent of the time during an average year, the well could produce approximately 605 acre-feet/year. Further assuming 61% of this yield, or 369 acre-feet, is produced during the six month dry season, the O'Neill Ranch will pump approximately 458 gpm (0.7 million gallons per day) continuously for 182.5 days between May and October.

At the O'Neill Ranch well site, Johnson et al. (2004) defined the top of the AA unit at 110 feet below ground surface based on the geophysical log from the O'Neill Ranch test hole. Luhdorff & Scalmanini (2000) reported that 20 feet of Santa Margarita sandstone (defined by Johnson et al. as the Tu unit) was located at the bottom of the test hole: 550 feet below ground surface (bgs). Therefore, the O'Neill Ranch well will likely be screened in the AA unit and possibly the Tu unit.

The estimated aquifer properties derived from the Main Street aquifer test were used for property values of the lower two units at the O'Neill Ranch well (Tu and AA units), and average regional values were used for the A unit. These values are combined with estimated thicknesses of the units at the O'Neill Ranch site to calculate aquifer transmissivity, storativity, and aquitard resistance, as shown on Table 13. Thicknesses are based on interpreted hydrostratigraphic contacts in Johnson et al. (2004). The thickness of the confining unit above the AA unit is assumed to be 1/3 of the AA unit thickness based on Figure 2-2 in Johnson et al. (2004).

The MLU model assumes the layers are horizontally infinite. However, the Purisima A unit pinches out to the west of the O'Neill Ranch well site. In order to estimate the effect of this western boundary on drawdowns at the City of Santa Cruz's Live Oak wellfield, we made the conservative assumption that no groundwater leaks into the A unit from the west. This assumption is extremely conservative because historical water level maps show water flowing from the west to the Live Oak wellfield. The assumption of zero inflow from west of the A unit outcrop was implemented by including an image well on the far side of the contact between the A and AA units, opposite the O'Neill Ranch well. Image wells are a method of including the effects of linear flow boundaries on otherwise radially-symmetrical drawdown patterns.

Table 13. Modeled Property Values at the O'Neill Ranch Well

Model Layer	Aquifer/Aquitard	Unit	Thickness	Match 18A/18AA			Match 10AA		
				T (ft ² /d)	Sy/S	c (d)	T (ft ² /d)	Sy/S	c (d)
1	Aquifer	A		1,235	0.03		1,235	0.03	
2	Aquitard	Above AA	103			128			27,831
	Aquifer	AA	207	1,668	6.2x 10 ⁻³		2,745	1.2x 10 ⁻⁴	
3	Aquitard	Tm	120			15,825			5,534
	Aquifer	Tu	30	475	2.3x 10 ⁻⁴		913	9.1x 10 ⁻⁶	

WATER LEVEL EFFECTS AT NEARBY PRIVATE WELLS

The County of Santa Cruz provided SqCWD with California Department of Water Resources well logs and estimated locations for private wells in the vicinity of the O'Neill Ranch site. Estimated locations cannot be displayed due to confidentiality laws governing use of the well logs. The depth of nearby wells, and distances from the O'Neill Ranch well are summarized in Table 14.

The nearest estimated well location is less than 1,000 feet away and is referred to as well O2. The log for well O2 shows the screen interval of the well is between 140 and 220 feet bgs, primarily in the estimated interval of the AA unit. Also less than 1,000 feet away from the O'Neill Ranch well site is a well referred to as O4, with a screened interval between 180 and 240 feet bgs; in the estimated AA unit. There is no depth to water data for this well. Well O5 is over 1,800 feet away and has a screen interval between 104 and 148 feet deep in the estimated A unit. Also within 3,500 feet of the proposed O'Neill Ranch well are several wells associated with gasoline stations such as wells O3, O10, and O13. The County's private well database (Wolcott, 1999) also includes a well at location O9. There is no screen interval information in this database, but the database reports a total depth of 85 feet for this well, placing it in the A unit. Todd Engineers (2001) previously identified a well at location O1, approximately 350 feet away from the O'Neill Ranch well site. This well was identified as a shallow well, but did not have any screen interval or water level information. Drawdowns calculated at all of these locations from the anticipated pumping at the O'Neill Ranch well are shown in Table 14 as water level changes. A range of modeled results are presented based

on two parameter sets matching different observation data sets. Drawdowns in the overlying A unit are not adjusted for a possible western boundary of the A unit, because the boundary is much farther than the distances between O’Neill Ranch and these wells.

Table 14. Estimated Water Level Changes at Nearby Private Wells from O’Neill Ranch Well Pumping

Well	Distance (ft)	Aquifer	Water Level Change (ft)	
			Match 18A/18AA	Match 10AA
O1	350	A	-9.9	-1.2
O2	600-1,000	AA	-9.0	-11.2
O3		A	-7.7	-1.1
O4		AA	-7.7	-10.0
O5	1,500-2,500	A	-4.8	-1.0
O6		AA	-4.0	-6.5
O7		AA	-4.0	-6.5
O8		A	-3.7	-1.0
O9	2,600	A	-3.5	-0.9
O10	3,000-3,500	A	-3.1	-0.9
O11		A	-3.0	-0.9
O12		AA	-3.0	-5.5
O13		AA	-2.8	-5.2

Comparisons of available water level data, screen intervals, and estimated drawdowns show that drawdown from pumping at the O’Neill Ranch well will result in marginal effects on any known nearby wells (Table 15). The available information from DWR logs for well O2 shows the top of screen was placed at static water level during construction. As a result, negative effects on the screen have likely already occurred as any decline in water level would expose the screen so any additional drawdown caused by O’Neill Ranch pumping will not materially add to the effects on the well screen. Available information from DWR logs also show that static water levels are lower than the top of the screens at the O3 and O10 wells. In these cases, 1-3 feet of additional drawdown are not restrictive effects because the risk of screen collapse due to corrosion is already present. A 4.8 feet drawdown at well O5 would drop pumping water levels below the top of the screen. It is equally likely that drawdown will be as little as 1.0 foot at this location which would not drop pumping water levels below the top of the screen. Even if pumping the O’Neill Ranch well drops water levels below the top of this screen, this is not a restrictive effect because water levels will remain above the top-of-screen in typical neighboring wells. The typical top of screen is an appropriate benchmark because it would be unreasonable for the

shallowest well in a basin such as well O4 to constrain the use of basin storage by all users.

Table 15. Water Level Effect of O'Neill Ranch Well Pumping on Nearby Private Well Screens

	Screen Length (ft)	Depths (ft)			Max Water Level Change (ft)
		Top of Screen	Static Water	Pumping Water	Based on Main St.
O2	80	140	140	N/A	-11.2
O3	19	80	84	N/A	-7.7
O4	60	180	100	N/A	-10.0
O5	44	104	97	100	-4.8
O6	80	250	150	N/A	-6.5
O7	120	377	32	360	-6.5
O8	20	80	50	N/A	-3.7
O10	20	15	20	N/A	-3.1
O11	20	36	25	N/A	-3.0
O12	28	180	165	N/A	-5.5
O13	60	240	150	N/A	-5.3

These estimated water level changes are not equivalent to the water level changes previously calculated for the O'Neill Ranch well mitigated negative declaration (Todd Engineers, 2001). The parameter values used above are different from the Todd analysis because they are calculated using the MLU model, which accounts for a multi-layer aquifer system. Water level change estimates calculated by Todd assumed nearby wells are in the same unit and estimated effects after 18 hours of pumping. The water level change estimates above calculate effects in different units and estimate effects after 182.5 days of average pumping.

Drought year water levels are not available for private wells, so water level effects on nearby private wells from pumping the O'Neill Ranch well by itself during drought years is not assessed.

YIELD EFFECTS AT NEARBY PRIVATE WELLS

At all nearby wells, the additional drawdown would increase the pumping lift slightly, which could marginally decrease the pumping rate. The drawdowns correspond to between 1 and 2% of the total dynamic pumping head at the two wells with available pumping water level data (assuming 50 psi discharge pressure and 20 feet of friction losses in addition to the depth to the pumping

water level). The percentage decrease in pump discharge rate would likely be slightly larger than the percentage increase in total dynamic head. The decrease in discharge is estimated to be less than 1 gpm of the tested rate of 30 gpm at well O5, and approximately 0.2 gpm of the tested 12 gpm at well O7. This decrease in pumping rate could easily be compensated for by increased operating time. Therefore, drawdown from the O'Neill Ranch well will not materially affect the yield available to the nearby private wells, and the drawdown effect on yield is marginal.

An additional potential yield effect from pumping the O'Neill Ranch well is the possible influence on nearby petroleum release sites. Wells associated with locations O3, O10, and O13 are gasoline station sites. Site O3 was closed in 2002 (SWRQB, 2009), and is no longer considered an active petroleum release site. Locations O10 and O13, as well as three other locations without DWR logs, are sites where no active remediation is taking place, but the sites are monitored to verify that contaminants will not pose a threat to the water resource. If pumping at the O'Neill Ranch well alters groundwater flow at a site such that contaminants would be more likely to travel to nearby private wells, the effect on the yield of nearby private wells could be restrictive.

These effects are evaluated by estimating the changed groundwater flow gradient from pumping the O'Neill Ranch well. Maximum water level changes in the A unit are used for the evaluation, because site monitoring wells are located in the shallow unit. The reported and estimated altered gradients are shown in Table 16. The table shows that O'Neill Ranch pumping does not exacerbate the flow gradient at the five sites and does not change the direction of flow at four of the five sites. The direction of flow at the Redtree site is altered, but the overall gradient remains very low so offsite transport of contaminants remains unlikely. As a result, the effect at nearby private wells resulting from transport of these contaminants is marginal.

Table 16. Estimated Gradient Effects at Verification Monitoring Sites from O'Neill Ranch Well Pumping

Site Name and Address	Measurement Date (Source)	Reported		With O'Neill Ranch Pumping	
		Gradient	Degrees from West	Gradient	Degrees from West
Exxon 7-0281 2501 S. Main St.	11/4/2008 (ERI, 2009b)	0.012	-30	0.011	-30
BP 11240 2178 41 st Ave.	10/27/2008 (Stantec, 2009)	0.044	-85	0.043	-85
Exxon 7-3604 836 Bay Ave.	11/3/2008 (ERI, 2009a)	0.004	0	0.003	11

Redtree 819 Bay Ave.	1/28/2008 (Geomatrix, 2008)	0.0007	-115	0.0007	57
76 2452 4860 Soquel Dr.	10/15/2008 (TRC, 2009)	0.17	0	0.17	0

WATER LEVEL EFFECTS AT THE CITY OF SANTA CRUZ'S LIVE OAK WELLFIELD

The City of Santa Cruz's Live Oak wellfield consists of three active wells (Beltz wells #7, #8 and #9) that are between 7,700 and 9,700 feet from the O'Neill Ranch well site. An additional inactive well (Beltz #4) is slightly closer to the O'Neill Ranch well site, at 7,400 feet away.

The calculated drawdowns in the A unit at the three active Live Oak wells and the inactive Beltz well #4 are listed in Table 17. Results are listed for simulations both with and without flow from west of the A unit outcrop, and for each of the two parameter sets. The true drawdown is likely between these bounding estimates and is represented in the table by the average of the estimates. A map of simulated A unit water level change contours with no inflow from west of the A unit outcrop is shown in Figure 15. Distance-drawdown curves for both parameter sets are shown in Figure 16. These results indicate that the maximum drawdown in the A unit at Live Oak wells will be between 0.3 and 0.7 feet.

Table 17: Maximum Effect of O'Neill Ranch Well on A Unit Water Levels at the Live Oak Wellfield

Parameters Matching 18A/18AA Data		Total Screen Length ¹ (ft)	Elevations (feet above sea level)			Water Level Change at Live Oak wells (feet) ^{4,5}		
Well Name	Nearby Monitor Well		Top of Screen	Static Water Level ²	Pumping Water Level ³	Horizontally Infinite A and AA Units	No Inflow from West of A Unit Outcrop	Average
Beltz #4	N/A	N/A	N/A	3.9	N/A	-0.6	-0.9	-0.7
Beltz #7	#4	110	-80	3.9	-115	-0.5	-0.7	-0.6
Beltz #8	#6	80	-58	-7.4	-35	-0.5	-0.7	-0.6
Beltz #9	#2	90	-70	5.7	-60	-0.3	-0.4	-0.3
Pleasure Pt	N/A	60	-65	2.1	N/A.	-0.2	-0.3	-0.3
Parameters Matching 10A Data		Screen Length	Elevations (feet above sea level)			Water Level Change at Live Oak wells (feet) ^{4,5}		
Beltz #4	N/A	N/A	N/A	3.9	N/A	-0.5	-0.8	-0.7
Beltz #7	#4	110	-80	3.9	-115	-0.4	-0.8	-0.6
Beltz #8	#6	80	-58	-7.4	-35	-0.5	-0.8	-0.6
Beltz #9	#2	90	-70	5.7	-60	-0.4	-0.6	-0.5
Pleasure Pt	N/A	60	-65	2.1	N/A.	-0.3	-0.6	-0.5

N/A. = not available

¹ Well #7 has two screened intervals, from -80 to -105 and -145 to -220 feet msl.

² Approximate static water levels based on minimum measurement for water years 2005-2008 from nearby monitor well

³ The low end of the pumping water level range for each well during 1980-2003 was selected from hydrographs in Johnson et al. (2004)

⁴ At the end of the May-October dry season, assuming O'Neill Ranch well operates at 750 gpm, 61% of the time during the dry season

⁵ Water level changes are based on drawdowns for the Purisima A unit. Drawdown in the AA unit at Beltz #7 (which is 75% screened in AA) is 0.6 feet and 3.3 feet for the two parameter sets.



Figure 15. Water Level Changes in A Unit for O'Neill Ranch Well Pumping Using Parameters Matching Main Street Pump Test Data at Wells 18A and 18AA and Assuming No Flow from West of A Unit Outcrop

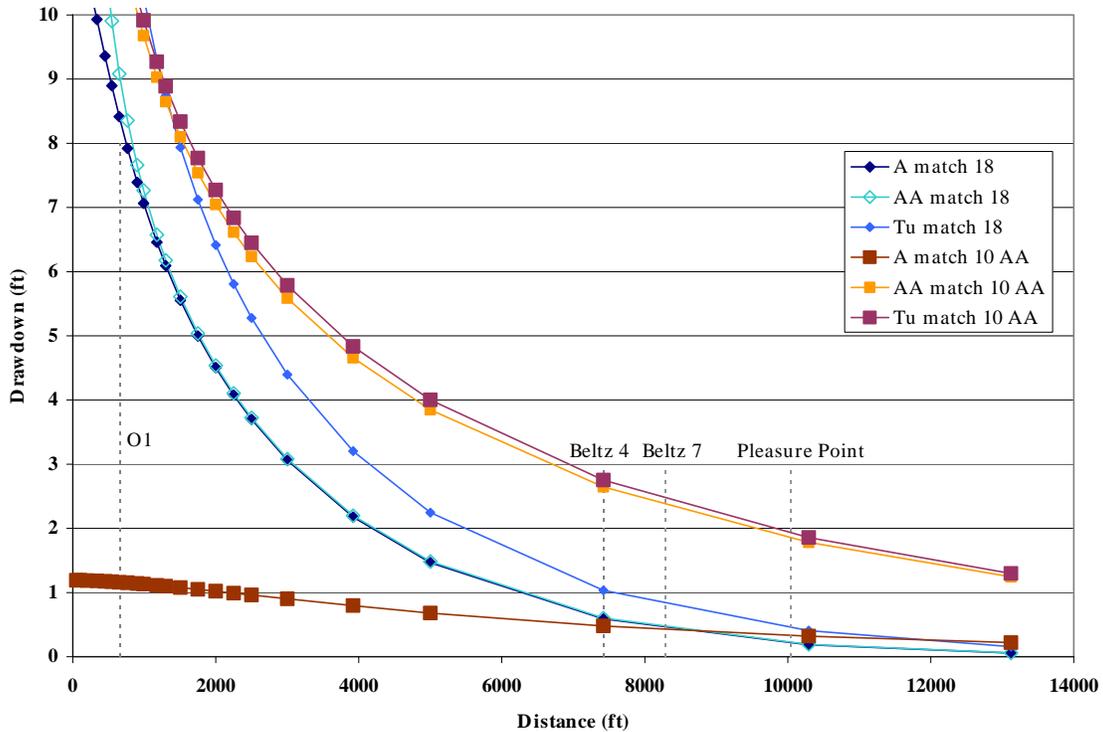


Figure 16. Distance-Drawdown Curves for O'Neill Ranch Pumping for 2 Parameter Sets

The possibility that drawdown from the O'Neill Ranch well could dewater the top of the screen at any of the active Live Oak wells can be explored by comparing the calculated drawdown with the static and pumping water levels and the elevation of the top of the screen. At the Beltz #7 well, the static water level is 86 feet above the top of the uppermost screened interval, and the pumping water level is 10 feet below the bottom of the uppermost screened interval. Thus, the uppermost screen is presently submerged when the well is off and fully dewatered when the well is on. Drawdowns at the Beltz #7 well from the proposed O'Neill Ranch well pumping are estimated at approximately 0.6 foot in the A unit and between 0.6 and 3.3 feet in the AA unit. Decreasing the static and pumping water levels by up to 3.3 feet would not increase the frequency or extent of screen dewatering, nor would it likely decrease the flow rate from the well.

At the Beltz #8 and #9 wells, pumping water levels are presently at least 10 feet above the top of the screened intervals. A decrease in water level of between 0.3 and 0.6 feet would not cause the screens to become dewatered. These calculations lead to the conclusion that pumping the O'Neill Ranch well will not cause physical damage to the Live Oak wells so the water level effect on these wells is marginal. The relationships between the existing range of water levels

(static and pumping) and the range with the O'Neill Ranch well operating are displayed graphically in Figure 17, which shows vertical profiles of each of the City's active wells.

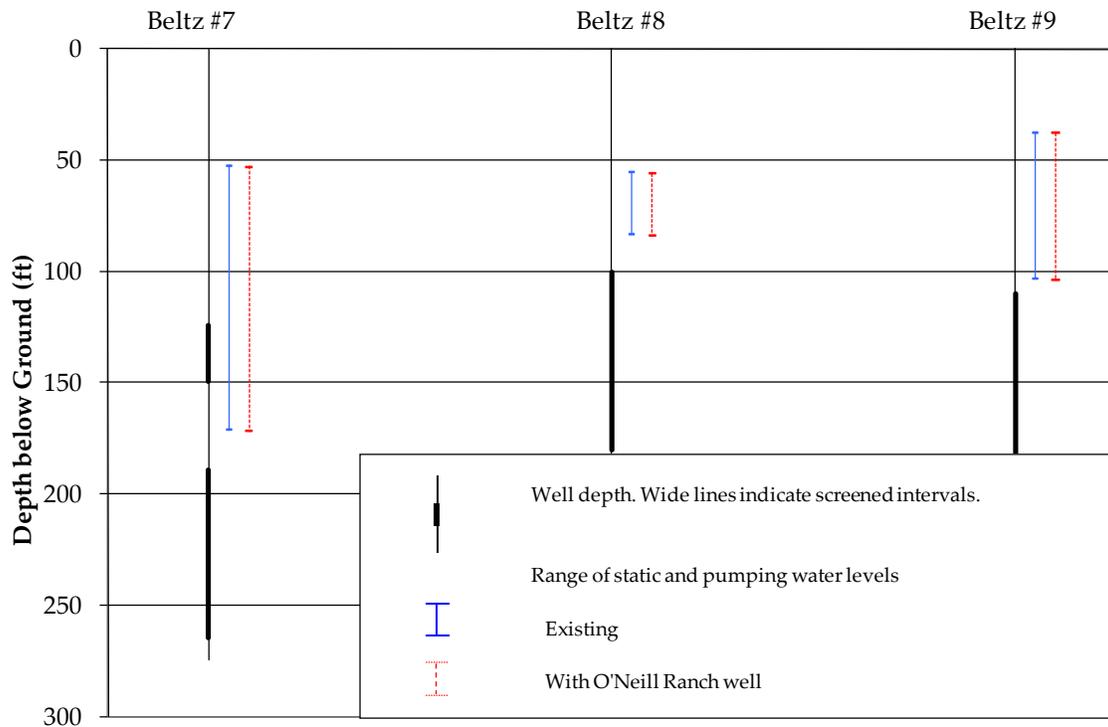


Figure 17. Vertical Profiles of City of Santa Cruz Live Oak Wells showing Screened Intervals and Water Level Ranges

ESTIMATED WATER LEVEL EFFECTS AT CITY OF SANTA CRUZ'S LIVE OAK WELLFIELD DURING DROUGHTS

During the last extended drought, between 1988 and 1992, water levels at the Live Oak wellfield were lower than current conditions. Static water levels at Beltz wells #2, #4, and #6 were lower by approximately 15 feet. Of the current production wells, only Beltz #7 produced water during the last extended drought. The pumping water level in Beltz well #7 was no lower in the 1988 to 1992 drought than current conditions, probably due to a different pumping distribution. Because the currently pumped wells in the Live Oak wellfield were apparently not used much during the last drought, accurate pumping water levels representative of drought conditions are not available for current production wells. To estimate the effect from pumping the O'Neill Ranch well during a drought, we applied the above drawdown analysis to the minimum static water levels recorded in the Live Oak wells observed from 1988-1992.

Table 18. Maximum Effect of O'Neill Ranch Well Pumping on Water Levels at Live Oak Wells during a Drought

Matching 18A/18AA		Total Screen Length ¹ (ft)	Elevations (feet above sea level)			Water Level Change at Live Oak wells (feet) ^{4,5}		
Well Name	Nearby Active Well		Top of Screen	Static Water Level ²	Pumping Water Level ³	Horizontally Infinite A and AA Units	No Inflow from West of A Unit Outcrop	Average
Beltz #4	#4	N/A	N/A	-7	N/A	-0.6	-0.9	-0.7
Beltz #7	#4	110	-80	-13	-29	-0.5	-0.7	-0.6
Beltz #8	#6	80	-58	-7	N/A	-0.5	-0.7	-0.6
Beltz #9	#2	90	-70	-6	N/A	-0.3	-0.4	-0.3
Pleasure Pt	N/A	60	-65	-1.4	N/A	-0.2	-0.3	-0.3
Matching 10A		Screen Length	Elevations (feet above sea level)			Water Level Change at Live Oak wells (feet) ^{4,5}		
Beltz #4	#4	N/A	N/A	-7	N/A	-0.5	-0.8	-0.7
Beltz #7	#7	110	-80	-13	-29	-0.4	-0.8	-0.6
Beltz #8	#6	80	-58	-7	N/A	-0.5	-0.8	-0.6
Beltz #9	#2	90	-70	-6	N/A	-0.4	-0.6	-0.5
Pleasure Pt	N/A	60	-65	-1.4	N/A	-0.3	-0.6	-0.4

N/A. = not available

¹ Well #7 has two screened intervals, from -80 to -105 and -145 to -220 feet msl.

² Minimum static water levels from 1988-1992 based on nearest active well.

³ Minimum pumping water level from 1988-1992 if well was active.

⁴ At the end of the May-October dry season, assuming O'Neill Ranch well operates at 750 gpm, 61% of the time during the dry season

⁵ Water level changes are based on drawdowns for the Purisima A unit. Drawdown in the AA unit at Beltz #7 (which is 75% screened in AA) is 0.6 feet and 3.3 feet for the two parameter sets.

The relationships between the water levels during the last drought, lowered by the estimated drawdown from pumping the O'Neill Ranch well, show that pumping the Polo Grounds well would not initiate screen dewatering in the Live Oak production wells (Table 18). These calculations lead to the conclusion that O'Neill Ranch well pumping would not cause physical damage to the Live Oak wells during a drought so the water level effect on these wells is marginal.

YIELD EFFECTS AT THE CITY OF SANTA CRUZ'S LIVE OAK WELLFIELD

The second type of potential effect is the possibility that pumping the O'Neill Ranch well will appreciably diminish the amount or quality of water available to the City of Santa Cruz. Because of the coastal location of the Live Oak wellfield, its yield is limited by seawater intrusion. Thus, the effect of concern is not simply drawdown but also groundwater gradients and elevations above sea level at the coastline. This analysis evaluates the influence of the O'Neill Ranch well pumping on seawater intrusion.

The most likely pathway for seawater intrusion is through the offshore outcrop of the Purisima A unit, which intersects the sea floor in a band extending south from the tip of Pleasure Point. Therefore, water levels at the Pleasure Point monitoring well are the leading indicators of seawater intrusion. Water levels at the Pleasure Point monitoring well are strongly affected by Live Oak pumping, as shown in Figure 18 where the Y-axis scale for water level is reversed to clearly reveal the strong inverse correlation between pumping and water levels. A similar plot, showing pumping from the Garnet well and water levels at Pleasure Point, is shown on Figure 19. The plot reveals little correlation between Garnet and Opal well pumping, and Pleasure Point water levels. The effect of pumping from the O'Neill Ranch well on Pleasure Point groundwater levels will be even smaller, because it is four times as far away from the Live Oak wells as the Garnet well and because drawdown diminishes logarithmically with distance.

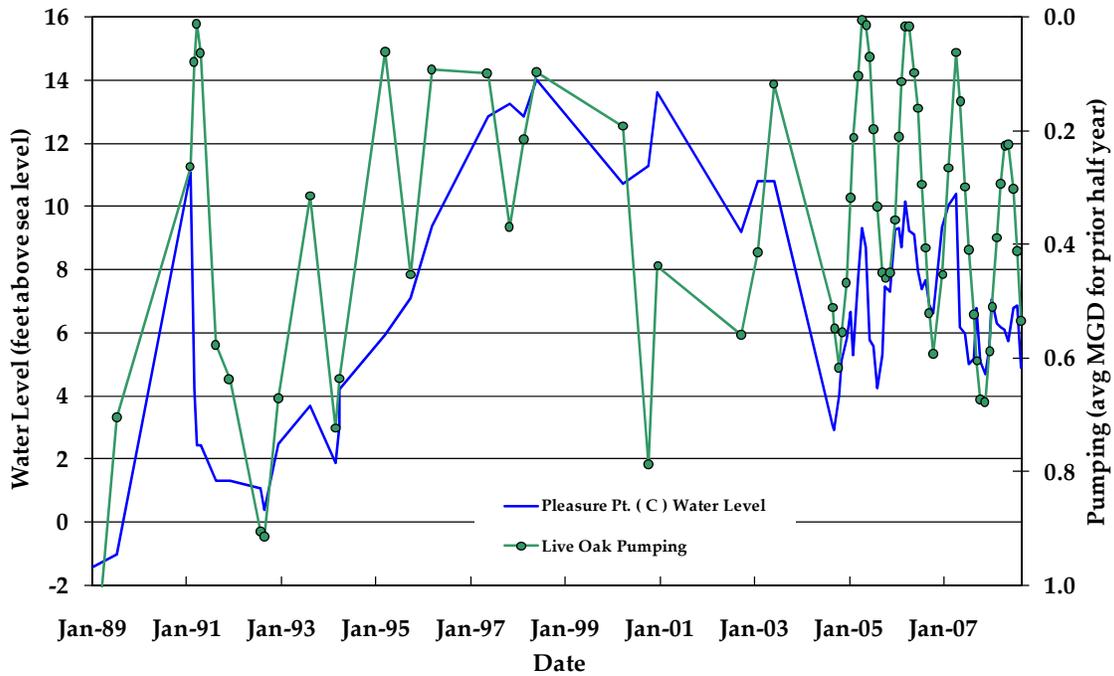


Figure 18. Groundwater Elevation at Pleasure Point and Semiannual Production from Live Oak Wellfield between 1989 and 2008

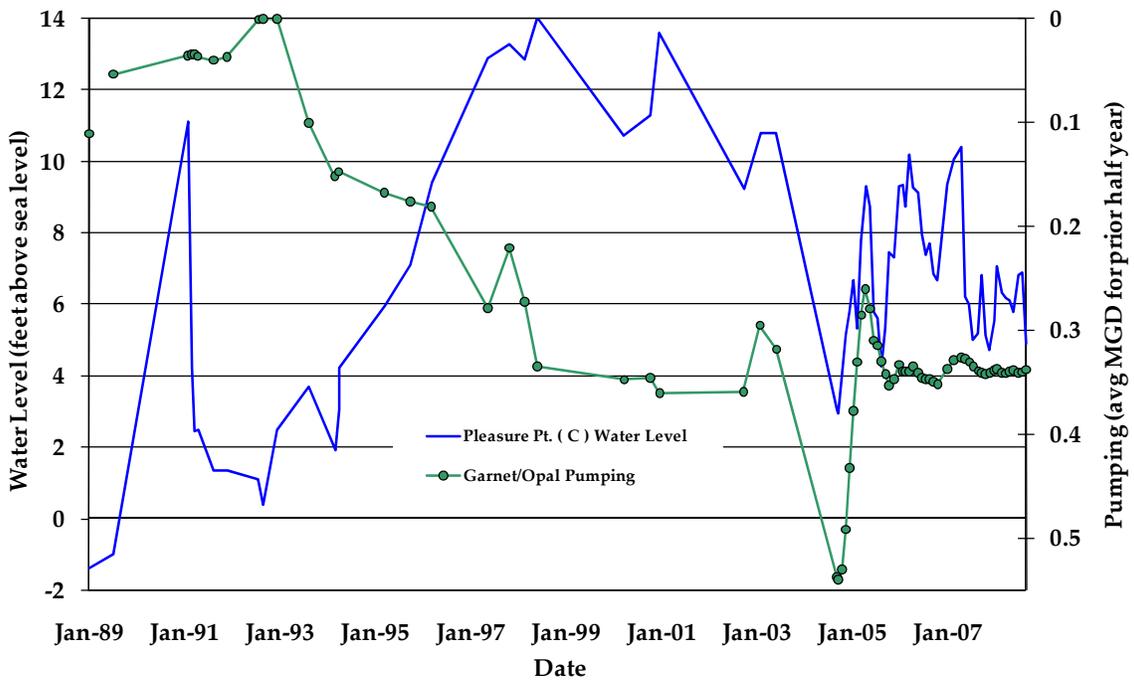


Figure 19. Groundwater Elevation at Pleasure Point and Semiannual Production from the Opal/Garnet Well between 1989 and 2008

The estimated maximum drawdown from the O'Neill Ranch well at the Pleasure Point monitoring well can be combined with the relationship of Live Oak pumping and Pleasure Point water levels to quantify the potential effect of O'Neill Ranch pumping on Live Oak yield. The data in Figure 18 can be displayed as a scatterplot, as shown in Figure 20. Although the data exhibit considerable scatter, a downward slope is clearly evident. A trend line fitted by linear regression has a slope of -7 feet of water level per average million gallons per day (MGD) of pumping during a half year period. The slope of the regression line in Figure 20 can be inverted to obtain the amount of Live Oak production lost in a half year period per foot of water-level decline at Pleasure Point. The result is 26.2 million gallons per foot. The MLU model analysis estimates that pumping the O'Neill Ranch well potentially results in between 0.3 and 0.5 feet of drawdown at Pleasure Point. Multiplying this drawdown by 26.2 million gallons per foot results in an estimated decrease in Live Oak yield of 13.1 million gallons/year, or 40 acre-feet/year.

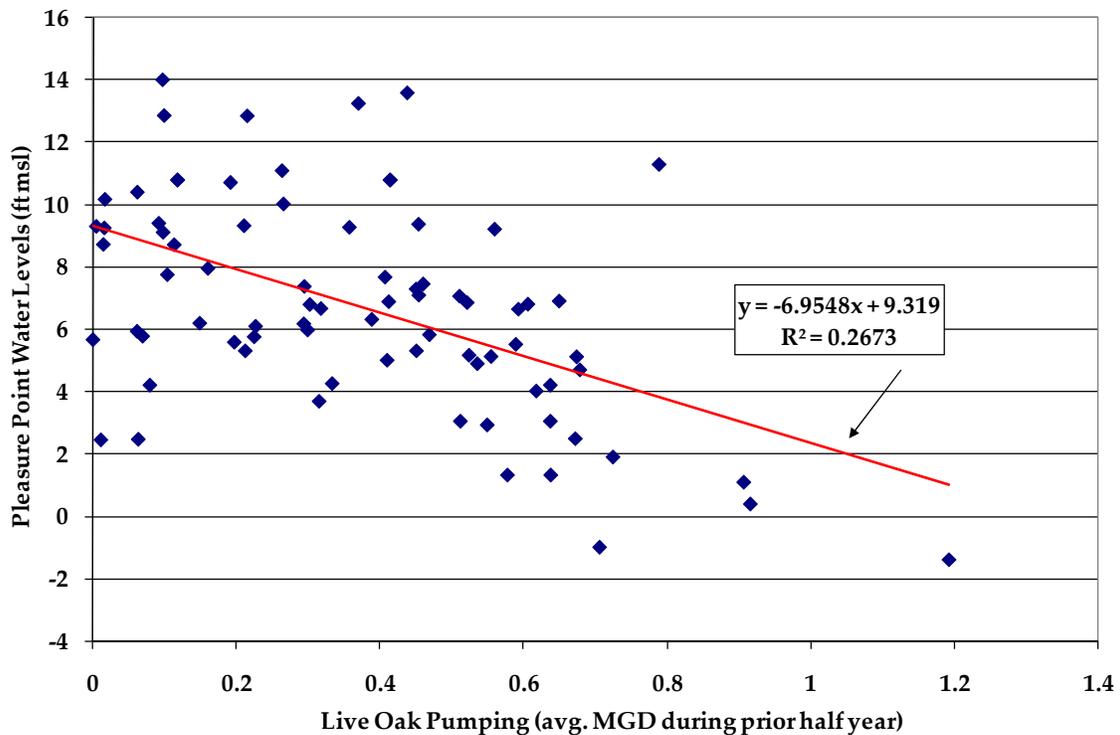


Figure 20. Scatterplot of Pleasure Point Water Levels and Live Oak Pumping

Because the City's existing water supplies are marginally adequate for drought conditions and because the Live Oak yield is smaller than the amount assumed by the City, any decrease in yield can be considered "appreciable" and therefore

significant. Accordingly, the 40 acre-feet/year decrease in yield that could potentially result from adding O'Neill Ranch well pumping without additional redistribution of pumping is considered a restrictive effect.

COMBINED EFFECTS FROM PUMPING THE O'NEILL RANCH WELL AND REDISTRIBUTING PUMPING, ON WATER LEVELS AND YIELD

The O'Neill Ranch well is only one component of the Well Master Plan, which is designed to allow SqCWD to redistribute pumping and implement elements of the Groundwater Management Plan. As part of the Well Master Plan, pumping will be redistributed among new and existing wells. Likely redistribution scenarios shown in Table 4 include an increase in drought year pumping at the Main Street well and a decrease in pumping at the Garnet well. The increase in drought year pumping at the Main Street well may add to the water level and yield effects on private wells near the O'Neill Ranch well. The decrease in pumping at the Garnet well may lessen the water level and yield effects on the City of Santa Cruz's Live Oak wells.

To ensure that our analysis is conservative and addresses the greatest expected drawdown, we compared expected pumping changes under both the basin management objective and maximum pumping conditions. The middle column in Table 4 ("BMO Pumping Condition") shows how the proposed new wells will increase or decrease nearby pumping if SqCWD pumping is 4,800 acre-feet/year. The rightmost column in Table 4 ("Maximum Pumping Condition") shows how the proposed new wells will increase or decrease nearby pumping if pumping is 5,675 acre-feet/year. In the O'Neill Ranch well area, the pumping changes under the basin management objective pumping condition are the same as pumping changes under the maximum pumping condition, as shown in Table 4. One condition will not result in the Well Master Plan adding more drawdown than the other condition. Therefore, combined drawdown effects are analyzed based on pumping changes under the basin management objective pumping condition (Scenario 1 versus 2005-2008 Average) for both non-drought and drought years.

COMBINED EFFECTS AT NEARBY PRIVATE WELLS FROM THE O'NEILL RANCH WELL AND THE MAIN STREET WELL

The redistribution scenarios show no planned increases in pumping at the Main Street well. During droughts, pumping would likely be shifted from the coastal Garnet well to the Main Street well. The increase of pumping at the Main Street well in drought years may have additional effects on private wells near the O'Neill Ranch well. To be conservative, and address the greatest expected drawdown, combined drawdown effects of the production increases during drought years are analyzed. Annual pumping at the Main Street well is

increased from current production by 100 acre-feet per year during a drought year as shown in Table 4. Assuming that 61% of pumping occurs during the dry season, Main Street well pumping would increase by 61 acre-feet over a 6-month period. Therefore, the MLU model was used to simulate the decline in water levels when pumping at the Main Street well is increased by a continuous rate of 76 gpm over 182.5 days. The aquifer properties used for the Main Street well modeling are those shown in Table 9 and Table 10. The additional drawdowns at private wells near the O'Neill Ranch well are shown in Table 19 as water level changes.

Table 19. Water Level Changes at Private Wells from Increases in Main Street Well Pumping

Well	Distance (ft)	Aquifer	Water Level Change (ft)	
			Match 18A/18AA	Match 10AA
O1	3,400	A	-0.3	-0.1
O2	3,000-4,000	AA	-0.3	-0.6
O3		A	-0.3	-0.1
O4		AA	-0.3	-0.6
O5		A	-0.3	-0.1
O6		4,000-5,000	AA	-0.2
O7	3,000-4,000	AA	-0.3	-0.5
O8	500-1,500	A	-0.8	-0.2
O9	4,300	A	-0.2	-0.1
O10	3,000-4,000	A	-0.3	-0.1
O11	100-500	A	-1.3	-0.2
O12	2,000-3,000	AA	-0.4	-0.6
O13	3,000-4,000	AA	-0.3	-0.5

Figure 21 and Figure 22 show maximum combined water level changes from drought year pumping at O'Neill Ranch well and the Main Street well in the A Unit and the AA unit.

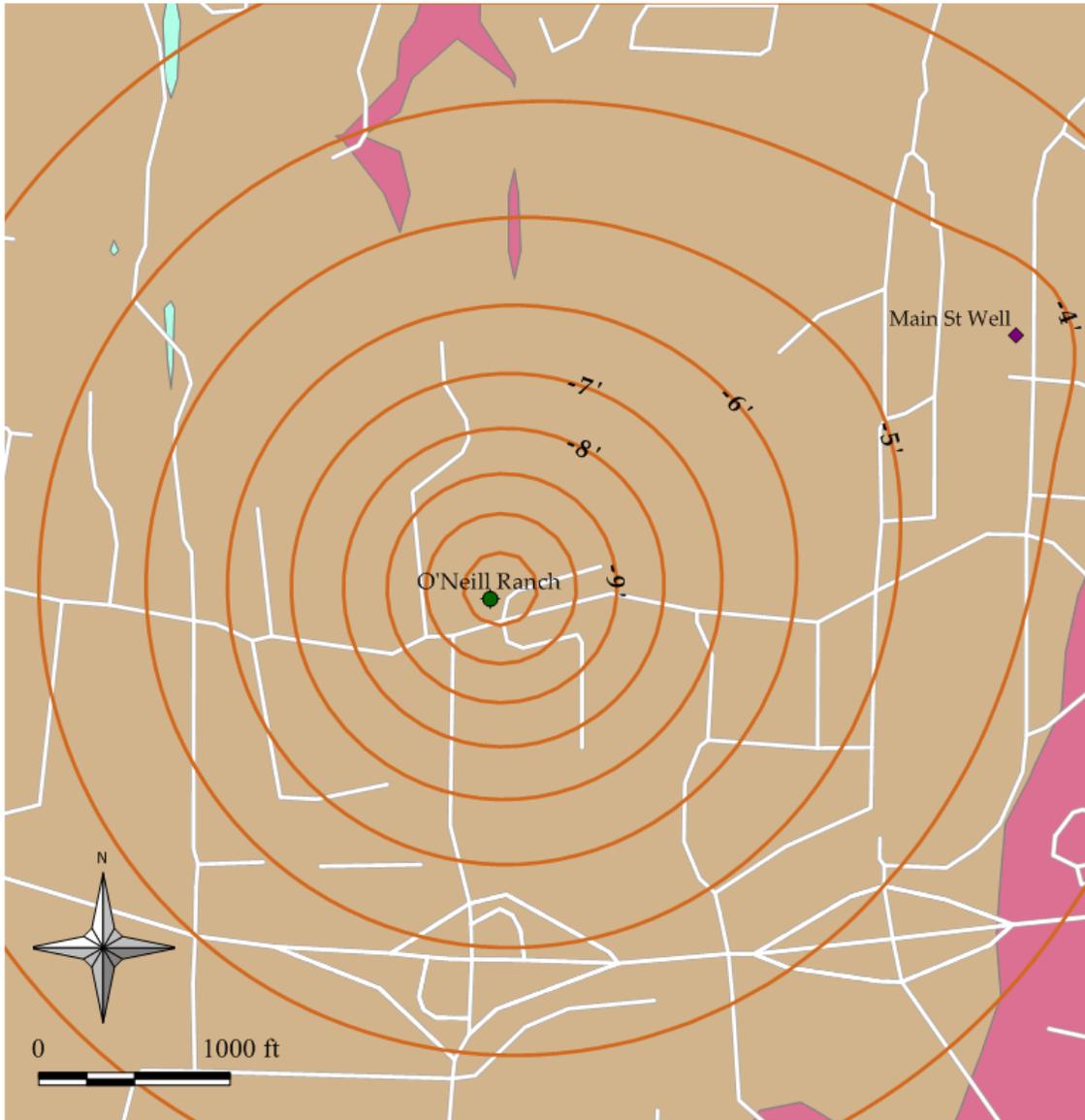


Figure 21. Combined Water Level Changes in A Unit for Drought Year O'Neill Ranch Well and Main Street Well Pumping Using Parameters Matching Main Street Pump Test Data at Wells 18A and 18AA

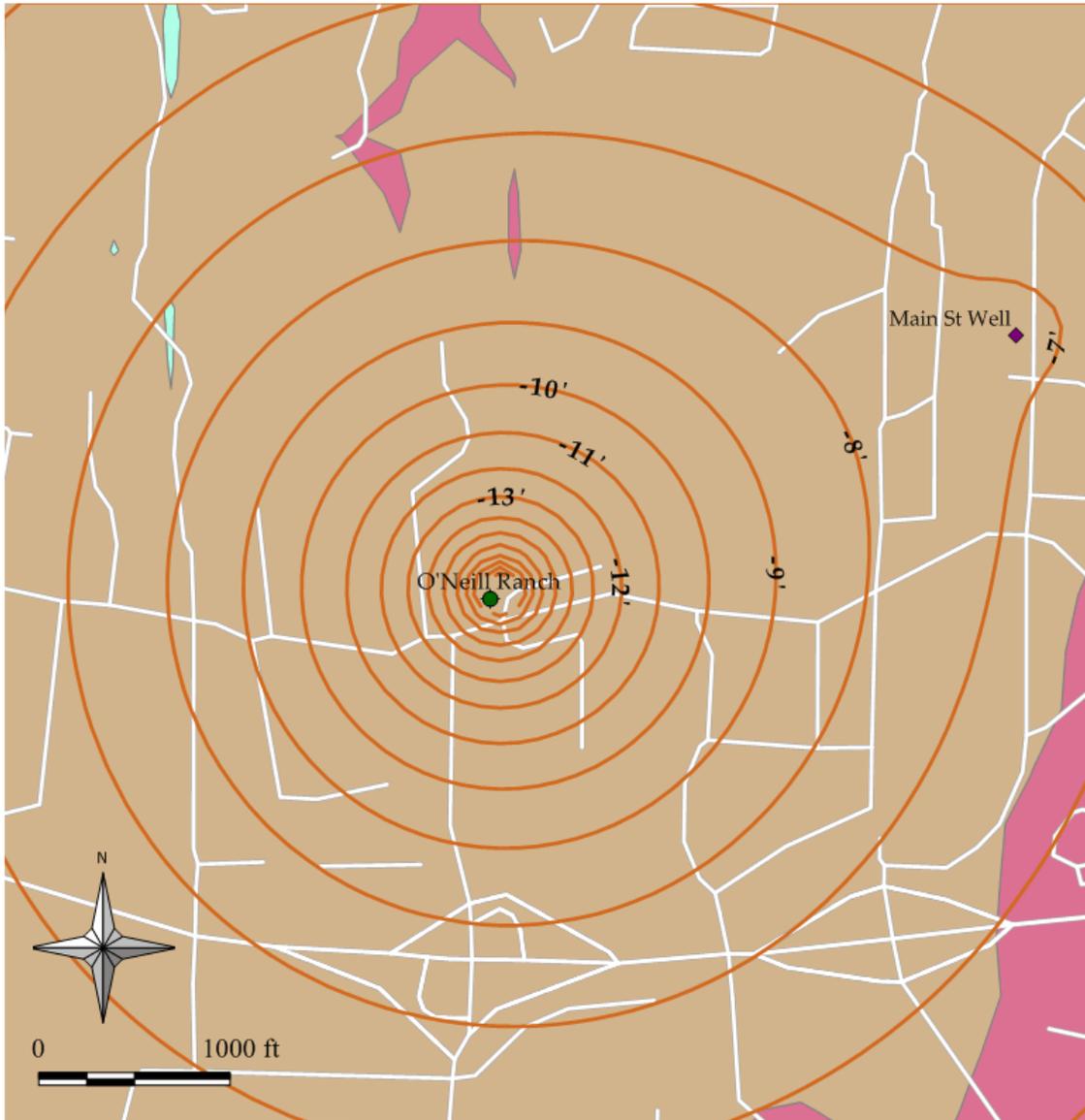


Figure 22. Combined Water Level Changes in AA Unit for Drought Year O'Neill Ranch Well and Main Street Well Pumping Using Parameters Matching Main Street Pump Test Data at Well 10A

Comparisons of available water level data, screen intervals, and estimated drawdowns show that combined drawdowns from pumping at the O'Neill Ranch well and Main Street well will have marginal effects on wells near the O'Neill Ranch well. Table 20 shows that the additional drawdown from drought year pumping of the Main Street well does not change the relationship of water levels to screen intervals.

Table 20. Combined Water Level Effect of Main Street and O'Neill Ranch Well Pumping on Nearby Private Well Screens

Well	Screen Length (ft)	Depths (ft)			Max Water Level Change (ft)
		Top of Screen	Static Water	Pumping Water	Based on Main St.
O2	80	140	140	N/A	-11.8
O3	19	80	84	N/A	-8.0
O4	60	180	100	N/A	-10.6
O5	44	104	97	100	-5.1
O6	80	250	150	N/A	-7.0
O7	120	377	320	360	-7.0
O8	20	80	50	N/A	-4.5
O10	26	14	18	N/A	-3.4
O11	20	36	25	N/A	-4.3
O12	28	180	165	N/A	-6.1
O13	60	240	150	N/A	-5.9

The additional drawdown from pumping the Main Street well will have only marginal effects on yields at wells near the O'Neill Ranch well. The drawdowns correspond to between 1.4 and 2.2% of the total dynamic pumping head at wells O5 and O7. The decrease in discharge is still estimated to be less than 1 gpm of the tested rate of 30 gpm at well O5, and approximately 0.2 gpm of the tested 12 gpm at well O7. This decrease in pumping rate could easily be compensated for by increased operating time.

COMBINED EFFECTS ON THE LIVE OAK WELLFIELD FROM THE O'NEILL RANCH WELL AND THE GARNET WELL

After implementing the Well Master Plan, the Garnet well will remain as the SqCWD well closest to the Live Oak wellfield and Pleasure Point, and consequently will have the largest water level effect on these wells. The Garnet well is located between 3,800 and 5,900 feet away from the Live Oak wells. The O'Neill Ranch well will be the second closest well to the Live Oak wellfield: between 7,400 and 9,700 feet away from the Live Oak wells. Redistributing pumping among new and existing wells will include a decrease in pumping at the Garnet well, which will increase water levels in the Live Oak and Pleasure Point areas. This could more than offset the water level decrease caused by O'Neill Ranch well pumping.

The redistribution scenarios shown in Table 3 include a substantial decrease in production at the Garnet well in non-drought years. Table 4 shows that the

drought year redistribution includes an additional decrease of 100 acre-feet/year; therefore non-drought years have more combined pumping in the area around the Live Oak wells than drought years. To be conservative and address the greatest expected drawdown, combined drawdown effects from the non-drought redistribution scenarios are evaluated for this area.

Scenario 1 decreases Garnet well pumping from the current 370 acre-feet per year to 200 acre-feet/year. Assuming annual pumping is decreased by 170 acre-feet per year and that 61% of pumping occurs during the dry season, Garnet well pumping would decrease by 104 acre-feet over the 6-month dry period. Therefore, the MLU model was used to simulate the rise in water levels when pumping at the Garnet well is decreased by a continuous rate of 129 gpm over 182.5 days. The aquifer properties used for the Garnet well modeling are those shown in Table 12.

Table 21 shows the combined effect on water levels at the Live Oak wellfield from the new pumping at the O'Neill Ranch well and the reduced pumping at the Garnet well. The maximum drawdowns modeled from the two parameter sets used for modeling O'Neill Ranch pumping are displayed. The beneficial effect of reducing pumping at the Garnet well offsets much of the negative effect of the new pumping at the O'Neill Ranch well. The linear relationship between pumping rate and drawdown can be used to calculate that annual Garnet well pumping would need to be decreased by 170 acre-feet to bring the average water-level effect at the Pleasure Point well to zero. If the Well Master Plan is implemented, SqCWD will decrease Garnet pumping by at least this amount in order to meet its objectives of minimizing seawater intrusion (Table 3). Therefore, the overall redistribution of pumping will not lower water levels at Pleasure Point and consequently will not adversely affect the risk of seawater intrusion to the Live Oak wellfield. Because of the pumping redistribution, any effects on the yield of the Live Oak wellfield resulting from potential seawater intrusion are reduced to the level of no effect.

As Table 21 shows, water levels in some Live Oak wellfield pumping wells are predicted to decline slightly, even with the beneficial effect of decreased pumping at the Garnet well. The additional drawdown will increase the pumping lift slightly in these wells, which could marginally decrease the pumping rate. The drawdowns correspond to less than 1% of the total dynamic pumping head (assuming 50 psi discharge pressure and 20 feet of friction losses in addition to the depth to the pumping water level). The percentage decrease in pump discharge rate will likely be slightly larger than the percentage increase in total dynamic head. The decrease in discharge is estimated to range up to 2 gpm at the Beltz #7 well. However, this would not diminish the amount of water available to the City. Planned production from these wells of 645 acre-feet over a

210 day pumping season would require operating the wells approximately 14 hours per day. Increasing operating time by 8 minutes per day would make up for the decrease in pump discharge rate related to additional drawdown. Therefore, drawdown from pumping the O'Neill Ranch well will not materially affect the yield available to the Live Oak wellfield when pumping is redistributed, and the combined drawdown effect on yield is marginal.

Table 21. Maximum Effect of SqCWD Pumping Redistribution on Water Levels in the A unit at the Live Oak Wellfield

Well Name	Nearby Monitor Well	Total Screen Length ¹ (ft)	Elevations (feet above sea level)			Water-Level Change at Beltz Wells due to Change in Pumping at SqCWD wells (ft) ^{4,5}		
			Top of Screen	Static Water Level ²	Pumping Water Level ³	O'Neill Ranch (max drawdown from 2 parameter sets)	Garnet	Total
Beltz #4	N/A	N/A	N/A	3.9	N/A.	-0.7	0.6	-0.1
Beltz #7 A	#4	110	-80	3.9	-115	-0.6	0.5	-0.1
Beltz #7 AA		110	-80	-7.4	-115	-3.3	0.5	-2.8
Beltz #8	#6	80	-58	5.7	-35	-0.6	0.8	0.2
Beltz #9	#2	90	-70	2.1	-60	-0.5	0.3	-0.2
Pleasure Point	N/A	60	-65	3.9	N/A	-0.4	0.4	0.0

N/A. = not available

1 Well #7 has two screened intervals, from -80 to -105 and -145 to -220 feet msl.

2 Approximate static water levels based on minimum measurement for water years 2005-2008 from nearby monitor well

3 The low end of the pumping water level range for each well during 1980-2003 was selected from hydrographs in Johnson et al. (2004)

4 The changes in pumping reflect the most likely pumping redistribution to minimize intrusion risk:

O'Neill Ranch: increase from 0 to 605 ac-ft/yr, or by 369 ac-ft during the 6-month dry season, equivalent to 458 gpm

Garnet: decrease from 370 to 200 ac-ft/yr, or by 104 ac-ft during the 6-month dry season, equivalent to 129 gpm

5 Drawdowns are for the Purisima A unit except at Beltz #7 where drawdowns for both the A and AA units are displayed because Beltz #7 is 75% screened in the AA unit.

CUNNISON LANE WELL

MODEL SETUP

For the proposed Cunnison Lane well, the MLU model was set up with four layers representing an overlying BC unit, the A unit planned for the production screen, and underlying AA and Tu units. Intervening aquitard units are included between each of the aquifer units, including the B unit. The B unit is represented by the vertical resistance between the A unit and overlying units. Because water levels may be lower than the estimated bottom of the BC unit and the depths of nearby wells appear to be located in the estimated interval of the B unit according to Johnson et al. (2004, Appendix B), we included an overlying unit representing the more productive intervals of the B unit.

PARAMETERS BASED ON PUBLISHED VALUES FROM THE TANNERY II AQUIFER TEST

The only aquifer test in the area of the Cunnison Lane well was performed in July 2001 at the Tannery II well. Drawdowns were measured in the Tannery II well during pumping of the Tannery II well. The MLU model was not used to estimate parameters from this data set, because no observation well data are available. Instead, published values from the analysis of this test were used in the MLU model. Johnson et al. (2004) published the following values for the A unit and the overlying B unit aquitard based on this aquifer test.

Table 22. Published Parameters for Tannery II Aquifer Test

Unit	Pump Test Parameter	Value	Assumed Thickness	Derived Parameter	Derived Value
A Unit Aquifer	Transmissivity (T)	2,060 ft ² /d	235 ft	Horizontal Conductivity (K _h)	8.75 ft/d
	Storativity (S)	5.5 x 10 ⁻⁴		Specific Storage (S _s)	2.3 x 10 ⁻⁶ ft ⁻¹
B Unit Aquitard	Leakage Factor (B)	500 ft	50-200 ft	Vertical Conductivity (K _v)	0.4-1.6 ft/d
	Vertical Resistance (c)	121 d			

The derived A unit horizontal conductivity of 8.75 feet/day is at the low end of the range of regional values shown in Table 6 while the derived B unit vertical conductivities of between 0.4 and 1.6 feet/day are higher than the range of regional values shown in Table 7 (0.001-0.1 feet/day). These low pumped unit horizontal conductivities and high aquitard vertical conductivities will maximize

drawdowns in the overlying unit where nearby wells are screened. The derived horizontal conductivity of the A unit is combined with the thickness of the A unit of 250 feet at Cunnison Lane provided by Johnson et al. (2004, Appendix B) to obtain the modeled value of transmissivity of the pumped A unit. The thickness of the aquitard between the A unit and the interval of nearby wells is unknown so the published value of 121 days for vertical resistance is used as the model parameter.

The published storativity value for the Tannery II aquifer test of 5.5×10^{-4} is in the middle of the range of regional values shown in Table 8 (10^{-5} to 0.007). Using a smaller storativity value in the pumped unit will increase drawdowns in the overlying unit, so the low end of the storativity range was tested for sensitivity and to provide a range of modeled results.

There is no local information about aquifer properties of the overlying B unit where nearby wells are screened. Johnson et al. (2004, Table 3-13) provide a range of transmissivities of 1-150 feet²/d. The nearby wells are likely screened in the more transmissive B unit intervals so the high end of transmissivities is used in the model, although the low end is tested for sensitivity. Average specific yield shown in Table 8 is used for the specific yield of the overlying unit.

Regional values of conductivities and storativities provided by Johnson et al. (Table 6, Table 7, and Table 8) were used for overlying and underlying units. These regional hydraulic property values are combined with estimated aquifer and aquitard thicknesses at the Cunnison Lane site for underlying units (Johnson et al., 2004, Appendix B) to calculate aquifer transmissivity, storativity and aquitard resistance, as shown on Table 23

Table 23. Aquifer Hydraulic Properties Used to Simulate Pumping at Cunnison Lane Well

Model Layer	Aquifer/ Aquitard	Unit	T (ft ² /d)	Sy/S (unitless)	c (days)
1	Aquifer	Overlying	150/1	0.03	
2	Aquitard	B			121
	Aquifer	A	2,191	$5.9 \times 10^{-4}/$ 1×10^{-5}	
3	Aquitard	Above AA			1,184
	Aquifer	AA	483	2.7×10^{-4}	
4	Aquitard	Tmp			338
	Aquifer	Tu	1,431	2.7×10^{-4}	

WATER LEVEL AND YIELD EFFECTS FROM PUMPING CUNNISON LANE WELL

Table 2 shows that the estimated instantaneous yield at the Cunnison Lane well is 538 gallons per minute (gpm). This estimate is based on the average yields of the Rosedale, Tannery, Monterey, and Maplethorpe wells. Assuming the Cunnison Lane well pumps 50 percent of the time during an average year, the well could produce approximately 434 acre-feet/year. Further assuming 61% of this yield, or 265 acre-feet, is produced during the six month dry season, the Cunnison Lane well simulations were based on a pumping rate of approximately 328 gpm continuously for 182.5 days between May and October. The distance-drawdown curve for pumping Cunnison Lane at that rate after 182.5 days is shown in Figure 23.

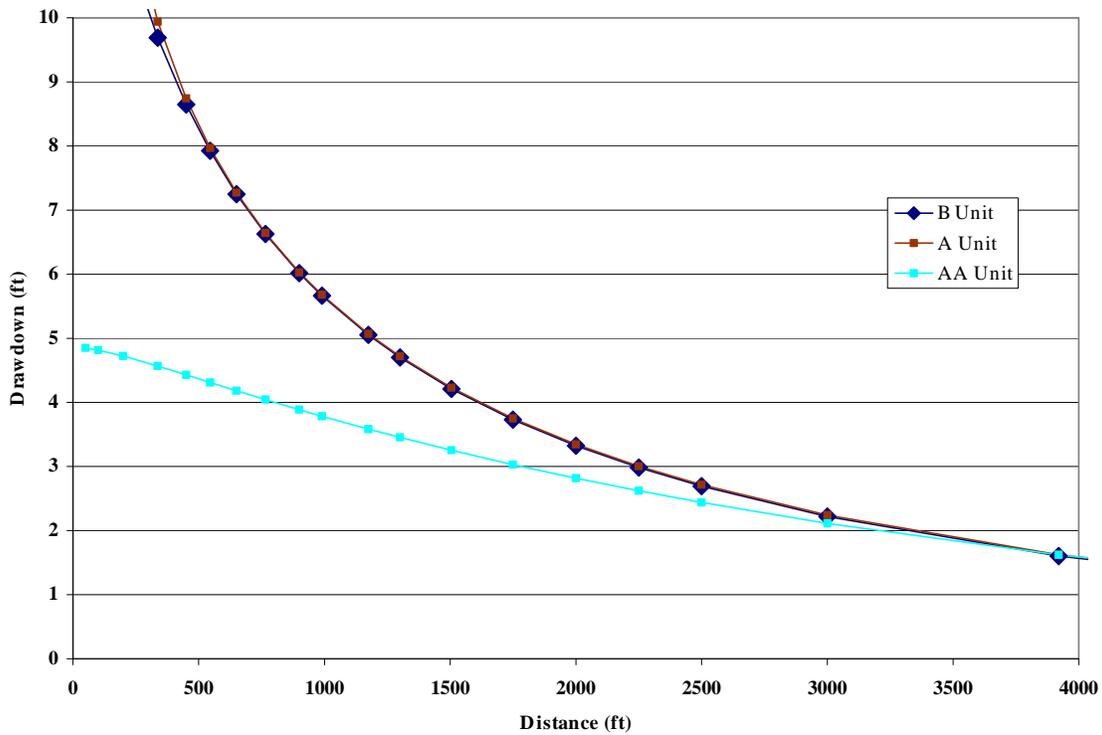


Figure 23. Distance-Drawdown Curves for Maximum Cunnison Lane Well Pumping

WATER LEVEL EFFECTS AT NEARBY WELLS

The County of Santa Cruz provided SqCWD with California Department of Water Resources well logs and estimated locations for wells near the Cunnison

Lane well. The depth of nearby wells, and distances from the O'Neill Ranch well are summarized in Table 24

Based on the estimated locations, the nearest well to the Cunnison Lane well is referred to as location C1, less than 500 feet away. The log shows the depth of well C1 is 240 feet, bottoming out in the estimated interval of the B unit. There is no screen interval and depth to water information for this well. There are three shallow remediation wells at a former Quik Stop gasoline station at 5505 Soquel Drive (Compliance & Closure, 2007). The County's private well database (Wolcott, 1999) shows a well within 1,000 feet of the Cunnison Lane well, at location referred to as C2. However, there is no depth information for this well. The nearest wells with screen interval and depth to water information are located at locations C4 and C5. The screen interval for the well C5 is between 120 and 263 feet deep, which spans the estimated contact between the B and A units. Drawdowns calculated at these locations from the anticipated maximum pumping at the Cunnison Lane well are shown in Table 24 as water level changes. The sensitivity of modeled drawdowns is represented by showing modeled results for minimum storativity and minimum overlying transmissivity. The table also shows the drawdown estimates for other nearby wells with available depth to water and screen interval information. Drawdowns for wells screened in the overlying BC aquifer are calculated from the model's overlying B aquifer unit.

Table 24. Estimated Water Level Changes at Nearby Wells from Cunnison Lane Well Pumping

Well	Distance (ft)	Aquifer	Water Level Change (ft)	
			Based on Tannery II	Low S, Low B unit T
C1	300-500	B	-9.0	-9.5
Quik Stop	800	BC	-6.5	-6.8
C2	500-1,000	B	-6.0	-6.3
C3		B	-5.6	-5.8
C4	1,200-1,500	B	-4.8	-4.9
C5		A	-4.8	-4.9
C6		BC	-4.4	-4.6
C7		A	-4.2	-4.4
C8	2,000-2,500	B	-3.3	-3.3
C9		A	-3.2	-3.3
C10		B	-2.9	-3.0
C11		BC	-2.8	-2.9
C12		BC	-2.7	-2.7
C13	2,500-3000	B	-2.6	-2.6
C14		A	-2.5	-2.6
C15		A	-2.5	-2.6
C16		A	-2.4	-2.5
C17		BC	-2.3	-2.4
C18		BC	-2.3	-2.4
C19		BC	-2.3	-2.4
C20	3,000-3,250	A	-2.2	-2.3
C21		B	-2.2	-2.2
C22		BC	-2.2	-2.2
C23		BC	-2.1	-2.1

Comparisons of available water level data, screen intervals, and estimated drawdowns show that drawdown from pumping the Cunnison Lane well will result in marginal effects to nearby private supply wells. Available information from DWR logs show that static water levels are higher than the tops of screens by more than estimated drawdowns. At wells C7 and C10, the top of screen was placed at static water level during construction. As a result, effects on the screen have likely already occurred as any decline in water level would expose the screen. Therefore, any additional drawdown caused by Cunnison Lane pumping will not materially add to the adverse effects on the well screen. At wells C4, C8, C11, C19, C21, C22, and C23, static or pumping water levels are already below the bottom of the screen so any additional drawdown will only marginally add to the effects on the well screen.

Calculated drawdowns at the Quik Stop remediation site would dewater remediation well screens. Actual drawdowns at these wells are likely less than calculated drawdowns because these wells are screened in a shallower unit than the model's overlying B aquifer unit. Reported pumping water levels (SWRCQB, 2009) are just 2 feet above the bottom of the screen at RW-2 (Mulkey, 2008) so a drawdown of 2 feet or greater will have a restrictive effect on pumping at these wells. Although these wells are above the typical well screen depth, the water level effect is restrictive because it may affect the ability of the wells to control the site contamination.

Table 25. Water Level Effect of Cunnison Lane Well Pumping on Nearby Well Screens

	Screen Length (ft)	Depths (ft)			Water Level Change (ft)
		Top of Screen	Static Water	Pumping Water	Based on Tannery II
Quik Stop RW-2	20	11	N/A	29	-6.5
Quik Stop RW-3	15	8	N/A	17	-6.5
Quik Stop MW-4R	15	15	N/A	24	-6.5
C4	88	120	160	173	-4.8
C5	133	130	50	N/A	-4.8
C6	44	106	40	N/A	-4.4
C7	204	200	200	N/A	-4.2
C8	92	250	242	320	-3.3
C9	240	540	340	N/A	-3.2
C10	90	240	240	N/A	-2.9
C11	8	172	110	N/A	-2.8
C12	40	245	150	170	-2.7
C13	100	370	300	360	-2.6
C14	160	390	275	N/A	-2.5
C15	88	492	370	N/A	-2.5
C16	40	70	50	50	-2.4
C17	30	170	135	N/A	-2.3
C18	90	185	120	N/A	-2.3
C19	28	172	140	N/A	-2.3
C20	100	500	343	N/A	-2.2
C21	100	305	255	320	-2.2
C22	80	133	162	N/A	-2.2
C23	30	250	220	360	-2.1

Drought year water levels are not available for private wells so water level effects to nearby wells during drought years by pumping at the Cunnison Lane well is not assessed.

YIELD EFFECTS AT NEARBY WELLS

At all wells, the additional drawdown would increase the pumping lift slightly, which could marginally decrease the pumping rate. The drawdowns correspond to between 0.4 and 1.6% of the total dynamic pumping head at the seven supply wells with pumping water levels (assuming 50 psi discharge pressure and 20 feet of friction losses in addition to the depth to the pumping water level). The percentage decrease in pump discharge rate would likely be slightly larger than the percentage increase in total dynamic head. The decrease in discharge is estimated to be less than 0.3 gpm of the tested rate of 12 gpm at well C4 and approximately 0.1 gpm of the tested 7 gpm at well C8. This decrease in pumping rate could easily be compensated for by increased operating time. Therefore, Cunnison Lane drawdown would not materially affect the yield available to the nearby private wells, and the drawdown effect on yield is marginal.

There is a potential effect on yield of nearby wells by causing transport of contaminants from the Quik Stop site to nearby private wells. Samples collected from wells at the site have shown methyl tertiary butyl ether (MTBE) concentrations down to 5.4 ug/L and concentrations of tert-butyl alcohol (TBA) at 1,700 ug/L in December 2008 (SWQCB, 2009). This concentration exceeds the California Department of Public Health's drinking water response levels for this chemical. The potential dewatering of these wells by drawdown at the Cunnison Lane well would affect the ability of this remediation system to control this contaminant. The effects on yield of nearby supply well from loss of contaminant control that could potentially result from adding Cunnison Lane well pumping without additional redistribution of pumping is considered a restrictive effect.

COMBINED EFFECTS FROM PUMPING THE CUNNISON LANE WELL AND REDISTRIBUTING PUMPING, ON WATER LEVELS AND YIELD

The Cunnison Lane well is only one component of the Well Master Plan, which is designed to allow SqCWD to redistribute pumping and implement elements of the Groundwater Management Plan. As part of the Well Master Plan, pumping will be redistributed amongst new and existing wells. Likely redistribution scenarios shown in Table 3 include use of the Cunnison Lane well at less than capacity, and reductions in pumping at the Rosedale and Tannery II wells. The decrease in pumping at the Rosedale and Tannery II wells may lessen the water level and yield effects on the private wells near Cunnison Lane.

To ensure that our analysis is conservative and addresses the greatest expected drawdown, we compared expected pumping changes under both the basin management objective and maximum pumping conditions. The middle column

in Table 4 (“BMO Pumping Condition”) shows how the proposed new wells will increase or decrease nearby pumping if SqCWD pumping is 4,800 acre-feet/year. The rightmost column in Table 4 (“Maximum Pumping Condition”) shows how the proposed new wells will increase or decrease nearby pumping if pumping is 5,675 acre-feet/year. In the Cunnison Lane well area the net pumping change under the basin management objective pumping condition is -460 acre-feet/year. The net pumping change under the maximum pumping condition is -430 acre-feet/year. The net decrease in pumping is therefore less under the maximum pumping condition. Because a decrease in pumping yields higher groundwater levels, we expect the maximum pumping condition to result in the least beneficial effects. Therefore, combined drawdown effects are analyzed based on pumping changes under the maximum pumping condition (Max Scenario 1 versus No Project Max).

For the most likely scenario under the maximum pumping condition, (Max Scenario 1, Table 3), annual pumping at the Cunnison Lane well will be 230 acre-feet per year. Assuming 61% of this yield or 140 acre-feet is produced during the six month dry season, the simulations were based on the Cunnison Lane well pumping approximately 174 gpm continuously for 182.5 days.

Comparing the rightmost two columns in Table 3, annual pumping at the Rosedale and Tannery wells would be lower if Scenario 1 is implemented under the maximum pumping condition (Max Scenario 1), than if the Well Master Plan is not implemented (No Project Max). The Rosedale well would pump by 350 acre-feet/year less if Scenario 1 was implemented, and the Tannery well would pump 310 acre-feet/year less if Scenario 1 were implemented. Assuming that 61% of pumping occurs during the dry season, Rosedale well pumping will decrease by 214 acre-feet over a 6 month period, equivalent to a continuous decrease of 265 gpm over 182.5 days. Likewise the Tannery II well will decrease by 189 acre-feet over a 6 month period, equivalent to a continuous decrease of 235 gpm over 182.5 days. The MLU model was used to simulate the rise in water levels when pumping at the Rosedale well is decreased by a continuous rate of 265 gpm, and the Tannery II well is decreased by a continuous rate of 235 gpm. The aquifer properties used for the Rosedale well and Tannery II well modeling are those shown in Table 26 and Table 27.

Table 26. Aquifer Properties Used to Simulate Rosedale Drawdowns

Model Layer	Aquifer / Aquitard	Unit	T (ft ² /d)	Sy/S (unitless)	c (days)
1	Aquifer	Overlying	150	0.03	
2	Aquitard	B			121
	Aquifer	A	2,367	6.3 x 10 ⁻⁴	
3	Aquitard	Above AA			1,184
	Aquifer	AA	483	2.7 x 10 ⁻⁴	
4	Aquitard	Tmp			4,000
	Aquifer	Tu	1,243	2.7x 10 ⁻⁴	

Table 27. Aquifer Properties Used to Simulate Tannery II Drawdowns

Model Layer	Aquifer / Aquitard	Unit	T (ft ² /d)	Sy/S (unitless)	c (days)
1	Aquifer	Overlying	150	0.03	
2	Aquitard	B			121
	Aquifer	A	2,060	5.5 x 10 ⁻⁴	
3	Aquitard	Above AA			1,019
	Aquifer	AA	416	2.7 x 10 ⁻⁴	
4	Aquitard	Tmp			800
	Aquifer	Tu	1,489	2.7x 10 ⁻⁴	

Figure 24 and Table 28 show that redistributing pumping raises water levels in nearby wells, including wells C7 and C10 (not shown on Figure 24 due to confidentiality rules). Therefore, there is a beneficial effect on nearby wells after the WMP is implemented.

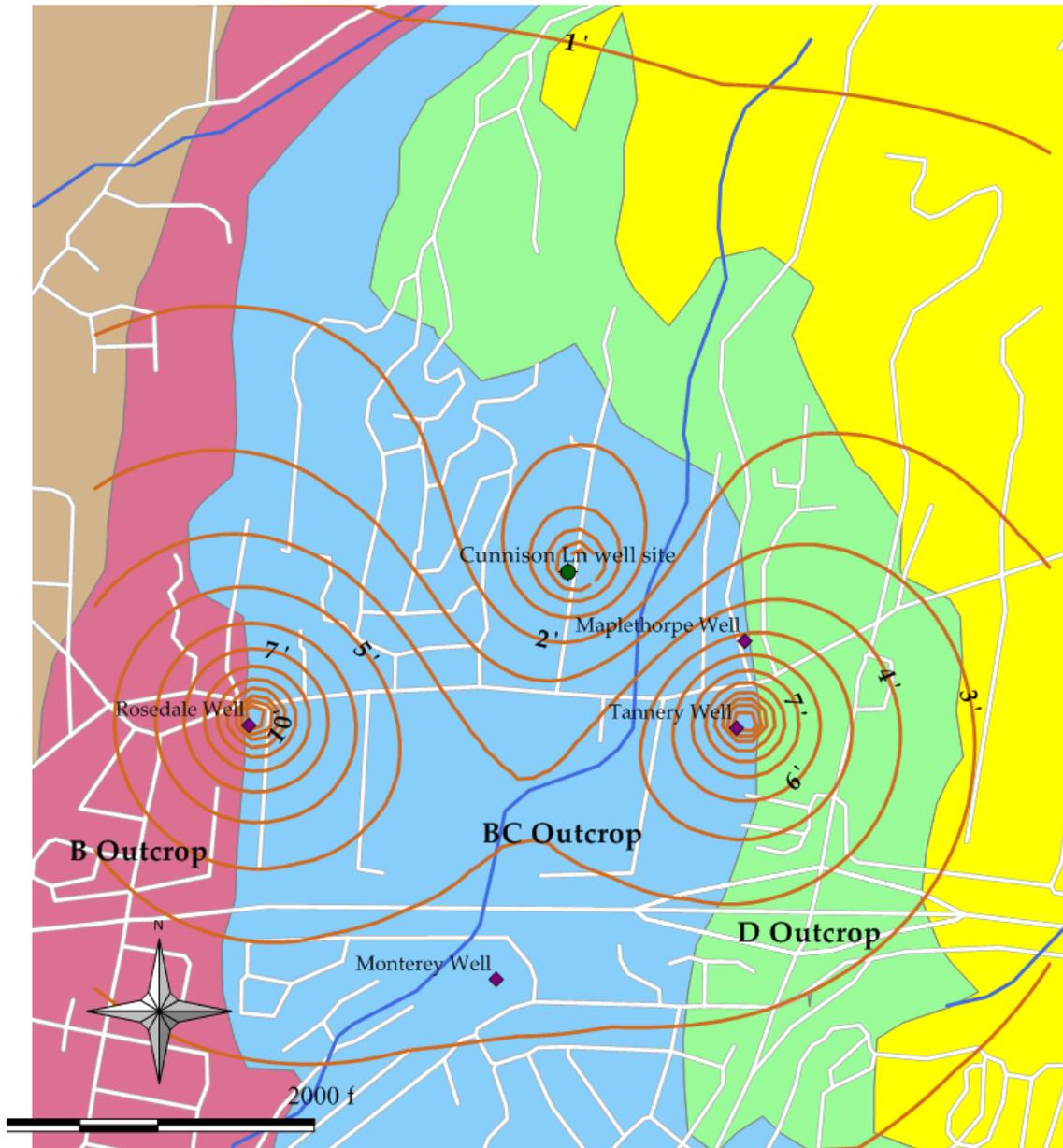


Figure 24. Combined Water Level Changes from Pumping at Rosedale, Tannery II and Cunnison Lane Wells Using Parameters Based on Tannery II Test

Table 28. Combined Water Level Change at Nearby Wells from Pumping at Rosedale, Tannery II and Cunnison Lane Wells

Well	Aquifer	Water Level Change (ft)			
		Cunnison	Rosedale	Tannery II	Combined
C1	B	-4.8	2.1	3.3	0.7
Quik Stop	BC	-3.6	2.9	3.5	2.8
C2	B	-3.2	1.9	4.6	3.3
C3	B	-3.0	2.4	5.0	4.4
C4	B	-2.5	3.8	1.9	3.2
C5	A	-2.5	4.2	2.5	4.2
C6	BC	-2.3	2.1	6.0	5.7
C7	A	-2.2	1.6	2.0	1.4
C8	B	-1.7	1.5	1.6	1.4
C9	A	-1.7	1.7	1.5	1.4
C10	B	-1.6	1.2	1.6	1.3
C11	BC	-1.5	1.1	2.3	1.9
C12	BC	-1.4	1.0	1.9	1.5
C13	B	-1.4	1.1	1.5	1.2
C14	A	-1.3	1.3	1.3	1.3
C15	A	-1.3	1.1	1.4	1.2
C16	A	-1.3	3.1	1.2	3.0
C17	BC	-1.2	0.9	2.0	1.6
C18	BC	-1.2	0.9	1.8	1.4
C19	BC	-1.2	0.9	1.9	1.6
C20	A	-1.2	1.1	1.2	1.1
C21	B	-1.2	0.9	1.3	1.1
C22	BC	-1.2	0.8	1.9	1.6
C23	BC	-1.1	1.0	1.1	1.0

At the Quik Stop wells, decreases of pumping at the Rosedale and Tannery II wells offset pumping at the Cunnison Lane well and water levels are predicted to rise. Therefore, the overall redistribution of pumping will not lower water levels at the Quik Stop remediation wells and consequently will not adversely affect the operation of the remediation system. Therefore, contaminants will not spread to nearby supply wells.

Because pumping redistribution raises water levels in nearby wells, the yield of nearby supply wells will marginally improve.

AUSTRIAN WAY WELL

MODEL SETUP

For the proposed Austrian Way well, the MLU model was set up with five layers; representing the overlying DEF unit, the BC unit likely used for the production well screen zone, and underlying A, AA, and Tu units. Although the sediments at the surface are likely part of the F unit, the existing water level is estimated to be in the DEF unit (HydroMetrics LLC, 2007). Intervening aquitard units are included between each of the aquifer units, including the D unit. The D unit is represented by the vertical resistance between the BC and overlying DEF unit. The nearest documented well has no depth information, but is likely screened in the DEF unit as the DEF unit is estimated to be 600 feet deep in this area.

PARAMETERS BASED ON PARAMETERS DERIVED FROM THE MADELINE WELL AQUIFER TEST

The closest well with an aquifer test is the Madeline well. HydroMetrics LLC (2007) correlated the geophysical well from the Austrian Way site to the Madeline well and Ledyard well. This correlation was used to identify sub-units of the Purisima Formation at the Austrian Way site. Aquifer property values from the Madeline well aquifer test are inspected to assess appropriateness for use in modeling pumping at Austrian Way.

The Madeline well aquifer test was performed in May 1984. Drawdowns were measured in the Madeline well while it was pumping. The Madeline well is screened in the BC unit. The MLU model was not used to estimate parameters from this data set, because no observation well data are available. Instead, published values from the analysis of this test were inspected to assess appropriateness for use in the MLU model. Johnson et al. (2004) published the values shown in Table 29 for the BC unit and the overlying D unit aquitard based on this aquifer test.

Table 29. Published Parameters for Madeline Well Aquifer Test

Unit	Pump Test Parameter	Value	Assumed Thickness	Derived Parameter	Derived Value
BC Unit Aquifer	Transmissivity (T)	240 feet ² /day	160/230 feet	Horizontal Conductivity (K _h)	1-1.5 foot/day
	Storativity (S)	4.5 x 10 ⁻³		Specific Storage (S _s)	2.0 x 10 ⁻⁵ foot ⁻¹
D Unit Aquitard	Leakage Factor (B)	1,000 feet	100/200 feet	Vertical Conductivity (K _v)	0.02-0.04 foot/day
	Vertical Resistance (c)	4,167 day			

The derived BC unit horizontal conductivity of 1 foot/day is at the low end of the range of regional values shown in Table 6 (between 1 and 3 feet/day). This low pumped unit horizontal conductivity will maximize drawdowns in the overlying unit. The derived D unit vertical conductivities are in the middle of the range of regional values shown in Table 7 (between 0.001 and 0.1 feet/day). Higher vertical conductivities will maximize drawdowns in the overlying unit so the maximum vertical conductivity is used to test sensitivity. The derived horizontal conductivity of 1 foot/day for the BC unit is combined with the thickness of the BC unit of 210 feet at Austrian Way to obtain the modeled value of transmissivity of the pumped BC unit. The derived vertical conductivity of 0.02 feet/day along with the regional maximum of 0.1 feet/day are combined with the thickness of the D unit aquitard of 90 feet to obtained modeled values of aquitard vertical resistance.

The published storativity value for the Madeline well aquifer test is at the high end of the range of regional values shown in Table 8 (10⁻⁵ to 0.007). Using a smaller storativity value in the pumped unit will increase drawdowns in the overlying unit, so the low end of the storativity range was tested for sensitivity.

There is no local information about aquifer properties of the overlying DEF unit where nearby wells are screened. Table 6 shows a range of hydraulic conductivities of between 2 and 6 feet/day for the DEF unit. The geometric average conductivity value is combined with the assumed saturated thickness of 300 feet to estimate a transmissivity of the DEF unit. The value at the low end of the conductivity range is tested for sensitivity. Average specific yield shown in Table 8 is used for the specific yield of the overlying unit.

Regional values of conductivities and storativities provided by Johnson et al. (Table 6, Table 7, and Table 8) were used for the units represented by model layers 2 through 5. These regional hydraulic property values are combined with

estimated aquifer and aquitard thicknesses at the Austrian site as defined by Johnson et al. (2004, Appendix B) to calculate aquifer transmissivity, storativity and aquitard resistance, as shown on Table 30.

Table 30. Aquifer Hydraulic Properties for Simulating Austrian Way Well

Model Layer	Aquifer/Aquitard	Unit	T (ft²/d)	Sy/S (unitless)	c (day)
1	Aquifer	Overlying DEF	1029/594	0.03	
2	Aquitard	D			3,359/79
	Aquifer	BC	213	4.0 x 10 ⁻³ / 9.6 x 10 ⁻⁶	
3	Aquitard	B			15,000
	Aquifer	A	2,806	2.7 x 10 ⁻⁴	
4	Aquitard	Above AA			1,179
	Aquifer	AA	481	2.7 x 10 ⁻⁴	
5	Aquitard	Tmp			10
	Aquifer	Tu	810	2.7 x 10 ⁻⁴	

WATER LEVEL AND YIELD EFFECTS FROM PUMPING AUSTRIAN WAY WELL

Table 2 shows that the estimated instantaneous yield at the Austrian Way well is 250 gallons per minute (gpm). This estimate is based on yields at the Ledyard and Madeline wells, as those wells have similar geology to the Austrian Way test boring (HydroMetrics LLC, 2007). Assuming the Austrian Way well pumps 50 percent of the time during an average year, the well could produce approximately 202 acre-feet/year. Further assuming 61% of this yield or 123 acre-feet is produced during the six month dry season, the Austrian Way simulations were based on a pumping rate of approximately 153 gpm continuously for 182.5 days between May and October. The distance drawdown curves for pumping the Austrian Way well after 182.5 days is shown in Figure 25. Drawdowns are also displayed as water level changes on Figure 26.

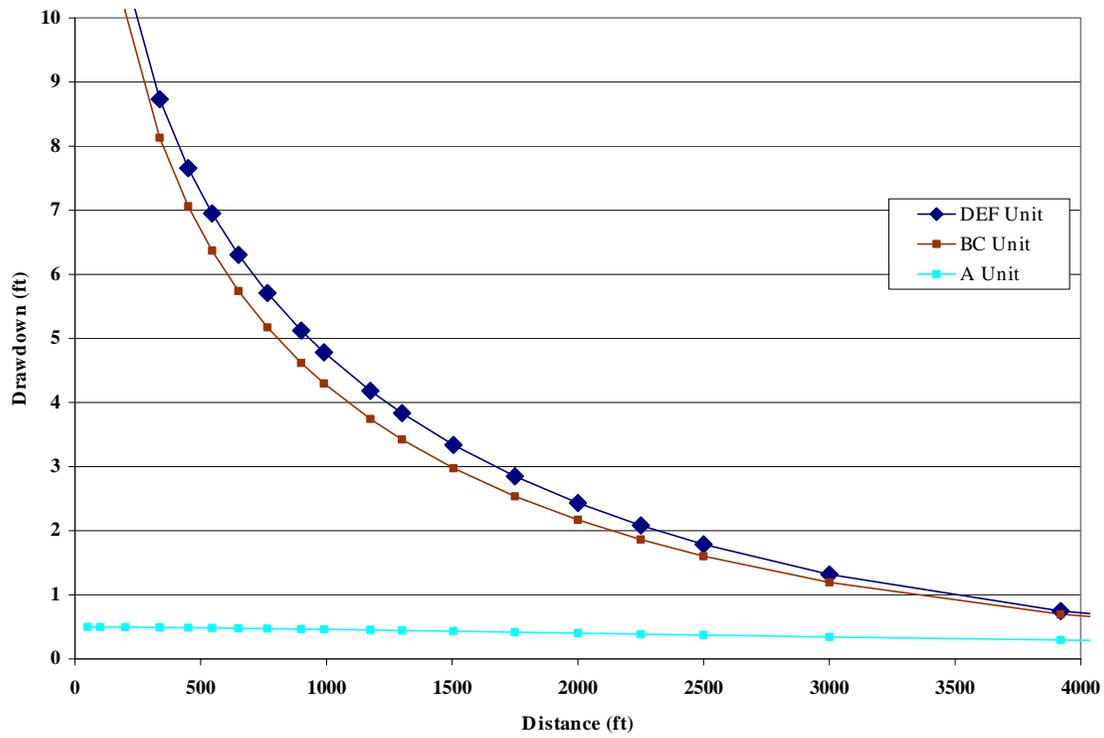


Figure 25. Distance Drawdown Curves for Austrian Way Well Pumping Using Parameters Based on Madeline Pump Test

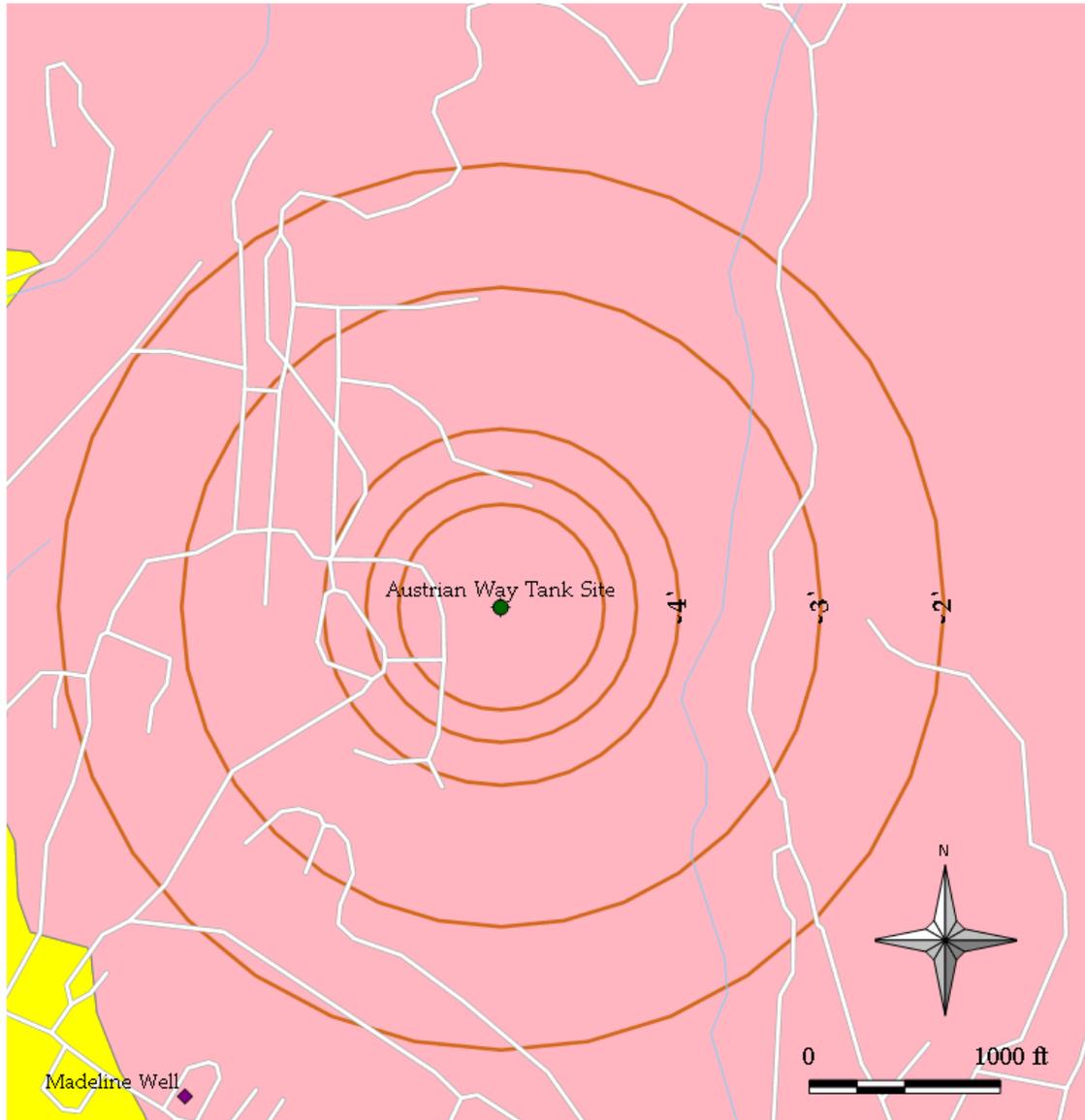


Figure 26. Water Level Changes in the DEF Aquifer from Pumping Austrian Way Well Using Parameters Based on the Madeline Well Aquifer Test

WATER LEVEL EFFECTS AT NEARBY WELLS

The County of Santa Cruz created a database of private wells (Wolcott, 1999) that identifies two private wells within 1,000 feet of the Austrian Way well location. The depth of nearby wells, and distances from the Austrian Way well are summarized in Table 31.

The well referred to as location A1 is approximately 500 feet away from the Austrian Way well. There is no depth information for this well, but it is

presumed to be completed in the DEF unit, which is estimated to be 586 feet deep at this location (Johnson et al., 2004 Appendix B). A second well, referred to as location A2, is estimated to be 1,000 feet away and is estimated to be completed in the DEF unit based on its depth of 240 feet. Topographically, this well with an estimated surface elevation of 119 feet is at a lower elevation than Austrian Way's surface elevation of 404 feet. The closest location with a well log provided by the County of Santa Cruz is over 1,800 feet away at location A3. Its screen interval is estimated to be in the F unit.

Table 31 shows drawdowns from the anticipated maximum pumping at the Austrian Way well calculated at these two well locations, as well as at other nearby well locations for which depth to water and screen information are available. The drawdowns are for the DEF unit. The F unit is not explicitly modeled at the Austrian Way well so the DEF unit drawdown shown for wells at A3 and A4 may overestimate drawdowns in the F unit. The sensitivity of modeled drawdowns is represented by showing modeled results for minimum storativity, maximum vertical conductivity and minimum overlying transmissivity.

Table 31. Estimated Water Level Change at Nearby Wells from Austrian Way Well Pumping

Well	Distance (ft)	Aquifer	Water Level Change (ft)	
			Parameters from Madeline Well Test	Low S, High Kv, Low DEF Unit T
A1	500	DEF	-6.9	-9.6
A2	1,000	DEF	-4.8	-6.3
A3	1,800-2,400	F	-2.7	-3.3
A4		F	-1.9	-2.2
A5	2,400-2,800	DEF	-1.7	-1.9
A6		DEF	-1.7	-1.9
A7		DEF	-1.6	-1.7
A8	2,800-3,500	F	-1.3	-1.4
A9		F	-1.2	-1.3
A10		DEF	-1.2	-1.2

Comparing available water level data, screen intervals, and estimated drawdowns, show that drawdown from pumping at the Austrian Way well will result in marginal effects on nearby wells. Available information from DWR logs show that static water levels are lower than the top of the screens at wells A3 and A4 and that pumping water levels are lower than the top of the screens at wells A9 and A10. In these cases, 2-3 feet of additional drawdown are not restrictive because the risk of screen collapse due to corrosion is already present. This small

amount of drawdown will not dewater the screens, as pumping water levels are at least 10 feet above the bottom of the screen. Static and pumping water levels are over 10 feet above the top of the screen at other nearby wells; and the additional drawdown will not expose the screen.

Table 32. Water Level Effect of Austrian Way Well Pumping on Nearby Well Screens

	Screen Length (ft)	Depths (ft)			Water Level Change (ft)
		Top of Screen	Static Water	Pumping Water	Based on Madeline
A3	80	135	190	195	-2.7
A4	120	290	300	360	-1.9
A5	60	182	40	100	-1.7
A6	58	100	36	N/A	-1.7
A7	510	284	20	N/A	-1.6
A8	140	160	142	N/A	-1.3
A9	100	300	290	390	-1.2
A10	64	115	85	119	-1.2

Drought year water levels are not available for private wells so water level effects on nearby wells during drought years by pumping at the Granite Way well is not assessed.

YIELD EFFECTS ON NEARBY WELLS

At all wells, the additional drawdown would increase the pumping lift slightly, which could marginally decrease the pumping rate. The drawdowns correspond to 0.4-0.8% of the total dynamic pumping head at the five wells with pumping water level data (assuming 50 psi discharge pressure and 20 feet of friction losses in addition to the depth to the pumping water level). The percentage decrease in pump discharge rate would likely be slightly larger than the percentage increase in total dynamic head. The decrease in discharge is estimated to be less than 0.2 gpm of the tested rates of between 8 and 30 gpm at the five wells. This decrease in pumping rate could easily be compensated for by increased operating time. Therefore, any additional drawdown from pumping the Austrian Way well would not materially affect the yield available to the nearby private wells, and the drawdown effect on yield is marginal.

There are no regulated facilities that show recent contaminant data within 1,000 meters of the Austrian Way site (SWRCB, 2009). Therefore, there is no potential effect on the yield of nearby wells resulting from drawdown from the Austrian Way well influencing the transport of contaminants.

COMBINED EFFECTS FROM PUMPING THE AUSTRIAN WAY WELL AND REDISTRIBUTING PUMPING, ON WATER LEVELS AND YIELD

Additional combined effects from pumping the Austrian Way well and redistributing pumping are unlikely to occur. The nearest existing SqCWD production well is the Madeline well which is over 3,000 feet away. The next nearest well is the Ledyard well, which is over 4,000 feet away. The distance of these wells suggests that changes in their pumping will have little if any effect on groundwater levels near the Austrian Way well.

GRANITE WAY WELL

MODEL SETUP

For the proposed Granite Way well, the MLU model was set up with six layers; representing the overlying F unit, the DEF unit planned for the production well screen zone, and the underlying BC, A, AA and Tu units. Intervening aquitard units are included between each of the aquifer units, including the top of the DEF unit. Although there is no unit defined as an aquitard between the DEF and F units, a schematic profile in Johnson et al. (2004, Figure 2-2) shows fine-grained sediment at the top of the DEF unit. This interval is represented in the MLU model by the vertical resistance between the DEF and overlying F units.

The nearest well has a screen that is predominantly located in the estimated interval of the F unit as defined by Johnson et al. (2004, Appendix B), but may be partially screened below the fine sediments modeled to be at the top of the DEF unit.

PARAMETERS BASED ON PUBLISHED VALUES FROM T. HOPKINS WELL SPECIFIC CAPACITY DATA

There are no aquifer test data in the area of the Granite Way well location. The T. Hopkins and Aptos Creek wells are nearby and Johnson et al. (2004) analyzed specific capacity data from those wells to estimate transmissivities of the DEF unit and BC unit. The estimated transmissivity of the DEF unit based on specific capacity data from the T. Hopkins well is 500 feet²/day. The derived hydraulic conductivity is 1.3 feet/day, for an assumed aquifer thickness of 385 feet at the T. Hopkins well. The range of estimated transmissivity based on specific capacity data for the Aptos Creek well is between 800 and 2,000 feet²/day. The Aptos Creek well is screened in an interval including both the DEF and BC units, but may also include the sediments of a highly transmissive paleochannel of Aptos Creek. Therefore, estimates of transmissivity at the Aptos Creek well are likely not representative of conditions at the Granite Way well.

The derived horizontal conductivity from the T. Hopkins specific capacity data is lower than the range of regional conductivities provided in Table 6. This low horizontal conductivity for the pumped unit will maximize drawdowns in the overlying unit where nearby wells are screened. Aquitard vertical resistance and aquifer storativity cannot be estimated from specific capacity data so average regional values shown in Table 7 and Table 8 are used in the analysis. Using the minimum vertical resistance and minimum aquifer storativity will maximize drawdowns in the overlying unit so those values are used for the aquitard representing the top of the DEF unit and the DEF unit to test sensitivity.

There is no local information about aquifer properties of the overlying F unit where nearby wells are screened. The average regional values for horizontal conductivity shown in Table 6 were used for the overlying F unit. The low end of horizontal conductivity is tested for sensitivity. Average specific yield shown in Table 8 is used for the specific yield of the overlying unit.

Regional values of conductivities and storativities provided by Johnson et al. (Table 6, Table 7, and Table 8) were used for overlying and underlying units. Regional hydraulic property values (Johnson et al., 2004, Appendix B) are combined with estimated aquifer and aquitard thicknesses at the Granite Way site to estimate the aquifer transmissivity, storativity and aquitard resistance of the units beneath the DEF unit, as shown on Table 33. The estimated aquitard thickness of the aquitard at the top of the DEF unit is 10% of the DEF unit thickness based on the schematic profile in Johnson et al. (2004)

Table 33. Aquifer Hydraulic Properties Used to Simulate Granite Way Well

Model Layer	Aquifer / Aquitard	Unit	T (ft ² /d)	Sy/S (unitless)	c (day)
1	Aquifer	Overlying F	1027/593	0.03	
2	Aquitard	Above DEF			209/66
	Aquifer	DEF	386	2.7 x 10 ⁻⁴ / 1.0 x 10 ⁻⁵	
3	Aquitard	D			8,000
	Aquifer	BC	346	2.7 x 10 ⁻⁴	
4	Aquitard	B			15,000
	Aquifer	A	2,806	2.7 x 10 ⁻⁴	
5	Aquitard	Above AA			1,181
	Aquifer	AA	482	2.7 x 10 ⁻⁴	
7	Aquitard	Tmp			10
	Aquifer	Tu	899	2.7 x 10 ⁻⁴	

WATER LEVEL AND YIELD EFFECTS FROM PUMPING GRANITE WAY WELL

Table 2 shows that the estimated instantaneous yield at the Granite Way well is 245 gallons per minute (gpm). This estimate is based on data from the nearby T. Hopkins well. Assuming the Granite Way well pumps 50 percent of the time during an average year, the well could produce approximately 198 acre-feet/year. Further assuming 61% of this yield or 121 acre-feet is produced during the six month dry season, the Granite Way simulations were based on a pumping rate of approximately 150 gpm continuously for 182.5 days between May and October. Distance drawdown curves for pumping the Granite Way well after 182.5 days are shown on Figure 27.

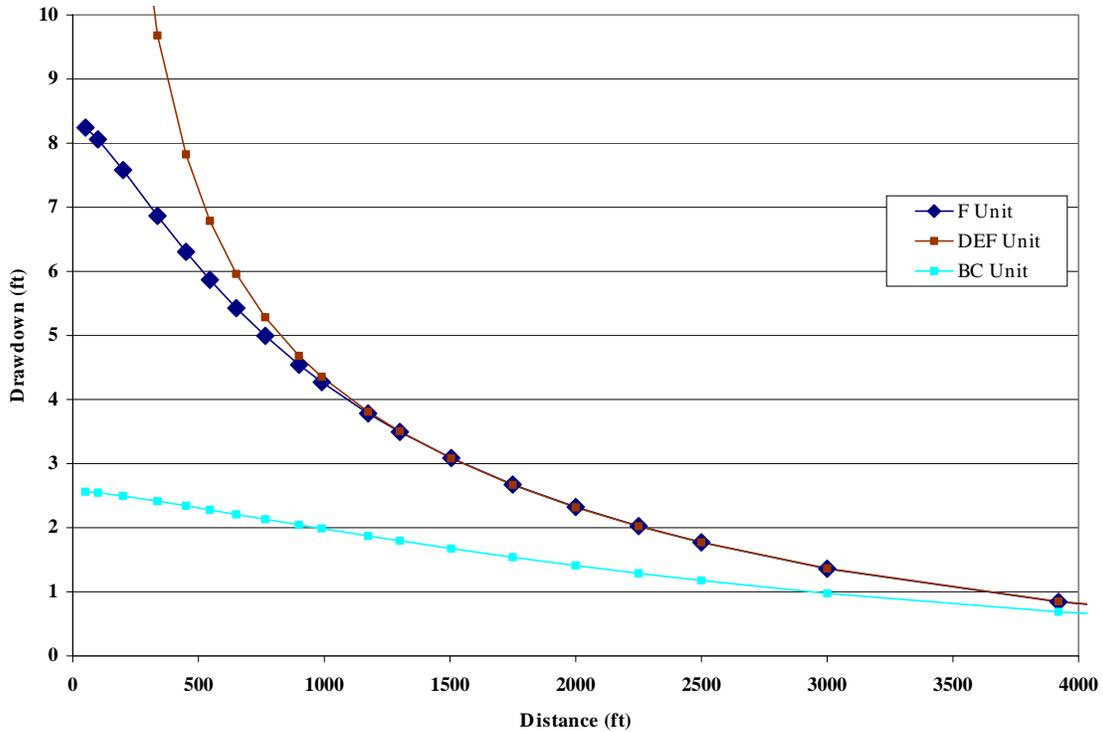


Figure 27. Distance Drawdown Curves for Granite Way Well Pumping Using Parameters Based on T. Hopkins Specific Capacity

WATER LEVEL EFFECTS AT NEARBY WELLS

The County of Santa Cruz provided SqCWD with California Department of Water Resources well logs and estimated locations for wells near the Granite Way well site. The depth of nearby wells, and distances from the Granite Way well are summarized in Table 34.

Based on the estimated locations, the nearest well to the Granite Way well is over 1,000 feet away, at a location referred to as G1. The log of this well shows the well is screened between 300 and 500 feet below ground surface, which spans the estimated contact between the DEF and F units. The closest well log with depth to water and screen interval information is at a location referred to as G4, a little over 2,000 feet away from the Granite Way well. Drawdowns from the anticipated pumping at the Granite Way well at these two locations, as well as other nearby well locations for which depth to water and screen interval information were available, are shown in Table 34 as water level changes. The drawdowns on Table 34 are for the overlying F unit for all wells except for well G1. The sensitivity of modeled drawdowns is represented by showing modeled

results for minimum storativity, maximum vertical conductivity and minimum overlying transmissivity.

Table 34. Estimated Water Level Changes at Nearby Wells from Granite Way Well Pumping

Well	Distance (ft)	Aquifer	Water Level Change (ft)	
			Based on T-Hopkins Parameters	Low S, High Kv, Low F unit T
G1	1,000-1,500	DEF	-3.8	-4.7
G2		F	-3.8	-4.7
G3		F	-3.1	-3.7
G4	2,000-2,500	F	-2.2	-2.6
G5		F	-2.0	-2.3
G6		F	-2.0	-2.2
G7		F	-2.0	-2.2
G8		F	-1.9	-2.1
G9		F	-1.9	-2.1
G10		F	-1.8	-2.0
G11	2,500-3,500	F	-1.7	-1.8
G12		F	-1.4	-1.5
G13		F	-1.2	-1.2

Comparing available water level data, screen intervals, and estimated drawdowns shows that drawdown from pumping the Granite Way well will result in marginal effects on nearby wells. Available information from DWR logs show that static water levels are higher than the tops of screens by more than estimated drawdowns (Table 35). One exception is well G5 where the top of screen was placed at static water level during construction. As a result, effects on the screen have likely already occurred, as any decline in water level will expose the screen. Any additional drawdown caused by Granite Way pumping will not materially add to the existing effects on the well screen. Static water levels are below the bottom of the first screen of well G7 so the screen depths shown on Table 35 are for the second screen. A 2 foot decline in static water levels will not expose this second screen. The pumping water level dewateres the second screen and an additional decline of 2 feet would not drop water levels below the top of the third screen at a depth of 180 feet. Static water levels for wells G9 and G13 are already below the top of the screen and additional drawdown will not materially add to the effects on the screen.

Table 35. Water Level Effect of Granite Way Well Pumping on Nearby Well Screens

Well	Screen Length (ft)	Depths (ft)			Water Level Change (ft)
		Top of Screen	Static Water	Pumping Water	Based on T-Hopkins
G4	80	185	40	N/A	-2.2
G5	78	136	136	N/A	-2.0
G6	100	151	125	137	-2.0
G7	10	160	150	170	-2.0
G8	60	205	90	105	-1.9
G9	60	160	170	N/A	-1.9
G10	110	180	100	N/A	-1.8
G11	60	345	300	N/A	-1.7
G12	62	400	300	390	-1.4
G13	200	102	270	N/A	-1.2

Drought year water levels are not available for private wells so water level effects on nearby wells during drought years by pumping at the Granite Way well is not assessed.

YIELD EFFECTS AT NEARBY WELLS

At all wells, the additional drawdown would increase the pumping lift slightly, which could marginally decrease the pumping rate. The drawdowns correspond to between 0.3 and 0.8% of the total dynamic pumping head at the four wells with pumping water levels (assuming 50 psi discharge pressure and 20 feet of friction losses in addition to the depth to the pumping water level). The percentage decrease in pump discharge rate will likely be slightly larger than the percentage increase in total dynamic head. The decrease in discharge is estimated to be less than 0.2 gpm at the tested rates of between 8 and 24 gpm at the two wells. This decrease in pumping rate could easily be compensated for by increased operating time. Therefore, drawdown from pumping the Granite Way well will not materially affect the yield available to the nearby private wells, and the drawdown effect on yield is marginal.

There are no regulated facilities within 1,000 meters of the Granite Way site that show recent detections of groundwater contaminants (SWRCB, 2009). Therefore, there is no potential effect on the yield of nearby wells resulting from drawdown from the Granite Way well influencing the transport of contaminants.

COMBINED EFFECTS FROM PUMPING THE GRANITE WAY WELL AND REDISTRIBUTING PUMPING, ON WATER LEVELS AND YIELD

The Granite Way well is only one component of the Well Master Plan, which is designed to allow SqCWD to redistribute pumping and implement elements of the Groundwater Management Plan. As part of the Well Master Plan, pumping will be redistributed amongst new and existing wells. The Aptos Creek well will be placed on standby status in most scenarios and some of the likely redistribution scenarios shown in Table 3 also include reduction in pumping at the T. Hopkins well. The decrease in pumping at the Aptos Creek and T. Hopkins wells may lessen the water level and yield effects on the private wells near the Granite Way well.

To ensure that our analysis is conservative and addresses the greatest expected drawdown, we compared expected pumping changes under both the basin management objective and maximum pumping conditions. The middle column in Table 4 (“BMO Pumping Condition”) shows how the proposed new wells will increase or decrease nearby pumping if SqCWD pumping is 4,800 acre-feet/year. The rightmost column in Table 4 (“Maximum Pumping Condition”) shows how the proposed new wells will increase or decrease nearby pumping if pumping is 5,675 acre-feet/year. In the Granite Way well area, the pumping changes under the basin management objective pumping condition are the same as pumping changes under the maximum pumping condition, as shown in Table 4. One condition will not result in the Well Master Plan adding more drawdown than the other condition. Therefore, combined drawdown effects are analyzed based on pumping changes under the basin management objective pumping condition (Scenario 1 versus 2005-2008 Average). There is no planned pumping difference between non-drought and drought years in Scenario 1.

Scenario 1 assumes no pumping change at the T. Hopkins well, so the T. Hopkins well is not modeled. Pumping from the Aptos Creek well decreases from the current 230 acre-feet/year to 0 acre-feet/year in non-drought and drought years. Assuming 61% of pumping occurs during the dry season, Aptos Creek well pumping will decrease by 140 acre-feet over a 6 month period. The MLU model was used to simulate the rise in water levels when pumping at the Aptos Creek well is decreased by a continuous rate of 174 gpm over 182.5 days. The aquifer properties used for the Aptos Creek well modeling are those shown in Table 36.

Table 36. Aquifer Hydraulic Properties Used to Simulate Aptos Creek Well

Model Layer	Aquifer / Aquitard	Unit	T (feet ² /d)	Sy/S (unitless)	c (day)
1	Aquifer	Overlying F	291	0.03	
2	Aquitard	Above DEF			221
	Aquifer	DEF	1,265	2.7 x 10 ⁻⁴	
3	Aquitard	D			8,000
	Aquifer	BC	370	2.7 x 10 ⁻⁴	
4	Aquitard	B			2,200
	Aquifer	A	3,895	2.7 x 10 ⁻⁴	
5	Aquitard	Above AA			1,355
	Aquifer	AA	552	2.7 x 10 ⁻⁴	
7	Aquitard	Tmp			100
	Aquifer	Tu	915	2.7 x 10 ⁻⁴	

Figure 28 shows the combined water level changes from pumping at the Granite Way well and the Aptos Creek well. Table 37 shows that redistributing pumping reduces water level effects from the Granite Way well pumping in nearby wells. Because all water level effects from pumping the Granite Way well were marginal, and reducing pumping at the Aptos Creek well only reduces the effect, the combined water level and yield effects on nearby wells after the WMP is implemented is also marginal.

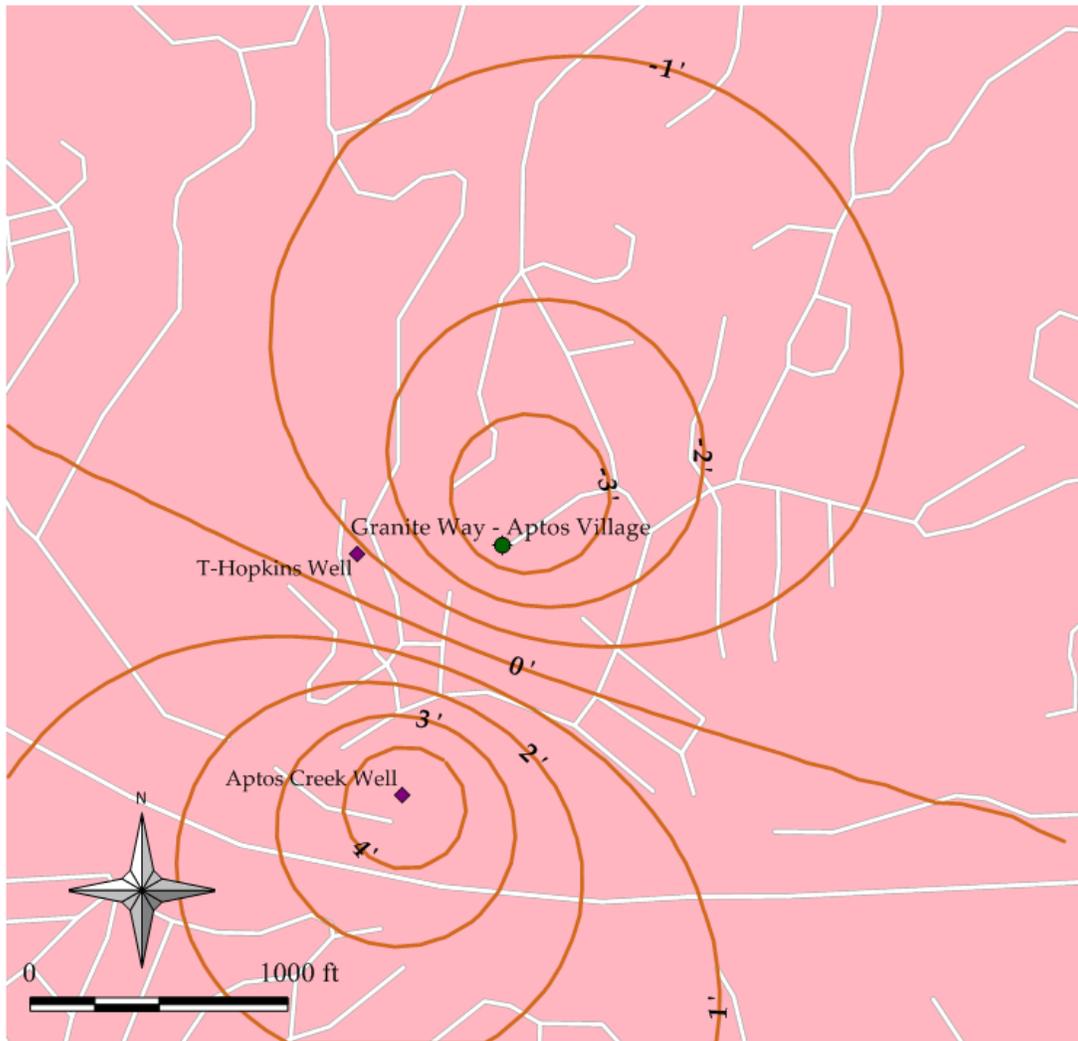


Figure 28. Combined Water Level Changes for Granite Way and Aptos Creek Well Pumping Using Parameters Based on T. Hopkins Specific Capacity (negative is drawdown, positive is water level build up)

Table 37. Combined Water Level Changes at Nearby Wells for Aptos Creek, and Granite Way Pumping

Well	Aquifer	Water Level Change (ft)		
		Granite Way	Aptos Creek	Combined
G1	DEF	-3.8	2.2	-1.6
G2	F	-3.8	2.9	-0.9
G3	F	-3.1	1.9	-1.2
G4	F	-2.2	1.4	-0.8
G5	F	-2.0	1.3	-0.7
G6	F	-2.0	1.3	-0.7
G7	F	-2.0	1.4	-0.6
G8	F	-1.9	1.2	-0.6
G9	F	-1.9	1.2	-0.6
G10	F	-1.8	1.2	-0.6
G11	F	-1.7	1.1	-0.5
G12	F	-1.4	1.0	-0.4
G13	F	-1.2	0.8	-0.4

POLO GROUNDS WELL

MODEL SETUP

For the Polo Grounds well, the MLU model was set up with 7 aquifer units representing an overlying Aromas Red Sands unit, the F unit where both the Polo Grounds and Aptos Jr. High well are screened, and underlying DEF, BC, A, AA, Tu units, with intervening aquitard units. Although the USGS does not include this location as part of the continuous Aromas Red Sands (Brabb, 1997) there is likely some Aromas Red Sands overlying the Purisima Formation in this area. No available evidence suggests that the thickness of the Aromas Red Sands in this area is much greater than 150 feet. Although the Aromas Red Sands are thin, we included an overlying unit representing the Aromas Red Sands in the MLU model in order to simulate leakage from above. The model includes an aquitard unit between the Purisima F and overlying Aromas to represent vertical resistance between the formations that may correlate to the erosional contact at the top of the Purisima F unit.

The nearest private well has a screen that is located in the same general hydrostratigraphic horizon as the Polo Grounds Well.

PARAMETERS ESTIMATED FROM POLO GROUNDS WELL AND APTOS JR. HIGH WELL SPECIFIC CAPACITY DATA, AND WATER LEVEL RESPONSES TO APTOS JR. HIGH WELL PUMPING

The modeled values for transmissivity at the Polo Grounds and Aptos Jr. High wells were based on published values derived from specific capacity data at those two wells. Additionally, parameter values were modified based on regional values tested against a new data set obtained at the private Huyck well, located near the Aptos Jr. High well.

LSCE (1983) estimated that, based on specific capacity data, the transmissivity of the aquifer screened by the Polo Grounds well is approximately 2,680 feet²/day. Johnson (2007) provided an estimated range of transmissivities for this well of between 1,500 and 2,500 feet²/day. An average value of 2,005 feet²/day was used in this analysis. The aquitard above the pumped unit was assumed to be 30 feet thick, based on the clay interval noted on the drillers log between 145 and 175 feet below ground surface. The regional value for vertical hydraulic conductivity of 0.05 feet/day was used to calculate the aquitard resistance of 600 days.

Regional values of conductivities and storativities provided by Johnson et al. (Table 6, Table 7, and Table 8) were used for the model parameters in the units overlying and underlying the F Unit. These regional hydraulic property values are combined with estimated aquifer and aquitard thicknesses at the Polo Grounds site for underlying units (Johnson et al., 2004, Appendix B) to calculate aquifer transmissivity, storativity and aquitard resistance, as shown on Table 38.

Table 38. Aquifer Hydraulic Properties used to Simulate the Polo Grounds Well

Model Layer	Aquifer / Aquitard	Unit	T (ft²/d)	Sy/S (unitless)	c (days)
1	Aquifer	Overlying	39	0.07	
2	Aquitard	Above F			600/6,000
	Aquifer	F	2,005	2.7 x 10 ⁻⁴	
3	Aquitard	Above DEF			209
	Aquifer	DEF	1,029	2.7 x 10 ⁻⁴	
4	Aquitard	D			8,000
	Aquifer	BC	346	2.7 x 10 ⁻⁴	
5	Aquitard	B			15,000
	Aquifer	A	2,806	2.7 x 10 ⁻⁴	
6	Aquitard	Above AA			25,709
	Aquifer	AA	115	2.7 x 10 ⁻⁴	
7	Aquitard	Tmp			1.3
	Aquifer	Tu	953	2.7x 10 ⁻⁴	

Published values of hydrogeologic parameters for the F Unit at the Aptos Jr. High well consist of transmissivity estimates based on specific capacity data. These estimates range from 1,300 to 1,900 feet²/day, with an average of 1,600 feet²/day (Johnson et al., 2004, Table 3-6). There are no site-specific published values for aquitard resistance and storativity, but regional values for the Purisima F unit (Table 7) are between 0.005 and 0.5 feet/day for vertical conductivity; and between 1×10^{-5} and 7×10^{-3} for storativity. For all other properties and units, default values representing logarithmic averages of conductivities and storativity shown in Table 7 were combined with estimated aquifer unit thicknesses at each well based on Johnson et al. (2004, Table 2-2 and Appendix B). Property values and ranges considered for the MLU model are shown in Table 39.

Table 39. Aquifer Hydraulic Properties for the Aptos Jr. High well, Based on Specific Capacity Data

Model Layer	Aquifer / Aquitard	Unit	T (ft²/d)	Sy/S (unitless)	c (day)
1	Aquifer	Overlying	823	0.07	
2	Aquitard	Above F			100-20,000
	Aquifer	F	1,300-1,900	10^{-5} - 7×10^{-3}	
3	Aquitard	Above DEF			209
	Aquifer	DEF	1,028	2.7×10^{-4}	
4	Aquitard	D			8,000
	Aquifer	BC	346	2.7×10^{-4}	
5	Aquitard	B			15,000
	Aquifer	A	2,806	2.7×10^{-4}	
6	Aquitard	Above AA			1,219
	Aquifer	AA	422	2.7×10^{-4}	
7	Aquitard	Tmp			11
	Aquifer	Tu	601	2.7×10^{-4}	

The parameters shown on Table 39 were checked and validated by using them to simulate the observed response to Aptos Jr. High well pumping in the Huyck well. The Huyck well is approximately 272 feet away from the Aptos Jr. High well (Figure 29). A transducer was installed in the Huyck well which measured water levels from August 10 through 14, 2007 at 15-minute intervals. A second transducer was installed in the Aptos Jr. High well, which also measured water levels from August 10 through 14, 2007 at 15-minute intervals. The five days of water level measurement covered eight pumping cycles in the Aptos Jr. High well, with pumping durations of at least two hours. A barometer located at the Aptos Jr. High well measured changes in atmospheric pressure of up to 0.2 feet of water during the time period. SqCWD provided flow meter data and on/off

times for the Aptos Jr. High well that showed an average flow rate of 417 gpm during the pumping cycles.



Figure 29. Location of Huyck Well Relative to Aptos Jr. High Well

The water level data obtained from the Huyck well are not strictly suitable for complete aquifer test analysis, because the Aptos Jr. High Well had been operating prior to installing the monitoring equipment; residual drawdowns from previous pumping cycles may affect water level measurements. However, the data are useful for checking the model setup for the drawdown analysis, and to inform the selection of model parameters.

The relationship between aquifer transmissivity, storage parameters, and aquitard resistance was tested against the longest pumping cycle in the data set, a 7.7 hour pumping cycle beginning at 4:13 AM August 13; and the following 3.5 hour recovery period. Several different values of resistance for the aquitard above the F unit were tested, and the MLU model was used to optimize F unit transmissivity and specific storage to the pumping cycle data. The parameter combinations shown in Table 40 result in similar matches with the data (Figure 30).

Table 40. Parameter Combinations that Match Huyck Well Response

Aquitard Resistance c (day)	Transmissivity T (ft ² /d)	Storativity S (unitless)
500	1,040	7.0×10^{-4}
1,000	1,290	6.3×10^{-4}
5,000	1,560	5.5×10^{-4}
10,000	1,600	5.4×10^{-4}
20,000	1,630	5.4×10^{-4}

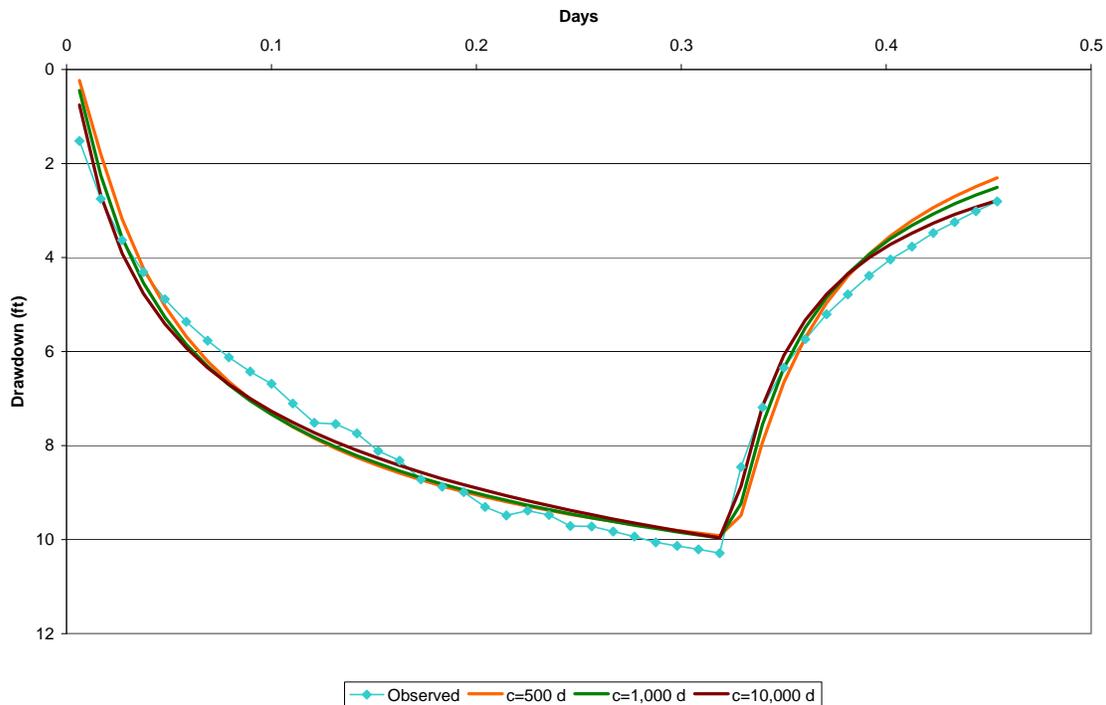


Figure 30. Simulated Drawdowns Using Different Parameter Combinations to Match Huyck Well Response to August 13 Morning Pumping

The uncertainty of overlying aquitard resistance is related to the unknown thickness of the overlying aquitard as well as the range in estimated vertical conductivity values. There are no geologic logs available for the Aptos Jr. High well and Huyck wells to estimate thickness of the overlying aquitard. An aquitard resistance of 1,000 days is equivalent to a thickness of 50 feet combined with a vertical conductivity of 0.05 feet/day; a value that lies in the middle of the published range of vertical conductivities. Using this aquitard resistance and a transmissivity of 1,300 feet²/day based on specific capacity data matches the

observed drawdown data quite well. An aquitard resistance of 10,000 days is equivalent to a thickness of 50 feet combined with a vertical conductivity of 0.005 feet/day; a value that lies at the low end of the published range of vertical conductivities. Using this aquitard resistance and the average transmissivity of 1,600 feet²/day also matches the observed drawdown data. Storativities in both of these simulations fall well within the published range. The order of magnitude uncertainty for the aquitard resistance is considered in the following analysis of water level and yield effects.

WATER LEVEL AND YIELD EFFECTS FROM INCREASED PUMPING AT THE POLO GROUNDS WELL

The Polo Grounds well is located at the north end of Polo Grounds Park. The well is presently used for irrigating several playing fields and produces approximately 30 acre-feet of water during the dry season (Gretchen Branham, Park Maintenance Supervisor, personal communication), which is equivalent to a continuous pumping rate of 37 gpm. Upon conversion to municipal use, a larger pump will be installed to fully use the well's capacity. Previous studies of the Polo Grounds site estimated a maximum long term pumping rate of 500 gpm (LSCE 1983). Assuming this well is pumped approximately 50% of the time, average annual production is estimated at 403 acre-feet. We further assume that 63% of the 403 acre-feet, or 254 acre-feet, are produced during the dry season. Our analyses therefore used an equivalent continuous pumping rate of 315 gpm, or a net increase of 278 gpm over existing conditions.

The Polo Grounds well is approximately 400 feet deep. According to elevations mapped in Johnson et al. (2004), the Purisima F unit extends from ground surface to approximately 800 feet below ground surface at this location or approximately 600 feet below sea level. As discussed above, there is likely a thin layer of Aromas Red Sands overlying this area. We assumed that the Polo Grounds well is screened completely in one unit that may be a combination of Purisima F unit and Aromas Red Sands.

Drawdown from pumping the Polo Grounds well was conducted using parameters shown in Table 38. Considering the order of magnitude uncertainty in aquitard resistance shown by modeling the Huyck well responses to the Aptos Jr. High well pumping, a second simulation using an aquitard resistance of 6,000 days was also conducted. Figure 31 show the distance drawdown curves by unit for the base simulation.

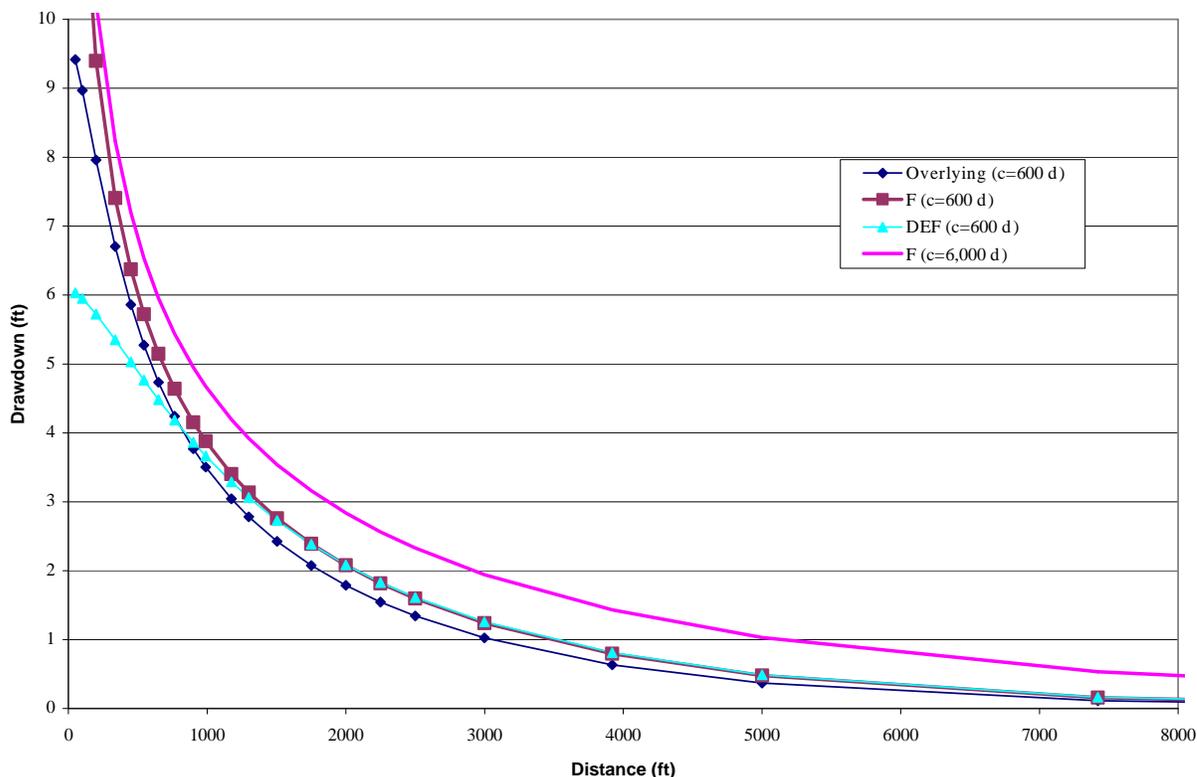


Figure 31. Distance-Drawdown Curves by Unit for Polo Grounds Well

WATER LEVEL EFFECTS AT NEARBY PRIVATE WELLS

The County of Santa Cruz provided SqCWD with California Department of Water Resources well logs. The nearest well to the Polo Grounds well with a log is at a location referred to as P2: over 1,300 feet away. The log shows the well perforations at site P2 are between 200 and 280 feet below ground surface, and between 300 and 400 feet below ground surface, suggesting it is completed in the same unit as the Polo Grounds well. The log for this well also has static depth to water information. The Mar Vista Water Company's Norman well is approximately 2,200 feet away. Drawdowns from the anticipated pumping at the Polo Grounds well calculated at these two well locations, as well as other nearby wells for which depth to water and screen interval information were available, are shown in Table 41 as water level changes. The sensitivity of modeled drawdowns is represented by showing modeled results for the range of vertical resistances. Table 41 also shows wells identified by the Martha's Way Association (Casale, 2007) with no available DWR log information. These wells are at locations P1, P3, and P5.

Table 41. Estimated Water Level Changes at Nearby Wells from Polo Grounds Well Pumping

Well	Distance (ft)	Aquifer	Water Level Changes (ft)	
			c=600 d	c=6,000 d
P1	1,250	F	-3.2	-4.0
P2	1,300-1,500	F	-3.1	-3.9
P3		F	-3.0	-3.7
P4		F	-2.9	-3.7
P5		F	-2.7	-3.5
P6	1,500-2,000	F	-2.6	-3.4
P7		F	-2.6	-3.3
P8		F	-2.2	-3.0
Mar Vista Norman		F	-1.9	-2.7
P9	2,400-3,200	F	-1.6	-2.4
P10		F	-1.3	-2.0
P11		F	-1.2	-1.9
P12		F	-1.2	-1.9

Comparing available water level data, screen intervals, and estimated drawdowns, shows that drawdown from pumping the Polo Grounds well will result in marginal effects on nearby wells. Static water levels are higher than the tops of screens by more than estimated drawdowns at most wells (Table 42). One exception is well P2 where the top of screen was placed at static water level during construction. As a result, effects to the screen have likely already occurred, as any decline in water level would expose the screen. Therefore any additional drawdown caused by pumping the Polo Grounds well will not materially add to the effects on the well screen. At wells P4, P10, and P12, static and pumping water levels are already below the top of the screen and risks due to corrosion, aeration or cavitation are already present. The two to four feet of additional drawdown resulting from pumping the Polo Grounds well will not materially increase these risks. There have been recent water level measurements in a well that may be well P6. Depth to water in this well has been measured at 240 feet (Cloud, 2008), which is below the top of the second screen in well P6 so additional drawdown of two to four feet will not materially increase risks of screen damage. At well P7, pumping water levels are just 1 foot above the bottom of the lower screen. An additional 3 feet of drawdown would desaturate all screens in this well, which would be a restrictive effect on this well. However, this effect does not meet the reasonable threshold of an overall restrictive effect because this poorly performing well should not constrain the use of basin storage by all users.

Table 42. Water Level Effect of Polo Grounds Well Pumping on Nearby Private Well Screens

Well	Screen Length (ft)	Depths (ft)			Water Level Change (ft)
		Top of Screen	Static Water	Pumping Water	Based on c=6,000 d
P2	80	200	200	N/A	-3.9
P4	195	240	285	345	-3.7
P6	20	200	240	N/A	-3.4
P7	10	203	171	252	-3.3
	20	233			
P8	20	280	230	310	-3.0
	20	320			
P9	10	280	273	275	-2.4
P10	150	220	260	276	-2.0
P11	10	205	160	N/A	-1.9
P12	20	200	215	N/A	-1.9

Drought year water levels are not available for private wells so water level effects on private wells during drought years by pumping at the Polo Grounds well is not assessed.

YIELD EFFECTS AT NEARBY PRIVATE WELLS

At all wells, the additional drawdown would increase the pumping lift slightly, which could marginally decrease the pumping rate. The drawdowns correspond to between 0.5 and 0.9% of the total dynamic pumping head at the wells with pumping water levels (assuming 50 psi discharge pressure and 20 feet of friction losses in addition to the depth to the pumping water level). The percentage decrease in pump discharge rate would likely be slightly larger than the percentage increase in total dynamic head. The decrease in discharge is estimated to be less than 0.2 gpm at the tested rates of between 6 and 18 gpm at the five wells with pumping water level data. This decrease in pumping rate could easily be compensated for by increased operating time. Therefore, drawdown from pumping the Polo Grounds well will not materially affect the yield available to the nearby private wells except for well P7, and the drawdown effect on yield is marginal. There will be a restrictive effect on the yield of well P7 because all well screens will be desaturated with any additional drawdown.

There are no regulated facilities that show recent contaminant data within 1,000 meters of the Polo Grounds site (SWRCB, 2009). Therefore, there is no potential effect on the yield of nearby wells resulting from the drawdown from the Polo Grounds well influencing transport of contaminants.

WATER LEVEL EFFECTS AT THE CENTRAL WATER DISTRICT WELLFIELDS

Wells operated by Central Water District are between 2,800 and 7,500 feet from the Polo Grounds well. Based on water quality data, wells in CWD’s Cox wellfield are presumably completed in the Purisima F unit. Wells in CWD’s Rob Roy wellfield are completed in the Aromas Red Sands, which is conservatively lumped with the F unit for this analysis. The calculated drawdowns at each of the five active CWD wells are shown in Table 43, along with the elevations of the screened intervals and recent static and pumping water levels. Simulated drawdowns from pumping the Polo Grounds well range from 0.2 to 2.1 feet at the CWD wells.

Table 43. Maximum Effect of Polo Grounds Well Pumping on Water Levels at CWD Wells

Well Field	Well Name	Distance from Polo Grounds Well (feet)	Top Screen Length ¹ (ft)	Elevations (feet above sea level)			Water Level Changes from Polo Grounds Well	
				Top of Screen ¹	Static Water Level ²	Pumping Water Level ³	c=600 d	c=6,000 d
Cox	Well #3	7,340	120	118	189	153	-0.2	-0.5
Rob Roy	Well #4	4,220	200	7	15	-6	-0.7	-1.3
Cox	Well #5	7,530	15	123	191	119	-0.2	-0.5
Rob Roy	Well #10	4,120	20	-4	16	-1	-0.7	-1.4
Rob Roy	Well #12	2,790	100	-59	11	-23	-1.4	-2.1

¹ Based on driller's report, lithology log, or e-log (Johnson, 2006)

² Minimum static groundwater elevations water years 2005-2008 (CWD, 2008)

³ Minimum dynamic groundwater elevations water years 2005-2008 (CWD, 2008)

Subtracting the water level changes induced by pumping the Polo Grounds well from the static and pumping water levels confirms that the additional drawdown will not cause static or pumping water levels to drop below the top of any well screen that is currently submerged. The pumping water levels at CWD Well #3 are usually tens of feet above the top of the screened interval, and an additional 0.5 foot of drawdown will not expose the top of the screen. The existing pumping water level at CWD well #10 is 3 feet above the top of the screen, and an additional 1.4 feet of drawdown will not expose the top of the screen. The existing pumping water level at CWD well #12 is over 35 feet above the top of the screen, and an additional 2.1 feet of drawdown from the Polo Grounds well would not expose the top of the screen.

At CWD wells #4 and #5, the existing static water level is above the top of the screen and the existing pumping water level is below the top of the screens. The additional drawdown from pumping the Polo Grounds well will not cause the static water levels to drop below the top of the screen. Because the pumping water levels are already below the top of the screen, any water level effects already exist and the additional drawdown from the Polo Grounds well will not materially affect the screen.

The relationships between the existing range of water levels (static and pumping) and the range with the Polo Grounds well operating are displayed graphically in Figure 32, which shows vertical profiles of each of CWD's active wells.

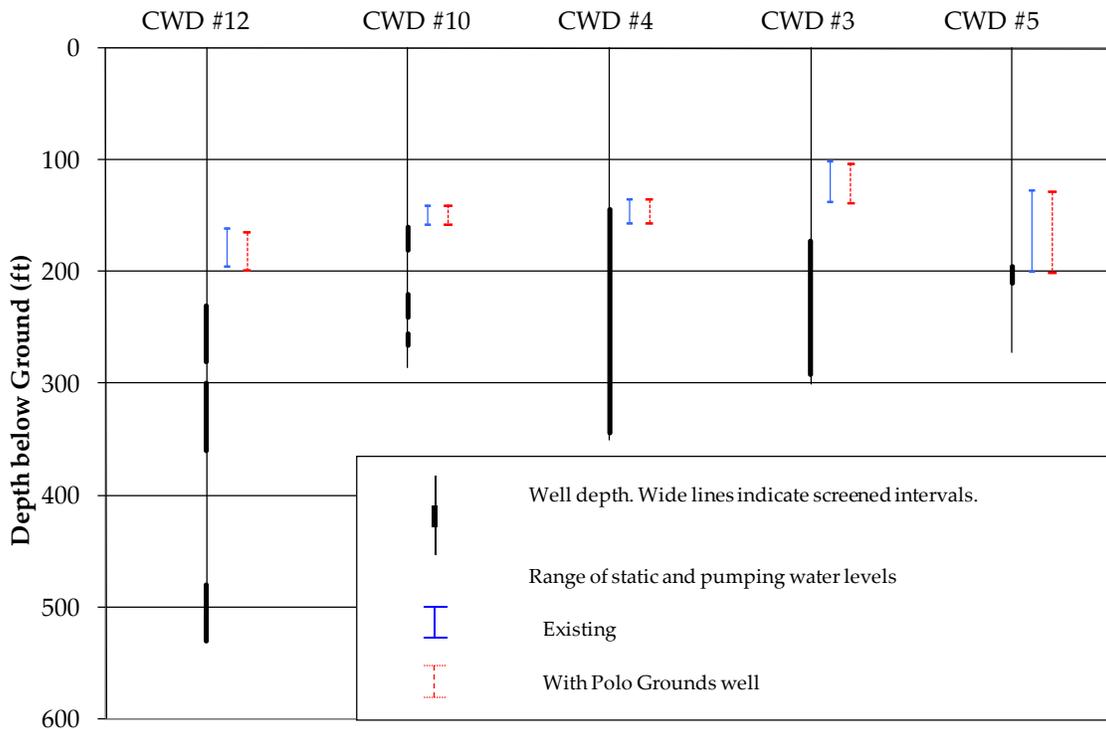


Figure 32. Vertical Profiles of CWD Wells showing Screened Intervals and Water Level Ranges

The above analyses were performed on minimum water levels observed in CWD wells from 2005-2008. These water levels are representative of pumping practices at the CWD wells that have been in place since water year 2000, when CWD #12 began supplying 59% or more of CWD's annual total pumping, and the CWD's Cox wells #3 and #5 were reduced from over 20% of the total pumping to less than 10%. It is worth noting that a review of annual minimum water levels measured in the Rob Roy wells since 2000 always show a similar relationship between water levels and well screen elevations: Pumping from the Polo Grounds well will not cause water levels to drop below the top of screens in

years in which the static or pumping water levels are above the well screens. Therefore, effects on the structural integrity of the wells are marginal under current conditions.

ESTIMATED WATER LEVEL EFFECTS AT CWD WELLFIELDS DURING DROUGHTS

In 1993-1994, after the end of the last drought, water levels at CWD wells #3, #4, #5, and #10 were lower than current conditions. Static water levels at the Cox wells #3 and #5 were lower by up to 35 feet and static water levels at the Rob Roy wells #4 and #10 were lower by up to 4 feet. The much lower water levels observed in the Cox wells is likely related to the higher pumping at these wells in the early 1990s; the current lead well, CWD well #12, did not operate until 1999.

To estimate the effect from pumping the Polo Grounds well during a drought, we applied the above drawdown analysis to the minimum water levels recorded in the CWD wells, which were observed in 1993-1994 (Table 44). The relationship between the water levels at the end of the last drought, lowered by the estimated drawdown from pumping the Polo Grounds well, show that pumping the Polo Grounds well would not initiate screen dewatering in three out of the four CWD wells operating at the end of the last drought (Table 44). The pumping water level at Rob Roy #10 was 6 feet lower at the end of the last drought bringing it to just 1 foot above the top of screen. Estimated drawdown from pumping the Polo Grounds well (1.4 feet) would initiate 0.4 foot of screen dewatering under these conditions and would have a restrictive effect (Figure 33).

Table 44. Maximum Effect of Polo Grounds Well Pumping on Water Levels at CWD Wells at the End of a Drought

Well Field	Well Name	Distance from Polo Grounds Well (feet)	Top Screen Length ₁ (ft)	Elevations (feet above sea level)			Water Level Change from Polo Grounds Well (feet)	
				Top of Screen ¹	Static Water Level ²	Pumping Water Level ³	c=600 d	c=6,000 d
Cox	Well #3	7,340	120	118	162	116	-0.2	-0.5
Rob Roy	Well #4	4,220	200	7	13	0	-0.7	-1.3
Cox	Well #5	7,530	15	123	163	86	-0.2	-0.5
Rob Roy	Well #10	4,120	20	-4	15	-3	-0.7	-1.4
Rob Roy	Well #12	2,790	100	-59	N/A	N/A	-1.4	-2.1

¹ Based on driller's report, lithology log, or e-log (Johnson, 2006)

² Minimum 1993-1994 static groundwater elevations (Johnson, et al., 2004)

³ Minimum 1993-1994 dynamic groundwater elevations (Johnson, et al., 2004)

Although the calculations show a potentially restrictive effect at the Rob Roy #10 well, recent changes to CWD pumping patterns make this effect less likely to occur. Pumping at the Rob Roy #10 well totaled approximately 250 acre-feet/year in 1994, but has been below 150 acre-feet/year since 2000 (Johnson et al, 2004). Total pumping from the Rob Roy #10 well was only 107 acre-feet/year in water year 2008 (CWD, 2008). Therefore the drawdown conditions used for the drought analysis are unlikely to occur during a new drought if CWD maintains their current pumping distribution. If water levels do decline at Rob Roy #10 due to drought conditions under CWD's current pumping distribution, SqCWD will reduce pumping at the Polo Grounds well to avoid causing restrictive effects to the Rob Roy #10 well.

Currently, CWD's largest well is Rob Roy #12. Drought conditions are unlikely to lower water levels near the top of the screen at this well such that drawdowns from Polo Grounds could have a restrictive effect. Pumping water levels are over 35 feet above the screen. Water levels at the Rob Roy wellfield after the last drought were less than 10 feet lower than current water levels, suggesting the pumping level at the Rob Roy #12 well would still be over 25 feet above the screen during a drought.

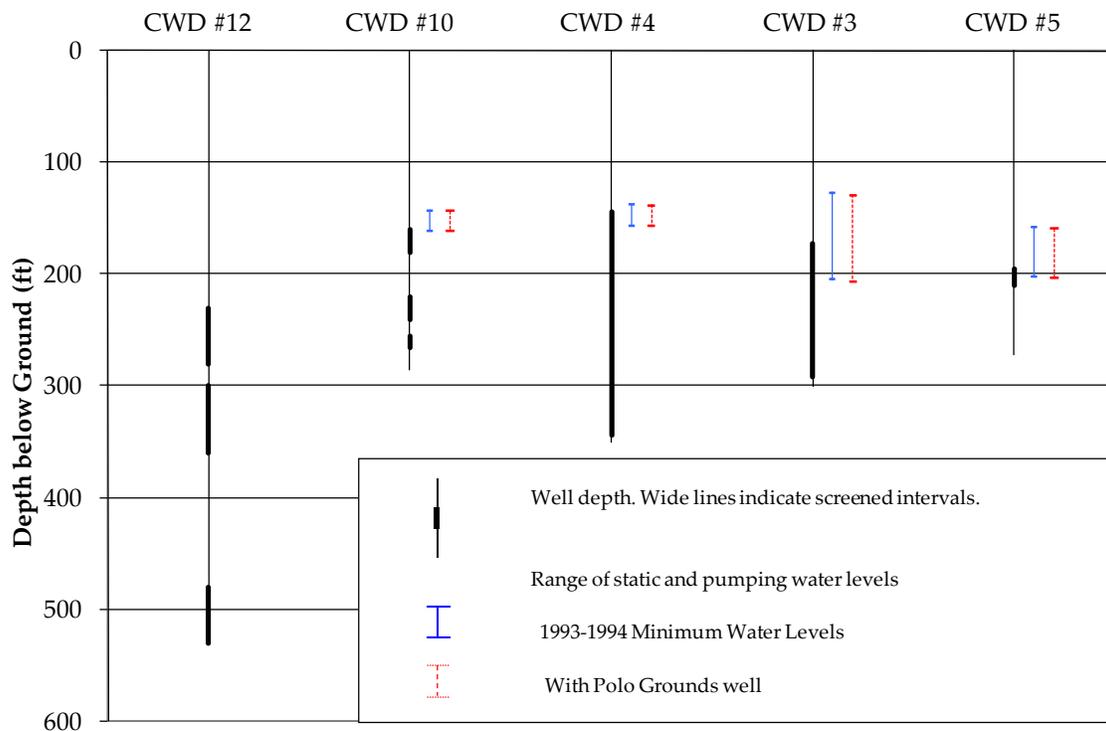


Figure 33. Vertical Profiles of CWD Wells showing Screened Intervals and 1993-1994 Water Level Ranges

YIELD EFFECTS AT CENTRAL WATER DISTRICT WELLS FROM PUMPING THE POLO GROUNDS WELL

At CWD's Well #4, the additional drawdown from the Polo Grounds well pumping will decrease the saturated length of screen during pumping by approximately 1%. At all wells, the additional drawdown will increase the pumping lift slightly, which could marginally decrease the pumping rate. The drawdowns correspond to between 0.1 and 0.6% of the total dynamic pumping head (assuming 50 psi discharge pressure and 20 feet of friction losses in addition to the depth to the pumping water level). The percentage decrease in pump discharge rate will likely be slightly larger than the percentage increase in total dynamic head. The decrease in discharge at any of the wells is estimated to range from approximately 0.2 to 3.2 gpm. However, this would not diminish the amount of water available to CWD. Recent annual production (560 acre-feet/year during water years 2005-2008) is only over half of the production capacity of the five active wells (approximately 1,000 acre-feet/year, assuming each well operates 50% of the time during the year). Thus, a decrease in pumping rate of less than 1% could easily be compensated for by increased operating time. Therefore, drawdown from pumping the Polo Grounds well will not materially affect the yield available to the CWD system, and the drawdown effect on yield is marginal.

COMBINED EFFECTS FROM PUMPING POLO GROUNDS WELL AND REDISTRIBUTING PUMPING, ON WATER LEVELS AND YIELD

The Polo Grounds well is only one component of the Well Master Plan, which is designed to allow SqCWD to redistribute pumping and implement elements of the Groundwater Management Plan. As part of the Well Master Plan, pumping will be redistributed amongst new and existing wells. Likely redistribution scenarios shown in Table 3 include continued pumping at the Aptos Jr. High well, which restarted full operation in 2008. The Bonita well will have reduced pumping. The increase in pumping at the Aptos Jr. High well may increase the drawdown and yield effects on wells near the Polo Grounds well. The decrease in pumping at the Bonita well may lessen the water level and yield effects on the nearby Central Water District wells.

To ensure that our analysis is conservative and addresses the greatest expected drawdown, we compared expected pumping changes under both the basin management objective and maximum pumping conditions. The middle column in Table 4 ("BMO Pumping Condition") shows how the proposed new wells will increase or decrease nearby pumping if SqCWD pumping is 4,800 acre-feet/year. The rightmost column in Table 4 ("Maximum Pumping Condition") shows how the proposed new wells will increase or decrease nearby pumping if pumping is

5,675 acre-feet/year. In the Polo Grounds well area, the pumping changes under the basin management objective pumping condition are the same as pumping changes under the maximum pumping condition, as shown in Table 4. One condition will not result in the Well Master Plan adding more drawdown than the other condition. Therefore, combined drawdown effects are analyzed based on pumping changes under the basin management objective pumping condition (Scenario 1 versus 2005-2008 Average). There is no planned pumping difference between non-drought and drought years in Scenario 1.

Scenario 1 includes pumping 400 acre-feet/year from the Polo Grounds well and 330 acre-feet/year from the Aptos Jr. High well (Table 3). Additionally, pumping at the Bonita well will be reduced from the current 570 acre-feet/year to 280 acre-feet/year. The pumping at the Country Club well is planned to remain constant with current amounts.

COMBINED EFFECTS ON NEARBY PRIVATE WELLS FROM THE POLO GROUNDS WELL AND THE APTOS JR. HIGH WELL

Scenario 1 shows the Aptos Jr. High well pumping its full potential production of 330 acre-feet per year, an increase from the 70 acre-feet/year average observed during water years 2005 through 2008. The combined drawdown effects of this potential production on private wells near the Polo Grounds well are analyzed based on a pumping increase at the Aptos Jr. High well of 260 acre-feet/year. Assuming that 63% of pumping occurs during the dry season, the Aptos Jr. High well pumping will increase by 164 acre-feet over the 6-month dry period. Therefore, the MLU model was used to simulate the decline in water levels when pumping at the Aptos Jr. High well is increased by a continuous rate of 203 gpm over 182.5 days.

The aquifer parameters used to calculate drawdown from pumping the Polo Grounds well is shown on Table 45. To simulate the combined drawdown, the high aquitard resistance of 6,000 days was used at the Polo Grounds well. The aquifer parameters used to calculate drawdown from pumping the Aptos Jr. High well is shown on Table 46. In the Aptos Jr. High well simulations, the average transmissivity of 1,600 feet²/day derived from specific capacity data was used for the Unit F conductivity. The aquitard resistance of 10,000 days was used at Aptos Jr. High based on the Huyck well data. The additional and combined water level changes from pumping the Aptos Jr. High well along with the Polo Grounds well area are shown in Table 47.

Table 45. Aquifer Hydraulic Properties used to Simulate Polo Grounds Well

Model Layer	Aquifer/Aquitard	Unit	T (ft ² /d)	Sy/S (unitless)	c (days)
1	Aquifer	Overlying	39	0.07	
2	Aquitard	Above F			6,000
	Aquifer	F	2,005	2.7 x 10 ⁻⁴	
3	Aquitard	Above DEF			209
	Aquifer	DEF	1,029	2.7 x 10 ⁻⁴	
4	Aquitard	D			8,000
	Aquifer	BC	346	2.7 x 10 ⁻⁴	
5	Aquitard	B			15,000
	Aquifer	A	2,806	2.7 x 10 ⁻⁴	
6	Aquitard	Above AA			25,709
	Aquifer	AA	115	2.7 x 10 ⁻⁴	
7	Aquitard	Tmp			1.3
	Aquifer	Tu	953	2.7x 10 ⁻⁴	

Table 46. Aquifer Hydraulic Properties used to Simulate Aptos Jr. High Well

Model Layer	Aquifer/Aquitard	Unit	T (ft ² /d)	Sy/S (unitless)	c (day)
1	Aquifer	Overlying	823	0.07	
2	Aquitard	Above F			10,000
	Aquifer	F	1,600	5.4 x 10 ⁻⁴	
3	Aquitard	Above DEF			209
	Aquifer	DEF	1,028	2.7 x 10 ⁻⁴	
4	Aquitard	D			8,000
	Aquifer	BC	346	2.7 x 10 ⁻⁴	
5	Aquitard	B			15,000
	Aquifer	A	2,806	2.7 x 10 ⁻⁴	
6	Aquitard	Above AA			1,219
	Aquifer	AA	422	2.7 x 10 ⁻⁴	
7	Aquitard	Tmp			11
	Aquifer	Tu	601	2.7 x 10 ⁻⁴	

Table 47. Combined Water Level Changes from Pumping Aptos Jr. High Well and Polo Grounds Well

Well	Distance to Aptos Jr. High Well (ft)	Aquifer	Water Level Change (ft)		
			Polo Grounds Well	Aptos Jr. High Well	Combined
P1	3,500-4,000	F	-4.0	-1.4	-5.5
P2		F	-3.9	-1.7	-5.6
P3	2,500-3,000	F	-3.7	-2.0	-5.7
P4	3,500-4,500	F	-3.7	-1.3	-5.0
P5		F	-3.5	-1.2	-4.7
P6		F	-3.4	-1.5	-4.9
P7	2,500-3,000	F	-3.3	-1.9	-5.2
P8		F	-3.0	-2.0	-4.9
Mar Vista Norman	2,170	F	-2.7	-2.0	-4.7
P9	4,500-6,000	F	-2.4	-1.0	-3.4
P10		F	-2.0	-0.8	-2.9
P11		F	-1.9	-0.8	-2.7
P12	3,500-4,000	F	-1.9	-1.4	-3.3

Combined drawdowns show that pumping both the Aptos Jr. High well and the Polo Grounds well will cause marginal effects at nearby wells. Table 48 shows that the combined effect of Aptos Jr. High pumping does not change the relationship between water levels and screen intervals observed when only drawdown effects from the Polo Grounds well were evaluated.

The additional drawdown from pumping the Aptos Jr. High well will have only marginal effects on yields at wells near the Polo Grounds well. The drawdowns correspond to between 0.7 and 1.3% of the total dynamic pumping head at the five wells with pumping water level data. The decrease in discharge is estimated to be no greater than 0.2 gpm at the tested rates of between 6 and 18 gpm at the five wells with pumping water level data. This decrease in pumping rate could easily be compensated for by increased operating time.

Table 48. Combined Water Level Effect of Aptos Jr. High and Polo Grounds Well Pumping on Nearby Well Screens

Well	Screen Length (ft)	Depths (ft)			Combined Water Level Change (ft)
		Top of Screen	Static Water	Pumping Water	
P2	80	200	200	N/A	-5.6
P4	195	240	285	345	-5.0
P6	20	170	150	N/A	-4.9
P7	10	203	171	252	-5.2
	20	233			
P8	20	280	230	310	-4.9
	20	320			
P9	10	280	273	275	-3.4
P10	150	220	260	276	-2.9
P11	10	205	160	N/A	-2.7
P12	20	200	215	N/A	-3.3

COMBINED EFFECTS ON CENTRAL WATER DISTRICT WELLS FROM THE POLO GROUNDS WELL, APTOS JR. HIGH WELL, AND BONITA WELL

To further evaluate the effects of the planned pumping redistribution on water levels at CWD wells, the MLU model was used to simulate the rise in water levels resulting from the planned decrease in pumping at SqCWD's Bonita well. Pumping from the Bonita well decreases from the current 570 acre-feet/year to 280 acre-feet/year in the most likely redistribution scenario, Scenario 1. Assuming 63% of pumping occurs during the dry season, Bonita well pumping will decrease by 183 acre-feet over a 6 month period. The MLU model was used to simulate the rise in water levels when pumping at the Bonita well is decreased by a continuous rate of 227 gpm over 182.5 days. In Scenario 1, the Country Club well has no change in production, and therefore will have no additional water level effects.

Hydraulic property values used to model effects from the pumping reduction at the Bonita well are shown on Table 49. The regional F unit hydraulic conductivity in Table 6 was used for the Bonita well simulation. For all other properties and units, regional values of conductivities and storativity provided in Table 6, Table 7, and Table 8 were combined with estimated aquifer unit thicknesses based on Johnson et al. (2004, Table 2-2 and Appendix B). The Bonita well is screened across both the lower Aromas (Q1a) and F units. The changes

caused by pumping all three wells are superimposed to obtain a net change in water level at each CWD well.

Table 50 lists the simulated effects of each of those changes in pumping on water levels at each of the CWD wells. Figure 34 shows combined water level changes surrounding the Polo Grounds, Aptos Jr. High, and Bonita wells.

Table 49. Aquifer Hydraulic Properties used to Simulate Bonita Well

Model Layer	Aquifer / Aquitard	Unit	T (ft ² /d)	Sy/S (unitless)	c (day)
1	Aquifer	Qua	2,739	0.07	
2	Aquitard	Above Qla			52
	Aquifer	Qla	2,572	2.7 x 10 ⁻⁴	
3	Aquitard	Above F			986
	Aquifer	F	1,537	2.7 x 10 ⁻⁴	
4	Aquitard	Above DEF			202
	Aquifer	DEF	996	2.7 x 10 ⁻⁴	
5	Aquitard	D			8,000
	Aquifer	BC	346	2.7 x 10 ⁻⁴	
6	Aquitard	B			15,000
	Aquifer	A	2,806	2.7 x 10 ⁻⁴	
7	Aquitard	Above AA			25,487
	Aquifer	AA	113	2.7 x 10 ⁻⁴	
8	Aquitard	Tmp			15
	Aquifer	Tu	1,151	2.7 x 10 ⁻⁴	

Table 50. Maximum Effect of SqCWD Pumping Redistribution on Water Levels at CWD Wells

Wellfield	Well Name	Water-Level Change at CWD Wells due to Change in Pumping at SqCWD wells (ft)				
		Polo Grounds	Aptos Jr. High	Country Club	Bonita	Total
Cox	Well #3	-0.5	-0.3	0.0	0.0	-0.9
Rob Roy	Well #4	-1.3	-1.4	0.0	0.7	-2.0
Cox	Well #5	-0.5	-0.3	0.0	0.0	-0.9
Rob Roy	Well #10	-1.4	-1.6	0.0	0.7	-2.2
Rob Roy	Well #12	-2.1	-1.4	0.0	0.4	-3.1

¹ Wells #10 and #12 both have three screened intervals 10-20 feet long.

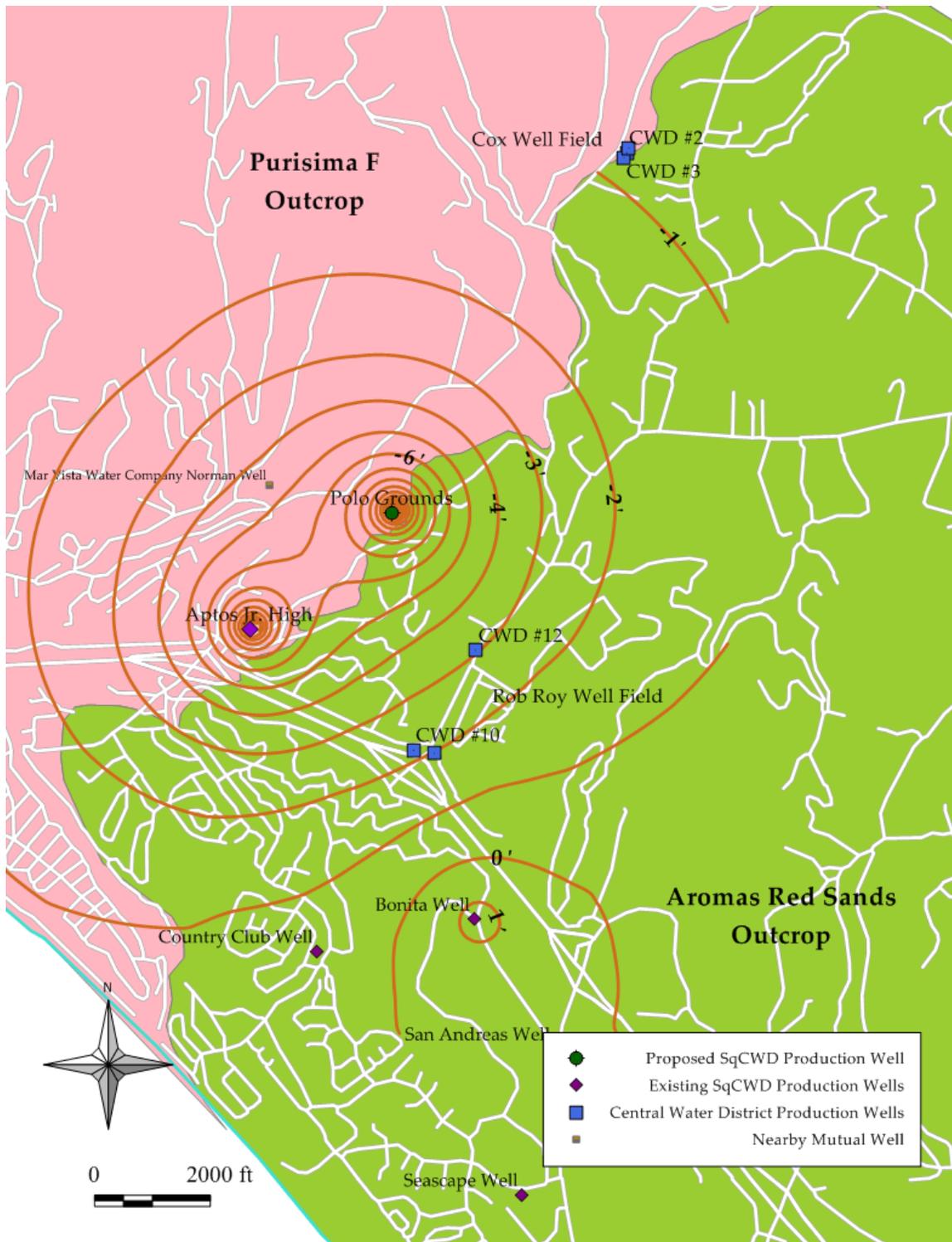


Figure 34. Simulated Water Level Changes in Purisima F Unit for Polo Grounds Well, Aptos Jr. High, and Bonita Well Pumping

The combined effects of pumping changes at all three nearby SqCWD wells are additional water-level declines of between 0.3 and 1.0 feet over the drawdown generated by pumping the Polo Grounds well alone. This is because the effect of decreased pumping at the Bonita well does not fully offset the effect of increased pumping at the Aptos Jr. High well. The net drawdowns are approximately 0.9 foot at the two Cox Wells, 2 feet at Rob Roy Wells #4 and #10, and 3 feet at Rob Roy Well #12.

The additional drawdown generated by the pumping redistribution does not change the relationship between water levels and screened intervals. The conclusions derived from the analysis of the Polo Grounds well by itself remain valid even with the additional drawdown. The water level ranges resulting from redistributing the pumping would be visually indistinguishable from the water level ranges resulting from pumping only the Polo Grounds well and the water level effects would also be marginal (Figure 32 and Figure 33).

The effect of pumping redistribution on water levels would not restrict CWD's water supply because the slight decrease in saturated screen length in one well and slight increase in pumping head in all wells could easily be compensated by an increase in pump operation time. The drawdowns correspond to between 0.3 and 0.9% of the total dynamic pumping head. The percentage decrease in pump discharge rate will likely be slightly larger than the percentage increase in total dynamic head. The decrease in discharge at any of the wells is estimated to range from approximately 0.3 to 4.7 gpm. As described earlier, CWD wells collectively pump only about 28% of the time during the year, or slightly more than half of their assumed capacity. An increased pumping time of up to 5 minutes per day in the wells would make up the lost yield.

The effect of pumping redistribution on the yield of CWD's wells as a result of lower water levels is marginal because there would not be an appreciable diminution in the ability of the wells to maintain their current annual production.

Section 7

STREAMFLOW EFFECT ANALYSES

Estimated effects of pumping on streamflow are presented for each of the proposed new wells below. The analyses address effects from pumping the new wells, as well as combined effects from pumping changes at existing nearby wells. Figure 35 shows the locations of streams near proposed new wells.

The streamflow effect analysis includes a checklist of conditions necessary for pumping to deplete baseflow. The list is checked for each new well in the Well Master Plan, and includes the following conditions:

1. A nearby stream has been identified that has dry season flows, is designated as a critical habitat, and is relatively close to the well.
2. There is a hydraulic connection between the groundwater and the stream.
3. The Well Master Plan results in a net increase in groundwater pumping near the stream under either the basin management objective pumping condition or the maximum pumping condition.

If these conditions are met, further analysis of potential effects and possible mitigation measures are discussed. Table 51 summarizes the results of the checklist for each of the proposed wells in the Well Master Plan. The nearby stream with potential for baseflow depletion is identified and its connection with groundwater is assessed. The nearby wells that affect net pumping change are listed and the net pumping changes under the basin management objective pumping condition and the maximum pumping condition are summarized. The net pumping change is calculated in similar fashion to Table 4; proposed pumping under the basin management objective condition is compared to 2005-2008 averages and proposed pumping under the maximum condition is compared to No-Project pumping under the maximum condition. The grouping of nearby wells in Table 51 is different from Table 4, because the location of nearby wells relative to the identified nearby stream are different than locations relative to nearby private wells.

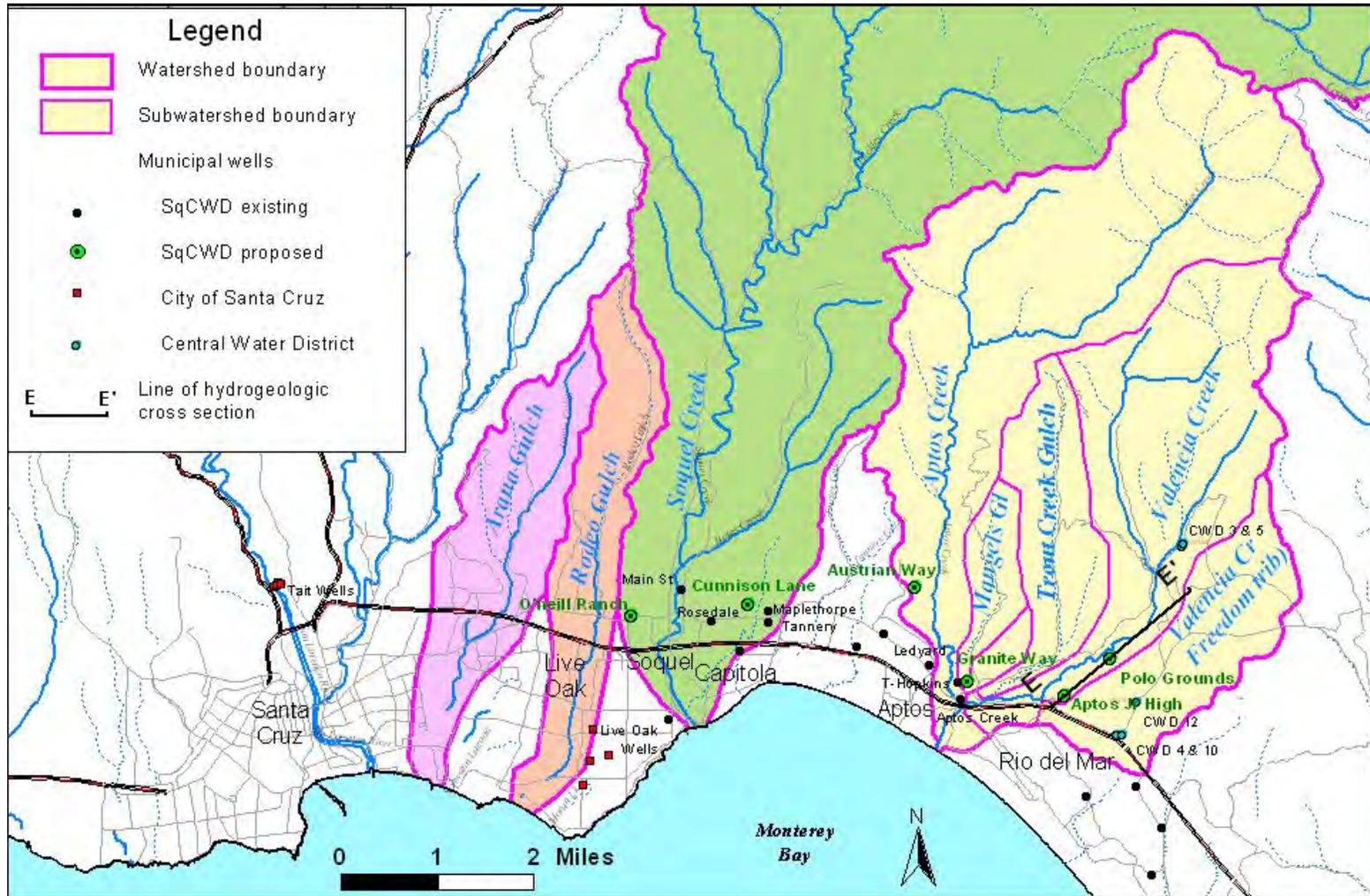


Figure 35. Locations of Existing and Proposed Municipal Wells and Watersheds Potentially Affected by Pumping Redistribution

Table 51. Summary of Checklist of Streamflow Effects for Each Proposed Well in Well Master Plan

Proposed Well	Nearby Stream (connected to groundwater?)	Nearby Pumping Wells	BMO Pumping Condition: Scenario 1 vs. 2005-2008 Pumping (af/yr)	Maximum Pumping Condition: Max Scenario 1 vs. No Project Max (af/yr)
O'Neill Ranch (non-drought)	Soquel Creek (connected)	Main Street Rosedale	+250	+250
O'Neill Ranch (drought)	Soquel Creek (connected)	Main Street Rosedale	+350	+350
Cunnison Lane	Soquel Creek (connected)	Tannery II	-110	-80
Austrian Way	Aptos Creek (connected)		+200	+200
Granite Way	Aptos Creek (connected)	Aptos Creek T. Hopkins	-35	-35
Polo Grounds	Valencia Creek (not connected)	Aptos Jr. High Bonita Country Club	+340	+80

The evaluation of each condition on the checklist is discussed below for each well. However, Table 51 shows that three well sites: Cunnison Lane, Granite Way, and Polo Grounds, do not meet all of the conditions for further analysis. Net pumping around Cunnison Lane and Granite Way wells decrease, leading to beneficial effects on nearby creeks. Groundwater near the Polo Grounds well is not connected to Valencia Creek. Only the O'Neill Ranch well and Austrian Way well meet all conditions for potential streamflow depletion and require further evaluation of streamflow depletion effects. This further evaluation is detailed below. The net increases in the areas around these two wells are the same for the

basin management objective pumping condition and the maximum pumping condition, so the evaluations of streamflow depletion are discussed in context of the planned basin management objective pumping condition.

O'NEILL RANCH WELL

The O'Neill Ranch well site is approximately 1,700 feet east of Rodeo Gulch, 2,200 feet west of Soquel Creek, and 6,700 feet east of Arana Gulch. The O'Neill Ranch well will be a new well with a likely annual production of 600 acre-feet/year (Table 3). The nearest existing SqCWD well is the Main Street well, which is expected to maintain the same level of production in non-drought years. There will be an expected decrease in production of 350 acre-feet/year at the Rosedale well, which is located approximately as far from Soquel Creek as the O'Neill Ranch well, but on the opposite side of Soquel Creek. Thus, locally there will be a net increase in groundwater production on the order of 250 acre-feet/year during non-drought years. In drought years, as pumping is shifted from the Garnet well to the Main Street well, there is an additional increase of pumping of 100 acre-feet/year in the area.

The closest waterway to the O'Neill Ranch well is Rodeo Gulch, west of the O'Neill Ranch well site. No flow records are available for Rodeo Gulch, but the small watershed area of only 3.4 square miles probably supports only a trickle of baseflow that likely disappears in dry years. Steelhead have not been reported in Rodeo Gulch, and the waterway is not included in the critical habitat designation (Podlech 2007).

The Arana Gulch watershed is also small, at 3.8 square miles, but baseflow of up to 0.18 cubic feet per second (cfs) was observed at six locations in October 1999. In spite of these small dry-season flows, steelhead currently use the creek and it is included in the critical habitat designation (Haver pers. comm. 2007). Effects of the O'Neill Ranch well on Arana Gulch baseflow will be marginal because at its nearest point the creek is 6,700 feet away from the well. Drawdown propagates radially outward from a pumping well, and a circle with a radius of 6,700 feet drawn around the O'Neill Ranch site encompasses 2.5 miles of the Rodeo Gulch channel, 2.7 miles of the Soquel Creek channel and 0.6 miles of the Bates Creek channel. Notwithstanding the tilt of the Purisima units, the latter stream reaches are far more likely to be affected by virtue of their proximity to the O'Neill Ranch well. The potential effect on Arana Gulch is considered marginal.

Soquel Creek is the largest creek in the area, draining a watershed of approximately 42 square miles. A gauging station has been operated by the U.S. Geological Survey on Soquel Creek near Highway 1 downstream of the Main

Street well since water year 1952. Except during prolonged droughts, baseflow in the creek is perennial. A short reach upstream of the Main Street well has historically been a losing reach, but this condition predated the construction of the Main Street well, and may simply result from a local increase in transmissivity of the shallow aquifers. Soquel Creek typically gains flow in late summer a short distance downstream of the Main Street well, and also in reaches farther upstream. Vertical head gradients measured in the shallow aquifers near the Main Street well do not support a conclusion that an unsaturated zone is present. Thus, even if the creek is losing flow slightly upstream of the well, the shallow groundwater still appears to be hydraulically connected to the stream. This means pumping near Soquel Creek can potentially affect baseflow.

This potential effect of pumping was the subject of several conflicting technical studies when SqCWD first proposed installing a well at the O'Neill Ranch well site in 2001 (Todd Engineers, 2001; Jackson, 2001; Environmental Science Associates, 2001; Friends of Soquel Creek, 2001; Johnson 2001). These studies were among those evaluated in the comprehensive review of baseflow relationship studies completed by Johnson et al. (2004). The review concluded that pumping the Main Street well might have depleted baseflow, but the amount of baseflow depletion has been small. In fact any potential baseflow depletion is not detectable with available data and analysis methods. The authors cautioned however that "... if groundwater production is further redistributed to inland wells (either existing or new) near Soquel Creek and/or other streams, such thresholds could be exceeded such that the influence of pumping on streamflow becomes discernable."

A recent spinner log test of the Main Street well confirmed that layering within the Purisima Formation partially explains the historical lack of detectable streamflow depletion. Spinner log tests measure the percentage of total well flow that is derived from each segment of well screen. The Main Street well has 266 feet of screen, but approximately 50% of the water enters through the lowermost 20 feet of the screened interval (Figure 11).

In order to estimate the maximum reasonable effects on Soquel Creek baseflow from implementing the Well Master Plan, two analyses are presented here. One analysis assumes that all effects on Soquel Creek are derived from the increased drought year pumping proposed for the Main Street well; the well nearest Soquel Creek. The second analysis assumes that the Main Street, Rosedale, and O'Neill Ranch wells all affect Soquel Creek baseflow similarly, even though the Rosedale and O'Neill wells are considerably farther from the creek than the Main Street well.

The first analysis looks only at the Main Street well. The Main Street well will have increased pumping during drought years as pumping is shifted inland from the near-coast Garnet well. The drought year increase over recent pumping is approximately 100 acre-feet/year. This is equivalent to an increase of approximately 0.14 cfs. In the analyses presented in Johnson et al. (2004) it was demonstrated that the historic Main Street well pumping of 1.0 cfs results in a baseflow reduction of less than 0.5 cfs. Using the worst case that 50% of the Main Street's water is derived from baseflow upstream of the gage, the pumping increase of 0.14 cfs may result in a baseflow depletion of up to 0.07 cfs. This is the worst case, and it is likely that the drought year baseflow depletion will be less than 0.07 cfs.

The second analysis looks at the combined net change in pumping from the Rosedale, Main Street, and O'Neill wells. This regional perspective is appropriate for the leaky confined aquifer conditions present in the area, because those conditions tend to spread potential baseflow effects over a larger area. The combined pumping rate for the Main Street and Rosedale wells during the 1989-2002 period used for the analyses in Johnson et al. (2004) was approximately 1,290 acre-feet/year, equivalent to 1.8 cfs. Any effects on Soquel Creek baseflow from this pumping is below the detection limit of approximately 0.5 cfs. If we assume the worst case, that the 1.8 cfs of pumping is depleting baseflow by exactly 0.5 cfs, this suggests that approximately 28% of the combined local pumping is derived from Soquel Creek baseflow. The combined future production of the three wells in non-drought years under most pumping redistribution scenarios is approximately 1,460 acre-feet/year, an increase of 250 acre-feet/year over current conditions based on 2005-2008 pumping. This increase is equivalent to a pumping increase of approximately 0.3 cfs over existing conditions. Applying the 28% baseflow capture estimate to the 0.3 cfs increase yields a baseflow depletion of 0.10 cfs over current conditions. This is the maximum additional baseflow depletion upstream of the Highway 1 gage due to redistributing pumping among the three wells. The true baseflow depletion is likely less.

The drought year scenario for the three wells in the region includes an additional increase as pumping is shifted inland from the Garnet well. The combined drought year production of the Rosedale, Main Street, and O'Neill wells is approximately 1,560 acre-feet/year, an increase of 350 acre-feet over current conditions. This increase is equivalent to a pumping increase of approximately 0.5 cfs over existing conditions. Applying the 28% baseflow capture estimate to the 0.5 cfs increase yields a baseflow depletion of 0.14 cfs over current conditions. This is the maximum additional baseflow depletion upstream of the Highway 1 gage due to redistributing pumping among the three wells during a drought year. The true baseflow depletion during a drought year is likely less.

The combined drawdown in drought years that would result in baseflow depletion in Soquel Creek is shown in Figure 36. This figure shows that pumping reductions at the Rosedale and Garnet wells reduce the drawdowns along Soquel Creek from the drawdowns shown in Figure 21. Figure 21 shows drawdowns estimated from pumping the O'Neill Ranch well and drought year increases in pumping at the Main Street well. The figure also includes combined water level changes by adding the Cunnison Lane well and decreasing pumping at the Tannery well under Scenario 1. With redistributed pumping, maximum drawdowns along Soquel Creek are slightly greater than 2 feet.

The estimated maximum effect on Soquel Creek baseflow is therefore between 0.07 and 0.14 cfs. The actual effect will probably be less than the maximum estimated effect. We cannot currently say how much less the effect will be, although it could be considerably less. The maximum effect is unlikely to result in detectable changes of any downstream gaining reaches to losing reaches. However, if a decrease of up to 0.14 cfs in Soquel Creek baseflow could decrease steelhead populations, monitoring and mitigation measures should be implemented to confirm and reduce the effect. An appropriate sequence of actions would be

- Ensure continued operation of the Highway 1 gauge on Soquel Creek.
- Periodically compare baseflow with nearby gauged streams (for example, the San Lorenzo River) using double-mass methods.
- If Soquel Creek baseflows decline relative to the other streams, and the timing and magnitude of the decline could plausibly result from increased pumping near the creek, decrease production from the Main Street, O'Neill and/or Rosedale wells.

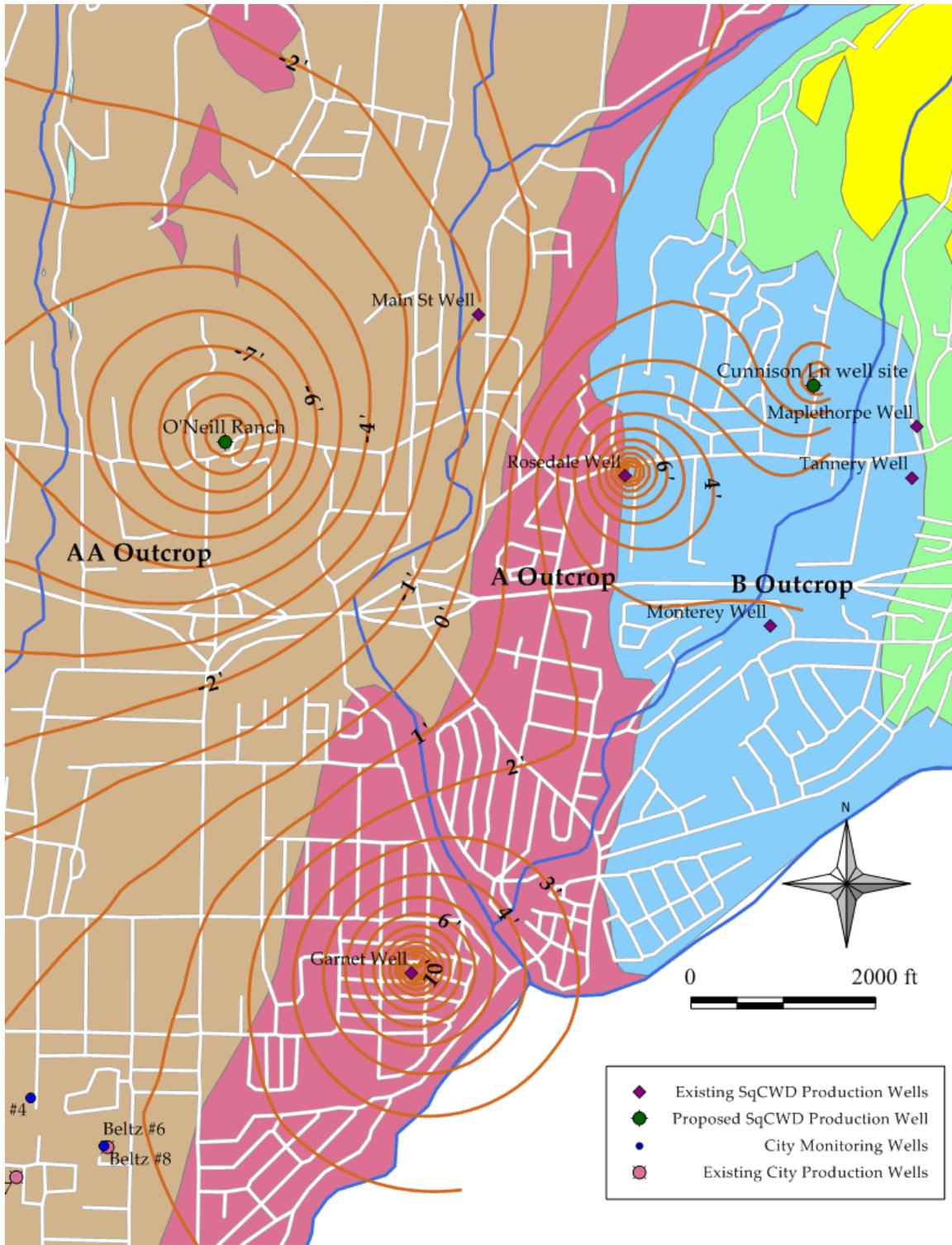


Figure 36. Combined Water Level Changes in A Unit for Drought Year A and AA Unit Wells

CUNNISON LANE WELL

The Cunnison Lane well site is approximately 500 feet west of Noble Gulch, 3,700 feet west of Tannery Gulch, and 3,900 feet east of Soquel Creek. The Cunnison Lane well replaces some of the production from the nearby Tannery II well.

The watershed of Noble Gulch is small, consistent with the other waterways that drain the coastal plain (Escalona Gulch, Tannery Gulch and Borregas Creek). No occurrences of listed aquatic species have been recorded from this drainage. Although there is a corridor of riparian vegetation along the gulch, flow is intermittent. Summer baseflow is unlikely in the stream reach near the well site, and therefore there are no anticipated effects to Noble Gulch.

Tannery Gulch has a small watershed with intermittent flow; summer baseflow is unlikely in the stream reach near the well site, and therefore there are no anticipated effects to Tannery Gulch.

Soquel Creek has been identified as having summer baseflow and hydraulic connection to the groundwater, and is the only creek that could require additional analysis. The only other nearby well along this stretch of Soquel Creek is the Tannery II well. The Tannery II well is 5,000 feet east of Soquel Creek and produces almost entirely from the Purisima A unit. In the most likely future pumping scenario (Table 3, Scenario 1), future production from the Tannery II well will be less than existing production by 290 acre-feet/year, which will more than offset the new production at the Cunnison Lane well. There will be a net decrease in production from the Purisima A unit in this vicinity, and any pumping effects on Soquel Creek baseflow will be the same as or smaller than existing effects. Therefore, no further analyses of stream effects are required for this well.

AUSTRIAN WAY WELL

The Austrian Way well site is located 1,140 feet west of Aptos Creek and 3,500 feet east of Tannery Gulch. There are no existing municipal wells near the Austrian Way site, so there will be a net increase in local groundwater production in this area. Data from a recent test boring program at the site indicated that a well at the Austrian Way site might produce up to 200 acre-feet/year (Table 3) from the Purisima BC and DEF units. This corresponds to an average pumping rate equivalent to 0.3 cfs.

Tannery Gulch has a small watershed with intermittent flow; summer baseflow is unlikely in the stream reach near the well site. Thus, Aptos Creek is the only potentially affected waterway. The Austrian Way well site is 0.65 miles

downstream of the Aptos stream gauge (U.S. Geological Survey station 11159690) along Aptos Creek, with no major intervening tributaries. The period of record for the gauge is water years 1972-1985. The minimum monthly flows during a hydrologically representative period (water years 1975-1985) were between 0.4 and 2.6 cfs, with an average flow of 1.0 cfs, and typically occurred in October. Baseflow during the 1976-1977 drought was similar to baseflow in normal years, confirming that baseflow is only gradually affected by changes in recharge and pumping. More recently, streamflow gains and losses between this gauge site and the lower gauge site (near the confluence with Valencia Creek; USGS station 11159700, Aptos Cr A Aptos) were measured nine times during water year 2002 (Beck and Mathias 2003). The creek tended to gain flow in winter by an average of 1.1 cfs on five dates between November and May, and lose water in summer by an average of 0.6 cfs on four dates between June and October.

The connection between groundwater and the creek is complex, and available data are consistent with the general hydrogeologic conceptual model of the basin described in Johnson et al. (2004). Groundwater at shallow depths tends to leak downward to deeper aquifers at a relatively constant rate and to seep into nearby creek channels at a rate that declines over time during dry periods. Water levels in private domestic wells in the upland part of the basin were systematically surveyed only once, in 1981 (Bloyd 1981). Domestic wells tend to be shallower than municipal wells, and the water-level contours developed by Bloyd showed a water table elevation of approximately 125 feet above sea level near the well site. The creek bed elevation at the nearest point is approximately 92 feet above sea level. Bloyd's contour inflections confirmed his interpretation that the creek gained flow from shallow groundwater.

In contrast to Bloyd's 1981 data, the groundwater elevation in the Austrian Way monitoring well drilled in 2007 was only 54 feet above sea level, or approximately 48 feet below the creek bed. This water level was probably influenced by pumping from the nearest municipal wells sharing the Purisima BC unit (Ledyard and Madeline wells) or DEF unit (Aptos Creek and T. Hopkins wells). This configuration of shallow groundwater levels in upper aquifers and deeper groundwater levels in lower aquifers is very similar to the pattern observed along lower Soquel Creek. Similar to existing wells along Soquel Creek, pumping from a well at the Austrian Way site could affect shallow groundwater and baseflow in Aptos Creek but that effect would be at a slow, steady rate spread out over a very large area.

The slow, steady leakage from the upper aquifer into the lower aquifer is a result of layering within the Purisima Formation. It is this layering that buffers the effects of pumping from a production well on stream baseflow. A production

well at the Austrian Way site would likely be screened in the BC and possibly lower DEF units of the Purisima Formation, where the existing water levels were measured at 54 feet above sea level. Aptos Creek flows across the F unit where the Bloyd data suggest water levels may be 125 feet above sea level. These data suggest that a downward gradient already exists near the Austrian Way site. Leakage rates induced by this existing downward gradient are likely controlled by local low conductivity clays and silts. Increasing the downward gradient by pumping a well at the Austrian Way site will only minimally increase the existing leakage rate.

Although baseflow effects from pumping a production well at the Austrian Way site is likely limited and diffuse, most of the yield of the Austrian Way well is likely to be derived from baseflow capture rather than a decrease in groundwater discharge to Monterey Bay. This is because Monterey Bay is six times farther away than Aptos Creek. Because of the Purisima Formation layering, any baseflow capture will be spread out regionally and will likely be difficult to detect. The combined baseflow depletion will register in the downstream area of Aptos Creek, but decreases in pumping in this downstream area by the Granite Way well will help mitigate effects. Therefore, any detectable depletion would more likely occur in the upper reaches of Aptos Creek and be far less than the annual production rate of the well.

If a decrease in late-summer baseflow in the upper reaches of Aptos Creek by the Austrian Way well could have a restrictive effect on steelhead populations, monitoring and mitigation measures should be implemented to confirm and reduce the effect. Given uncertainties regarding future production from the Austrian Way well and uncertainties in the above hydraulic analysis, an appropriate sequence of actions would be:

- Reactivate the upper gauge on Aptos Creek and monitor streamflow, with particular emphasis on baseflow.
- Periodically compare baseflow with nearby gauged streams (for example, Soquel Creek and the San Lorenzo River) using double-mass methods.
- If Aptos Creek baseflow declines relative to the other streams and the timing and magnitude of the decline could plausibly result from pumping at the Austrian Way well, decrease production from that well.

GRANITE WAY WELL

The Granite Way well site is located approximately 900 feet from Aptos Creek. The Granite Way well will replace a portion of the existing production at the nearby Aptos Creek well (Table 3, Scenario 1). The Aptos Creek well is adjacent to Aptos Creek and produced an average of 230 acre-feet/year between 2005 and

2008, of which about 86% was drawn from the Purisima DEF unit. The Granite Way well is likewise expected to produce almost all of its water from the Purisima DEF unit. Under likely pumping redistribution scenarios, new production from the Granite Way well will be 195 acre-feet/year in both non-drought and drought years; less than the decrease in production from eliminating pumping at the Aptos Creek well. Thus, there would be a net decrease in groundwater production in that area. Any pumping effects on Aptos Creek baseflow will be beneficial, and no further analysis is necessary. The net pumping decrease of approximately 35 acre-feet/year may also mitigate effects on Aptos Creek from planned pumping at the Austrian Way well.

POLO GROUNDS WELL

The Polo Grounds well is located less than 400 feet from Valencia Creek. The nearby Aptos Jr. High School well is also within 1,000 feet of Valencia Creek. They are considered together in this analysis because their potential effects on Valencia Creek baseflow are similar and potentially overlapping. The Polo Grounds well is presently used for irrigating several playing fields at the Polo Grounds County Park and produces approximately 30 acre-feet during the dry season (Gretchen Branham, Park Maintenance Supervisor, personal communication). The Aptos Jr. High well only recently restarted production and has had an average annual production of 70 acre-feet for water years 2005-2008. The two wells' combined annual production under likely pumping redistribution scenarios will be 730 acre-feet/year (Table 3), for a net increase of up to 630 acre-feet/year in groundwater production along this reach of Valencia Creek.

Valencia Creek has never had any long-term stream gauge measurements, although several measurements were made during water year 2002 to support the watershed assessment and enhancement plan (Conrad and Dvorsky, 2003). Changes in flow between Polo Grounds Park and the confluence with Trout Creek were measured on four dates between December and April 2002. Valencia Creek lost water on every measurement date, and would certainly also have lost water during the dry season months of May through October. A losing stream may be in hydraulic connection with groundwater if the depth to the water table is not large. The maximum vertical separation between the creek bed and water table that can remain saturated and thereby support a hydraulic connection depends on the vertical permeabilities of the creek bed and shallow subsurface geologic materials.

A hydrogeologic cross section parallel to Valencia Creek was prepared to determine the types of subsurface materials and the relationship of the groundwater table to the creek bed. The cross section is shown in Figure 37, and its location is indicated on Figure 35. Depth-to-water measurements were

available for seven wells, including Central Water District's (CWD's) Cox wells (located 1,500 feet beyond the right end of the cross section). Three of the water level measurements are over 20 years old and were taken from the drillers' logs (wells 9178, 9194 and 9307). The other four measurements (well 2760, the Aptos Jr. High well, the Polo Grounds well and the Cox wells) are from 2001-2007. Creekbed elevations at the points nearest the six well locations with water-level data were obtained from U.S. Geological Survey quadrangle maps, cross-checked with Google Earth® and Topo!® software. These different sources generally agreed with each other to within +/-3 feet.

These data reveal that the groundwater table is 50-125 feet below the creek bed. Based on the widespread occurrence of relatively permeable shallow subsurface materials and measured flow losses of only 0.14 to 0.72 cfs, this separation is too large to maintain a hydraulic connection between groundwater and the creek. Therefore, groundwater pumping and changes in water table elevation have no effect on seepage losses from the creek, which occurs at a rate limited by creek bed permeability, not water table elevation. Historical water levels indicate that a large vertical separation between the creek bed and water table has existed for at least the last 30 years. Because of the large depth to the water table beneath Valencia Creek, and lack of hydraulic connection between groundwater and surface water in the vicinity of the Polo Grounds and Aptos Jr. High wells, increased pumping at these wells will not deplete baseflow and will have no effect on fish populations.

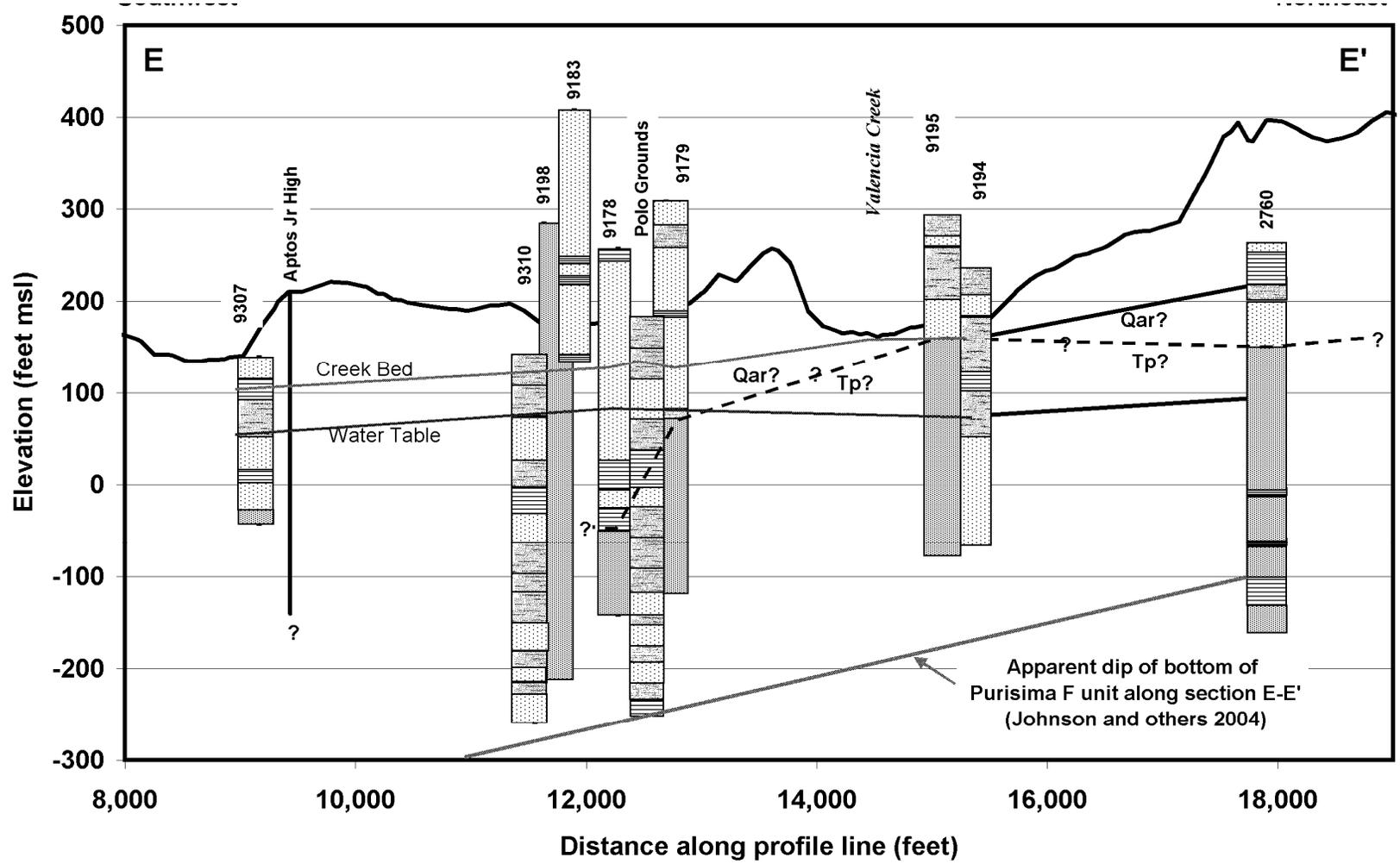


Figure 37. Southwest-Northeast Hydrogeologic Section E-E' Parallel to Valencia Creek

Section 8 CONCLUSIONS

The major conclusions reached by this analysis are grouped below based on type of effect.

WATER LEVEL EFFECTS

Based on comparisons of the estimated drawdown around the proposed new wells and available information from nearby private and municipal wells, pumping at the five preferred well sites will only marginally affect water levels in nearby wells. At specific locations where effects may occur from pumping the new wells, the effects can be mitigated through redistributing pumping. Particular results for each well site include the following:

- Cunnison Lane and Granite Way Well Sites. The planned pumping at both the Cunnison Lane and Granite Way well sites will have marginal effects on nearby wells. Additionally, the likely redistribution scenarios include decreased pumping at existing wells near the Cunnison Lane and Granite Way well sites. This redistribution will more than offset drawdown effects from the Cunnison Lane and Granite Way wells. Therefore, there is a beneficial combined effect from redistributing pumping.
 - O'Neill Ranch Well Site. Operating the O'Neill Ranch well at its maximum seasonal rate will lower water levels at the City of Santa Cruz's Live Oak wells, but water levels will not reach the level of a restrictive effect based on recent data. Additionally, the planned decrease in pumping at the Garnet well will mitigate any water level decreases at the Live Oak wells. Pumping the O'Neill Ranch well will lower water levels at nearby private wells but these water level effects on the nearby wells will be marginal. Pumping may also increase at the Main Street well during droughts, and the combined pumping at the O'Neill Ranch and Main Street well will lower water levels at nearby private wells, but these water level effects on the nearby wells will be marginal. Therefore, the water level effects from the O'Neill Ranch well and redistributing pumping in this area are marginal at worst.
 - Polo Grounds Well Site. Operating the Polo Grounds well at its maximum seasonal rate will lower water levels at the Central Water District's wellfields, but water levels will not reach the level of a restrictive effect based on recent data. The planned pumping redistribution will further lower water levels in the CWD wells; however under average conditions water levels will not reach the level of a restrictive effect. Redistributing pumping could initiate dewatering of a well screen at CWD well #10 if background water levels ever
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fall to levels observed at the end of the last extended drought. This is a potentially restrictive effect that could be mitigated by reducing pumping at the Polo Grounds well and/or the Aptos Jr. High well. Increases of pumping at the Polo Grounds well and Aptos Jr. High well will lower water levels at nearby private wells, but these water level effects will be marginal.

- Austrian Way Well Site. Operating the Austrian Way well at its maximum seasonal rate will have marginal effects on nearby wells. Pumping the Austrian Way well will lower water levels at nearby private wells, but water levels will not reach the level of a restrictive effect. There are no other municipal wells in this area, so the planned pumping redistribution has no effect on nearby water levels. Therefore, there is no combined effect from redistributing pumping in this area.

WELL YIELD EFFECTS

Well yield effects due to lower water levels are marginal for all private and most municipal wells. At nearby wells, the simulated drawdown is a small percentage of the total operating head of the well pump and could increase pump operating time slightly. The nearby private wells are all domestic wells which typically operate only occasionally during the day, so a small increase in pump run time would not diminish the amount of water available to the user.

Well yield effects due to changes in the direction of contaminant transport at nearby regulated sites are marginal. At regulated sites near the O'Neill Ranch well site where contaminant levels are monitored, the direction of contaminant movement is only marginally affected by pumping the O'Neill Ranch well. At the Quik Stop site near the Cunnison Lane well site, likely decreases in pumping at the Rosedale and Tannery II wells will offset effects on remediation wells by pumping the Cunnison Lane well, resulting in no adverse effect on yields of nearby private wells.

Lower water levels could potentially decrease the yield of the City's Live Oak wells due to the increased threat of seawater intrusion. This restrictive effect can be mitigated by redistributing pumping away from the Garnet well. Likely decreases in pumping at the Garnet well will offset yield effects at the Live Oak wells caused by pumping the O'Neill Ranch well, resulting in no well yield effect.

STREAM EFFECTS

Particular results for each well site include the following:

- Cunnison Lane and Granite Way Well Sites. The likely redistribution scenarios include decreasing pumping at existing wells near the Cunnison Lane and Granite Way well sites. There will be a net decrease of groundwater pumping in the area and any pumping effects on nearby creeks will be beneficial.
- Austrian Way Well Site. Water levels measured in the newly installed monitoring well at the site are 350 feet below ground surface, indicating a large vertical hydraulic separation between the shallow aquifer and the BC aquifer that will likely be pumped by a well at this location. This existing downward gradient implies that some leakage is already occurring, and pumping a well at the Austrian Way site will likely increase this leakage rate only minimally. Furthermore, streamflow depletion from pumping a well at this site will be slow and diffuse, and decreases in pumping along Aptos Creek downstream of this site will mitigate the effects. Therefore, the effects are likely to be marginal.
- O'Neill Ranch Well Site. The only nearby creek with the necessary conditions for baseflow depletion and fish habitats is Soquel Creek. Due to its distance from Soquel Creek, the O'Neill Ranch well will have less effect on baseflows than the Main Street Well effects, which have thus far been below the detection threshold. The maximum possible effect on baseflows by the new O'Neill Ranch pumping and the pumping redistribution in non-drought and drought years is estimated to be between 0.07 and 0.14 cfs. The actual effect will likely be less than this and marginal.
- Polo Grounds Well Site. Historical water levels indicate that a large vertical separation has existed between the Valencia Creek bed and the water table for the last 30 years. Therefore, there is no hydraulic connection between surface water and groundwater in the vicinity of this well and increased pumping in this area will have no effect on baseflow.

Sincerely,



Cameron Tana



Derrick Williams
HydroMetrics LLC

Attached: References
Attachment 1: Well Site Selection Process

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Attachment 1. Well Site Selection Process

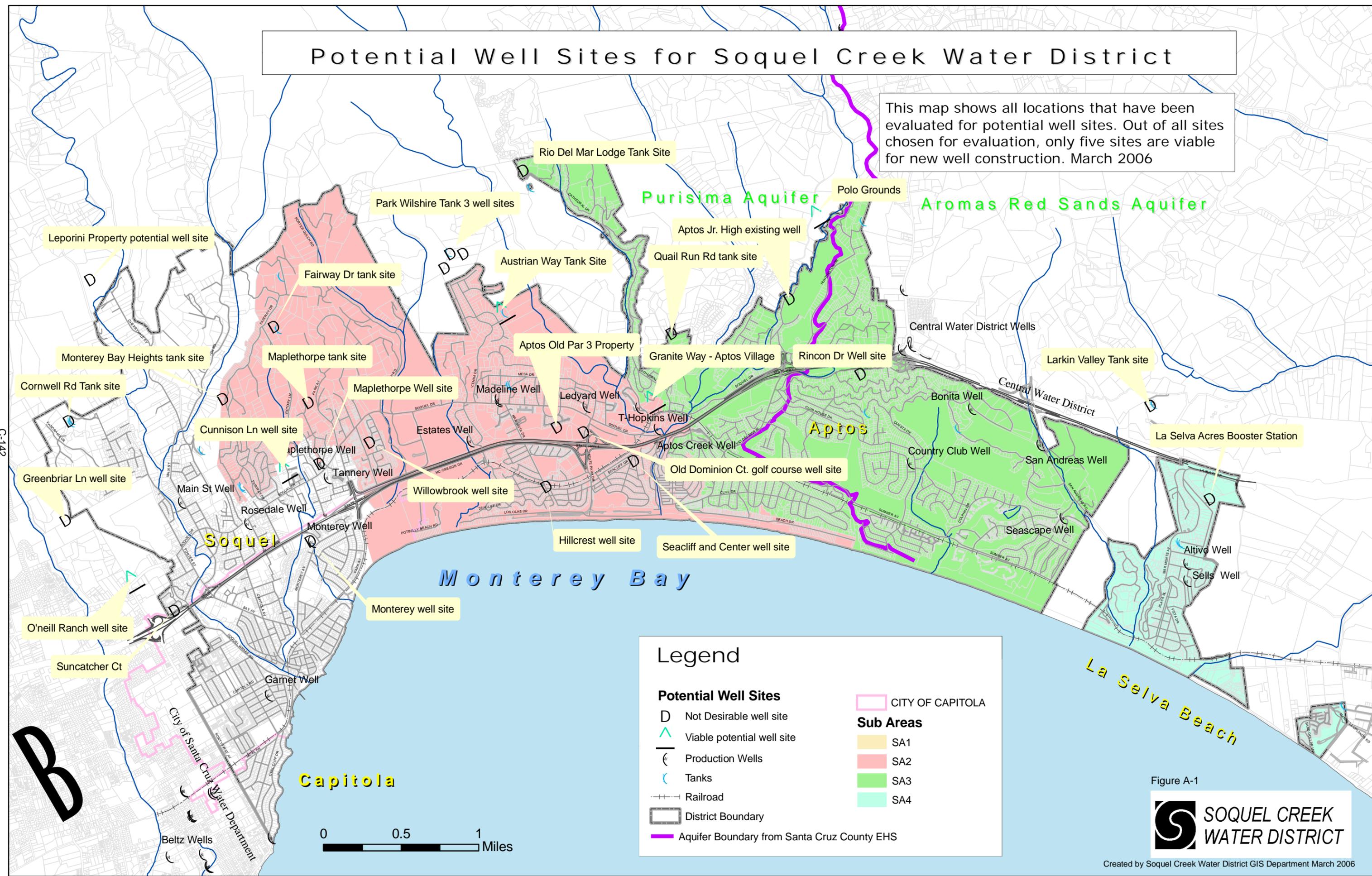
The five proposed sites for new supply wells were the result of a screening process in which a large number of potential sites were identified and ranked according to a number of feasibility and cost criteria. Soquel Creek Water District staff identified 25 parcels potentially suitable as well sites. These were parcels that SqCWD owns or could likely purchase, are located in or near the service area and existing water distribution system and are not too close to the coast or to existing wells. The locations of the candidate sites are shown in **Figure 1-1**. Each site was visited and relevant site characteristics were inventoried. These included size, access, ownership, construction logistics, general groundwater conditions, availability of power, storm drainage and sanitary sewer service, proximity to potential sources of contamination, and other characteristics.

Sixteen of the site characteristics were chosen as site selection criteria, and a score of 1 to 5 (worst to best) was assigned for each characteristic at each site. The sites were ranked on the basis of their total scores. Sixteen sites had one or more characteristics deemed sufficiently poor to be a “fatal flaw”. These were excluded from further scoring. **Table 1-1** lists all of the sites and describes the fatal flaws that were the basis for excluding some wells. It also shows the total scores for wells that were carried forward in the evaluation. **Table 1-2** shows the scoring details for those wells.

A final consideration was to meet the internal yield objectives for each of SqCWD’s four service areas. The five preferred well sites were selected from among the top-ranking sites to achieve the desired geographical distribution of new production capacity.

Potential Well Sites for Soquel Creek Water District

This map shows all locations that have been evaluated for potential well sites. Out of all sites chosen for evaluation, only five sites are viable for new well construction. March 2006



Legend

- | | |
|---|------------------|
| Potential Well Sites | CITY OF CAPITOLA |
| Not Desirable well site | Sub Areas |
| Viable potential well site | SA1 |
| Production Wells | SA2 |
| Tanks | SA3 |
| Railroad | SA4 |
| District Boundary | |
| Aquifer Boundary from Santa Cruz County EHS | |

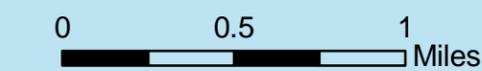
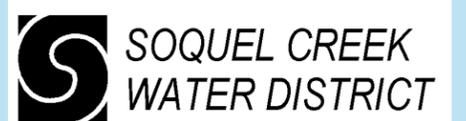


Figure A-1



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Table 1-1
Soquel Creek Water District Well Master Plan
Potential Well Site Evaluation and Selection

Sub Area	Well	Score	Description
I	Cornwell Road Tank Site	None	Fatal Flaw- Too close to nearby septic systems
I	Fairway Drive Tank Site	None	Fatal Flaw- Too close to nearby septic systems
I	Maplethorpe Well Site	None	Fatal Flaw- Too close to Tannery Well
I	Monterey Well Site (replacement well)	None	Fatal Flaw- Too close to the coast
I	Leporini Property	None	Fatal Flaw- Outside of Urban Services Line and Distance to WM
I	Greenbriar Lane	None	Fatal Flaw- Riparian ROW on the property
II	Hillcrest	None	Fatal Flaw- Site too small
II	Monterey Bay Heights Tank Site	None	Fatal Flaw- Site too small and too close to nearby septic systems
II	Seacliff Dr. & Center Ave., Aptos	None	Fatal Flaw- Site too small
II	Willowbrook Lane Well Site	None	Fatal Flaw- Too close to Tannery & Estates Well and impacted GW area
II	Aptos Par 3 Property (acquire site)	None	Fatal Flaw - depressed ground water area
II	Old Dominion Court	None	Fatal Flaw- Site too small
III	Rincon Drive Well Site	None	Fatal Flaw- Too close to nearby septic systems
III	Quail Run Road Tank Site	None	Fatal Flaw- Too close to nearby septic systems and site conditions
III	Rio Del Mar Lodge Tank Site	None	Fatal Flaw- Site too small
IV	La Selva Acres	None	Fatal Flaw- Site Too Small
I	O'Neill Ranch Well Site	72	
II	Austrian Way Tank Site	70	
I	Cunnison Lane	68	
III	Polo Grounds	68	
I	Suncatcher Court	67	
II	Park Wilshire Tank Site (Surplus Property)	66	
III	Aptos Village	66	
IV	Larkin Valley Tank Site	65	
I	Maplethorpe Tank Site	63	

Table 1-2
Soquel Creek Water District Well Master Plan
Potential Well Site Evaluation and Selection

Sub Area I

Criteria	Cornwell Road Tank Site		O'Neill Ranch Well Site		Suncatcher Court		Cunnison Lane		Leporini Property	
	Description	Score	Description	Score	Description	Score	Description	Score	Description	Score
1 Subarea to Serve			Service Area I		Service Area I		Service Area I			
2 Location: Coastal Zone or Inland			Inland	5	Inland	5	Inland	5		
3 SqCWD-owned Property			No	3	Yes	5	Yes	5		
4 Interference with other Municipal Wells			No (>3000 ft.)	5	No (>3,000 ft.)	5	Yes (Tannery Well approx. 1500' away)	3		
5 Proximity to shallow wells			Yes (neighbors use shallow private wells)	3	No (neighbors served by SqCWD)	5	Yes (neighbors use shallow private wells)	3		
6 Property Size (for pump house and Treatment Plant, if required)			Excellent	5	Good	3	Excellent	5		
7 Purisima or Aromas Aquifer			Purisima		Purisima		Purisima			
8 Formation Considerations			None	5	Close proximity to Soquel Creek	3	None	5		
9 Access to Site for Drill Rig and Equipment			Excellent	5	Difficult	2	Excellent	5		
10 Distance to water distribution and existing pipe size			12", 1000' LF	4	8", at street	3	12", On-site	5	8", 3,900 LF	FATAL FLAW- distance to existing WM
11 Water Treatment Required			Yes	3	Yes	3	Yes	3		
12 Groundwater elevations in the area			High	5	High	5	Fair	3		
13 Hazards assessment	High	FATAL FLAW- Proximity to Seacrest Subdivision's Septic Fields as well as other nearby septic systems	None to Minimal	5	None to Minimal	5	Medium to High	3		
14 Agricultural operations			No	5	No	5	Minimal	4		
15 Residential Disturbance and Noise			Minimal	4	Medium to High	3	Minimal	4		
16 PG&E Power available			Yes	5	Yes	5	Yes	5		
17 Storm Drain Availability for well discharge of raw water			Yes	5	Yes	5	Yes	5		
18 Sewer Collection system for treatment plant sludge			Yes	5	Yes	5	Yes	5	No	FATAL FLAW- outside of Urban Services Line
Score Total:	None		72		67		68		None	

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Table 1-2
Soquel Creek Water District Well Master Plan
Potential Well Site Evaluation and Selection

Sub Area I (continued)

Criteria	Monterey Well Site (replacement well)		Maplethorpe Well Site		Fairway Drive Tank Site		Maplethorpe Tank Site		Greenbriar Lane	
	Description	Score	Description	Score	Description	Score	Description	Score	Description	Score
1 Subarea to Serve							Service Area I			
2 Location: Coastal Zone or Inland	Coastal Zone	FATAL FLAW- Too close to the Coast					Inland	5		
3 SqCWD-owned Property							Yes	5		
4 Interference with other Municipal Wells			Yes (Tannery is approx. 500' away)	FATAL FLAW- Too close to Tannery Well			No (>3000 ft.)	5		
5 Proximity to shallow wells							Yes (neighbors use shallow private wells)	3		
6 Property Size (for pump house and Treatment Plant, if required)							Good	3	Riparian ROW is in the middle of the property	FATAL FLAW- Site Restrictions
7 Purisima or Aromas Aquifer							Purisima			
8 Formation Considerations							None	5		
9 Access to Site for Drill Rig and Equipment							OK, Slopes	3		
10 Distance to water distribution and existing pipe size							100' to 8" Main	4		
11 Water Treatment Required							Yes	3		
12 Groundwater elevations in the area							High	5		
13 Hazards assessment					High	FATAL FLAW- Too close to nearby septic systems	Medium to High (goats next door)	3		
14 Agricultural operations							No	5		
15 Residential Disturbance and Noise							Medium to High	3		
16 PG&E Power available							No	3		
17 Storm Drain Availability for well discharge of raw water							Yes	5		
18 Sewer Collection system for treatment plant sludge							Septic. A lateral 175 LF of lateral extension will need to be constructed	3		
Score Total:	None		None		None		63		None	

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Table 1-2
Soquel Creek Water District Well Master Plan
Potential Well Site Evaluation and Selection

Sub Area II

Criteria	Willowbrook Lane Well Site		Aptos Par 3 Property		Park Wilshire Tank Site (Surplus Property)		Austrian Way Tank Site	
	Description	Score	Description	Score	Description	Score	Description	Score
1 Subarea to Serve					Service Area II		Service Area II	
2 Location: Coastal Zone or Inland					Inland	5	Inland	5
3 SqCWD-owned Property					Yes	5	Yes	5
4 Interference with other Municipal Wells	Site is between Estates and Tannery	FATAL FLAW- Too close to Tannery Well			No (>3000 ft.)	5	No (2,950 ft. from Madeline)	5
5 Private or Mutual Wells nearby					No private wells are known to be nearby. Area is served by SqCWD	5	No private wells are known to be nearby. Area is served by SqCWD	5
6 Property Size (for pump house and Treatment Plant, if required)					Good	3	Excellent	5
7 Purisima or Aromas Aquifer					Purisima		Purisima	
8 Formation Considerations	Low GW Levels in area	FATAL FLAW- Too close to impacted GW Area			Site is on high ground. May be more advantageous to drill in a lower elevation of the District	3	Site is on high ground	3
9 Access to Site for Drill Rig and Equipment					Difficult	2	Fair to Good	4
10 Distance to water distribution and existing pipe size					8" main, on-site	4	10" main, on-site	4
11 Water Treatment Required					Yes	3	Yes	3
12 Groundwater elevations in the area	Depressed area	FATAL FLAW- Depressed GW Conditions	Very Low	FATAL FLAW- DEPRESSED GW AREA	High	5	High	5
13 Hazards assessment					None to Minimal	5	None to Minimal	5
14 Agricultural operations					No	5	No	5
15 Residential Disturbance and Noise					Medium to High	3	Medium to High	3
16 PG&E Power available					Yes (On-Site)	5	Yes (On-Site)	5
17 Storm Drain Availability for well discharge of raw water					Yes, roadside drainage ditch	5	Yes (approx. 1 block away)	5
18 Sewer Collection system for treatment plant sludge					No. 1,500 LF sewer lateral extension will need to be constructed	3	No. 1,500 LF sewer lateral extension will need to be constructed	3
Score Total:	None		None		66		70	

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Table 1-2
Soquel Creek Water District Well Master Plan
Potential Well Site Evaluation and Selection

Sub Area II (continued)

<i>Criteria</i>	Monterey Bay Heights Tank Site		Hillcrest		Seacliff Dr. & Center Ave., Aptos		Old Dominion Court	
	<i>Description</i>	<i>Score</i>	<i>Description</i>	<i>Score</i>	<i>Description</i>	<i>Score</i>	<i>Description</i>	<i>Score</i>
1 Subarea to Serve								
2 Location: Coastal Zone or Inland			Coastal Zone	Fatal Flaw- Close to Coast	Coastal Zone	Fatal Flaw- Close to Coast		
3 SqCWD-owned Property								
4 Interference with other Municipal Wells								
5 Private or Mutual Wells nearby								
6 Property Size (for pump house and Treatment Plant, if required)	Very Small	Fatal Flaw- Too Small	Very Small, too close to coast, Site is Fatally Flawed	Fatal Flaw- Too Small	Very Small, too close to coast, Site is Fatally Flawed	Fatal Flaw- Too Small	Very Small	Fatal Flaw- Too Small
7 Purisima or Aromas Aquifer								
8 Formation Considerations								
9								
10 Access to Site for Drill Rig and Equipment								
11 Distance to water distribution and existing pipe size								
12 Water Treatment Required								
13 Groundwater elevations in the area								
14 Hazards assessment								
15 Agricultural operations								
16 Residential Disturbance and Noise								
17 PG&E Power available								
18 Storm Drain Availability for well discharge of raw water								
19 Sewer Collection system for treatment plant sludge								
Score Total:		None		None		None		None

Table 1-2
Soquel Creek Water District Well Master Plan
Potential Well Site Evaluation and Selection

Sub Area III

Criteria	Aptos Village		Polo Grounds		Quail Run Road Tank Site		Rincon Drive Well Site		Rio Del Mar Lodge	
	Description	Score	Description	Score	Description	Score	Description	Score	Description	Score
1 Subarea to Serve	Service Area III		Service Area III							
2 Location: Coastal Zone or Inland	Inland	5	Inland	5			Coastal Zone	Fatal Flaw- Close to Coast		
3 SqCWD-owned Property	No, although purchase of small parcel could be available from the Aptos Village Project	3	No, owned by County of Santa Cruz. Existing well is only used for irrigation.	3						
4 Interference with other Municipal Wells	Yes, T-Hopkins and Ledyard Well. Aptos Creek Well would be destroyed with the construction of this well at Aptos Village	1	No, 3,000 LF from Aptos Jr. High Well	5						
5 Private or Mutual Wells nearby	No private wells are known to be nearby. Area is served by SqCWD	5	Yes (neighbors use shallow private wells)	3						
6 Property Size (for pump house and Treatment Plant, if required)	Good	3	Excellent	5					Very Small	Fatal Flaw- Too Small
7 Purisima or Aromas Aquifer	Purisima		Purisima							
8 Formation Considerations	None	5	Near Valencia Creek	3						
9 Access to Site for Drill Rig and Equipment	Excellent	5	Excellent	5	Difficult due to hillside. Would require extensive site prep with grading and retaining walls.	FATAL FLAW- Site is too steep				
10 Distance to water distribution and existing pipe size	Well would require 500-600 LF of raw water line to the T-Hopkins Treatment Plant	4	No water main at this time but it will be constructed as part of the Prop 50 Grant, if awarded.	4						
11 Water Treatment Required	Yes (would use T-Hopkins)	4	Yes	3						
12 Groundwater elevations in the area	Fair	3	High, according to L&S (Well Analysis File)	5						
13 Hazards assessment	None to Minimal	5	Minimal (fertilizers)	4	Medium to High (Septic systems)	FATAL FLAW- Too close to Septic Systems	High	FATAL FLAW- Too close to Septic Systems		
14 Agricultural operations	No	5	No	5						
15 Residential Disturbance and Noise	Medium to High	3	Medium to High	3						
16 PG&E Power available	No PG&E at this time, but will be constructed as part of Aptos Village Projects in the future.	5	Yes (On-Site)	5						
17 Storm Drain Availability for well discharge of raw water	No SD at this time, but will be constructed as part of Aptos Village Projects in the future.	5	Yes, Riparian Corridor near site.	5						
18 Sewer Collection system for treatment plant sludge	No sewer lateral at this time, but will be constructed as part of Aptos Village Projects in the future.	5	No. Sewer Lateral and lift station will be constructed as part of the Prop 50 Grant, if awarded.	5						
Score Total:		66		68		None		None		None

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Table 1-2
Soquel Creek Water District Well Master Plan
Potential Well Site Evaluation and Selection

Sub Area IV

<i>Criteria</i>		<i>La Selva Acres</i>		<i>Larkin Valley Tank Site</i>	
		<i>Description</i>	<i>Score</i>	<i>Description</i>	<i>Score</i>
1	Subarea to Serve			Service Area IV	
2	Location: Coastal Zone or Inland			Inland	5
3	SqCWD-owned Property			Yes	5
4	Interference with other Municipal Wells			No (>4,500 ft.)	5
5	Private or Mutual Wells nearby			Yes (neighbors use shallow private wells)	3
6	Property Size (for pump house and Treatment Plant, if required)	Very Small	FATAL FLAW- Too Small and difficult access	good size	3
7	Purissima or Aromas Aquifer			Aromas Red Sands	
8	Formation Considerations			Would require a deep well since site is on high ground	3
9	Access to Site for Drill Rig and Equipment			Poor	2
10	Distance to water distribution and existing pipe size			12" on site	5
11	Water Treatment Required			No	5
12	Groundwater elevations in the area			unknown	2
13	Hazards assessment			Minimal	5
14	Agricultural operations			No	5
15	Residential Disturbance and Noise			Minimal	4
16	PG&E Power available			Yes	5
17	Storm Drain Availability for well discharge of raw water			No	3
18	Sewer Collection system for treatment plant sludge			Not Needed	5
Score Total:		None		65	