TO: James L. App, City Manager

FROM: Doug Monn, Director of Public Works

SUBJECT: **Water Resources - Groundwater**

DATE: September 7, 2010

Needs: City Council to receive and file the findings and recommendations of recent studies and planning documents concerning the Paso Robles Groundwater Basin.

Facts:

1. Presently the City relies on groundwater to supply community water needs - 7,600 acre feet annually.

   NOTE: Nacimiento water will provide approximately half of the City's annual use once a treatment plant is constructed.

2. Current basin-wide use (including City) approximates 103,000 acre feet annually.[1]

3. Recent studies of the basin conclude that:

   a. Pumping is approaching the "safe" perennial yield

   b. Information on basin water resources is insufficient, monitoring needs to be improved, and the basin computer model needs to be improved and regularly updated.

   c. Active management of the basin, and development of additional water supplies, is needed to maintain a reliable and high quality water supply.

4. In July 2010 the County circulated a draft of the "Resource Capacity Study, Water Supply in the Paso Robles Groundwater Basin" (RCS), **Attachment A**. The RCS's purpose is to inform land use planning decisions by the County Board of Supervisors.

5. The RCS recommends a Level of Severity III for the entire basin, including the Atascadero subbasin. A Level of Severity III designation means that groundwater is being used at its upper dependable limit and/or groundwater depletion may occur before new supplies are developed.

6. The draft RCS recommends:

   a. limitations on non-agricultural development and water use
   b. preparation of a Groundwater Basin Management Plan
   c. collaboration with agriculture for water conservation
   d. conservation outreach to rural groundwater users
   e. an expanded groundwater monitoring network
   f. regular updates to groundwater studies

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[1] Source: Fugro March 2010 Water Balance Update; summation of outflows for the Paso Robles Groundwater Basin plus the Atascadero Subbasin

7. The overall findings of the draft RCS seem correct. The City's comments (**Attachment B**) urged the RCS to:

    a. Underscore the interconnectivity, or "unity," of the entire groundwater basin,

    b. Provide more focus on surface water projects to supplement supply, and

    c. Clarify County roles in implementing recommendations.

8. The City and County, with other groundwater users, is preparing a Groundwater Management Plan (GMP) which identifies objectives to stabilize groundwater levels. The GMP also identifies actions to achieve the objectives including improved monitoring, increased conservation, use of surface water, and growth management, among others.

9. Other County planning efforts with implications for local groundwater management include the County Conservation and Open Space Element (COSE), Agricultural Element, the Shandon Community Plan, Integrated Regional Water Management Plan, the Master County Water Plan, and the recently launched Land Use and Circulation Elements Update.

10. City water resource management is guided by the City General Plan, Urban Water Management Plan (UWMP), and the 2007 Integrated Water Resources Plan. The 2010 update of the UWMP is underway and will document City water supply, demand, and reliability and it will encourage water recycling, and conservation.

11. Additionally, The City is party to an agreement with various landowners, San Miguel CSD, and the County, which calls for cooperation in basin management efforts.

12. Last, groundwater studies published in 2009 and 2010 offer observations about basin status (**Attachments C through E**).

Analysis and Conclusion: Groundwater remains a cornerstone of City water supply, to be supplemented with Nacimiento Water upon completion of the water treatment plant.

The attached matrix (**Attachment F**) illustrates selected planning/policy documents, resource management plans/agreements, and technical studies/monitoring programs with implications for groundwater.

Given these inter-related efforts, the City needs—and is developing—a consistent approach to groundwater management and a clear message firmly grounded in the water resource goals defined in 2004 including:

- Improve water quality
- Increase and diversify water resources
- Increase reliability of water supplies
- Reduce groundwater basin dependence
- Reduce salt loading into the basin

Specific objectives to achieve these goals include:

1. Supplement current water supply with reliable, better quality surface water from Lake Nacimiento at the earliest possible date
2. Carefully evaluate the adequacy and reliability of water resources when considering land development projects
3. Balance land planning against the adequacy and reliability of the water resources available
4. Encourage pumpers to cooperate in groundwater basin management
5. Support the County in regulating rural residential development and managing groundwater
6. Support conservation by all groundwater users
7. Improve water resource monitoring programs and regularly update the computer model

And, once the UWMP is updated, review and revise City policy documents including a General Plan update to link water supply to growth and development policies .

Policy Reference: City Municipal Code Section 14.02; 2005 UWMP; and 2007 Integrated Water Resources Plan.

Fiscal Impact: None.

Options: Receive and file.

Attachments:

A. "Revised Draft Resource Capacity Study Water Supply in the Paso Robles Groundwater Basin" (RCS) prepared by the San Luis Obispo County Planning Department dated July 2010.

B. City Comments on RCS dated August 25, 2010

C. "Evaluation of Paso Robles Groundwater Basin Pumping Water Year 2006" by Todd Engineers dated May 2009.

D. "Paso Robles Groundwater Basin Water Balance Review and Update" by Fugro West, Inc. dated March 2010

E. "Peer Review of Paso Robles Groundwater Basin Studies Executive Summary" dated July 15, 2010

F. Matrix of Recent Water Management Plans and Studies, Paso Robles Groundwater Basin dated August 2010

Attachment A
Revised Draft Resource Capacity Study
Water Supply in the Paso Robles Groundwater Basin

Revised

Resource Capacity Study

Water Supply in the Paso Robles Groundwater Basin

July 2010

Board of Supervisors

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EXECUTIVE SUMMARY

This Resource Capacity Study (RCS) addresses the state of the Paso Robles Groundwater Basin. It is based on work already accomplished by the County through:

- Fugro 2002 Paso Robles Groundwater Basin Study
- Fugro 2005 Phase II Report
- Todd Engineers 2009 Evaluation of Paso Robles Groundwater Basin Pumping
- Fugro 2010 Paso Robles Groundwater Basin Water Balance Review and Update.

These studies have calculated water use by the major groundwater use sectors (agriculture, rural land uses, small commercial uses, municipal systems and small community systems). Water use by these sectors has increased during the period 1980 to 2009 to the point where basin outflows will soon be greater than basin inflows.

A Level of Severity (LOS) III is recommended for the Paso Robles Groundwater Basin, the Atascadero Subbasin and the Estrella/Creston Area of Concern. Recommended actions include water conservation measures that will lead to more efficient water use and land use controls that will reduce conflicts over the limited groundwater resource.

INTRODUCTION

The Resource Management System

The County's Resource Management System (RMS) is a mechanism for ensuring a balance between land development and the resources necessary to sustain such development. When a resource deficiency becomes apparent, efforts are made to determine how the resource capacity might be expanded, whether conservation measures could be introduced to extend the availability of unused capacity, or whether development should be limited or redirected to areas with remaining resource capacity. The RMS is designed to avoid adverse impacts from depletion of a resource.

The RMS describes a resource in terms of its "level of severity" (LOS) based on the rate of depletion and an estimate of the remaining capacity, if any. In response to a resource issue or recommended LOS, the Board of Supervisors may direct that a Resource Capacity Study (RCS) be conducted. A RCS provides additional details that enable the Board of Supervisors to certify a LOS and adopt whatever measures are needed to eliminate or reduce the potential for undesirable consequences. The Board of Supervisors directed the preparation of this RCS in January 2007.

Level I	**Resource Capacity Problem** – Projected consumption estimated to exceed dependable supply within 9 years
Level II	**Diminishing Resource Capacity** – Seven year time to develop supplementary water for delivery to users.
Level III	**Resource Capacity Met or Exceeded** – Resource is being used at or beyond its estimated dependable supply or will deplete dependable supply before new supplies are developed.

BACKGROUND

According to the 2002 report on the Paso Robles groundwater basin (the basin) prepared by Fugro, Inc., the basin encompasses an area of approximately 505,000 acres (790 square miles). The basin extends from the Garden Farms area south of Atascadero to San Ardo in Monterey County, and from the Highway 101 corridor east to Shandon (See Attachment 1). Internally, the Atascadero subbasin was defined as a single hydrologically distinct subbasin. It encompasses the Salinas River corridor area south of Paso Robles and includes the communities of Garden Farms, Atascadero, Templeton and a portion of the City of Paso Robles' water supply.

The basin also contains "sub-areas" (as opposed to the subbasin) that are identified for management purposes only (see Attachment 1). They do not constitute separate subbasins such as the Atascadero subbasin. These sub-areas do not have safe yields separate from the basin as a whole. Due to the complexity of the hydrogeology at the sub-area boundaries and the amount of data that would be needed to determine the behavior at those boundaries, it is not possible to establish a safe yield for these sub-areas. However, it is possible to draw conclusions regarding the proportions of total basin pumping by sub–area. This RCS addresses this issue below.

<u>What is the "safe yield" of a groundwater basin?</u>

Safe yield (often called perennial yield or sustainable yield) is the amount of naturally occurring groundwater that can be withdrawn from an aquifer on a sustained basis, economically and legally, without impairing the native groundwater quality or creating an undesirable effect such as environmental damage (C. W. Fetter, Applied Hydrogeology, Third Edition, 1994). “Undesirable effects” frequently cited as consequences of exceeding safe yield include:

- Reductions in streamflow and lake levels
- Drying of wetlands
- Subsidence of the land surface
- Degradation of water quality
- Seawater intrusion into the aquifer’s fresh water in storage (coastal locations)
- Lowering groundwater levels leading to increase in pumping cost
- Lowering groundwater levels leading to the need for deeper wells

How are groundwater levels related to the safe yield of a groundwater basin?

Groundwater levels in wells fluctuate over time, representing the continuous adjustment of groundwater in storage to changes in recharge and discharge. Groundwater levels may fluctuate seasonally and over a period of years, reflecting the net effect of changes in recharge (e.g., percolation of precipitation and streamflow, infiltration of applied water, and subsurface inflow) and changes in outflow (e.g., pumping and subsurface outflow). Groundwater level changes also may be sustained. A long-term trend of groundwater level declines would indicate an imbalance of outflows over inflows.

A water level analysis is based on empirical measurement of water levels in both production wells and monitoring wells. Water levels in individual wells are compared to levels in other wells throughout a basin to create a contour map showing elevations of the groundwater surface. Contour maps are useful for estimating the direction and rate of flow of groundwater within an aquifer. They are also used for estimating the amount of groundwater in storage. Observation of water levels over time can illuminate trends and implications about the long-term prospects for a basin. A series of groundwater elevation maps have been developed for the basin over the years. The maps show contour lines of equal water level elevation (see Attachments 2 and 3).

In general, long-term observation of groundwater levels has found a large area of drawdown. This area of concern is located roughly east and north of the City of Paso Robles, both north and south of State Highway 46. Data collected and analyzed from 1980 to 2006 indicate that the area of drawdown is growing both horizontally and vertically.

Annual recharge of groundwater from precipitation, as well as resulting streamflow, is highly variable; therefore, a long-term analysis of water level trends must include representative periods of above average, below average and average rainfall. Determination of trends is based on a period of observation that is not biased by an unusually dry or wet year or series of years. The data available from the 2002 Fugro report and the 2009 pumping update by Todd Engineers covers the time period 1980 to 2009, an adequate span of time to include varied conditions.

The basin's safe yield has been calculated by Fugro to be 97,700 acre feet/year (afy). The Atascadero subbasin's safe yield has been calculated at 16,400 afy. That means that over a given period of time, which in this case is 1980-1997, outflows of 97,700 acre feet/year can be offset by the same amount of inflow. This will not occur each year (i.e. inflow might not total 97,700 acre feet in any given year). However, when considering the balance of inflows and outflows over a long period of time, 97,700 afy of water can be removed on average, with no long-term effect on the basin. If outflows over a longer term basis, are greater than 97,700 acre feet per year, it is assumed that water cannot be replaced and the process of "mining" groundwater has occurred. Mining of groundwater means that the water removed can never be replaced. Outflows would have to be lower than the safe yield in a future year(s) to the same degree that outflows exceeded the safe yield in order for mining of groundwater to not occur.

The most important thing to remember is that given a reliable safe yield figure, as is the case in the basin, control of outflows so that they never reach safe yield is critical to the health of the basin. As explained above, outflows exceeding the safe yield cannot be replaced through normal inflow conditions unless outflows are brought under the safe yield by the same amount in a future year(s). Therefore, while below or above-average rainfall and attendant basin inflow might have short-term or temporary effects on groundwater levels; in the long-term, basin health is dependent on keeping outflows under the safe yield.

Information Base

This Resource Capacity Study now has three methods to estimate present and forecasted groundwater supply and demand and the state of the basin:

- A water balance and water balance projection from 1998 to 2025 (Fugro 2010).
- Pumping report and safe yield analysis (Todd 2009).
- Observed change in the level of groundwater over 30 years. (Fugro 2005 and Todd 2009).

The information base must be used carefully as many assumptions have gone into the gathering and reporting of data. The data used to calculate present and future demand in the agriculture, rural, small commercial and small community systems is based on estimated factors or "water duties" for each pumping sector.

BASIN WATER SUPPLY AND DEMAND

Basin-wide Supply and Demand

The 2005 Fugro report estimated that the perennial yield of the basin is approximately 97,700 afy. The report estimated that annual pumping had reached approximately 82,600 afy as of the year 2000. The pumping estimate was updated by the 2009 Todd Report (using the 2006 water year), and compared the 2006 pumping estimates with pumping estimates for 1997 and 2000. In 2010, Fugro estimated total pumping in the basin and subbasin as of the year 2009. These estimates show total outflows of 91,838 afy to 96,723 afy in the basin and 15,255 afy to 16,012 afy in the Atascadero subbasin. The ranges are due to use of two different water duties for rural pumping: 1.0 afy and 1.7 afy.

Estimated Basin Pumping by Users

There are five different groups of groundwater “users” included in the supply/demand analysis:

- Agriculture
- Municipal
- Rural
- Small Community Systems
- Small Commercial Systems (e.g. golf courses, wineries, institutional uses)

Table 1
Total Groundwater Pumping by User (1997, 2000, 2006) (afy)

Groundwater User	1997	2000	2006
Net Agriculture	49,683 afy	56,551 afy	58,680 afy
Urban	13,513	14,629	15,665
Rural	9,400	9,993	10,891
Small Community	---	----	594
Small Commercial	1,465	1,465	2,323
Total	**74,061**	**82,638**	**88,153**

Small Community was included in Rural in 1997 and 2000.

As a matter of comparison, the estimated safe yield of the basin is approximately 97,700 afy, while the estimated 2006 total basin pumping was 88,153 afy, or 90% of the safe yield. Fugro 2010 estimates are that the basin has reached 91,838 afy to 96,723 afy (94% - 99% of safe yield) and the Atascadero subbasin has reached approximately 15,255 afy to 16,012 afy (93% - 98% of safe yield). Stated another way, approximate inflows are 977 acre feet/year to 5,862 acre feet/year more than outflows in the basin.

The Todd Report identified the amount of groundwater pumping by each user group. The report also explains the methods used to estimate groundwater pumping where actual pumping records do not exist.

Municipal Pumping

Municipal pumping includes four public water purveyors: 1) City of Paso Robles; 2) Atascadero Mutual Water Co. (AMWC); 3) Templeton Community Services District (CSD); and 4) San Miguel Community Services District. Pumping records from each jurisdiction were used to calculate total municipal pumping.

The City of Paso Robles pumps from both the Atascadero subbasin and the Estrella sub-area portion of the main groundwater basin. Well records were used to accurately determine the volume of pumping from the subbasin and Paso Robles groundwater basin. The AMWC and the Templeton CSD pump from the Atascadero subbasin. The San Miguel CSD pumps from the Estrella sub-area portion of the main Paso Robles groundwater basin. The data for municipal pumping are the most accurate of all uses, as they are based on well pumping records.

In 2010, Fugro updated the estimated municipal pumping figures for the years 2007-2009:

Table 2
Urban Pumping 2007-2009

	AMWC	Paso Robles	Templeton	San Miguel	Total
2007	6210	7668	1673	354	15905
2008	6200	7850	1727	367	16144
2009	6189	8032	1782	379	16382

Agricultural Pumping

Estimating the amount of agricultural pumping is more complex than for other basin users. Agricultural pumping was estimated using acreage and water demands of different types of crops. Crop data show that irrigated acreage rose from 20,172 acres in 1997 to 40,836 acres in 2006. Table 1 (above) shows that although irrigated acreage increased by approximately 100% from 1997-2006, water use increased by less than 20% in the same time frame.

The following is Fugro's 2010 estimate for agricultural pumping for the years 2007-2009:

Table 3
Agricultural Pumping 2007-2009

2007	2008	2009
61,026 afy	62,052 afy	63,077 afy

Small Community Systems

This water use sector includes mutual water companies, county service areas, and mobilehome parks. For small community systems that report groundwater pumping, well records were used to accurately determine their pumping. Using these reports, estimates were derived for the systems that do not report their water use.

Small Commercial Systems

The small commercial pumping sector includes such users as wineries, golf courses and schools. Estimates of water use had to be derived for most of the users, as no data are reported in this sector (only Atascadero State Hospital and the California Youth Authority reported pumping). Water use estimates are based on factors from the Pacific Institute and information from consultation with winery operators.

Rural Pumping

This sector is domestic water use by development in the rural areas. No data exist to measure groundwater pumping by rural domestic users. An estimate was derived by using parcel data and applying a water use factor or "water duty." The assumed water duty of 1.7 afy/dwelling unit was taken from Fugro 2002 and Todd 2009.

There are two alternative water duties for rural pumping used in Fugro's 2010 report. Water duties of 1.00 and 1.7 afy/dwelling were used to calculate rural pumping. These two water duties were used in order to observe the sensitivity of outflows to changes in rural water duties. This Resource Capacity Study uses 1.7 afy, except where noted.

Table 4
Total Basin Pumping by Sector
Safe Yield = 97,700 afy

Groundwater User	1997	2000	2006	2009
Net Agriculture	49,683 afy	56,551 afy	58,680 afy	63,077
Urban	13,513	14,629	15,665	16,382
Rural	9,400	9,993	10,891	11,817
Small Community	---	----	594	----
Small Commercial	1,465	1,465	2,323	2631
Total	**74,061**	**82,638**	**88,153**	**93,907**

Subbasin and Sub-area Pumping

Groundwater pumping is not uniform throughout the basin. Most pumping (39% of the basin total) takes place in the Estrella sub-area. The Atascadero subbasin is next in pumping volume at 18% of the basin total, and the Shandon sub-area is third at 13% of total basin pumping The Estrella sub-area is where the most serious groundwater level declines have been identified (see Attachment 1 for the basin and its sub-areas and subbasin).

The Estrella sub-area does not have its own safe yield estimate, as it is hydrologically part of the larger basin. The Atascadero subbasin, however, is hydrologically distinct from the rest of the basin. Its safe yield is estimated at 16,400 afy (Fugro, 2000). Estimated pumping in the Atascadero subbasin reached 95% of its safe yield in 2006 and reached its safe yield in 2008 (Todd, 2009). A separate LOS can be assigned to the subbasin based on the definitions in the RMS, because the subbasin is hydrologically distinct from the entire basin and has its own safe yield.

Staff has identified an area of the basin--made up of a portion of the Estrella sub-area and the northern portion of the Creston sub-area--that has shown the greatest and most consistent drawdown of water levels since 1980. This area is identified as the "Estrella/Creston Area of Concern" (see Attachment 4).

Atascadero Subbasin

The Atascadero subbasin is a long and narrow strip that extends from the south end of Paso Robles to Santa Margarita on both the east and west sides of the Salinas River (see Attachment 1), Pumping in the subbasin in 2006 is estimated by Todd (2009) as tabulated below. The percentage of total subbasin pumping is also shown for each type of user.

Table 5
Atascadero Subbasin Pumping, 2006

Groundwater User	Amount (afy)	% of Total Subbasin
Agriculture	1,348	9%
Municipal	11,582	75%
Small Community	213	1.3%
Small Commercial	430	2.7%
Rural	1,819	12%
Total	**15,392**	**100%**

Safe yield estimated at 16,400 afy

Municipal pumpers are the primary groundwater users of the Atascadero subbasin. The City of Paso Robles pumps approximately 3,896 afy and

Atascadero Mutual Water Company (AMWC) pumps approximately 6,221 afy from the subbasin. This is approximately 62% of the safe yield of the basin.

Table 6 shows Fugro's 2010 estimated water use in the subbasin for the years 2007-2009. Total pumping in the subbasin is approaching the safe yield.

Table 6
Estimated Atascadero Subbasin Pumping 2007-2009

Groundwater User	2007	2008	2009
Agriculture	1384 afy	1420 afy	1456 afy
Municipal	11,717 afy	11,852 afy	11,987 afy
Rural/Sm. Community	1832 afy	1836 afy	1839 afy
Small Commercial	444 afy	459 afy	473 afy
Total	15,377 afy	15567 afy	15755 afy

Safe yield estimated at 16,400 afy

Estrella Subarea

The Estrella sub-area is not a hydrologically separate part of the basin as is the Atascadero subbasin. Therefore, no separate safe yield figure is available for the sub-area. The area that has shown the most severe and constant lowering of groundwater levels since 1980 is located in the southern Estrella sub-area and the northern Creston sub-area. As shown below, the Todd Report estimated the breakdown of pumping in the Estrella sub-area in terms of afy and as a percentage of the total pumping:

Table 7
Estrella Sub area Pumping, 2006

Groundwater User	Amount (afy)	% of Total Subbasin
Agriculture	23,110	68%
Municipal	3,930	11.5%
Small Community	156	0.45%
Small Commercial	1,603	5%
Rural	5,277	15.5%
Total	**34,076**	**100%**

In 2006, agriculture was the primary user of water in this sub-area, at 68% of total water use. Rural pumping accounts for 15.5% of total water use and urban use 11.5%.

The Estrella sub-area represents approximately 16% of the total land area in the basin. According to Todd (2009), pumping in the subbasin accounts for approximately 40% of the total amount of water pumped from the entire basin. This proportion will be considered in development of recommended actions in this RCS.

Basin Water Balance

This RCS has been updated to include a groundwater basin water balance continued from 2006 through 2009 and then 2009 through 2025. The water balance update was developed specifically to gauge the effect of varying the rural water duty factor on the overall water balance for the years 1998 through 2009 and of the introduction of Nacimiento Project water into the basin and sub-basin from 2009 through 2025. Attachments 5-13 contain the water balance tables for the Paso Robles groundwater basin developed by Fugro in 2010 (Atascadero subbasin water balance forecasts are discussed separately below). In those tables, all other pumping is held constant and urban pumping is varied according to the delivery schedules of the Nacimiento Project. The water balance shows that urban pumping in the basin grows slowly over the period 2010 to 2016 and then decreases as additional Nacimiento Project water is used in the basin.

In order to see the effects of different assumptions for pumping and growth rates on the water balance, staff developed several different scenarios using different assumptions for water duty (e.g. 1.7 afy vs. 1.0 afy for rural pumping; 1.25 afy/ac for vineyards vs. 0.75 afy/ac.) and forecasted growth in each pumping sector. These water balance projections or scenarios each forecast the status of the basin to the year 2025. A summary of the scenarios, including the projected year when overdraft is reached for each scenario, is as follows:

1. Scenario 1
    a. Agricultural pumping increases 1.5% per year.
    b. Rural\Small Community increases 1.7% per year.
    c. Small commercial pumping increases 4% per year.
    d. Overdraft - 2011

2. Scenario 2
    a. Agricultural pumping increases 3.0% per year.
    b. Rural\Small Community increases 3.47% per year.
    c. Small commercial pumping increases 8% per year.
    d. Overdraft - 2010

3. Scenario 3
    a. Same rate of increase as Scenario 1.
    b. Vineyards use decreased by 0.25 afy/ac.
    c. Overdraft - 2019

4. Scenario 4
    a. Same rate of increase as Scenario 1.

   b. Vineyards use decreased by 0.50 afy/ac.
   c. Overdraft - 2025

5. Scenario 5
   a. Same rate of increase as Scenario 2
   b. Vineyard use decreases by 0.25 afy/ac.
   c. Overdraft - 2014

6. Scenario 6
   a. Same rate of increase as Scenario 2
   b. Vineyard use decreases by 0.50 afy/ac.
   c. Overdraft - 2019

7. Scenario 7
   a. Same rate of increase as Scenario 1.
   b. Rural pumping uses 1.0 afy vs. 1.7 afy.
   c. Overdraft - 2014

8. Scenario 8
   a. Same rate of increase as Scenario 2.
   b. Rural pumping uses 1.0 afy vs. 1.7 afy.
   c. Overdraft - 2011

These eight scenarios all result in inevitable overdraft of the basin anywhere from the year 2010 to 2025. The scenarios that exhibited the greatest effect on overdraft projections were those that reduced vineyard water use from 1.25 and 1.50 afy/acre to 1.00 and 1.25 afy/acre and to 0.75 and 1.00 afy/acre.

Atascadero Subbasin Water Balance

The water balance in the Atascadero subbasin differs from the Paso Robles basin in that a majority of the subbasin pumping is in the urban sector (cities of Paso Robles, Atascadero and the Templeton Community Services District (CSD). The City of Paso Robles receives half of its water supply from wells in the subbasin, while the Templeton CSD and the AMWC receive all their water from the subbasin. Together, these groundwater users account for more than 65% of the water use in the subbasin.

These jurisdictions will be importing Nacimiento Project water into the basin. This imported water resource will keep urban pumping fairly constant through the year 2019 (10,673 afy in 2010 vs. 11,683 afy in 2019). After the year 2019, urban pumping will increase again to 12,567 afy. Outflows in the subbasin are estimated to consistently exceed safe yield (16,400 afy) in year 2021 and thereafter.

Attachment 13 contains the water balance forecasts for the subbasin. Urban pumping values are from Fugro (2010) and are based on a schedule of Nacimiento Project water delivery to the three urban water purveyors.

<u>Summary of the Problem</u>

a. The 2009 Todd Report found that water demand in both the basin and subbasin is approaching safe yields.
b. Groundwater level contour maps have shown consistent lowering of groundwater levels in a wide area east of the City of Paso Robles. Specific well locations and their groundwater levels over time are as follows (from the Paso Robles Groundwater Basin Management Plan):

Table 8
Selected Groundwater Elevations

Well No.	Location	Long Term decline	1997-2009 decline
25S/12E[7] 26K01	North of Airport Rd	80 feet	40 feet
26S/13E[7] 5D01	North of Jardine Rd	120 feet	90 feet
27S/12E[7] 2F02	Southwest corner of City	110 feet	95 feet
26S/12E[7] 15N01	North of City	60' to stable	80 feet

c. The Fugro 2010 Water Balance review finds that the basin is at or nearly at safe yield in 2010, and the introduction of Nacimiento Project water into the basin will offset approximately 66,798 afy of pumping by the year 2025.
d. Increases in outflows in pumping sectors lead the basin into overdraft in spite of the introduction of Nacimiento Project water.
e. According to the Scenarios 7 and 8 above, use of alternative water duties for rural pumping (1.7 afy vs. 1.0 afy) does not result in substantive change to the water balance and the estimated time to reach the basin's safe yield.
f. Introduction of Nacimiento Project water into the Atascadero sub-basin will keep outflows at or just above safe yield through 2016. Outflows will be greater than inflows after 2016 .

Estrella/Creston Area of Concern

An area of the basin - the southern portion of the Estrella sub-area and the northern portion of the Creston sub-area - has shown the greatest and most consistent decline of water levels since 1980 (see Attachment 4). This area is being called the "Estrella/Creston Area of Concern." There is no safe yield estimate for this area. Sustained groundwater level declines represent a stressing of the groundwater resource, may cause water quality problems, and may require groundwater users to lower wells as groundwater levels decline.

The Estrella sub-area (most of which is in the Area of Concern) represents approximately 16% of the area of the groundwater basin. However, approximately 40% of all groundwater pumping takes place within this area. The amount of pumping has caused a substantial drop in groundwater elevations since 1980. The preceding Table 8 is based on data from the Groundwater Management Plan effort by the City of Paso Robles and the County. It shows both short and longer-term declines in wells in the Area of Concern.

Conservation and Data Collection Efforts

Both agricultural and municipal groundwater users have made substantial strides in water efficiency and conservation. Vineyards in the basin have reduced their water use due to economic conditions, more efficient vine and soil management and a commitment to sustainable operations. According to information from the Paso Robles Wine Country Alliance (PRWCA), vineyard water use on a per-acre basis has dropped 50% in the last 10 years. Many vineyards have adopted the "Code of Sustainable Winegrowing Practices" that covers sustainable operations in water, energy, ecosystem management, solid waste reductions and other areas. The result of this multi-year effort is seen in the declining amount of water used on each acre of vineyard. According to the PRWCA, water use in vineyards has been reduced in some cases to less than one acre-foot/acre/year. The Alliance states that ten years ago, vineyard water use was over two acre-feet/acre/year.

Winery water use has also been in decline. For example, J. Lohr Vineyards has an aggressive water efficiency and conservation program at its facilities. Water use at wineries has been reduced from 3.5 gallons of water/gallon of wine to 1.2 gallons of water/gallon of wine (2003-2007); a 66% reduction at this facility.

The vineyard industry has commenced a three year study by U.C. Extension of vineyard water use. It is hoped that this study will more accurately estimate water use in the vineyards. Attachments 5-13 are water balance forecasts using different outflows and water duty assumptions. These scenarios include 0.25-0.50 afy/acre reductions in vineyard water use.

Additionally, the Department has worked with the PRWCA to develop Best Management Practices (BMPs) for water conservation by wineries. These BMPs will address new wineries and will identify actions existing wineries can take to be more water efficient.

The City of Paso Robles has embarked on a far-reaching water conservation effort. Mandatory three-day water use restrictions for residential customers were implemented in April 2009, and the City is committing substantial funds to its water conservation program. A comprehensive long-range water conservation plan is in development with the goal of achieving significant reductions in future per capita water use.

To reduce consumption, Atascadero MWC is aggressively promoting a reduction in use of potable water for landscape irrigation. Educational resources are available on the AMWC website, in its offices, and in periodic brochures included with water bills. A rebate program subsidizes consumers for:

- Turf conversion
- Lawn aeration
- Sprinkler nozzle replacement
- Installation of automated sensors to control irrigation
- Installation of rainwater harvesting systems

Atascadero MWC is a member of the California Urban Water Conservation Council and Partners in Water Conservation.

The Templeton CSD currently promotes water conservation throughout the District. The District has a full time water conservation coordinator who works to educate the public through informational workshops, literature, handouts, and occasional rebate programs. Recently, the District has revised their Water Conservation Ordinance to ensure that conservation standards for the District remain current and efficient. The District is an active member in the SLO County Partners in Water Conservation, Central Coast Partners in Water Quality, and the California Urban Water Conservation Council.

Decision–Making Constraints

There are several possible actions available to address the problem of basin overdraft. However, there are over-arching issues that complicate any action the County might wish to take:

1. The County has a limited regulatory role in water use, especially by cities and agriculture. Therefore, it will be difficult for the County to directly affect the use of water by the two primary groundwater users.
2. The County's primary regulatory role is land use and building.
3. The major portion of basin outflows are not measured, but are estimated. While municipal pumping is measured, agricultural, rural, and small community/commercial pumping is estimated. This adds to the uncertainty regarding actual groundwater use.

4. Identification of rising and falling groundwater levels is based on limited data.

Consistency With the General Plan

As noted above, the County's primary regulatory role is land use regulation and issuance of building permits. The recommended actions below emphasize this regulatory role. These recommended land use and building actions must be consistent with any applicable general plan policies. The Water Resource chapter of the Conservation and Open Space Element (COSE) contains goals, policies and implementation strategies that will affect the recommended actions in this RCS. Policies in the Agriculture Element address the preeminence of agricultural water supply.

Conservation and Open Space Element (COSE)

Goal 1 of the COSE Water Resources chapter states:

> *The County will have a reliable and secure regional water supply*.

Policies in support of this goal include:

> **Policy WR 1.14 Avoid net increase in water use** - Avoid a net increase in non-agricultural water use in groundwater basins that are recommended or certified as Level of Severity II or III for water supply. Place limitations on further land divisions in these areas until plans are in place and funded to ensure that the safe yield will not be exceeded.
>
> **Policy WR 1.2 Conserve Water Resources** - Water conservation is acknowledged to be the primary method to serve the county's increasing population. Water conservation programs should be implemented countywide before more expensive and environmentally costly forms of new water are secured.
>
> **Policy WR 1.7 Agricultural operations** - Groundwater management strategies will give priority to agricultural operations. Protect agricultural water supplies from competition by incompatible development through land use controls.
>
>> **Implementation Strategy WR 1.7.1 Protect agricultural water supplies** - Consider adopting land use standards, such as growth management ordinance limits for non-agriculturally-related development on certain rural areas, larger minimum parcel sizes in certain rural areas, and merger of substandard rural parcels, in

order to protect agricultural water supplies from competing land uses.

Implementation Strategy WR 1.12.2 Require water supply assessments - Require applications for land divisions, which would increase density or intensity in groundwater basins with recommended or certified Levels of Severity II or III for water supply or water systems and are not in adjudication, to include a water supply assessment (WSA) prepared by the applicable urban water supplier (as defined by California Water Code Section 10617). The WSA should:

a. Determine whether the total projected water supplies for the project during the next 20 years will meet the projected water demand associated with the proposed project, in addition to existing and planned future uses, including agricultural uses.
b. If water supplies will be insufficient, the WSA should include the water purveyor’s plans for acquiring additional water supplies.
c. If there is no water purveyor, then the County will direct the preparation of the WSA at the subdivider’s expense.

Goal 2 of the COSE Water Resources chapter states:

The County will collaboratively manage groundwater resources to ensure sustainable supplies for all beneficial uses.

Policies in support of this goal include

a. Implementation Strategy WR 2.2.2 Improve well permit data collection - Improve data obtained from well permit applications regarding location, depth, yield, use, flow direction, and water levels.

b. Implementation Strategy WR 2.2.3 Pursue data collection from all groundwater wells - Secure right of access to all new key wells together with retaining voluntary access to existing wells having useful histories to ensure that the County's investment in these records is protected. Develop a data collection program by seeking permission from each of the well owners for County use with identification of the land owner protected from public or other uses and individual data shall remain confidential.

c. **Implementation Strategy WR 2.2.4 Groundwater data collection from water purveyors** - Require, to the extent feasible, all water purveyors with five or more connections to report monthly pumping data to the Department of Planning and Building on an annual basis for use in the Resource Management System.

d. **Implementation Strategy WR 2.2.5 Groundwater data collection for new development** - Condition discretionary land use permits for new, nonagricultural uses in groundwater basins with a recommended or certified Level of Severity I, II, or III to monitor and report water use to the Department of Planning and Building on an annual basis for use in the Resource Management System.

Agriculture Element

The Agriculture Element addresses priority of groundwater use. The Element states:

AGP11: Agricultural Water Supplies.

a. Maintain water resources for production agriculture, both in quality and quantity, so as to prevent the loss of agriculture due to competition for water with urban and suburban development.
b. Do not approve proposed general plan amendments or rezonings that result in increased residential density or urban expansion if the subsequent development would adversely affect: (1) water supplies and quality, or (2) groundwater recharge capability needed for agricultural use.
c. Do not approve facilities to move groundwater from areas of overdraft to any other area, as determined by the Resource Management System in the Land Use Element.

LOS Criteria

For water supply, the RMS defines levels of severity in relation to the time it would take for the resource to be used to its capacity, as follows:

Level I	**Resource Capacity Problem** – Projected consumption estimated to exceed dependable supply within 9 years
Level II	**Diminishing Resource Capacity** – Seven- year lead time to develop supplementary water for delivery to users.
Level III	**Resource Capacity Met or Exceeded** – Resource is

	being used at or beyond its estimated dependable supply, or dependable supply will be depleted before new supplies are developed.

According to the above table, a Level of Severity III (LOS III) can be established if a basin has reached its safe (or dependable) yield *or dependable supply will be depleted before new supplies are developed* (emphasis added). The water forecasts in Attachments 5-13 indicate that safe yield will be reached in the Paso Robles basin anywhere from 2010 to 2025. With the exception of unallocated Nacimiento Project water, no additional supplemental water supplies are on the horizon.

RECOMMENDATIONS

The following are recommended levels of severity for the basin, the subbasin and Estrella Area of Concern. Recommended actions are divided into conservation and monitoring and land use controls.

A. Paso Robles Groundwater Basin

Recommended Level of Severity: **III**

Recommended Conservation and Monitoring Actions:

1. The City of Paso Robles and the County should complete the Groundwater Management Plan now under preparation. The Plan should, among other things, identify basin management objectives that bring the basin outflows under the safe yield. A basin management objective should be to attain the lowest LOS feasible within the framework of the plan. The District, in coordination with the Planning Department, should facilitate the development of a cooperative agreement amongst basin users to maintain and implement the Plan over time.

2. The County shall work with the agriculture industry, especially grape growers, to collect pumping data from all growers, report water use and identify water use trends with the goal of reducing pumping on an industry-wide basis. Encourage the agriculture industry to increase conservation and sustainability efforts. Report on the outcome of such conservation outreach efforts.

3. The County will continue to conduct biannual groundwater measurements to chart the scope of groundwater level declines.

4. Amend Title 8 of the County Code as follows:

    a. Require measuring devices on new wells in the basin. Develop a protocol for deciding when a well permit application is required to provide the flow or measuring device. Also develop a program by which flow readings are taken and reported to the County.
    b. Require that the new well be a part of the County groundwater level measuring program if needed.
    c. Require, to the extent feasible, all water purveyors with five or more connections to report monthly pumping data to the County.

5. Develop a water conservation outreach and education program for the rural area. The outreach program will inform rural groundwater users of the state of the basin, include suggested conservation and efficiency measures, and if possible, subsidize water conservation and efficiency efforts.

6. Conduct another pumping update after the initial delivery of Nacimiento water and the completion of the Groundwater Management Plan. Additional measures will be recommended at that time as appropriate.

Recommended Land Use Actions

7. Require new discretionary development that uses groundwater to:

    a. Be a part of the County groundwater level measuring program, if needed.
    b. Meter, monitor and report water usage on a yearly basis to the Department of Public Works.
    c. Use best management practices for water conservation and offset new water use.

8. Do not approve General Plan amendments or land divisions in the basin that result in a net increase in the non-agricultural use of water.

9. New wineries shall use best management practices consistent with the BMP's identified in Attachment 14.

10. Revise the Growth Management Ordinance and the Resource Management System to substantially limit yearly non-agricultural development in the basin.

B. Atascadero Subbasin

Recommended Level of Severity: **III**

Recommended Actions: **In addition to the preceding recommendations A1-10:**

1. Encourage the Atascadero Mutual Water Company, the Templeton CSD and the City of Paso Robles to continue to expand their water conservation efforts.

2. Do not approve General Plan amendments or land divisions in the Atascadero subbasin that result in a net increase in the non-agricultural use of water.

C. Estrella/Creston Area of Concern

Recommended Level of Severity: **III**

Recommended Actions: **In addition to the preceding recommendations A1-10:**

1. Require new development in the “Estrella/Creston Area of Concern” that would result in a net increase in the use of water and that is subject to discretionary approval by the County to offset 100% of its water use.

2. Do not approve subdivisions within the “Estrella/Creston Area of Concern”.

3. Revise the Growth Management Ordinance and the Resource Management System to substantially limit yearly non-agricultural development in the Area of Concern.

Attachments:

1. Map of the Basin and subareas
2. Groundwater elevations (2000)
3. Groundwater elevations (2006)
4. Estrella/Creston Area of Concern
5. Scenario 1
6. Scenario 2
7. Scenario 3
8. Scenario 4
9. Scenario 5
10. Scenario 6
11. Scenario 7
12. Scenario 8
13. Atascadero Subbasin Scenario
14. Winery Best Management Practices

References:

1. Todd Engineers; Update for the Paso Robles Groundwater Basin, December 2007

2. Fugro; Final Report; Paso Robles Groundwater Basin Study – Phase II; February 2005

3. Fugro; Final Report; Paso Robles Groundwater Basin Study – Phase I; August 2002

5. Todd Engineers; Evaluation of Paso Robles Groundwater Basin Pumping, Water Year 2006; May 2009

6. Fugro; Paso Robles Groundwater Basin Water Balance Review and Update; March 2010

Attachment B
City Comments on RCS

PASO ROBLES GROUNDWATER BASIN

<u>City of Paso Robles Comments on Draft (July 2010) Resource Capacity Study</u>

Thank you for the opportunity to comment on the Revised Draft Resource Capacity Study Water Supply in the Paso Robles Groundwater Basin (RCS) prepared by the San Luis Obispo County Planning Department dated July 2010.

The City agrees that north county water users have a shared interest, i.e. maintaining a consistent, good quality groundwater supply throughout the Paso Robles Groundwater Basin. Accordingly, the City would urge that the RCS underscore the unity of basin resources as a guiding principle.

General Comments

1) Sustained groundwater level declines occurring over large areas of the basin indicate the need for concrete actions to better balance groundwater supply and demand. The Level of Severity (LOS) III designation seems appropriate and alerts the community to the risk of overdraft if effective action is not taken.

2) The City does not challenge the magnitude and persistence of groundwater level declines, but recommends that the RCS acknowledge significant gaps in the monitoring program (consistent with the findings of recent basin update studies).

3) The RCS should acknowledge that the Atascadero sub-basin is upstream of and drains into the remainder of the basin, specifically the Estrella subarea. In that sense, the Atascadero sub-basin is not separate from the remainder of the basin.

4) The RCS would benefit from additional discussion regarding the feasibility of longer-term water projects (e.g., reclaimed, recycled, and State Water Project supplies) and how these projects might benefit the basin.

5) The County's Resource Management System is a mechanism to evaluate *land development* decisions in the unincorporated areas. As stated on Page 14, "The County has a limited regulatory role in water use, especially by cities and agriculture." With this in mind, RCS recommendations should focus on land development in unincorporated areas.

6) The RCS should clearly delineate the differing roles and responsibilities of the County Planning Department and the Flood Control District. The Planning Department can implement land use and related policies. The Flood Control District must address how to balance the basin and other water supplies.

Page-Specific Comments and suggestions on the Draft RCS are:

- Pg. 2 –*Background*, P2: States it is "not possible" to establish safe yields for basin subareas. This is an over-statement. It would be sufficient to note that separate perennial yields have not been established for the separate subareas.
- Pg. 4 - The discussion uses inaccurate phrases like "mining" and "water cannot be replaced or can never be replaced." The basin does experience recharge (replacement of supply) in certain areas. The discussion also states that outflows must be controlled so that they never reach safe yield. This

also is inaccurate. In the short term, outflows can exceed inflows, and storage will decrease. However, for the long-term average condition, we seek a balance of outflows and inflows to avoid chronic depletion of groundwater storage.

The discussion states that outflows must be controlled so that they never reach safe yield. This is inaccurate. In the short term, outflows can exceed inflows, and storage will decrease. However, for the long-term average condition, a balance of outflows and inflows can avoid chronic depletion of groundwater storage.

- Pg. 12 – The *Summary of the Problem,* item c, states that Nacimiento water will offset 66,798 afy of pumping. This is a misinterpretation of the Fugro Study. The Fugro work states that Nacimiento imports will result in an increase in storage equal to 66,798 AF in the year 2025 (Note: Agricultural, rural residential, and small commercial growth was assumed unchanged from 2009. Such an assumption is unrealistic and confusing; we recommend removing it.
- Pg. 13 – *Conservation and Data Collection Efforts, P1:* The statement is made "According to information from the PRWCA, vineyard water use on a per-acre basis has dropped 50% in the last 10 years." What is the data source or assumptions that provide the basis for this statement? If the statement is anecdotal, it should be specified, or removed altogether.
- Pg. 13 – *Conservation and Data Collection Efforts, P3:* The statement is made that "These scenarios include 0.25-0.50 afy/acre reductions in vineyard water use." This should be clarified as an assumed change in the estimate of water used in the water balance scenarios; it does not refer to an expectation of that level of future gain in vineyard water use efficiency.
- Pg. 14 - *Conservation and Data Collection Efforts*: The discussion of the City of Paso Robles water conservation program should be expanded to include the following.

  The City's existing program includes:

  - Free home water audits
  - Rebates for High Efficiency Toilet retrofits
  - Rebates for turf conversion
  - Regular conservation outreach using bill inserts, direct mail, radio, print media advertising.
  - A school education program.
  - Membership in the California Urban Water Conservation Council.

  Change the last sentence of the first paragraph to *"A comprehensive long-range water conservation plan is in development, with the goal of achieving a 20 percent reduction in per capita water use by the year 2020."*
- Pg. 16 – *Last paragraph:* Even wells with little or no historic data can be valuable to the monitoring network. The point is to add wells that yield meaningful data.

Comments on Recommendations Section (Paragraph numbers noted below)

Overall Recommendation Comment – Since the purpose of the Resource Management System is to evaluate *land development* decisions in the unincorporated areas, the RCS recommendations should dwell on that topic. Other recommendations may be advisory and directed at the Flood Control District.

A. Paso Robles Groundwater Basin – Note that none of this category pertains to land development in unincorporated areas. These may best be communicated in a separate Planning Department communiqué to the Public Works Department.

Specific comments by paragraph:

P1 This section should provide clarification of the respective roles of the Groundwater Management Plan and the RCS. The objective of the GWMP is to achieve a long-term sustainable water supply for the basin.

P3 This section should be amended to read, "The Flood Control District will continue to conduct biannual groundwater measurements to chart the scope of groundwater level declines, publish regularly a groundwater monitoring report, including updates of water level decline maps and trends. In addition, the Flood Control District will increase its efforts to bring additional wells into the water level monitoring network, including seeking funding for construction of dedicated monitoring wells. *"*

P5 This last sentence of this section should read "*The County will develop a water conservation outreach and education program for the unincorporated rural areas. The program will inform rural groundwater users of the state of the basin, include suggesting conservation and efficiency measures, and (resources permitting) include financial incentives for water conservation and efficiency efforts."*

P6 Amend this section to read: "Update the numerical groundwater model within the next 3 to 5 years. Such a timeframe will allow for incorporation of Nacimiento water, inclusion of additional wells to the monitoring network, additional water level and vineyard demand data, and the effect of the water conservation programs outlined in the Groundwater Management Plan."

B. Atascadero Sub-basin – Focus on land development recommendations in unincorporated areas.

<u>Other Comments:</u>

- Where would a landowner go to determine whether his/her parcel is affected by these recommendations?
- The document is silent on the 1/3 of the groundwater basin that extends into Monterey County.

Submitted by:
City of Paso Robles
August 25 2010

Attachment C
Evaluation of Paso Robles Groundwater Basin Pumping
Water Year 2006 by Todd Engineers

Prepared for the
City of Paso Robles
San Luis Obispo County Department of Public Works

Evaluation of Paso Robles Groundwater Basin Pumping

Water Year 2006

May 2009

Todd Engineers
Alameda, California

Evaluation of Paso Robles Groundwater Basin Pumping

Water Year 2006

May 2009

Prepared for the
City of Paso Robles
San Luis Obispo County Department of Public Works

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APPENDIX B

Pumping Within Areas of Declining Groundwater Storage

Background

This report presents a current (2006) estimate of groundwater pumping in the Paso Robles Groundwater Basin (Basin). This evaluation updates the pumping estimate from the *Paso Robles Groundwater Basin Study* (Phase I Report, Fugro, 2002), which provided estimates of pumping for 1997 and 2000.

This pumping evaluation represents another step in the ongoing collaborative effort of local agencies and landowners to monitor and manage groundwater resources in the Paso Robles Groundwater Basin. This pumping evaluation supplements the first Basin Update (Todd Engineers, 2007), which provided an overview of the current condition of the Paso Robles Groundwater Basin, including rainfall, groundwater levels and storage, groundwater quality, and groundwater management planning. Both the Basin Update and this evaluation have been prepared in accordance with the August 2005 Paso Robles Groundwater Basin Agreement among the San Luis Obispo County Flood Control and Water Conservation District (District), City of Paso Robles (City), and certain private landowners, who have organized as the Paso Robles Imperiled Overlying Rights (PRIOR) group. Key elements of the Agreement are a clear acknowledgment that the basin is not in overdraft now, and that the parties will not take court action to establish any priority of groundwater rights over another party as long as the Agreement is in effect.

The District, City, and PRIOR landowners have designated representatives to participate in a committee, informally termed the Paso Robles Groundwater Basin Committee, to develop a plan or program (Plan) for monitoring groundwater conditions in the basin. This Committee, which has conducted periodic meetings since February 2006, has supported preparation of the Basin Update and the Pumping Evaluation as a means of reporting on groundwater conditions and developing recommendations for improved monitoring.

This evaluation of pumping also is responsive to the San Luis Obispo (SLO) County Resource Capacity Study (RCS) for the Paso Robles Groundwater Basin (SLO County, February 2008). The Board of Supervisors conducted a public hearing in January 2007 on the Resource Management System's *Annual Summary Report*. One of the actions taken by the Board that day included a recommendation for a designation of Level of Severity (LOS) I for a portion of the Paso Robles Groundwater Basin. At that time, the Board directed its staff to prepare a Resource Capacity Study (RCS) to determine the groundwater level cone of depression at the -20 foot contour on the west side of the Basin (Figure 34, Fugro, 2002). In response to this directive, County staff is preparing the RCS, which requires an analysis of groundwater basin pumping.

The annual groundwater monitoring and management effort will be continued as part of the development of a SB 1938-compliant Groundwater Management Plan, which was initiated last year as a cooperative effort of the District and City with grant funds awarded by the California Department of Water Resources (DWR). The Plan will bring together all the stakeholders in the basin (District, cities, smaller communities, agricultural interests, landowners, and others) to develop a comprehensive approach to the protection of groundwater resources.

Scope

In order to update the Phase I report, data on land use, population, well production, well location, and water demands were compiled and evaluated. This pumping evaluation includes agricultural, urban, small water system, and rural groundwater use. Total groundwater pumping is compared to the Phase I Report estimate for 1997 and 2000. Groundwater pumping in 2006 is compared to a build-out projection completed as part of the Phase II Report (Fugro, 2005). Based on currently available information, a new projection of groundwater pumping in 2025 was completed. The rural portion of this pumping is compared to an "ultimate build-out" scenario, supplied by SLO County. As part of their RCS, the County requested an analysis of the amount and type of pumping within the -20 foot storage change contour. This analysis is included as an appendix.

Acknowledgments

This evaluation was performed by Linda Spencer, P.G., and Iris Priestaf, Ph.D. We appreciate the cooperation from the City, the District, SLO County Public Works (County Public Works) and Planning departments, and the SLO and Monterey county agricultural commissioner offices (ACO) in supplying data and providing guidance throughout this project. John Kelly from SLO County Planning Department provided extensive GIS analysis of land use parcel data. John McKenzie from SLO County Planning Department provided water use information. Mike Isensee from SLO ACO assisted with crop classifications and provided geographic information system (GIS) coverages of agricultural land use. Mark Gomes from Monterey County ACO provided GIS information and support for agricultural land use. Courtney Howard, Sylas Cranor, and James Caruso of SLO County provided input on land and water use issues and commented on the draft report. Christopher Alakel from the City provided water use data and comments on the draft report.

Hydrologic Conditions in 2006

Figure 1 shows the Paso Robles Groundwater Basin and the location of seven rainfall stations. The stations are distributed throughout the basin representing a range of annual rainfall amounts. The table on Figure 1 summarizes each station's length of record, which range from 25 to 120 years. Historic average annual (July – June) rainfall amounts at these stations range from 9.8 to 19.3 inches while the average of all stations is 14 inches. The data presented are denoted by their ending year. Average rainfall amounts in both 1997 (15.9 inches) and 2006 (17.9 inches) were above the historic average, while 2000 (12.79) was below the historic average.

Evaluation of Pumping

The following sections summarize the data, methodology, and results of the evaluation of pumping for agriculture, municipal uses, small systems (community and commercial), and rural domestic uses.

Agricultural Pumping –58,680 AF

Agricultural pumping was estimated from information on agricultural land use (crop type and acreage) and crop water demands. Crop irrigation water demands are assumed to be satisfied wholly with groundwater. In SLO County, the primary sources of agricultural land use data are reports provided by farmers to the ACO as part of its restricted use materials (e.g., pesticides) permitting process. The data are updated on an ongoing basis as permits are renewed. The data reflect information provided to the ACO as of December 1, 2007. However, some permits are only updated every two years, so some of the information may be up to two years old. The ACO creates a GIS shapefile of the applicant data. A calculation of the crop acreages is based on this shapefile.

The original shapefile from the ACO for SLO County was analyzed and modified as follows:

- Editing to rectify discrepancies between permit numbers and parcels (see Appendix A)
- Identification of agricultural parcels within the Paso Robles Groundwater Basin
- Addition of organic grower parcels, based on data supplied by ACO
- Classification of crops into nine categories in consultation with ACO (Table 1)

In Monterey County, a crop acreage spreadsheet was developed in cooperation with the ACO. Restricted use materials permits within the groundwater basin were compiled by the ACO. The resulting spreadsheet with all crop types was then analyzed to identify the irrigated crops. ACO also provided output from their GIS database. However, the GIS database cannot be directly linked to the spreadsheet because permit numbers are reused and ranch names change frequently. In general, the source maps for south Monterey County are of poor quality and the ranch boundaries may not match actual agricultural use areas. As a result, aerial images were reviewed to confirm the location and size of irrigated parcels.

Agricultural water demand was calculated as follows (see Tables 2 through 5)[1]:

- Irrigated acreage (Table 4) was determined as a percentage of total acreage based on the ratio used in the Phase I Report for 1997 (Table 2).

[1] It should be noted that water demand and groundwater pumping computations may be reported to a fraction of an acre foot. This level of reporting is not intended to claim accuracy to this degree, but is maintained to retain accuracy throughout subsequent computations and to allow the reader to replicate the computations.

- Field crops (e.g., forage and hay) and grains were assumed to be dry-farmed during the relatively wet 2006 season based on discussions with the SLO ACO.
- Gross irrigation water requirements (Table 3) were based on EDAW (1998) except for vineyard demand, which was based on Honeycutt (2004) and Battany (2004).
- Total irrigated acreage (Table 4) was multiplied by gross irrigation water requirements (Table 3) to yield gross irrigation demand (Table 5).

The methodology for calculating the 2006 water demand is comparable to that used in 1997. However, different land use data sources were used to derive total acreages. The 1997 estimate relied on DWR land use studies, while the 2006 estimate relied on land use data generated by ACO permits.

Table 4 summarizes the irrigated crop acreage. Field crops and grains are not listed in the table, consistent with the assumption that these crops were not irrigated in 2006. As shown, an estimated 40,836 acres were irrigated in the Paso Robles Groundwater Basin in 2006. This is a substantial increase from 1997, when 20,172 acres were irrigated. Table 6 provides a comparison of 1997 and 2006 irrigated acreage; as shown, the largest increase occurred in vineyard acreage. Truck crops have increased since 1997, while alfalfa, grains, and field crops have declined.

Figure 2 shows the distribution of irrigated crops for the Paso Robles Groundwater Basin. Salient features of the map are the concentration of irrigated crops in the Estrella, Shandon, Bradley and Creston subareas and the predominance of vineyards. For the purposes of evaluating groundwater pumping on a geographic basis, it was assumed that each irrigated parcel was supplied by a well on that parcel. The resulting assigned location of irrigation pumping is shown on Figure 3.

Based on the above evaluation, gross agricultural pumping was 60,000 acre feet (AF) in 2006. This is about an 18 percent increase over the gross pumping estimate in 1997 (50,768 AF). Despite the 100 percent net increase in irrigated land between 1997 and 2006, the effect on total water demand of increased acreage was offset by the shift from the relatively high-water-use alfalfa to relatively low-water-use vineyards. To calculate net pumping, irrigation return flows were estimated to be 2.2 percent of gross pumping (1,320 AF), based on the proportion used to approximate return flows in the Phase II Report (Fugro, 2005). Therefore net pumping in 2006 is estimated to be 58,680 AF.

Recent agricultural trends since the late 1990s have involved an expansion of irrigated crop acreage, primarily through the planting of vineyards. In the last three years, the SLO ACO has observed expanded vegetable and seed crop acreage in the Paso Robles Basin. The SLO ACO also anticipates a continuing trend to such higher value irrigated crops in locations where irrigation is feasible. Further water conservation in agriculture is considered as becoming less likely, as the most cost-effective conservation measure (e.g., shifting from overhead to drip irrigation) has already occurred. Many vineyards that have instituted irrigation reductions in recent years may not be able to sustain these practices during periods of multiple dry years due to the buildup of salts impacting crop yields (Isensee, M., personal communication, Feb 28, 2008).

Municipal Pumping – 15,665 AF

Municipal pumping includes two relatively large systems (Atascadero Mutual Water Company and Paso Robles Water Department), a medium system (Templeton Community Services District), and one small system (San Miguel Community Services District). A GIS coverage of municipal wells is shown in Figure 4. Although San Miguel and Shandon are both classified by the State of California as small systems, San Miguel was categorized as a municipality and Shandon as a small system (next section) to maintain consistency with the Phase I Report.

Municipal pumping data were provided by County Public Works. Raw pumping data, based on the fiscal year, were converted into water year values.[2] Pumping by the City of Paso Robles occurs within the Estrella subarea and the Atascadero subbasin. To correctly allocate the pumping between the two areas, records for individual wells supplied by the City of Paso Robles were reviewed.

Municipal pumping, totaling 15,665 AF in 2006, is summarized on Table 7. This represents a 16 percent increase from 1997 (13,513 AF).

Small Systems Pumping

The United States Environmental Protection Agency (USEPA) classifies public water systems as those that have at least 15 connections or serve an average of 25 people for at least 60 days a year. Public systems fall into one of three categories:

1. Community water systems that supply water to the same population year-round.
2. Non-transient non-community water systems that supply water to at least 25 of the same people at least six months per year, but not year-round. Examples include schools, factories, office buildings, and hospitals.
3. Transient non-community water systems that provide water in places where people do not remain for long periods of time. Examples include gas stations and campgrounds.

For the purposes of this study, the first category is called "small community systems" and the second and third categories are grouped together into "small commercial systems." Figure 5 shows the location of all small system wells, based on a GIS coverage created for this project.

Small Community Systems Pumping – 594 AF

SLO County provided names and addresses for the small community systems. The systems within the Paso Robles Groundwater Basin are listed below:

1. Adelaide Estates Mutual Water Company (MWC)
2. Almira Water Association

[2] A water year begins on October 1 and ends on September 30. The year is denoted by the ending year. Therefore, water year 2006 begins on October 1, 2005 and ends on September 30, 2006.

3. Garden Farms Community Water District
4. Green River MWC
5. Los Robles Mobile Home Park (MHP)
6. Mustang Springs MWC
7. Rancho Salinas MHP
8. Rest Haven MHP
9. Santa Ysabel Ranch MWC
10. Shandon County Service Area (CSA 16)
11. Spanish Lakes MWC
12. Sweet Springs Mobile MHP
13. Walnut Hills MWC

Information provided included pumping records for Green River Mutual (2005 and 2006), Garden Farms (2005), and Shandon (2005 and 2006). Net pumping was reported for Garden Farms. Net pumping represents metered water use and does not account for system losses. Gross pumping represents metered groundwater pumping. In order to calculate the gross pumping, data from six systems (Shandon, Cayucos, Santa Margarita, Atascadero, Templeton, and San Miguel) were reviewed. The average ratio of gross to net pumping was 1.13. This multiplier was used to estimate gross pumping for Green River. For Garden Farms, data from July through September of 2005 were used for July through September of 2006, as no 2006 data were provided. Small community system water use in Monterey County was considered negligible.

The USEPA (2004) population data for small community systems are shown on Table 8. The number of persons per dwelling unit was determined from the 2000 US Census. Based on the three systems with pumping records, an average 0.25 AF per person per year, or 0.72 AF per dwelling unit, was calculated. This average per dwelling unit was applied to the other small systems. The total pumping for 2006 was estimated to be 594 AF. For the 1997 estimate, small community use was included in the rural water estimate.

Small Commercial Pumping –2324 AF

County Public Works provided addresses of small commercial and institutional systems. There are no known industrial facilities that rely on groundwater. This list was screened to remove systems located outside of the Paso Robles Groundwater Basin. Additional systems were added based on information from the State Water Resources Control Board database (Geotracker) (SWRCB, 2008) and USEPA (2004). The process yielded eighteen commercial systems. Additional research by County Public Works identified 64 wineries in the Basin that are not served by other water supplies.

SLO County has requested that these systems provide monthly pumping data. To date, only Atascadero State Hospital and El Paso de Robles Youth Authority have provided monthly pumping data. Camp Roberts pumping reported by staff (Fugro, 2009) is assumed to take place entirely within the basin. The SLO County Planning Department provided commercial water use coefficients based on research conducted by the Pacific Institute (2003). These coefficients included the following: camp (0.208), school (0.163), institution (0.107) and restaurant (0.229). Winery demand was estimated based on an average demand of 2.5 gallons per gallon of wine produced. Wine production was obtained by County Public Works from Department of Alcohol Beverage Control permit data (DABC, 2009). The current production is assumed to also represent 2006 production.

The coefficient for institutions was checked against reported pumping for Atascadero State Hospital and El Paso de Robles Youth Authority. The coefficient of 0.107 per capita per year was multiplied by population estimated from data on each facility's web site; the computed results for both the hospital and youth facility agreed well with the actual reported pumping. Therefore, the Pacific Institute coefficients listed above were used to calculate pumping for the remaining systems, as shown on Table 9. The total commercial pumping was estimated to be 2,324 AFY. Compared with the 1997 estimate of 1,465 AFY, commercial pumping has increased by 59 percent.

Rural Domestic Groundwater Pumping – 10,891 AFY

The SLO County Planning Department staff provided an analysis of the County parcel GIS database. This analysis includes the number of each type of development by subarea within the Basin. There are nearly twenty different development types including single-family residences, mobile homes, duplexes, apartments, etc. An individual parcel might contain a single family residence and a 2 to 4 unit apartment, for example. Because of known inaccuracies in the database, SLO County staff completed a detailed review of each parcel including the land improvement value and the homeowner's tax credit to determine if dwellings were likely to be present. This resulted in additional dwellings being added within development types that would not typically be included (e.g., agriculture over 20 acres). Table 10 lists the number of units of each development type by subarea.

Rural population for Monterey County was estimated from well permits supplied by Monterey County Environmental Health. Each well was assumed to service a single family dwelling. Census 2000 data were also used to supplement data for Bradley.

Rural water use was determined by applying a water duty factor of 1.7 AFY per dwelling unit. This factor is based on the *San Luis Obispo County Master Water Plan Update* (EDAW, 1998) and was used for the 1997 Phase I estimate. This consumption rate is more than twice the average demand calculated from pumping records from Garden Farms CWD, Green River MWC, and Shandon CSA 16-1. However, in order to compare the 1997 estimate with the 2006 estimate and to represent an average between rural parcels that use more or less water, 1.7 AFY per dwelling unit was used. Table 11 summarizes the rural pumping based on the data in Table 10. Adjustments were made to avoid double counting the population served by the small community systems listed on Table 8. In order to compare to the 1997 estimate, pumping from the population served by small community systems is retained. The total rural pumping, 11,485 AFY, is 2,085 AF greater than the 1997 estimate of 9,400 AFY.

Total Groundwater Pumping - 88,154 AF

Table 12 shows the total 2006 groundwater pumping on a subarea basis for agriculture, municipal, small community, and small commercial and rural water uses. In order to estimate net agricultural pumping, estimated irrigation return flows were subtracted from the gross pumping. As indicated, agriculture accounts for 58,680 AF or about 67 percent of total pumping, municipal pumping represents about 18 percent of total pumping, and the remaining small system and rural pumping combined is about 16 percent. The greatest percentage of pumping occurs in the Estrella subarea (39 percent) followed by Atascadero (18 percent), Creston (14 percent), and Shandon (13 percent). The remaining subareas each constitute less than 10 percent of total pumping. The total pumping for 2006 (88,154 AF) is 90 percent of the perennial yield (97,700 AF) of the entire basin (including Atascadero). Pumping in Atascadero subbasin in 2006 (15,532 AF) is 94 percent of the perennial yield (16,400 AFY).

Table 13 provides a comparison of groundwater pumping in 1997, 2000 and 2006. As shown, total groundwater pumping was 74,061 AF in 1997, 82,638 AF in 2000, and 88,154 AF in 2006. This represents an average annual increase of 3.8 percent between 1997 and 2000 and 1 percent between 2000 and 2006.

Future Groundwater Pumping

Future pumping was estimated in the Phase II Report (Fugro, 2005). Table 14 summarizes the Model Scenario 2, a projection that estimates a total build-out pumping of 107,315 AFY without Nacimiento delivery. Build-out is a planning horizon that does not represent a specific year. Compared to this scenario, agricultural pumping in 2006 was 99 percent of build-out and small commercial pumping is over 200 percent of build-out. Urban pumping is 60 percent of build-out while rural is 52 percent of build-out.

Pumping in 2025 was estimated using readily available data for each pumping sector. For agricultural and commercial pumping, the rate of growth between 2000 and 2006 was projected to 2025. Urban pumping in 2025 was estimated using a combination of data from available planning documents (Atascadero, Templeton, and Paso Robles) and projection of the growth rate between 2000 and 2006 (San Miguel). For rural pumping, County Planning recommended use of a rural growth rate of 2.3 percent. This demand was compared to an "ultimate" build-out demand developed from a detailed parcel analysis.

Agricultural pumping increased from 56,551 AF in 2000 to 58,680 AF in 2006. The annual rate of increase over the six-year period is 0.6 percent. In 2025, assuming the same rate, the agricultural pumping would be 65,421 AF. Urban pumping projections (Table 14) show a 58% increase from 15,226 in 2006 to 24,773 in 2025. The assumptions on Nacimiento deliveries are included on Table 15.

The projection of rural growth demand is based on an analysis of parcels at build-out. The SLO County Planning Department reviewed their parcels database and identified all current and future parcels that could be developed and/or sub-divided and developed. It includes parcels within the agriculture, residential rural and residential suburban land use categories that have nonconforming or "antiquated" subdivisions. These parcels could be legally subdivided at urban and suburban densities (if minimum requirements—access, water, and sewer—are met) even though they are out of compliance with County standards policies and standards. Most of the parcels were created as part of land speculation efforts prior to 1935 before the County had established minimum lot size requirements.

Table 16 summarizes this analysis. The SLO County Planning Department assumes that a reasonable "ultimate" build-out is development of 75 percent of all possible parcels. As shown on Table 16, "ultimate" build-out pumping would be just over 37,000 AF. This estimate includes small community systems. If "ultimate" build-out occurred by 2025, the annual growth rate would be an unrealistic 12.8 percent. In order to determine the demand in 2025, a growth rate of 2.3 percent per year was assumed. As a result, rural pumping would be 16,504 AF, which is 44 percent of "ultimate" build-out.

Discussion

This evaluation of pumping has resulted in the following key findings:

1. The estimated groundwater pumping in 2006 of 88,154 AFY is 90 percent of the estimated perennial yield of 97,700 AFY for the Paso Robles Groundwater Basin.

2. Pumping in Atascadero subbasin in 2006 (15,545 AF) was 95 percent of the perennial yield (16,400 AFY).

3. Irrigated acreage increased 100 percent between 1997 and 2006, but pumping only increased 20 percent. The effect of increased acreage was offset by the shift from alfalfa to vineyards.

4. Rural and small community pumping has increased at the annual rate of 1.4 percent between 2000 and 2006.

5. Total groundwater pumping has increased by 5,516 AFY between 2000 and 2006—an average annual increase of 919 AF. Assuming *no* water management actions (including delivery of Nacimiento Project Water), this rate of increase would result in overdraft by 2017.

6. Groundwater pumping in the Atascadero Subbasin increased 4,445 AF between 2000 and 2006—an annual increase of 740 AF. At this rate of increase, the perennial yield would have been exceeded in 2008. It should be noted that this is a simple extrapolation and does not represent actual pumping, which likely was affected in 2008 by drought-related limitations and conservation.

7. Current (2006) agricultural and commercial pumping have reached or exceeded the amounts estimated as build-out in the Phase II Report Model Scenario 2 while municipal and rural pumping are well below the build-out predictions.

8. Water management actions now being implemented—notably development of Nacimiento water supply for Paso Robles, Templeton, and Atascadero—will help reduce groundwater pumping.

9. A 2025 projection of groundwater pumping of 106,797 (accounting for Nacimiento delivery) exceeds the Paso Robles Groundwater Basin perennial yield by 8,641 AFY.

10. For the 2025 projection, an annual rural growth rate of 2.3% was assumed. The 2025 rural pumping is 40% of an "ultimate" build-out scenario.

11. Agricultural pumping is the result of numerous farmers making decisions in light of local conditions (such as water supply) and within the context of global market forces. As a result, cropping patterns and groundwater use can change substantially over a period of years. Given that agriculture accounts for two-thirds of pumping, regular updating of agricultural pumping (land use, cropping, and irrigation rate data) is essential to management of groundwater resources for long-term sustainability.

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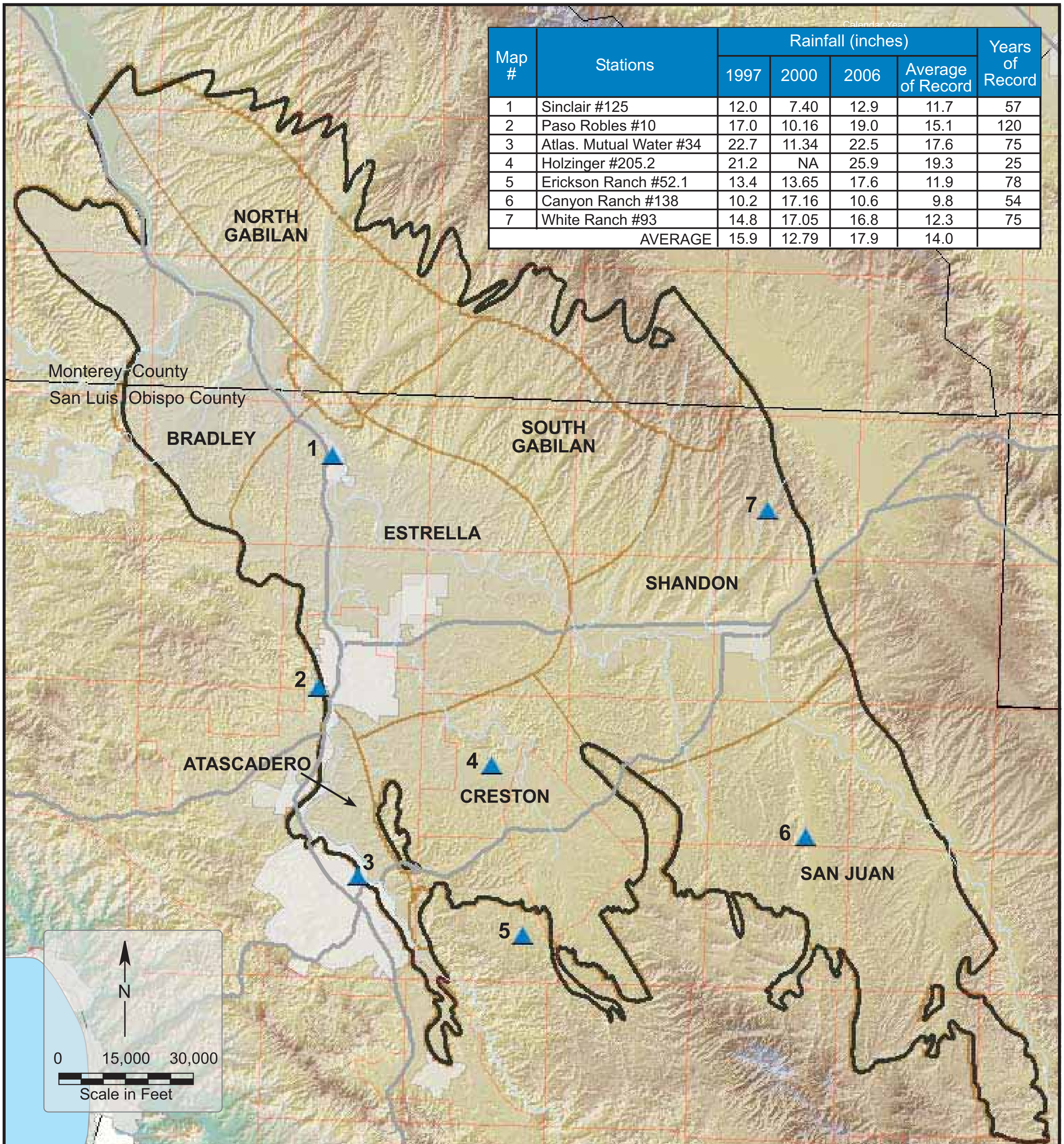
Figures



Map #	Stations	Rainfall (inches)				Years of Record
		1997	2000	2006	Average of Record	
1	Sinclair #125	12.0	7.40	12.9	11.7	57
2	Paso Robles #10	17.0	10.16	19.0	15.1	120
3	Atlas. Mutual Water #34	22.7	11.34	22.5	17.6	75
4	Holzinger #205.2	21.2	NA	25.9	19.3	25
5	Erickson Ranch #52.1	13.4	13.65	17.6	11.9	78
6	Canyon Ranch #138	10.2	17.16	10.6	9.8	54
7	White Ranch #93	14.8	17.05	16.8	12.3	75
	AVERAGE	15.9	12.79	17.9	14.0	

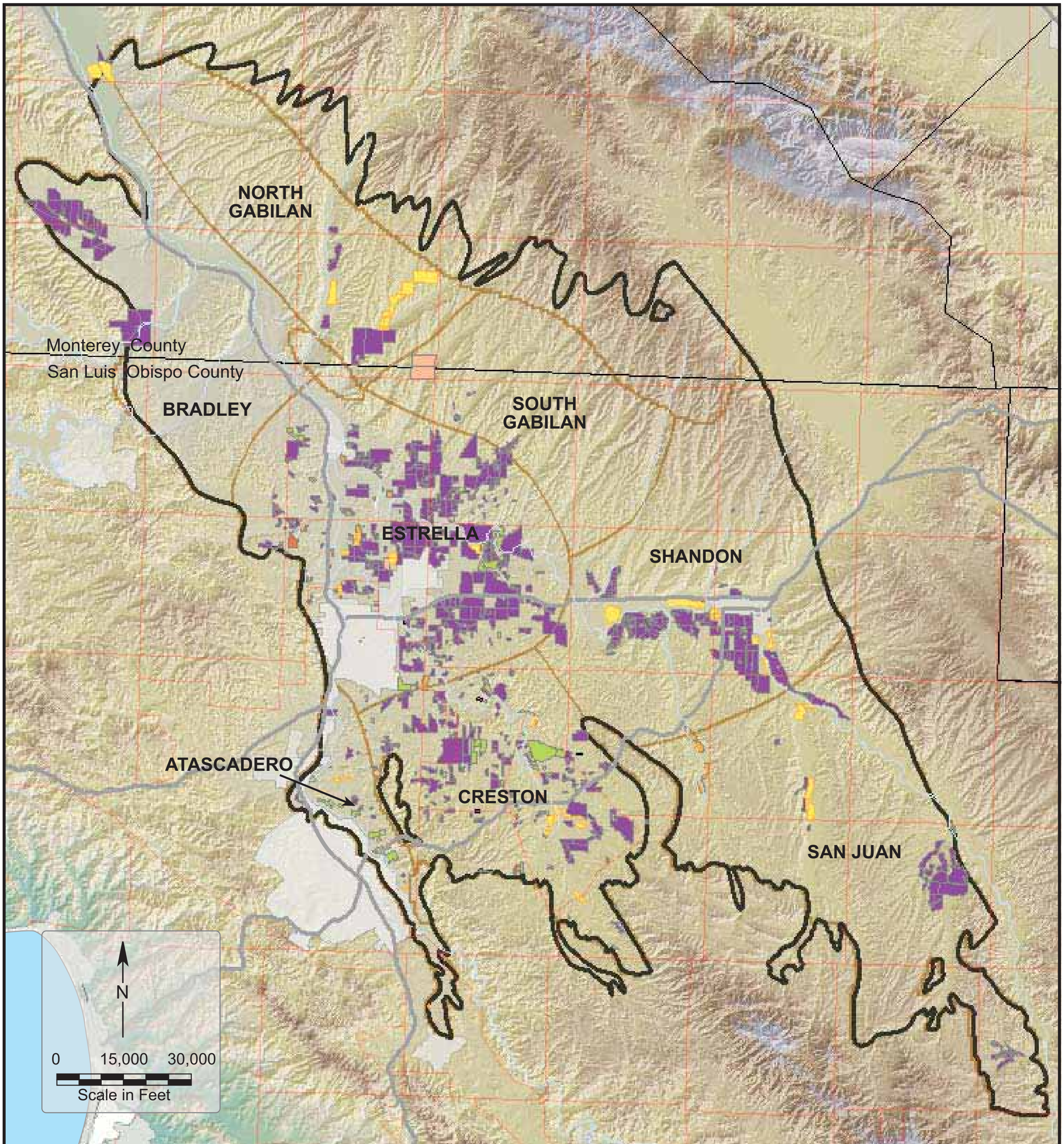
Legend

- Rainfall Station
- Streams
- State Highways
- Township and Range Grid
- Basin Boundary
- Cities/Communities
- Subareas
- County Line

May 2009

TODD ENGINEERS
Alameda, California

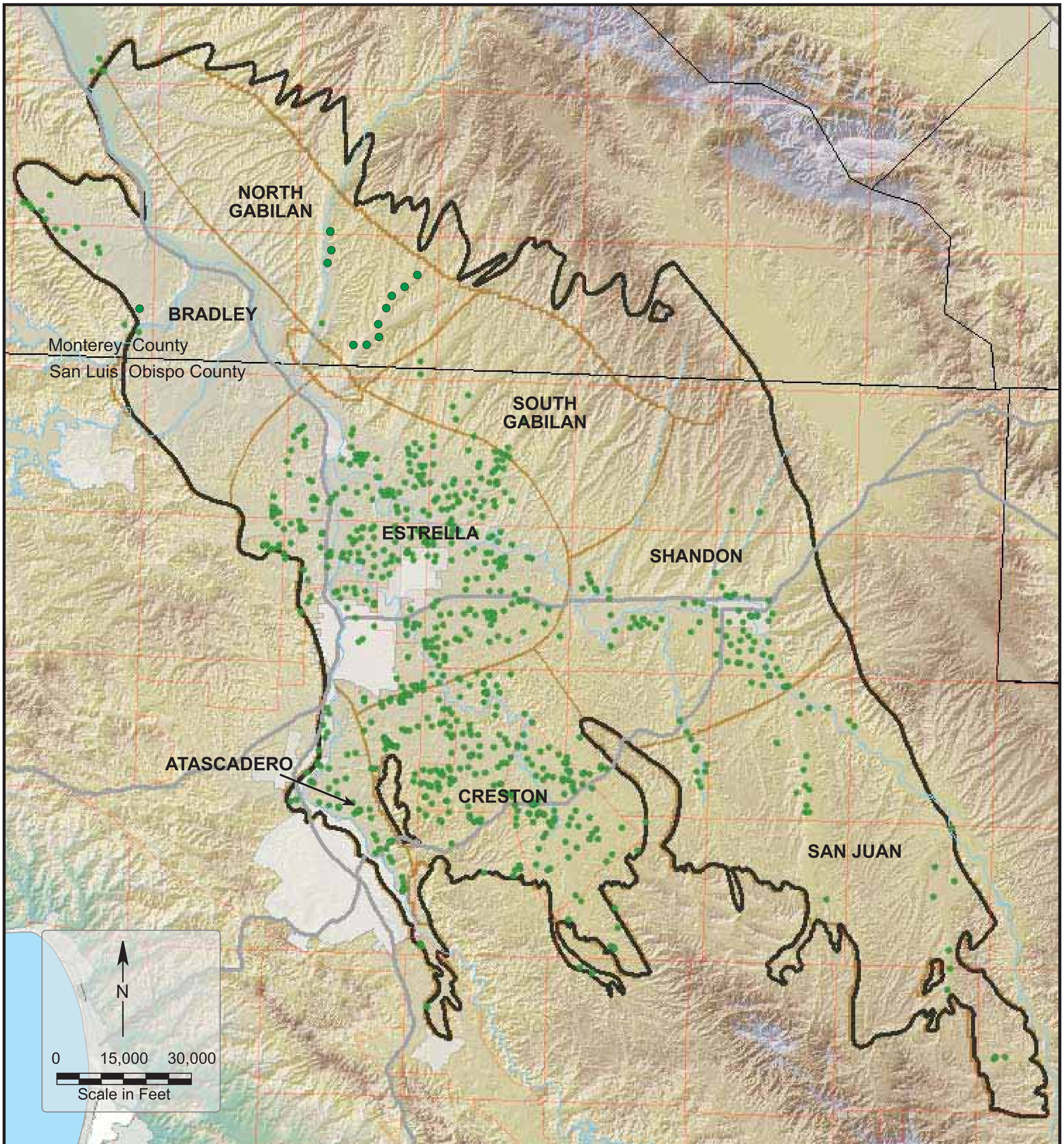
Figure 1
Paso Robles Groundwater Basin



Legend

- Alfalfa
- Citrus
- Deciduous
- Nursery
- Pasture
- Truck
- Vineyards

May 2009	**Figure 2** **Irrigated Crops**
TODD ENGINEERS Alameda, California	



Legend

- Assigned Location of Irrigation Pumping
- Streams
- State Highways
- Township and Range Grid
- Basin Boundary
- Cities/Communities
- Subareas
- County Line

May 2009	**Figure 3**
TODD ENGINEERS Alameda, California	**Assigned Location of Irrigation Pumping**

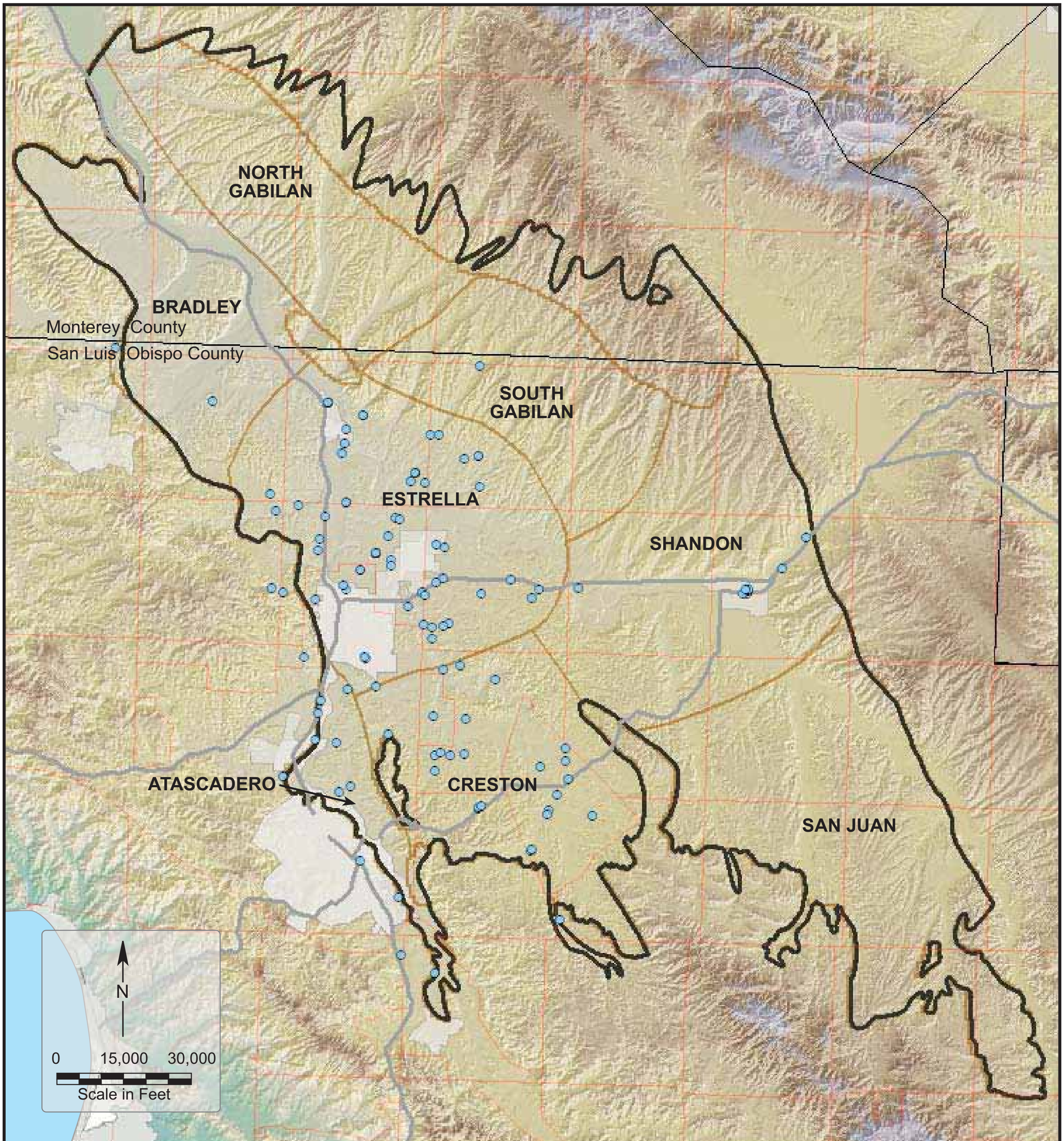
Legend

- Municipal Wells
- Streams
- State Highways
- Township and Range Grid
- Basin Boundary
- Cities/Communities
- Subareas
- County Line

May 2009

TODD ENGINEERS
Alameda, California

Figure 4
Municipal Wells



Legend

- Small System Wells
- Streams
- State Highways
- Township and Range Grid
- Basin Boundary
- Cities/Communities
- Subareas
- County Line

May 2009	Figure 5 Small System Wells
TODD ENGINEERS Alameda, California	

Tables

Table 1. Crop Type Classification

Category	Crop types
Alfalfa	alfalfa
Nursery	flowers, nursery, Christmas trees
Pasture	clover, mixed pasture, native pasture, misc. grasses, turf farms, turf/sod, sudangrass
Citrus	grapefruit, lemons, oranges, dates, avocados, olives, kiwis, jojoba, eucalyptus, pomegranate, subtropical fruits
Deciduous	apples, apricots, cherries, peaches, nectarines, pears, plums, prunes, figs, pistachios, persimmon, quince
Truck	artichokes, asparagus, beans (green), corn, cole crops, carrots, celery, lettuce, melon, squash, cucumbers, onion, garlic, peas, potatoes, sweet potatoes, spinach, tomatoes, bush berries, strawberries, peppers, broccoli, cabbage, cauliflower, brussels sprouts, mushroom, mixture, miscellaneous truck
Vineyard	raisin grapes, table grapes, wine grapes
Field Crop	forage, forage mix, hay, forage hay, rotational field
Grain	barley, grain-hay, oats

Developed in cooperation with the SLO ACO

Table 2. Irrigated Acreage Percent

Category	Percent of total acreage irrigated
Truck	100
Vineyard	100
Alfalfa	71
Pasture	51
Deciduous	8
Citrus	8
Field Crop	0
Grain	0

Source: Modified from Fugro (2002), Table 46 and Table 47

Table 3. Gross Irrigation Water Requirements (acre-foot per acre per year)

Subarea	Crop Type						
	Alfalfa	Nursery	Pasture	Citrus	Deciduous	Truck[1]	Vineyard
Atascadero	3.8	2	4	1.8	2.8	1.6	1.25
Bradley	3.8	2	4	1.8	2.8	1.6	1.25
Creston	3.8	2	4	1.8	2.8	1.6	1.25
Estrella	3.8	2	4	1.8	2.8	1.6	1.25
North Gabilan	4.6	2.6	4.8	2.5	3.5	1.9	1.5
San Juan	4.6	2.6	4.8	2.5	3.5	1.9	1.5
Shandon	4.6	2.6	4.8	2.5	3.5	1.9	1.5
South Gabilan	4.6	2.6	4.8	2.5	3.5	1.9	1.5

Source: Average values reported by (EDAW, 1998) except vineyard which is from Honeycutt (2004) and Battany (2004)

[1] 2x adjustment factor for multiple cropping (EDAW, 1998)

Table 4. Irrigated Acreage by Subarea for 2006 (acres)

Subarea	Alfalfa	Nursery	Pasture	Citrus	Deciduous	Truck	Vineyard	Vineyard (organic)	Total
Atascadero	0.0	1.8	221.9	0.3	0.1	56.0	293.1	0.0	573.2
Bradley	0.0	0.0	0.0	0.0	0.0	1,004.0	4,261.0	0.0	5,265.0
Creston	12.4	39.8	565.5	11.6	6.8	426.6	5,460.0	0.0	6,522.7
Estrella	220.6	10.3	339.1	13.7	15.8	252.6	15,843.0	495.0	17,190.1
North Gabilan	0.0	0.0	13.9	0.2	0.2	725.0	208.0	0.0	947.4
San Juan	199.4	0.0	7.5	0.0	0.0	441.2	2,370.5	0.0	3,018.6
Shandon	27.4	0.0	0.0	1.4	0.1	795.0	5,503.9	0.0	6,327.9
South Gabilan	0.0	0.0	0.0	0.0	0.0	460.0	531.1	0.0	991.1
Total	459.8	52.0	1,148.0	27.3	23.0	4,160.4	34,470.6	495.0	40,836.0

Table 5. Gross Agricultural Pumping (acre foot per year)

Subarea	Alfalfa	Nursery	Pasture	Citrus	Deciduous	Truck	Vineyard*	Total
Atascadero	0.0	3.6	887.7	0.6	0.2	89.6	366.3	1,348.1
Bradley	0.0	0.0	0.0	0.0	0.0	1,606.4	5,326.3	6,932.7
Creston	47.2	79.6	2,262.1	20.9	19.0	682.5	6,825.0	9,936.3
Estrella	838.3	20.7	1,356.4	24.7	44.1	404.2	20,422.5	23,110.8
North Gabilan	0.0	0.0	66.9	0.5	0.9	1,377.5	312.0	1,757.8
San Juan	917.0	0.0	35.9	0.0	0.0	838.4	3,555.7	5,347.0
Shandon	126.1	0.0	0.0	3.6	0.4	1,510.5	8,255.9	9,896.4
South Gabilan	0	0.0	0.0	0.0	0.0	874.0	796.7	1,670.7
Total	1,928.6	103.9	4,609.0	50.3	64.5	7,383.1	45,860.4	59,999.9

** Includes organic acreage from Table 4*

Table 6. Irrigated Acreage in 1997 and 2006

Crop Type	Acres	
	1997	2006
Alfalfa	2,541	460
Nursery	NR	52
Pasture	1,891	1,148
Citrus	NR	27
Deciduous	312	23
Truck Crop	384	4,160
Vineyard	12,582	34,966
Grain	1,339	0
Field Crop	1,123	0
Total	20,172	**40,836**

NR - not reported
Note that totals reflect rounding
Grain and field crops not irrigated in 2006.

Table 7. Municipal Pumping in 2006 (acre-feet)

City	Estrella	Atascadero	TOTAL
Paso Robles	3,589	3,896	7,485
Atascadero	0	6,221	6,221
San Miguel	341	0	341
Templeton	0	1,618	1,618
TOTAL	3,930	11,735	15,665

Table 8. Small Community Pumping Estimate

System	Subarea	Population[1]	Persons/DU[2]	Reported Gross Pumping (AFY)[3]	Estimated Gross Pumping (AFY)[4]	AFY per person	AFY per DU
Adelaide Estates MWC	Estrella	15	2.73		3.94		
Almira Water Association	Atascadero	40	2.98		9.63		
Garden Farms CWD	Atascadero	240	2.62	80.29	80.29	0.33	0.88
Green River MWC[5]	Shandon	300	2.73	86.30	86.30	0.29	0.79
Los Robles MHP	Estrella	420	2.73		110.35		
Mustang Springs MWC	Estrella	30	2.73		7.88		
Rancho Salinas MHP	Estrella	25	2.73		6.57		
Rest Haven MHP	Estrella	75	2.73		19.70		
Santa Ysabel Ranch MWC	Atascadero	25	2.98		6.02		
Shandon CSA 16-1	Shandon	986	3.67	131.62	131.62	0.13	0.49
Spanish Lakes MWC	Creston	25	2.63		6.82		
Sweet Springs MHP	Estrella	30	2.73		7.88		
Walnut Hills MWC	Atascadero	486	2.98		116.97		
					Average	0.25	0.72
				Total	593.97		

[1] SLO County IRWMP, December 2005. USEPA Public Water System Inventory Data (2004)

[2] U.S. Census Bureau, Population Statistics, 2000 Census. http://factfinder.census.gov

[3] Pumping records submitted to SLO County; 2006 Garden Farms estimated from 2005 data

[4] Based on average use per dwelling unit of 0.72 AFY

[5] Reported net pumping x 1.13 = Gross Pumping

DU = Dwelling Unit

AFY = acre feet per year

Table 9. Small Commercial Pumping

System	Subbasin	Facility type	Population [1]	Acres [2]	Water Use Coefficient [3]	Winery Production (Gallons)[4]	Calculated Demand (AFY)	Reported Pumping (AFY)
Atascadero State Hospital	Atascadero	hospital	3200		0.107		342.4	343.52
Bella Luna Winery Inc	Atascadero	winery				5,000	0.04	
Chalk Mountain [5]	Atascadero	golf course					80.0	80.03
Constellation Wines U S Inc	Atascadero	winery				1,000,000	7.67	
Mikulics Matthew Raymond	Atascadero	winery				5,000	0.04	
Camp Roberts [6]	Bradley	military facility	100				184.0	184
Bello Jerry Melvin	Creston	winery				5,000	0.04	
Chateau Margene	Creston	winery				20,000	0.15	
Creston Country Store	Creston	store	25		0.04		1.0	
Creston Elementary School	Creston	school	100		0.163		16.3	
Emmanual Heights Camp	Creston	camp	25		0.208		5.2	
Frankel Revocable Trust	Creston	winery				20,000	0.15	
Gelfand Janet Bernice	Creston	winery				5,000	0.04	
Geneseo Partners LLC	Creston	winery				5,000	0.04	
Gremark Vineyards LLC	Creston	winery				5,000	0.04	
Hansen Bruce Edwin	Creston	winery				5,000	0.04	
Hidden Oak Winery Inc	Creston	winery				5,000	0.04	
Hoover Patricia Ann	Creston	winery				20,000	0.15	
Loading Chute	Creston	restaurant	25		0.229		5.7	
Long Branch Saloon	Creston	bar	30		0.229		6.9	
Maloy O'Neill Inc	Creston	winery				20,000	0.15	
Pomar Junction Cellars LLC	Creston	winery				5,000	0.04	
Roberts Leslie Grattan	Creston	winery				100,000	0.77	
Sarzotti Cheryl Ann	Creston	winery				5,000	0.04	
Saxby Winery And Vineyard	Creston	winery				5,000	0.04	
Wasserman Donald R	Creston	winery				20,000	0.15	

Table 9. Small Commercial Pumping (continued)

System	Subbasin	Facility type	Population [1]	Acres [2]	Water Use Coefficient [3]	Winery Production (Gallons)[4]	Calculated Demand (AFY)	Reported Pumping (AFY)
8585 Cross Canyons L-Pship	Estrella	winery				20,000	0.15	
Barreto Cellars LLC	Estrella	winery				5,000	0.04	
Bear And The Bull LLC	Estrella	winery				5,000	0.04	
Caparone Winery LLC	Estrella	winery				5,000	0.04	
Castoro Cellars	Estrella	winery				1,000,000	7.67	
Charity Vines Inc	Estrella	winery				5,000	0.04	
Clautiere LLC	Estrella	winery				20,000	0.15	
Courtside Cellars LLC	Estrella	winery				1,000,000	7.67	
Eastside Cellars LLC	Estrella	winery				5,000	0.04	
El Paso de Robles Youth Authority	Estrella	correctional institution	950		0.107		101.7	102.16
Fetzer Vineyards	Estrella	winery				1,000,000	7.67	
Gh Holdings L-Pship	Estrella	winery				5,000	0.04	
Grande Carolynn Chiyoko	Estrella	winery				20,000	0.15	
Hunter Ranch Golf Course	Estrella	golf course	50	128	3.5		448.0	
Hinkle Carol J	Estrella	winery				5,000	0.04	
Hinrichs Teresa Marie	Estrella	winery				20,000	0.15	
J Lohr Winery Corporation	Estrella	winery				1,000,000	7.67	
J Paul Rosilez Winery LLC	Estrella	winery				5,000	0.04	
Jettlynn Winery LLC	Estrella	winery				5,000	0.04	
K4 Development LLC	Estrella	winery				5,000	0.04	
King John David	Estrella	winery				5,000	0.04	
Lawrence Andrew Cellars	Estrella	winery				5,000	0.04	

Table 9. Small Commercial Pumping (continued)

System	Subbasin	Facility type	Population [1]	Acres [2]	Water Use Coefficient [3]	Winery Production (Gallons)[4]	Calculated Demand (AFY)	Reported Pumping (AFY)
Le Vigne Di San Domenico Inc	Estrella	winery				100,000	0.77	
Links Golf Course	Estrella	golf course	25	143	3.5		500.5	
Luneau Usa Inc	Estrella	winery				5,000	0.04	
Martin Weyrich Winery LLC	Estrella	winery				200,000	1.53	
McCasland A Elizabeth	Estrella	winery				5,000	0.04	
Mirasol Wine LLC	Estrella	winery				5,000	0.04	
Modern Development Company	Estrella	winery				100,000	0.77	
Nagengast David Alan	Estrella	winery				5,000	0.04	
Nichols Keith Orval	Estrella	winery				5,000	0.04	
Paso Robles Golf Club	Estrella	golf course		107	3.5		374.5	
Paso Robles RV Ranch	Estrella	campground	105		0.208		21.8	
Paso Robles Truck Plaza	Estrella	automotive	25		0.07		1.8	
Pear Valley Vineyard Inc	Estrella	winery				20,000	0.15	
Pete Johnson Chevrolet	Estrella	automotive	25		0.07		1.8	
Pleasant Valley Elementary	Estrella	school	100		0.163		16.3	
Pretty Smith Enterprises LLC	Estrella	winery				5,000	0.04	
Q4x LLC	Estrella	winery				5,000	0.04	
R Golden Land Corp	Estrella	winery				5,000	0.04	
Rabbit Ridge Wine Sales Inc	Estrella	winery				100,000	0.77	
Raft River Vintners LLC	Estrella	winery				1,000,000	7.67	
Rainbows End Vineyard	Estrella	winery				5,000	0.04	
Rammel Heather Kaye	Estrella	winery				5,000	0.04	
River Oaks Golf Course	Estrella	golf course		23	3.5		80.5	
Rubato Inc	Estrella	winery				5,000	0.04	
San Paso Truck & Auto	Estrella	truck stop	25		0.07		1.8	

Table 9. Small Commercial Pumping (continued)

System	Subbasin	Facility type	Population [1]	Acres [2]	Water Use Coefficient [3]	Winery Production (Gallons)[4]	Calculated Demand (AFY)	Reported Pumping (AFY)
Sylvester Winery Inc	Estrella	winery				200,000	1.53	
Tackitt Corp	Estrella	winery				5,000	0.04	
Tobin James Cellars	Estrella	winery				1,000,000	7.67	
Toft Jacob Daniel	Estrella	winery				5,000	0.04	
Villa San Juliette Holdings LLC	Estrella	winery				100,000	0.77	
Villa San Juliette Holdings LLC	Estrella	winery				5,000	0.04	
Vina Robles Inc	Estrella	winery				100,000	0.77	
Way Out Wine Company LLC	Estrella	winery				5,000	0.04	
Wine101	Estrella	winery				5,000	0.04	
Shandon Rest Stop	Shandon	rest stop	986		0.07		69.0	
					TOTAL		**2,323.5**	

[1] SWRCB geotracker database www.geotracker.swrcb.ca.gov; hospital data from www.dmh.ca.gov; youth authority data from www.cyajobs.org

[2] Golf Course average acreages measured from Google Earth. Turf grass irrigation rate of 3.5 AFY/acre (Baca, 1992)

[3] Pacific Institute (2003)

[4] Winery Production from www.abc.ca.gov; demand is 2.5 gallons per gallon of wine produced, converted to acre-feet

[5] Chalk Mountain 2006 pumping provided by the City of Atascadero

[6] Annual demand estimated by Camp Roberts personnel

Table 10. Developed Rural Parcels and Groundwater Demand

Subarea	Development Type	Existing Units	Existing Water Use (AFY)
ATASCADERO	AG over 20 acres	94	160
	Apartments	6	10
	Condo - 1 unit	14	24
	Duplex	22	37
	Fourplex	12	20
	MH - Manufactured/Modular	20	34
	MH Park	307	522
	Mixed Living	12	20
	SFR - Single Family Residential	601	1,022
	SFR with additional residential units	86	146
	Triplex	21	36
	Vacant or Under-developed	0	0
	SUB-TOTAL	**1,195**	**2,032**
BRADLEY	Estimate based on 2000 census population of 120		70
	Single Family[1]	23	39
	SUB-TOTAL	**23**	**109**
CRESTON	AG over 20 acres	279	474
	MH - Manufactured/Modular Home	89	151
	Mixed Living	5	9
	SFR - Single Family Residence	760	1,292
	SFR with additional residential units	242	411
	SUB-TOTAL	**1,375**	**2,338**
ESTRELLA	AG over 20 acres	369	627
	Apartments	28	48
	Duplex	6	10
	Fourplex	32	54
	MH - Manufactured/Modular Home	79	134
	MH Park	48	82
	MH and RV Park	1	2
	Mixed Living	45	77
	SFR - Single Family Residence	2,379	4,044
	SFR with additional residential units	200	340
	Triplex	9	15
	SUB-TOTAL	**3,196**	**5,433**

Table 10. Developed Rural Parcels and Groundwater Demand (Continued)

Subbasin	Development Type	Existing Units	Existing Water Use (AFY)
NORTH GABILAN	Single Family[1]	30	51
	SUB-TOTAL	**30**	**51**
SAN JUAN	AG over 20 acres	56	95
	Mixed Living	1	2
	SFR - Single Family Residence	3	5
	SFR with additional residential units	2	3
	Vacant or Under-developed	0	0
	SUB-TOTAL	**62**	**105**
SHANDON	AG over 20 acres	63	107
	MH - Manufactured/Modular Home	33	56
	MH and Commercial	1	2
	Mixed Living	5	9
	SFR - Single Family Residence	569	967
	SFR with additional residential units	38	65
	Vacant or Under-developed	0	0
	SUB-TOTAL	**709**	**1,205**
SOUTH GABILAN	AG over 20 acres	49	83
	SFR - Single Family Residence	2	3
	Vacant or Under-developed	0	0
	Single Family[1]	74	126
	SUB-TOTAL	**125**	**213**
	TOTAL		**11,485**
	Small Community Systems		**594**
	ADJUSTED TOTAL		**10,891**

[1] *Monterey County supplied the total number of wells per subbasin. It is assumed that each well serves a single residence.*

Table 11. Summary of Rural Pumping, 2006 (AFY)

Subarea	Total Rural	Small Community	Net Rural
Atascadero	2,032	213	1,819
Bradley	109		109
Creston	2,338	7	2,331
Estrella	5,433	156	5,277
North Gabilan	51		51
San Juan	105		105
Shandon	1,205	218	987
South Gabilan	213		213
2006 Total	**11,485**	**594**	**10,891**
1997 Total	**9,400**		

Table 12. Total Estimated Pumping by Subarea, 2006 (AF)

Subarea	Agriculture	Municipal	Small Community	Small Commercial	Rural	Total	Percent of Total
Atascadero	1,348.1	11,735	213	430	1,819	15,545	18
Bradley	6,932.7	0	0	184	109	7,226	8
Creston	9,936.3	0	7	37	2,331	12,311	14
Estrella	23,110.8	3,930	156	1,603	5,277	34,078	39
North Gabilan	1,757.8	0	0	0	51	1,809	2
San Juan	5,347.0	0	0	0	105	5,452	6
Shandon	9,896.4	0	218	69	987	11,171	13
South Gabilan	1,670.7	0	0	0	213	1,443.4	2
Subtotal	**60,000**						
Returns	**1,320**						
Net Pumping	**58,680**	**15,665**	**594**	**2,323**	**10,891**	**88,154**	
Percent of Total	**67**	**18**	**16**				

Perennial Yield for Basin = 97,700 AFY   Perennial Yield for Atascadero Subbasin = 16,400 AF

Table 13. Total Groundwater Pumping WY 1997, 2000, and 2006

Water Demand AFY	1997	2000	2006
Net Agricultural [1]	49,683	56,551	58,680
Urban	13,513	14,629	15,665
Rural	9,400	9,993	10,891
Small Community [2]	---	---	594
Small Commercial	1,465	1,465	2,323
TOTAL	**74,061**	**82,638**	**88,154**

[1] Net Agriculture = Gross pumping - return flows

[2] Small Community included in rural in Fugro (2002)

Table 14. Groundwater Pumping Projections

Groundwater Demand AFY	1997	2000	2006	Model Scenario 2 [1]	2025
Net Agricultural	49,683	56,551	58,680	58,700	65,421
Urban	13,513	14,629	15,665	26,034	19,373
Rural	9,400	9,993	11,485	21,623	16,504
Commercial	1,465	1,465	2,323	958	5,042
Total	74,061	82,638	88,154	107,315	106,341

Rural includes small community systems

[1] Fugro (2005) represents build-out without Nacimiento delivery

Table 15. Projected Urban Demand (AF)

Water Demand AFY	1997	2006	2025 [1]
Atascadero MWC	6,317	6,221	9,024
Templeton CSD	1,126	1,618	3,267
City of Paso Robles	5,844	7,485	6,500
San Miguel	226	341	582
Total	13,513	15,665	19,373

[1]Assumptions for 2025 Projection

Atascadero MWD- Total demand is projected to be 11,024 AF including losses (AMWD, 2006); Nacimiento will supply 2,000AF

Templeton Build-out 2030 - 15,000 population; http://www.templetoncsd.org/index.asp, demand estimated based on 2006 per capita use; Nacimiento will supply 250 AF. (SLO County, 2007)

City of Paso Robles - Based on current city demand 2025 estimate of 11,900 AFY; assumes successful 20-25% conservation. Includes Nacimiento delivery and additional future supply.

San Miguel - demand projected based on 12.7 AF per year increase, the rate of change between 1997 and 2006

Table 16. Rural Build-Out Unit Estimate

Subarea/ Planning Area	Development Type	Existing Units	Potential Units[1]	Estimated New Units at Build-Out[2]	Total Units at Build-Out	Total Build-out Water Use (AFY)
		A	B	C C = B x 0.75	D D = A + C	E E = D x 1.7
ATASCADERO	AG over 20 acres	94	444	333	427	726
	Apartments	6	6	0	6	10
	Condo - 1 unit	14	14	0	14	24
	Duplex	22	22	0	22	37
	Fourplex	12	12	0	12	20
	MH - Manufactured/Modular	20	55	41	61	104
	MH Park	307	307	0	307	522
	Mixed Living	12	16	12	24	41
	SFR - Single Family Residential	601	1,403	1,052	1,653	2,811
	SFR with additional residential units	86	431	323	409	696
	Triplex	21	31	23	44	75
	Vacant or Under-developed	0	1,067	800	800	1,360
	SUB-TOTAL	**1,195**	**3,808**	**2,585**	**3,780**	**6,426**
BRADLEY						
SLO County	Estimate based on 2000 census population of 120	46		35	81	137
	Vacant or Under-developed		51	38	38	86.7
Monterey County	Single Family[3]	23		17	40	68
	SUB-TOTAL	**69**	**51**	**90**	**159**	**292**

Table 16. Rural Build-Out Unit Estimate (continued)

Subarea/ Planning Area	Development Type	Existing Units	Potential Units[1]	Estimated New Units at Build-Out[2]	Total Units at Build-Out	Total Build-out Water Use (AFY)
CRESTON	AG over 20 acres	279	1,087	815	1,094	1,860
	MH - Manufactured/Modular Home	89	284	213	302	513
	Mixed Living	5	8	6	11	19
	SFR - Single Family Residence	760	1,897	1,423	2,183	3,711
	SFR with additional residential units	242	392	294	536	911
	Vacant or Under-developed		803	602	602	1,024
	SUB-TOTAL	**1,375**	**3,668**	**2,751**	**4,126**	**8,038**
ESTRELLA	AG over 20 acres	369	1,394	1,046	1,415	2,405
	Apartments	28	28	0	28	48
	Duplex	6	6	0	6	10
	Fourplex	32	32	0	32	54
	MH - Manufactured/Modular Home	79	401	301	380	646
	MH Park	48	70	53	101	171
	MH and RV Park	1	1	0	1	2
	Mixed Living	45	278	209	254	431
	SFR - Single Family Residence	2,379	5,354	4,016	6,395	10,871
	SFR with additional residential units	200	323	242	442	752
	Triplex	9	14	11	20	33
	SUB-TOTAL	**3,196**	**7,901**	**5,876**	**9,072**	**15,422**
NORTH GABILAN	AG over 20 acres		2	2	2	3
	Single Family[1]	30		23	53	51
	SUB-TOTAL	**30**	**2**		**54**	**54**
SAN JUAN						
	AG over 20 acres	56	1,122	842	898	1,526
	Mixed Living	1	16	12	13	22
	SFR - Single Family Residence	3	8	6	9	15
	SFR with additional residential units	2	2	0	2	3
	Vacant or Under-developed	0	70	53	53	89
	SUB-TOTAL	**62**	**1,218**		**974**	**1,656**

Table 16. Rural Build-Out Unit Estimate (continued)

Subarea/ Planning Area	Development Type	Existing Units	Potential Units[1]	Estimated New Units at Build-Out[2]	Total Units at Build-Out	Total Build-out Water Use (AFY)
SHANDON	AG over 20 acres	63	980	735	798	1,357
	MH - Manufactured/Modular Home	33	91	68	101	172
	MH and Commercial	1	2	2	3	4
	Mixed Living	5	2	0	5	9
	SFR - Single Family Residence	569	945	709	1,278	2,172
	SFR with additional residential units	38	42	32	70	118
	Vacant or Under-developed	0	733	550	550	935
	SUB-TOTAL	**709**	**2,795**	**2,095**	**2,804**	**4,766**
SOUTH GABILAN						
	AG over 20 acres	49	344	258	307	522
	SFR - Single Family Residence	2	4	3	5	9
	Vacant or Under-developed	0	19	14	14	24
	Single Family[1]	74		56	130	220
	SUB-TOTAL	**125**	**367**	**275**	**326**	**775**
	TOTAL	**6,761**	**19,810**	**13,672**	**21,295**	**37,429**

[1] Based on SLO County analysis of subdivision potential of parcels

[2] Assumes 75% of parcels that could be developed are actually developed

[3] Monterey County supplied the total number of wells per subbasin; assume that each well serves a single residence.

[4] Monterey County growth estimated to be a 75% increase over current conditions.

Appendix A

Documentation of GIS Shapefile Editing

Editing Process 1

The *All_County_Crop_Location* shapefile received from SLO Agricultural Commissioner's Office consisted of 4,081 entries. Detailed sorting and review of the shapefile acreage data using ArcGIS revealed that 39 entries were entered more than once. Three different issues were caused by the multiple counts:

1. Duplicated data - some of the agricultural areas were entered twice.
2. Different permits and dates for the same area - when pesticide permits were updated, older permits were kept with new permits. Some of these areas were switched to different crop types while other areas maintained the same crops.

   Multiple entries for one area - one farmer received a permit for each crop type (various orchard trees) and for the total site, resulting in multiple (11) entries for one area.

The database was edited as follows. Duplicated data were eliminated, maintaining only one entry for each area. Data with an older permit date were eliminated and the newer entry was retained. For the multiple entries for one area, 10 of the 11 entries were eliminated for the plot, and the crop type was entered as "orchard."
As a result of these edits, crop data for 4,042 entries were used to intersect with subbasin boundaries.

Editing Process 2

Intersection of the crop data and the subbasin boundary resulted in 1,263 polygons with 66,571 acres. Two different kinds of overlapping problems were encountered as a result of this intersecting process.

1. Small plots within large plots.
2. Discrepancies between boundaries of many plots, resulting in overlap.

Among 1,263 entries, 52 polygons were identified as overlapping polygons, or polygons located inside other polygons. Some of these areas had different permit dates and/or different crop types. Data with older permit dates were eliminated. If the polygons in question had the same permit date, it was assumed that the farmer had a different crop within a larger parcel, so the overlapping portion of the larger polygon was eliminated. Some small overlapping areas among plots may have been produced during creation of polygons in GIS. These small overlapping areas were eliminated.

Finally 1,206 entries with 65,667 acres were retained for land use classification. Nine categories were created, of which seven are irrigated. From these seven categories, 713 data entries with 35,126 acres were used for analysis.

Appendix B

Pumping within Areas of Declining Groundwater Storage

The change in groundwater storage over time was evaluated in Phase I (Fugro, 2002) and more recently in the Update for the Paso Robles Groundwater Basin (Todd, 2007). Phase I included a storage change map for the time period Spring 1980 to Spring 1997 (see Figure 34, Fugro, 2002). In February 2008, the SLO County Board of Supervisors directed its staff to further investigate the area contained within the -20 foot storage change contour in Figure 34. However, the location of the -20 foot contour will vary depending on fluctuations in rainfall, recharge, and pumping. Figure B-1 illustrates the change in storage between 1997 and 2006 (Todd, 2007). Based on a comparison of the Phase I map and Figure 6, groundwater declines are persisting locally within the Atascadero subbasin and the Creston and Estrella subareas.

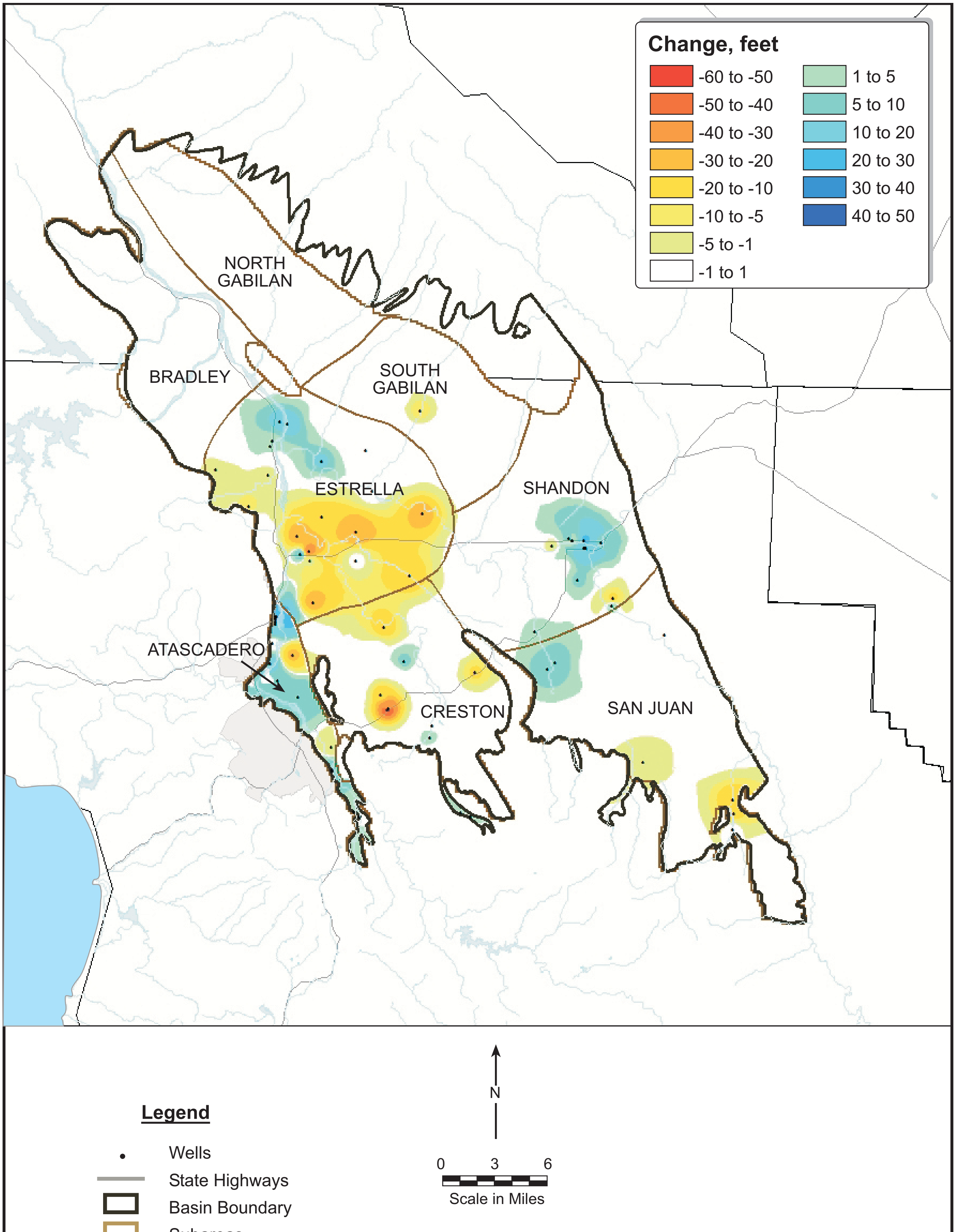
Figure B-2 shows the -20 foot storage change contour for 1997 to 2006 with all the wells and assigned pumping locations in the groundwater basin. In San Luis Obispo County, the domestic wells shown are only those in the County's monitoring program. Golf course irrigation wells were assigned to locations within each golf course. The areas of decline are described below:

- Atascadero subbasin – east of Templeton, pumping for agricultural irrigation.
- Creston subarea – Highway 41 near Creston, pumping primarily for agricultural irrigation
- Estrella subarea (from east to west and south):
    - Unincorporated area along the Estrella River – pumping primarily for agricultural irrigation.
    - East Paso Robles - Jardine Road/Highway 46 near the airport; groundwater pumping for agricultural irrigation, City of Paso Robles municipal, golf course irrigation, and rural uses.
    - West Paso Robles – North of Highway 46 and east of the Salinas River; groundwater pumping for agricultural irrigation and City of Paso Robles municipal supply.
    - South Paso Robles – pumping for City of Paso Robles' municipal supply and golf course irrigation.

Table B-1 provides an estimate of groundwater pumping within the three subareas of decline. The total of all the pumping within the -20 foot storage change contour is 3,947 acre feet. Within the Atascadero subbasin and the Creston subarea, the volume of water pumped within the areas of decline is less than one percent of the total pumping. In the Estrella subarea, approximately 11 percent of the total pumping occurs within the area of decline.

Table B-1. Subarea Pumping Within the -20 Foot Storage Change Contour

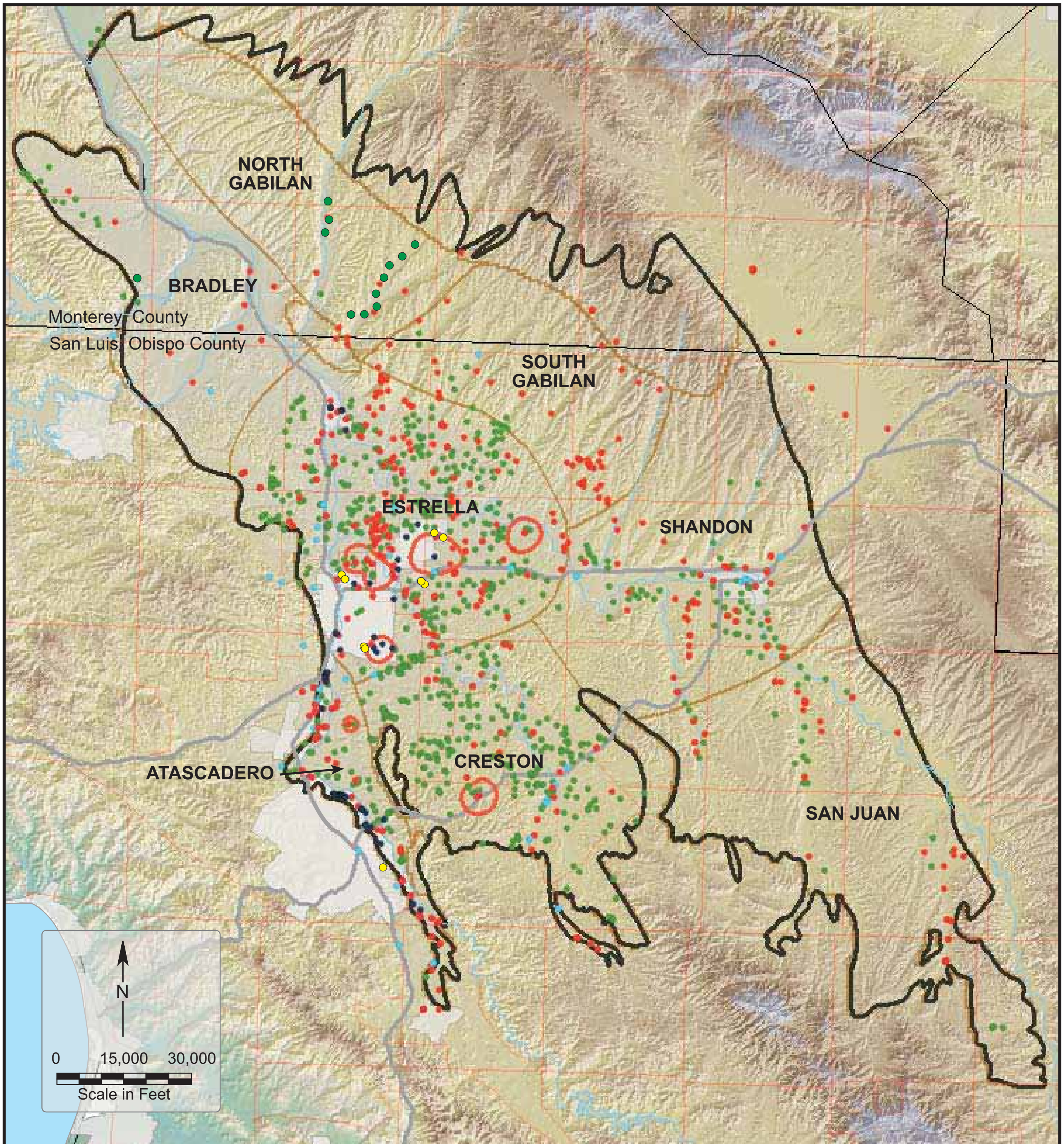
Subarea	2006 Pumping AFY		
	Decline Area Pumping	Total Subarea Pumping	% of total
Atascadero	80	16,238	0.5
Creston	56	14,544	0.4
Estrella	3,811	35,602	11
Total	3,947	66,384	6



May 2009

TODD ENGINEERS
Alameda, California

Figure B-1
Change in Groundwater Storage (Spring 1997 - Spring 2006)



Legend

- -20 foot Groundwater Decline (Spring 1997 - Spring 2006)
- Municipal Wells
- Agricultural Wells (Assigned Locations)
- Domestic Wells (in County Monitoring Program)
- Small System Wells
- Golf Course Wells (Assigned Locations)

May 2009

TODD ENGINEERS
Alameda, California

Figure B-2
Groundwater Levels Decline and Wells

Attachment D
Paso Robles Groundwater Basin
Water Balance Review and Update" by Fugro West, Inc.

FUGRO WEST, INC.

PASO ROBLES GROUNDWATER BASIN WATER BALANCE REVIEW AND UPDATE

Prepared for:
County of San Luis Obispo, Department of Public Works
City of Atascadero
Atascadero Mutual Water Company
Templeton Community Services District
City of Paso Robles

March 2010

660 Clarion Court, Suite A
San Luis Obispo, California 93401
Tel: (805) 542-0797
Fax: (805) 542-9311

March 4, 2010
Project No. 3014.036

County of San Luis Obispo
Public Works Department
County Government Center, Room 207
San Luis Obispo, California 93408

Attention: *Ms. Courtney Howard*

Subject: Paso Robles Groundwater Basin Water Balance Review and Update

Dear Ms. Howard:

This report presents an update of the water balance for the Paso Robles Groundwater Basin and the Atascadero Subbasin for the water years of 1998 to 2009, as well as a projected water balance for both the Basin and Subbasin for the future period of 2010 to 2025.

The water balance calculations presented in this report show that demand in both the Atascadero Subbasin and the Paso Robles Groundwater Basin as a whole is approaching the average annual perennial yield. Given the degree of uncertainty of the estimates of inflow and outflow components of the water balance equation, it may be advisable to assume that the Basin is essentially in balance by a small margin.

Total annual groundwater outflow (i.e., total groundwater pumping) in the Paso Robles Groundwater Basin and the Atascadero Subbasin increased during the period from 1998 to 2009. In 2009, the water balance calculation (assuming a rural domestic water demand of 1.0 acre feet per year per dwelling unit (AFY/DU)) shows that total groundwater outflow in the Basin was approximately 91,915 AF (or approximately 94% of the perennial yield of 97,700 AFY). The water balance for the scenario that assumes a rural domestic water demand of 1.7 AFY/DU indicates total groundwater outflow of 96,781 AF in 2009 (or approximately 99% of the perennial yield).

In the Atascadero Subbasin, the water balance calculation (assuming a rural domestic demand of 1.0 AFY/DU) shows that total groundwater outflow in the Subbasin in 2009 was approximately 15,255 AF (or about 93% of the perennial yield of 16,400 AFY). The water balance calculation for the scenario that assumes a rural domestic demand of 1.7 AFY/DU indicates total groundwater outflow in the Subbasin in 2009 of 16,012 AF (or approximately 98% of the perennial yield).

With outflows in the Basin and Subbasin approaching the perennial yield values, it may be appropriate in future investigations to evaluate groundwater in storage separately for the three different aquifer regimes (shallow alluvial aquifers, the Paso Robles Formation in the Subbasin, and the Paso Robles Formation within the entire Basin). Given the significant groundwater in storage in the alluvium within the Subbasin relative to the storage in the Paso Robles Formation in the Subbasin, it is appropriate that future studies account for annual groundwater extractions in the Subbasin from the alluvium separately from those from the Paso Robles Formation. For example, the City of Paso Robles produces approximately one-half of their groundwater production from the alluvial aquifer in the Atascadero Subbasin. Such pumping has little to no impact on water levels within the Paso Robles Formation in the Subbasin. The perennial yield for the Subbasin theoretically applies to combined groundwater extractions from the shallow alluvium and deeper Paso Robles Formation. Exceeding the perennial yield in the Subbasin may not necessarily be reflected by decreasing groundwater levels in the Paso Robles Formation since significant pumping occurs in the alluvium, as evidenced by the pumping totals of the City of Paso Robles. Therefore, the overdraft status of the Subbasin needs to be evaluated by assessment of groundwater level changes in both the alluvium and the Paso Robles Formation relative to the respective pumping from those aquifers.

The results of this study reinforce the need for implementation of an effective basin monitoring and management plan. The results also demonstrate the need to update the County's numerical groundwater flow model, which was developed by Fugro and is based on data through 1997. An update and recalibration of the model would help to refine the many uncertainties and assumptions that were used throughout this water balance update.

Please let us know if you have any questions.

Sincerely,

FUGRO WEST, INC.

Nels Ruud, Ph.D
Project Hydrogeologist

Paul A. Sorensen, P.G., CHg
Principal Hydrogeologist

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PASO ROBLES GROUNDWATER BASIN WATER BALANCE REVIEW AND UPDATE

1.0 INTRODUCTION

This report presents an update of the annual water balance for the Paso Robles Groundwater Basin (Basin) and the Atascadero Groundwater Subbasin (Subbasin) for the period of 1998 to 2009 (Plate 1). The purpose of the report is to provide the County of San Luis Obispo (County) with updated information to assist in the preparation of a Resource Capacity Study (RCS) for the Basin and Subbasin and ongoing Basin and Subbasin management efforts. This update is a continuation of the water balance that was estimated as part of the Paso Robles Groundwater Basin Study (Fugro and Cleath 2002). That study consisted of data collection, conceptualization of the basin hydrogeology, and estimation of a water balance from 1981 to 1997. Phase II of that study (Fugro, ETIC, and Cleath 2005) consisted of the development of a numerical groundwater flow model for the Basin that was used to evaluate several future scenarios of water supply and demand in the Basin. The results of Phase I were documented in a report entitled "*Final Report Paso Robles Groundwater Basin Study*" (Fugro West, 2002). Similarly, the findings of Phase II were documented in a report entitled "*Final Report Paso Robles Groundwater Basin Study, Phase II Numerical Model Development, Calibration, and Application*" (Fugro West, 2005). A major application of the groundwater model during Phase II was to estimate the perennial yields of the Basin and the Subbasin, which were estimated to be 97,700 acre-feet per year (AFY) and 16,400 AFY, respectively.

Groundwater pumping in the Basin during the 2006 water year was recently estimated in a study performed by Todd Engineering for the City of Paso Robles and the County (Todd, 2009). The results of that study were documented in a report entitled "*Evaluation of Paso Robles Groundwater Basin Pumping, Water Year 2006*" (Todd, 2009). The water balance update performed in this study expands on the work of Fugro and Cleath (Fugro West, 2002) and Todd (2009). The water balance consists of the quantification of the major natural and anthropogenic sources of groundwater recharge and discharge in the Basin and Subbasin from 1998 to 2009. The 1998 to 2009 water balance was then combined with the 1981 to 1997 water balance from Fugro (2002). Cumulative groundwater storage changes in the Basin and Subbasin from 1981 to 2009 were calculated from their respective water balances.

In addition to updating the water balances from 1998 to 2009, this report also provides a projected water balance for both the Basin and Subbasin for the future period of 2010 to 2025. These projected water balances include future water demand estimates of the major urban communities in the Basin and Subbasin (the projections do not include estimates of future changes in agricultural pumping, which constitutes the single largest component of groundwater pumping in the Basin). Within the next few years, the cities of Paso Robles and Atascadero and the community of Templeton each anticipate receiving surface water supplies from the Nacimiento Water Project. These supplies will be used in conjunction with pumped groundwater to satisfy local urban water demands in the future. In addition to providing an alternative and reliable source of water supply, these surface water deliveries will also reduce the future groundwater pumping demands of these communities.

Numerous uncertainties and assumptions are used, by necessity, in the calculation of the water balance. Additional detailed studies that might refine the methodologies used to develop the assumptions, or the development of new data that might reduce the uncertainties, could potentially significantly affect the results of these calculations. Furthermore, the projected water balances from 2010 to 2025 are not intended to provide absolute predictions of future groundwater recharge and discharge rates, and subsequent groundwater storage changes. Instead, they provide for a general assessment of anticipated future groundwater pumping demands with respect to current estimates of perennial yield given assumed trends in agricultural, urban, and rural water use and future climate. The specific assumptions used in the calculation of the water balances for the Basin and Subbasin from 2010 to 2025 are discussed in this report.

The groundwater supplies in the Basin and Subbasin are predominantly derived from aquifer storage of the Salinas River alluvium and the Paso Robles Formation (Plate 2). Although these aquifers are hydraulically connected, the recharge and discharge processes operating on them are not identical. Therefore, this report also provides a qualitative discussion of the interaction between the underflow in the Salinas River alluvium and the groundwater reservoir of the Paso Robles Formation. That discussion provides clarification of the perennial yield concept with respect to the groundwater flow and storage characteristics of the alluvium and the Paso Robles Formation.

2.0 BACKGROUND AND SETTING

2.1 STUDY AREA

The Paso Robles Groundwater Basin is 505,000 acres in size and spans southern Monterey County and northern San Luis Obispo County (Plate 1). The Paso Robles Groundwater Basin is divided into eight sub-areas: 1) Atascadero Groundwater Subbasin, 2) Bradley Subarea, 3) Creston Subarea, 4) Estrella Subarea, 5) North Gabilan Subarea, 6) San Juan Subarea, 7) Shandon Subarea, and 8) South Gabilan Subarea. The Atascadero Groundwater Subbasin is 14,577 acres in size.

The four major urban communities in the Basin are the cities of Paso Robles and Atascadero, and the communities of Templeton and San Miguel (Plate 1). The City of Paso Robles is the water purveyor to its resident population and also operates the associated wastewater treatment plant. The Templeton Community Services District (CSD) and the San Miguel CSD each also provide both potable water service and wastewater treatment for their respective communities. The Atascadero Mutual Water Company (MWC) is the water purveyor to the City of Atascadero, however wastewater treatment is provided by the City of Atascadero.

2.2 RECENT CLIMATE

Measured annual precipitation from 1998 to 2009 at seven rainfall gauge stations located in the Basin is presented in Table 1 (data obtained from County of San Luis Obispo Department of Public Works). The locations of the seven gauge stations are shown on Plate 1. (Four instances of missing annual precipitation measurements are indicated by "red" cells in

Table 1. For those instances, annual precipitation was estimated using correlation relationships with the other gauge stations.) Overall, average annual precipitation over the seven stations varied from 9.6 inches at Camatta Canyon Station No. 138 to 30.3 inches at Santa Margarita Station No. 95 (Table 1).

An annual reference precipitation time series for the Basin was calculated as the average of annual precipitation from six of the seven stations. The Santa Margarita station was omitted from the average calculation because rainfall levels at that station were considered significantly higher, and thus non-representative, than those measured in the valley or otherwise lower lying areas in the Basin. The calculated average of the annual reference precipitation from 1998 to 2009 was 12.9 inches (Table 1).

Based on designated water year types, the water years of 2007 and 2008 were considered ‘critical’; 2001, 2002, 2004, and 2009 were considered ‘dry’; 2003 was ‘below normal’; 1999 and 2000 were ‘above normal’; and 1998, 2005, and 2006 were ‘wet’ water years. Given these water year types and the average annual reference precipitation for the Basin (i.e., 12.9 inches), seven of the twelve years from 1998 to 2009 were below the average annual reference precipitation while the other five years were above.

A long-term average annual precipitation of 17.6 inches per year was computed for the Atascadero MWC Station No. 34 using annual precipitation totals from 1916 to 2009 (Figure 1). Measured annual precipitation for each year from 1998 to 2009 was subtracted from the long-term average of 17.6 inches per year (i.e., to generate the annual departure from the long-term mean) and these departures are presented in Table 2. These departures were then summed to calculate the cumulative change in precipitation from 1998 to 2009 with respect to the long-term average (Table 2). From 1998 to 2009, the cumulative departure of precipitation from the long-term average was –10.4 inches. This negative cumulative departure indicates that the region from 1998 to 2009 received less precipitation on an average annual basis (i.e., 0.9 inches per year less) in comparison to its long-term annual average. The cumulative departure curve for the Atascadero MWC Station No. 34 over the long-term period of 1916 to 2009 is presented on Figure 2.

3.0 ESTIMATED WATER BALANCES FROM 1998 TO 2009

The water balances for the Basin and Subbasin consist of the major groundwater recharge and discharge processes that occur in these areas. In general, the major groundwater recharge components of each water balance are: 1) subsurface inflows, 2) deep percolation of precipitation, 3) streambed percolation, 4) agricultural irrigation return flows, and 5) discharge of treated wastewater. Conversely, the major groundwater discharge components of each water balance are: 1) subsurface outflows, 2) agricultural pumping, 4) urban pumping, 5) small commercial pumping, 6) rural domestic pumping, and 7) phreatophyte extraction. Of note, the County water year begins on July 1 and ends after June 30. For example, the 2006 water year began on July 1, 2005 and ended after June 30, 2006. Therefore, the 12-year study period in this water balance update is from July 1, 1997 to June 30, 2009.

As directed, most of the components of the water balance were based on the assumptions and values presented in the previous Basin study (Fugro, 2002), and were either held constant throughout the water balance update or modified according to a straight-line interpolation between the two known data points of 1997 and 2006. The primary components that were modified as part of this study include the water duty factor of rural domestic pumping (Section 3.2.5) and wastewater discharge and return flows (Section 3.1.5).

As described in Section 3.2.5 – Rural Domestic and Small Community Pumping, two different sets of water duty factors were used to estimate rural domestic pumping in the Basin and Subbasin. This resulted in the development of two water balances for the Basin (Tables 3 and 4) and two water balances for the Subbasin (Tables 5 and 6) from 1998 to 2009. Tables 3 and 4 differ only in the estimation of rural domestic pumping in the Basin. Likewise, Tables 5 and 6 also differ only in the estimation of rural domestic pumping in the Subbasin. These tables are introduced here and are referenced in the subsequent sections that describe the estimation of the individual components in the Basin and Subbasin.

It should be noted that the precision of the results estimated by the methods employed in this study and subsequently presented in the report text and tables do not imply a similar level of accuracy. In other words, a number of assumptions were invoked in the estimation of the recharge and discharge components. These estimated components therefore represent approximations that lie within a reasonable range of expected values. The values of the estimated components were presented “as is” in the report text and tables rather than being subjected to numerical rounding.

3.1 GROUNDWATER RECHARGE

3.1.1 Subsurface Inflows

Annual subsurface inflow in the Basin from 1998 to 2009 was calculated using a linear regression equation developed between estimated annual subsurface inflow and annual measured precipitation at Atascadero MWC Station No. 34 from 1981 to 1997 (Table 1). As part of the regression equation parameter estimation, a multiple R-square statistic is calculated. The multiple R-square statistic is the correlation coefficient of a predicted dependent variable and the measured dependent variable used in the regression equation to estimate the prediction. This statistic provides a measure of the amount of variation that the independent variable (i.e., annual precipitation) can account for of the dependent variable (i.e., subsurface inflow) in the regression relationship. In other words, the multiple R-square statistic provides a measure of how well predictions are made by the regression equation. The multiple R-square statistic varies between 0 and 1, where a value close to 0 indicates that the regression equation is a poor predictor of the dependent variable and a value close to 1 indicates that the regression equation is a good predictor. The computed multiple R-square statistic between annual subsurface inflow and annual precipitation from 1981 to 1997 is 0.94. The regression equation line and the paired values of annual subsurface inflow and annual precipitation from 1981 to 1997 are plotted together on Figure 3. Annual subsurface inflow in the Basin was then estimated from 1998 to 2009 using this regression equation and varied from 3,510 AF in 2007 to 13,033 AF in 2005, with an average annual value of 6,729 AF (Tables 3 and 4).

A similar linear regression relationship was also developed between annual estimated subsurface inflow in the Subbasin and annual measured precipitation at Atascadero MWC Station No. 34 from 1981 to 1997. The associated multiple R-square was also 0.94. The regression equation line and the paired values of annual subsurface inflow and annual precipitation from 1981 to 1997 are plotted together on Figure 4. From 1998 to 2009, estimated subsurface inflows in the Subbasin varied from 375 AF in 2007 to 1,325 AF in 2005, with an average annual value of 696 AF (Tables 5 and 6).

3.1.2 Deep Percolation of Precipitation

Annual deep percolation of precipitation in the Basin from 1998 to 2009 was estimated using a methodology developed by Blaney (1933). The Blaney method was also used in the Phase I Report to estimate deep percolation of precipitation in the Basin from 1981 to 1997 (Fugro West, 2002). Originally, Blaney (1933) measured the amount of precipitation that percolated beyond the root zone for different categories of vegetative cover and for different amounts of precipitation. Using the measured data, Blaney developed a linear regression relationship between the rate of deep percolation of precipitation and the rate of precipitation falling on the ground surface for each of the vegetative cover categories. The applicable vegetative cover categories from the Blaney study used in this update are: 1) grasses and weeds, 2) truck, alfalfa, and miscellaneous crops, 3) non-irrigated grain crops, and 4) deciduous tree crops. The associated linear regression equations developed by Blaney for these four categories are displayed on Figure 5. As noted in the Phase I Report, regression equations were not developed specifically for urban, rural, and suburban land uses, and vineyard crops. As in the Phase I Report, it is assumed here that deep percolation of precipitation for urban, rural, and suburban land uses is modeled by the regression equation for grasses and weeds. Similarly, deep percolation of precipitation for vineyards is modeled using the regression equation for deciduous tree crops.

The total acreage for each of the four vegetative cover categories listed above in the Basin from 1998 to 2009 is presented in Table 7. A reference annual precipitation used here in the Blaney method was calculated as the average annual precipitation of all the gauged stations in Table 1 (excluding the data from the Santa Margarita Station No. 95 (see Section 2.1 – Recent Climate for discussion)). Applying the Blaney method, annual deep percolation of precipitation in the Basin was estimated to be negligible or small during the water years of 1999, 2000, 2002 to 2004, and 2007 to 2009. For the two wettest water years, annual deep percolation of precipitation was estimated to be 321,785 AF in 1998 and 215,760 AF in 2005 (Tables 3 and 4).

Annual deep percolation of precipitation in the Subbasin was also estimated using the regression equations developed by Blaney (1933). The total acreage for each of the four vegetative cover categories is presented in Table 8. Again, annual precipitation used in the Blaney method was calculated as the average annual precipitation of all the gauged stations in Table 1, except for Santa Margarita Station No. 95. Similar to the Basin, annual deep percolation of precipitation in the Subbasin was estimated to be negligible or small during 1999, 2000, 2002 to 2004, and 2007 to 2009. For the two wettest water years, annual deep percolation of precipitation was estimated to be 16,803 AF in 1998 and 18,478 AF in 2005 (Tables 5 and 6).

It should be noted that the annual estimate of deep percolation of precipitation for a particular year is not identical to the amount of precipitation that recharges the aquifer system during that same year. The recharge rate of precipitation that has percolated into the subsurface is a function of the thickness and transmissive properties of the unsaturated zone. For example, groundwater recharge from precipitation in the shallow Salinas River alluvium likely occurs within the same year that the precipitation infiltrates into the coarse-grained sediments associated with the alluvium. However, the downward flow of precipitation is generally slower through the deeper and lesser permeable sediments of the unsaturated zone associated with a large area of the Paso Robles Formation. As such, the unsaturated zone attenuates the rate at which deep percolation of precipitation recharges the underlying aquifer. The significant volume of precipitation that percolates into the subsurface during a particular year may take several years to recharge the aquifer.

3.1.3 Streambed Percolation

Annual streambed percolation in the Basin from 1998 to 2009 was also estimated using a linear regression relationship developed between estimated annual streambed percolation and annual measured precipitation at Santa Margarita Booster Station No. 95 from 1981 to 1997. The calculated multiple R-square statistic in this regression relationship was 0.82. The regression equation line and the paired values of annual streambed percolation and measured precipitation from 1981 to 1997 are plotted together on Figure 6. Annual streambed percolation in the Basin was then estimated from 1998 to 2009 using this regression equation and varied from 1,500 AF in 2007 to 103,408 AF in 1998, with an average annual value of 40,700 AF (Tables 3 and 4).

A similar linear regression relationship was also developed between annual estimated streambed percolation in the Subbasin and annual measured precipitation at Santa Margarita Booster Station No. 95 from 1981 to 1997. The associated multiple R-square was 0.77. The regression equation line and the paired values of annual streambed percolation and annual precipitation from 1981 to 1997 are plotted together on Figure 7. From 1998 to 2009, estimated streambed percolation in the Subbasin varied from 5,071 AF in 2007 to 16,994 AF in 1998, with an average annual value of 9,874 AF (Tables 5 and 6).

3.1.4 Agricultural Irrigation Return Flows

Annual agricultural irrigation return flows in the Basin from 1998 to 2009 were estimated as a percentage of the gross annual agricultural groundwater pumping (i.e., applied irrigation water). During 1997, irrigation return flows in the Basin were estimated in the Phase I Report to be an average of about 2.2 percent of the gross agricultural pumping demand. From a practical standpoint, it is unlikely that inefficiencies could be reduced below this percentage loss by further improvements to irrigation methods. Therefore, annual irrigation return flows from 1998 to 2009 were estimated as 2.2 percent of annual gross agricultural pumping. Using this percentage loss, annual irrigation return flows in the Basin increased annually from 1,139 AF in

1998 to 1,388 AF in 2009, with an average annual value of 1,264 AF (Table 9). In the Subbasin, annual irrigation return flows increased from 23 AF in 1998 to 32 AF in 2009, with an average annual value of 28 AF (Table 9).

3.1.5 Wastewater Discharge

Wastewater discharge includes discharge of treated effluent from wastewater treatment plants and discharge from on-site septic systems. The City of Paso Robles, City of Atascadero, Templeton CSD, and San Miguel CSD each discharge treated wastewater effluent in the Salinas River alluvium from their respective treatment facilities. Annual discharge volumes of treated wastewater from 1998 to 2009 from these four treatment facilities are presented in Table 10 (a complete data set for 1998 to 2001 was not available from San Miguel CSD and are annual discharge values are estimated. Wastewater discharge by the Templeton CSD began in 2003). The City of Paso Robles and San Miguel CSD discharge to areas in the Salinas River alluvium that are located in the Basin but downstream of the Subbasin. Conversely, the City of Atascadero and Templeton CSD discharge treated wastewater in areas of the alluvium within the Subbasin. The combined annual discharge of treated wastewater in the Basin by all four treatment facilities varied from 4,102 AF in 1999 to 4,862 AF in 2005, with an average annual value of 4,497 AF (Table 10). The annual discharge of treated wastewater in the Subbasin by the City of Atascadero and Templeton CSD varied from 1,030 AF in 2000 to 1,423 in 2005, with an average annual value of 1,178 AF (Table 10).

Small commercial enterprises that provide their own water supply by private wells (see 3.2.4 – Small Commercial Pumping) are assumed to discharge their wastewater in on-site septic systems. Similarly, rural residences and small community water systems that operate private wells (see 3.2.5 – Rural Domestic and Small Community System Pumping) are also assumed to discharge their wastewater in on-site septic systems. For both small commercial and rural domestic/small community private well systems, annual wastewater discharge is further assumed to be 50 percent of the annual pumped volume. Consequently, annual wastewater discharge from small commercial systems increased from 751 AF in 1998 to 1,315 in 2009 in the Basin (Tables 3 and 4) and from 157 AF in 1998 to 237 AF in 2009 in the Subbasin (Tables 5 and 6).

As described later in 3.2.5 – Rural Domestic and Small Community System Pumping, two different sets of water duty factors were used to estimate annual pumping by rural domestic private wells. Under water duty factor Set No. 1, annual wastewater discharge from rural domestic/small community systems increased from 2,824 AF in 1998 to 3,476 AF in 2009 in the Basin (Table 3) and from 530 AF in 1998 to 541 AF in 2009 in the Subbasin (Table 5). Conversely, under water duty factor Set No. 2 annual wastewater discharge from rural domestic/small community systems increased from 4,801 AF in 1998 to 5,909 AF in 2009 in the Basin (Table 4) and from 902 AF in 1998 to 919 AF in 2009 in the Subbasin (Table 6).

3.2 GROUNDWATER DISCHARGE

3.2.1 Subsurface Outflows

Annual subsurface outflow in the Basin from 1981 to 1997 was estimated as a constant value of 600 AF. This estimate for the Basin was also applied to each year from 1998 to 2009 (Tables 3 and 4). Similarly, annual subsurface outflow in the Subbasin from 1981 to 1997 was estimated as a constant value of 150 AF and was also applied to each year from 1998 to 2009 (Tables 5 and 6).

3.2.2 Agricultural Pumping

Gross agricultural pumping in the Basin and Subbasin during 2006 was estimated to be 60,000 and 1,348 AF, respectively (Todd, 2009). Estimated gross agricultural pumping in the Basin during 1997 by Fugro and Cleath (Fugro West, 2005) was used in conjunction with the corresponding Todd estimate during 2006 to estimate via straight-line interpolation the annual gross agricultural pumping in the Basin from 1998 to 2005. Annual gross agricultural pumping from 2007 to 2009 was subsequently estimated by extrapolation from the 2006 estimate by Todd (2009). Similarly, annual gross agricultural pumping in the Subbasin from 1998 to 2005 and from 2007 to 2009 was also estimated by straight-line interpolation and extrapolation, respectively.

By this methodology, annual gross agricultural pumping in the Basin increased from 51,794 AF in 1998 to 63,077 AF in 2009 (Table 10). In a similar manner, annual gross agricultural pumping in the Subbasin increased monotonically from 1,059 AF in 1998 to 1,456 AF in 2009 (Table 10).

3.2.3 Urban Pumping

Annual urban pumping from 1998 to 2009 by the City of Paso Robles, Atascadero MWC, Templeton CSD, and San Miguel CSD is presented in Table 11. Production wells operated by the Atascadero MWC and Templeton CSD are located entirely within the Subbasin whereas the production wells operated by San Miguel CSD are located entirely within the Estrella Sub-area of the Basin. The City of Paso Robles Thunderbird well field is located in the shallow alluvium within the Subbasin whereas the City's other shallow and deep production wells are located in the Estrella Sub-area of the Basin. According to historical data, approximately 50 percent of the City's total groundwater extraction occurs in the Thunderbird well field. Therefore, for this study it is assumed that 50 percent of the City's annual extraction from 1998 to 2009 occurs within the Subbasin and the other 50 percent occurs in the Estrella Sub-area.

Annual urban pumping from 1998 to 2009 for the City of Paso Robles, Templeton CSD, and San Miguel CSD were estimated by straight-line interpolation using reported pumped volumes for 1997 and 2006. Annual pumping by the Atascadero MWC was instead reported for each calendar year from 1998 to 2009. In Table 11, annual pumping by the City of Paso Robles increased from 6,026 AF in 1998 to 8,032 AF in 2009; increased from 1,181 AF in 1998 to 1,782 AF in 2009 for Templeton CSD; and increased from 239 AF in 1998 to 379 AF in 2009 for San

Miguel CSD. Annual pumping by the Atascadero MWC varied from 6,189 AF in 2009 to 6,307 AF in 1998, with an average annual pumping rate of 6,248 AF. Total annual urban pumping in the Basin by all four purveyors increased from 13,752 AF in 1998 to 16,382 AF in 2009, whereas the total annual urban pumping in the Subbasin increased from 10,500 AF in 1998 to 11,987 AF in 2009 (Table 11).

3.2.4 Small Commercial Pumping

Small commercial pumping in the Basin and Subbasin during 2006 was estimated to be 2,323 and 430 AF, respectively, by Todd (2009). Similarly, small commercial pumping in the Basin and Subbasin during 1997 was estimated to be 1,400 and 300 AF, respectively, by Fugro and Cleath (Fugro West, 2002). These estimates during 1997 and 2006 were used to estimate, via straight-line interpolation, the annual small commercial pumping in the Basin and Subbasin from 1998 to 2005. Annual small commercial pumping in the Basin and Subbasin from 2007 to 2009 was subsequently estimated by extrapolation from the corresponding estimates for 2006 by Todd (2009). Using this approach, annual small commercial pumping in the Basin increased from 1,503 AF in 1998 to 2,631 AF in 2009 (Tables 3 and 4). Similarly, annual small commercial pumping in the Subbasin increased from 314 AF in 1998 to 473 AF in 2009 (Tables 5 and 6).

3.2.5 Rural Domestic and Small Community Pumping

Rural domestic pumping for the 2006 water year was estimated by Todd (2009) for the eight major sub-areas of the Basin. For this, Todd performed a survey of the dwelling unit types associated with the rural parcels in each sub-area and assumed that each dwelling unit pumped groundwater at a water duty factor of 1.7 acre-foot per year per dwelling unit (AFY/DU). As of the 2006 water year, there were 6,596 dwelling units in the Basin and 1,076 dwelling units within the Subbasin. The parcels surveyed by Todd included those serviced by small community water systems. Therefore, the rural domestic pumping demand estimated by Todd represented both actual rural domestic demand as well as small community pumping demand. Similarly, the rural domestic pumping demand estimated in this study will also include actual rural domestic demand and small community pumping demand.

Rural domestic pumping in the Basin and Subbasin during 1997 in the Phase I Report was also estimated using a water duty factor of 1.7 AFY/DU. The Phase I Report estimate of rural domestic pumping during 1997 was 9,400 AF whereas the estimate for the Subbasin was 1,800 AF. Dividing these two pumping rates by 1.7 AFY/DU results in 5,529 dwelling units in the Basin and 1,059 dwelling units in the Subbasin. The number of dwelling units for each year from 1998 to 2005 in the Basin was then estimated by interpolating between the calculated number of dwelling units during 1997 and the surveyed number from Todd (2009) for 2006. The number of dwelling units for 2007 to 2009 was simply extrapolated from the 2006 number. A similar approach was also used to estimate the number dwelling units for each year in the Subbasin from 1998 to 2005 and from 2007 to 2009.

Rural domestic pumping was estimated for two different sets of water duty factors. Set No. 1 consisted of a single water duty factor of 1.0 AFY/DU that was applied to all dwelling units in the Basin (i.e., all dwelling units in the seven sub-areas and the Subbasin). Set No. 2 similarly consisted of a single water duty factor of 1.7 AFY/DU that was also applied to all dwelling units in the Basin.

Annual rural domestic pumping in the Basin increased linearly from 1998 to 2009 for both sets of water duty factors. For Set No. 1, rural domestic pumping increased from 5,648 AF in 1997 to 6,951 AF in 2009 (Table 12). For Set No. 2, rural domestic pumping increased from 9,601 AF in 1997 to 11,817 AF in 2009 (Table 13).

Annual rural domestic pumping in the Subbasin also increased linearly from 1998 to 2009 for both sets of water duty factors. For Set No. 1, rural domestic pumping increased from 1,061 AF in 1997 to 1,082 AF in 2009 (Table 12). For Set No. 2, rural domestic pumping increased from 1,803 AF in 1997 to 1,839 AF in 2009 (Table 13).

3.2.6 Phreatophyte Extraction

Phreatophyte extraction refers to consumptive use by vegetation along the riparian corridors in the Basin. Areas of riparian vegetation in the Basin were mapped as part of the Phase I Report and a water duty factor was subsequently applied in that study to estimate the annual consumptive use of the phreatophytes. In this study, annual phreatophyte extraction in the Basin from 1998 to 2009 was estimated using a linear regression equation developed between estimated annual phreatophyte extraction in the Basin and annual measured precipitation at Atascadero MWC Station No. 34 from 1981 to 1997 (Figure 8). The calculated multiple R-square statistic in this regression relationship was 0.96. From 1998 to 2009 estimated phreatophyte extraction in the Basin varied from 1,592 AF in 2007 to 7,085 AF in 2005, with an average annual value of 3,449 AF (Tables 3 and 4).

A similar linear regression equation was developed between annual phreatophyte extraction in the Subbasin and measured precipitation at Atascadero MWC Station No. 34 from 1981 to 1997 (Figure 9). The calculated multiple R-square statistic in this regression relationship was 0.9. Using this relation, estimated subsurface inflows in the Subbasin from 1998 to 2009 varied from 74 AF in 2007 to 334 AF in 2005, with an average annual value of 162 AF (Tables 5 and 6).

3.3 GROUNDWATER STORAGE CHANGES AND BASIN OVERDRAFT STATUS

3.3.1 Groundwater Storage Changes

Annual groundwater storage change is equal to the difference between annual recharge and annual discharge. Cumulative groundwater storage change is equal to the sum of the annual changes in groundwater storage over the study period.

Annual and cumulative groundwater storage changes in the Basin from 1998 to 2009 for rural domestic water duty factor sets No. 1 and No. 2 are presented in Tables 3 and 4. Under Set No. 1 (rural domestic pumping of 1.0 AFY/DU), annual groundwater storage change varied from a decrease of 72,736 AF in 2007 to an increase of 366,756 AF in 1998, with an average annual change of 19,108 AF. Cumulatively, groundwater storage increased by 229,292 AF under Set No. 1 from 1998 to 2009. Under Set No. 2 (rural domestic pumping of 1.7 AFY/DU), annual groundwater storage change varied from a decrease of 75,086 AF in 2007 to an increase of 364,779 AF in 1998, with an average annual change of 16,903 AF. Cumulatively, groundwater storage increased by 202,834 AF under Set No. 2 from 1998 to 2009.

Annual and cumulative groundwater storage changes in the Subbasin from 1998 to 2009 for rural domestic water duty factor sets No. 1 and No. 2 are presented in Tables 5 and 6. Under Set No. 1, annual groundwater storage change varied from a decrease of 7,508 AF in 2007 to an increase of 23,711 AF in 1998, with an average annual change of 1,804 AF. Cumulatively, groundwater storage increased by 21,646 AF under Set No. 1 from 1998 to 2009. Under Set No. 2, annual groundwater storage change varied from a decrease of 7,885 AF in 2007 to an increase of 23,339 AF in 1998, with an average annual change of 1,429 AF. Cumulatively, groundwater storage increased by 17,147 AF under Set No. 2 from 1998 to 2009.

3.3.2 Groundwater Basin Overdraft Status

The perennial yields of the Basin and Subbasin were estimated during Phase II of the Paso Robles Groundwater Basin Study as 97,700 and 16,400 AFY, respectively (Fugro 2005). The water balance calculation from 1998 to 2009 for water duty factor set No. 1 (which assumes a rural domestic water duty factor of 1.0 AFY/DU) shows an estimated total groundwater outflow in 2009 of 91,915 AF (equal to approximately 94% of the perennial yield). The water balance calculation for set No. 2 (rural domestic water factor of 1.7 AFY/DU) suggests an estimated total groundwater outflow in 2009 of 96,781 AF (or approximately 99% of the perennial yield).

For the Subbasin, the water balance from 1998 to 2009 for water duty factor set No. 1 indicated a total groundwater outflow in the Subbasin in 2009 of 15,255 AF (or approximately 93% of the perennial yield). The water balance for set No. 2 suggests a total groundwater outflow in the Subbasin in 2009 of 16,012 AF (or approximately 98% of the perennial yield).

4.0 PROJECTED WATER BALANCES FROM 2010 TO 2025

Projected water balances in the Basin and Subbasin for the future period of 2010 to 2025 were also computed for this study. For this, projected water demands of the four urban areas were provided by staff representatives of these communities (Table 16). In addition to groundwater pumping, the City of Paso Robles, the City of Atascadero, and the community of Templeton each anticipate receiving surface water supplies from the Nacimiento Water Project starting in 2010 or 2011. These surface water supplies are used in conjunction with pumped groundwater to satisfy local urban water demands. In addition to providing an alternative source of water supply, these surface water deliveries will also offset the future groundwater pumping demands of these communities. Table 16 summarizes the anticipated future water demands of the four urban communities (as represented by information provided to us by staff) and the distribution of anticipated Nacimiento deliveries and groundwater pumping. As urban demands increase (according to the projections shown on Table 16), treated wastewater discharge also increases as shown on Table 17.

In the projected water balances for the Basin and Subbasin, the values of the following recharge and discharge components from 2010 to 2025 are assumed to equal their respective 2009 values: 1) irrigation return flows, 2) subsurface outflows, 3) gross agricultural pumping, 4) rural domestic/small community pumping, and 5) small commercial pumping. The 15-year climate (i.e., annual precipitation) from 1994 to 2009 is also assumed to repeat itself from 2010 to 2025. Therefore, the precipitation-dependent and runoff-dependent components of subsurface inflow, streambed percolation, and phreatophyte extraction from 2010 to 2025 are estimated using the annual estimates from 1994 to 2009. For the projected water balance, land use in the Basin during 2009 is assumed to remain the same for each year from 2010 to 2025. Consequently, annual deep percolation of precipitation from 2010 to 2025 is estimated by the Blaney method using this fixed land use distribution and the annual precipitation totals from 1994 to 2009.

It should be reiterated here that these projected water balances from 2010 to 2025 are not intended to provide absolute predictions of future groundwater recharge and discharge rates, and subsequent groundwater storage changes. Instead, they are meant to provide a general assessment of anticipated future groundwater pumping demands with respect to current estimates of perennial yield given assumed trends in urban groundwater use, which takes into account estimates of urban groundwater pumping, water conservation, and the importation of Nacimiento water. Moreover, the projected water balance assumes that future climate patterns will be similar to historical patterns observed over the original 1981 to 1997 base period. As such, the projected water balance did not attempt to account for possible impacts of theorized global climate change (e.g., long-term upward or downward trends in annual rainfall), or future changes in pumping by agricultural, rural/community, or small commercial pumping.

The projected water balance for the Basin is presented in Table 14. The average annual total groundwater outflow in the Basin from 2010 to 2025 is calculated to be 96,625 AF, and ranges from 92,645 AF to as high as 100,441 AF. Based on an average annual Basin outflow of 96,625 AF, the cumulative change in groundwater storage in the Basin from 2010 to 2025 is 406,943 AF (Table 14). Offsets of urban groundwater pumping by supplemental surface water supplies provided by the Nacimiento Water Project amounted to 66,798 AF from 2010 to 2025. Similarly, aquifer recharge from wastewater discharge in rural domestic/small community and small commercial septic systems accounted for 115,585 AF from 2010 to 2025 or an average of 6 percent of total annual recharge. The combined impacts of the Nacimiento Water Project and the inclusion of wastewater discharges from rural domestic/small community and small commercial operations equate to 44 percent of the 406,943 AF increase in groundwater storage from 2010 to 2025. On an annual average basis, deep percolation of precipitation and streambed percolation accounted for 46 and 37 percent of total annual recharge. Irrigation return flows and wastewater discharge from urban, small commercial, and rural domestic/small community systems accounted for 12 percent of total annual recharge. Subsurface inflows accounted for the remaining 5 percent of total annual recharge. On an annual average basis, agricultural groundwater pumping accounted for 65 percent of total annual discharge. Urban, rural domestic/small community water systems, and small commercial pumping accounted for 15, 12, and 3 percent of total annual discharge. Subsurface outflows and phreatophyte extraction accounted for the remaining 1 and 4 percent of total annual discharge.

The projected water balance for the Subbasin is presented in Table 15. The average annual total groundwater outflow in the Subbasin from 2010 to 2025 is calculated to be 15,420 AF, and ranges from 13,833 AF to 16,592 AF. The cumulative change in groundwater storage in the Subbasin from 2010 to 2025 is 41,224 AF (Table 15). Supplemental surface water supplies provided by the Nacimiento Water Project resulted in an offset of urban groundwater pumping of 43,298 AF from 2010 to 2025. Similarly, aquifer recharge from wastewater discharge in rural domestic/small community and small commercial septic systems amounted to 18,496 AF from 2010 to 2025. On an annual average basis, deep percolation of precipitation and streambed percolation accounted for 22 and 58 percent of total annual recharge. Irrigation return flows and wastewater discharge from urban, small commercial, and rural domestic/small community systems accounted for 14 percent of total annual recharge. Subsurface inflows accounted for the remaining 4 percent of total annual recharge. On an annual average basis, urban groundwater pumping accounted for 73 percent of total annual discharge. Agricultural, rural domestic/small community water systems, and small commercial pumping accounted for 9, 12, and 3 percent of total annual discharge. Subsurface outflows and phreatophyte extraction each accounted for 1 percent of total annual discharge.

5.0 INTERACTION OF SHALLOW ALLUVIUM AND PASO ROBLES FORMATION

The aquifer system in the Paso Robles Groundwater Basin consists of the Paso Robles Formation and the shallow alluvial aquifers associated with the Salinas River, Estrella River, Huer Huero Creek, and other tributary creeks. The aquifer system in the Atascadero Groundwater Subbasin consists of a stretch of the Salinas River alluvium and a region of the Paso Robles Formation. The Atascadero Subbasin is a subbasin within the Paso Robles Basin. The Rinconada Fault acts as a hydraulic barrier within the Paso Robles Formation and represents the boundary that separates the Subbasin from the rest of the Basin. However, the Rinconada Fault does not act similarly as a hydraulic barrier to groundwater flow in the Salinas River alluvium. As such, groundwater flow in the alluvium is continuous along the stretch of the Salinas River that traverses the entire Basin.

Groundwater in storage should be calculated separately for three different subsurface regions: 1) the shallow alluvial aquifers, 2) the Paso Robles Formation within the Subbasin, and 3) the Paso Robles Formation within the entire Basin. The alluvial aquifers are a significant source of recharge to the Paso Robles Formation, particularly along the western region of the Basin and Subbasin where the Salinas River alluvium is located. Although the shallow alluvium and the underlying Paso Robles Formation are distinctly different aquifers, the low permeable layer that separates them varies spatially in terms of thickness and permeability. Consequently, recharge of the Paso Robles Formation from alluvium underflow varies along the stretches of alluvial deposits in the Basin and Subbasin. In addition to the thickness and permeability of the sediments separating the alluvium from the Paso Robles Formation, the rate of recharge is also dependent on the hydraulic head gradient across these sediments (i.e., difference in groundwater levels between the alluvium and the Paso Robles Formation). Pumping in the Paso Robles Formation may result in significant drawdown of groundwater levels in this aquifer, thus increasing the hydraulic gradient and subsequently the recharge rate from the overlying alluvium.

Groundwater flow between the alluvium and the Paso Robles Formation can occur either in the upward or downward direction. The downward direction of groundwater flow occurs in the form of recharge from the alluvium into the Paso Robles Formation. Recharge occurs when a hydraulic head gradient exists between the shallow alluvium and the underlying formation in the downward direction, in other words, when groundwater levels in the alluvium are greater than levels in the Paso Robles Formation. Upward flows of groundwater from the Paso Robles Formation into the shallow alluvium can also occur if the hydraulic head gradient between the two aquifers is in the upward direction. This occurs when the groundwater pressure in the Paso Robles Formation is greater than the hydraulic head in the shallow alluvium. The hydraulic head gradient between the aquifers in a particular area can be determined by measuring groundwater levels in wells screened in the alluvium and subtracting those from measured groundwater levels in nearby wells screened in the Paso Robles Formation.

The actual amount of groundwater in storage in the Paso Robles Formation is significantly greater than that of the shallow alluvial aquifers. Groundwater in storage within the Paso Robles Formation in the Basin from 1981 to 1997 was estimated to be 30,534,000 AF on an average annual basis. The combined area of alluvium in the Basin (i.e., including the Salinas River, Estrella River, Huer Huero Creek, San Juan Creek, and other small creeks in the Basin) is 49,500 acres. Using the spatial distribution of specific yield and groundwater levels during the water year of 1980 from the Basin groundwater flow model, the volume of groundwater in storage in the combined area of alluvium was estimated to be 681,974 AF. In particular, the Salinas River alluvium and its tributaries accounted for 447,480 AF of this storage volume while the Estrella River and its tributaries accounted for 234,494 AF of this total. The combined groundwater in storage for both the alluvial aquifers and the underlying Paso Robles Formation is on the order of 31,215,974 AF. Overall, groundwater in storage in the alluvial aquifers within the Basin accounts for only about 2.1 percent of the total groundwater in storage in the entire Basin.

Groundwater in storage within the Paso Robles Formation in the Subbasin from 1981 to 1997 was estimated to be 513,600 AF on an average annual basis. Within the Subbasin, groundwater in storage in the Salinas River alluvium was estimated to be 134,274 AF. The combined groundwater in storage for both the Salinas River alluvium and the underlying Paso Robles Formation within the Subbasin is on the order of 647,874 AF. Overall, groundwater in storage in the alluvium within the Subbasin accounts for 21 percent of the total groundwater in storage in the Subbasin. In contrast to the Basin where the total groundwater in storage is predominantly in the Paso Robles Formation, the alluvium in the Subbasin accounts for a significant percentage of the total groundwater storage in the Subbasin.

Although the total groundwater in storage in the alluvial aquifers is small relative to the Paso Robles Formation, the alluvial aquifers are a significant source of recharge to the underlying Paso Robles Formation. For example, streambed percolation in the Basin accounts for approximately 38 percent of the total annual recharge on an average annual basis. Moreover, in the Subbasin streambed percolation accounts for as much as 62 percent of the total annual recharge on average.

Due to its large storage capacity, the Paso Robles Formation represents a more robust groundwater reservoir than the shallow alluvial aquifers of the rivers and creeks. Storage changes in the Paso Robles Formation due to annual variations in climate are buffered to a greater degree than those in the alluvial aquifers. By contrast, groundwater storage in the alluvium fluctuates in direct response to annual variations in climate. Consequently, the estimation of a perennial yield for the alluvial aquifers is problematic due to the extreme year-to-year fluctuations in annual precipitation, runoff, and streamflow that provide recharge to the alluvial aquifers. A separate estimated perennial yield for the alluvial aquifers would therefore not provide a measure of the reliable amount of groundwater that could be sustainably extracted from them on an annual basis.

Total annual pumping from the shallow alluvial aquifers and the Paso Robles Formation can be assessed against the estimated perennial yield for the Basin. However, given the large volume of groundwater in storage in the Basin, successive annual exceedences of the perennial yield may not be immediately reflected by decreases in groundwater levels in the Paso Robles Formation in all areas of the Basin.

Given the significant groundwater in storage in the alluvium within the Subbasin relative to the storage in the Paso Robles Formation in the Subbasin, annual groundwater extractions in the Subbasin from the alluvium should be accounted for separately from those from the Paso Robles Formation. Changes in groundwater levels in the alluvium should be evaluated with respect to annual extractions from the alluvium. Similarly, changes in groundwater levels in the Paso Robles Formation within the Subbasin should be evaluated with respect to annual extractions from the Paso Robles Formation within the Subbasin. The perennial yield for the Subbasin theoretically applies to combined groundwater extractions from the shallow alluvium and deeper Paso Robles Formation. Exceeding the perennial yield in the Subbasin may not necessarily be reflected by decreasing groundwater levels in the Paso Robles Formation since significant pumping occurs in the alluvium. Therefore, the overdraft status of the Subbasin needs to be evaluated by assessment of groundwater level changes in both the alluvium and the Paso Robles Formation relative to the respective pumping from those aquifers.

6.0 SUMMARY AND CONCLUSIONS

In this report, the water balances from 1981 to 1997 for the Basin and Subbasin, as originally estimated by Fugro and Cleath (Fugro West, 2002), were updated for the period from 1998 to 2009. Each water balance consisted of the estimated major natural and anthropogenic sources of groundwater recharge and discharge in the Basin and Subbasin from 1998 to 2009. As part of this update, two different sets of water duty factors were used to estimate rural domestic pumping in the Basin and Subbasin. This resulted in the development of two water balances for the Basin (Tables 3 and 4) and two water balances for the Subbasin (Tables 5 and 6) from 1998 to 2009. This report also provided a projected water balance for both the Basin and Subbasin for the future period of 2010 to 2025 (see Tables 14 and 15). The projected water balances, in particular, evaluated the impacts on Basin and Subbasin groundwater storage of offsetting urban groundwater pumping by supplemental surface water supplies from the Nacimiento Water Project for the City of Paso Robles, Atascadero MWC, and Templeton CSD. The major conclusions of the study include:

- The water balance calculations presented in this report show that demand in both the Atascadero Subbasin and the Paso Robles Groundwater Basin as a whole is approaching the average annual perennial yield. Given the degree of uncertainty of the estimates of inflow and outflow components of the water balance equation, the Basin should be considered to be essentially in balance by a small margin.

- Total annual groundwater outflow (i.e., total groundwater pumping) in the Paso Robles Groundwater Basin and the Atascadero Subbasin increased during the period from 1998 to 2009. In 2009, the water balance for the scenario which assumes a rural domestic water demand of 1.0 AFY/DU suggests a total groundwater outflow in the Basin of 91,915 AF (or approximately 94% of the perennial yield of 97,700 AFY). The water balance for the scenario that assumes a rural domestic water demand of 1.7 AFY/DU suggests a total groundwater outflow of 96,781 AF in 2009 (or approximately 99% of the perennial yield).

- In the Atascadero Subbasin, the water balance for water duty factor set No. 1 (assuming a rural domestic demand of 1.0 AFY/DU) and No. 2 (assuming a rural domestic demand of 1.7 AFY/DU) shows total groundwater outflows in the Subbasin during 2009 of 15,255 and 16,012 AF, respectively (or approximately 93% and 98% of the perennial yield of 16,400 AF).

- The two different sets of water duty factors used in the estimation of annual rural domestic pumping resulted in significantly different estimates of cumulative groundwater storage change in the Subbasin from 1998 to 2009. This finding illustrates the need to more accurately quantify the of water duty factors for rural domestic water use throughout the Basin.

- Groundwater in storage in the Basin and Subbasin increased from 1998 to 2009, partly because total groundwater outflow was slightly less than the perennial yield, but also partly because significant recharge from percolation of precipitation occurred in two of these years (1998 and 2005). The overall increase in groundwater storage in both the Basin and Subbasin from 1981 to 2009 generally supports the conclusion that estimated total annual groundwater outflows for each year in the Basin and Subbasin were less than their respective perennial yield values. It should be noted that short-term periods when pumpage might exceed the perennial yield do not necessarily constitute an overdraft condition.

- In the projected water balances from 2010 to 2025, offsets of urban groundwater pumping by supplemental surface water supplies from the Nacimiento Water Project to the City of Paso Robles, Atascadero MWC, and Templeton CSD resulted in beneficial impacts to groundwater storage for the Basin and Subbasin. Offsets of urban groundwater pumping by supplemental surface water supplies of the Nacimiento Water Project from 2010 to 2025 amounted to 66,798 AF in the Basin and 43,298 AF in the Subbasin.

- It should be noted that the future basin outflow figures shown in the water balance projections through 2025 may understate actual future Basin and Subbasin outflows because, in the projections, rural domestic, commercial, and agricultural pumping were held constant at 2009 rates (this was done in order to illustrate the potential effects of importing Nacimiento Water on urban pumping). Growth or changes in water demand from rural domestic, commercial, or agricultural market changes could result in total basin demand exceeding perennial yield in the future. Furthermore, the water balance projections through 2025 assume a repeat of precipitation patterns from 1994 to 2009. This prior 16-year rainfall record may or may not reflect long-term conditions.

- The projected water balances from 2010 to 2025 were not intended to provide absolute predictions of future groundwater recharge and discharge and subsequent groundwater storage changes. Instead, they provide a general assessment of anticipated future groundwater pumping demands with respect to current estimates of perennial yield given assumed trends in urban groundwater use, which takes into account estimates of urban groundwater pumping, water conservation, and the importation of Nacimiento Water. Moreover, the projected water balance assumed that future climate patterns will be similar to historical patterns observed over the original 1981 to 1997 base period. As such, the projected water balance did not attempt to account for possible impacts of theorized global climate change (e.g., long-term upward or downward trends in annual rainfall), or future changes in pumping by agricultural, rural/small community, or small commercial pumping.

- Percolation of precipitation is a major source of basin recharge that is accompanied by a large degree of uncertainty. The effect of rainfall recharge may not immediately result in a water level change in wells that are located in areas of highest pumping (that is, in areas of depressed water levels). Additional monitoring wells located in recharge areas of the Basin are recommended to monitor the effects of percolation of precipitation in these areas and in the Basin as a whole.

- Streambed percolation is a major component of basin recharge, with large annual fluctuations depending on yearly rainfall. Additional monitoring wells in shallow alluvial aquifers associated with the Salinas River, Estrella River, Huer Huero Creek, and other tributary creeks as well as deep monitoring wells in the Paso Robles Formation adjacent to the streams, and monitoring of water level data in those wells, are recommended to develop data to refine estimates of streambed percolation.

- The results of this study reinforce the need for implementation of an effective basin monitoring and management plan. The results also demonstrate the need to update the numerical groundwater flow model, which is based on data through 1997. An update and recalibration of the Fugro (2005) model would help to refine the many uncertainties and assumptions that were used throughout this water balance update.

- It should be noted that the precision of the results estimated by the methods employed in this study and subsequently presented in the report text and tables do not imply a similar level of accuracy. In other words, a number of assumptions were invoked in the estimation of the recharge and discharge components. These estimated components therefore represent approximations that lie within a reasonable range of expected values. The values of the estimated components were presented "as is" in the report text and tables rather than being subjected to numerical rounding.

7.0 REFERENCES

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TABLES

Table 1. Precipitation Measurements at Seven Gauge Stations from 1998 to 2009

Water Year	Paso Robles CDF Station No. 101 (inches)	Atascadero MWC Station No. 34 (inches)	Creston 4.5 NW Station No. 52.1 (inches)	Shandon Station No. 73 (inches)	Santa Margarita Station No. 95 (inches)	San Miguel Station No. 125 (inches)	Camatta Canyon. Station No. 138 (inches)	Estimated Reference (inches)
1998	30.8	33.1	25.5	21.8	57.4	23.2	23.8	26.3
1999	10.5	12.2	8.2	6.9	24.4	7.1	7.4	8.7
2000	14.9	17.2	11.3	8.4	32.0	10.2	7.4	11.6
2001	22.8	19.1	14.6	13.1	28.1	15.3	11.1	16.0
2002	7.5	7.9	5.1	6.1	19.1	5.1	4.9	6.1
2003	13.8	10.7	9.9	10.6	30.7	11.2	9.0	10.9
2004	10.9	8.8	7.4	8.8	18.4	7.3	7.2	8.4
2005	32.6	34.6	21.7	17.5	55.2	22.3	13.0	23.6
2006	23.4	22.5	17.6	15.5	34.3	12.9	10.6	17.1
2007	7.1	7.6	6.3	5.6	12.1	4.4	4.7	5.9
2008	15.3	16.1	11.2	11.4	31.0	10.8	9.1	12.3
2009	9.0	11.0	6.0	7.3	21.3	6.4	6.7	7.7
Minimum	7.1	7.6	5.1	5.6	12.1	4.4	4.7	5.9
Maximum	32.6	34.6	25.5	21.8	57.4	23.2	23.8	26.3
Average	16.5	16.7	12.1	11.1	30.3	11.3	9.6	12.9

Note: Precipitation data obtained from County of San Luis Obispo Department of Public Works

Table 2. Cumulative Departure of Annual Precipitation from 1998 to 2009

Water Year	Annual Precipitation Atascadero MWC Station No. 34 (inches)	Average Annual Precipitation (1916 to 2009) (inches)	Annual Departure from Long-term Annual Average (inches)	Cumulative Departure from Long-term Annual Average (inches)
1998	33.1	17.6	15.5	15.5
1999	12.2	17.6	-5.4	10.2
2000	17.2	17.6	-0.5	9.7
2001	19.1	17.6	1.5	11.3
2002	7.9	17.6	-9.7	1.6
2003	10.7	17.6	-6.9	-5.3
2004	8.8	17.6	-8.8	-14.1
2005	34.6	17.6	17.0	2.9
2006	22.5	17.6	4.9	7.8
2007	7.6	17.6	-10.0	-2.2
2008	16.1	17.6	-1.5	-3.7
2009	11.0	17.6	-6.7	-10.4
Minimum	7.6	--	-10.0	--
Maximum	34.6	--	17.0	--
Average	16.7	--	-0.9	--

Table 3. Water Balance for the Paso Robles Groundwater Basin from 1998 to 2009 for Rural Domestic Water Duty Factor Set No. 1

Water Year	Subsurface Inflow (acre-feet)	Precipitation Percolation (acre-feet)	Streambed Percolation (acre-feet)	Irrigation Return Flow (acre-feet)	Urban Wastewater Discharge (acre-feet)	Rural\Small Community Wastewater Discharge (acre-feet)	Small Commercial Wastewater Discharge (acre-feet)	Total Inflow (acre-feet)	Subsurface Outflow (acre-feet)	Agricultural Groundwater Pumping (acre-feet)	Urban Groundwater Pumping (acre-feet)	Rural\Small Community Groundwater Pumping (acre-feet)	Small Commercial Groundwater Pumping (acre-feet)	Phreatophyte Extraction (acre-feet)	Total Outflow (acre-feet)	Annual Storage Change (acre-feet)	Cumulative Storage Change (acre-feet)
1998	12,511	321,785	103,408	1,139	4,418	2,824	751	446,837	600	51,794	13,752	5,648	1,503	6,784	80,081	366,756	366,756
1999	5,142	0	26,644	1,162	4,102	2,883	803	40,736	600	52,820	13,991	5,766	1,605	2,533	77,316	-36,580	330,177
2000	6,876	11	44,369	1,185	4,239	2,942	854	60,476	600	53,845	14,230	5,885	1,708	3,536	79,804	-19,328	310,849
2001	7,573	8,842	35,181	1,207	4,393	3,002	905	61,103	600	54,871	14,469	6,003	1,810	3,936	81,690	-20,587	290,261
2002	3,626	0	14,269	1,230	4,327	3,061	956	27,469	600	55,897	14,709	6,122	1,913	1,659	80,899	-53,431	236,831
2003	4,599	0	41,206	1,252	4,487	3,120	1,008	55,672	600	56,923	14,948	6,240	2,015	2,220	82,946	-27,275	209,556
2004	3,943	0	12,734	1,275	4,500	3,179	1,059	26,690	600	57,948	15,187	6,359	2,118	1,842	84,054	-57,364	152,192
2005	13,033	215,760	98,220	1,297	4,862	3,239	1,110	337,5220	600	58,974	15,426	6,477	2,220	7,085	90,783	246,739	398,930
2006	8,751	13,119	49,650	1,320	4,744	3,298	1,162	82,043	600	60,000	15,665	6,596	2,323	4,615	89,799	-7,756	391,174
2007	3,510	0	1,500	1,343	4,604	3,357	1,213	15,526	600	61,026	15,904	6,714	2,426	1,592	88,262	-72,736	318,439
2008	6,499	312	41,834	1,365	4,675	3,416	1,264	59,365	600	62,052	16,143	6,833	2,528	3,316	91,472	-32,107	286,332
2009	4,691	0	19,386	1,388	4,620	3,476	1,315	34,875	600	63,077	16,382	6,951	2,631	2,273	91,915	-57,040	229,292
Minimum	3,510	0	1,500	1,139	4,102	2,824	751	15,526	600	51,794	13,752	5,648	1,503	1,592	77,316	-72,736	--
Maximum	13,033	321,785	103,408	1,388	4,862	3,476	1,315	446,837	600	63,077	16,382	6,951	2,631	7,085	91,915	366,756	--
Average	6,729	46,652	40,700	1,264	4,497	3,150	1,033	104,026	600	57,436	15,067	6,300	2,067	3,449	84,918	19,108	--

Table 4. Water Balance for the Paso Robles Groundwater Basin from 1998 to 2009 for Rural Domestic Water Duty Factor Set No. 2

Water Year	Subsurface Inflow (acre-feet)	Precipitation Percolation (acre-feet)	Streambed Percolation (acre-feet)	Irrigation Return Flow (acre-feet)	Urban Wastewater Discharge (acre-feet)	Rural\Small Community Wastewater Discharge (acre-feet)	Small Commercial Wastewater Discharge (acre-feet)	Total Inflow (acre-feet)	Subsurface Outflow (acre-feet)	Agricultural Groundwater Pumping (acre-feet)	Urban Groundwater Pumping (acre-feet)	Rural\Small Community Groundwater Pumping (acre-feet)	Small Commercial Groundwater Pumping (acre-feet)	Phreatophyte Extraction (acre-feet)	Total Outflow (acre-feet)	Annual Storage Change (acre-feet)	Cumulative Storage Change (acre-feet)
1998	12,511	321,785	103,408	1,139	4,418	4,801	751	448,814	600	51,794	13,752	9,601	1,503	6,784	84,034	364,779	364,779
1999	5,142	0	26,644	1,162	4,102	4,901	803	42,754	600	52,820	13,991	9,803	1,605	2,533	81,352	-38,598	326,182
2000	6,876	11	44,369	1,185	4,239	5,002	854	62,536	600	53,845	14,230	10,004	1,708	3,536	83,923	-21,388	304,794
2001	7,573	8,842	35,181	1,207	4,393	5,103	905	63,204	600	54,871	14,469	10,206	1,810	3,936	85,893	-22,689	282,105
2002	3,626	0	14,269	1,230	4,327	5,204	956	29,611	600	55,897	14,709	10,407	1,913	1,659	85,185	-55,573	226,532
2003	4,599	0	41,206	1,252	4,487	5,304	1,008	57,856	600	56,923	14,948	10,609	2,015	2,220	87,315	-29,459	197,073
2004	3,943	0	12,734	1,275	4,500	5,405	1,059	28,915	600	57,948	15,187	10,810	2,118	1,842	88,505	-59,590	137,483
2005	13,033	215,760	98,220	1,297	4,862	5,506	1,110	339,789	600	58,974	15,426	11,012	2,220	7,085	95,317	244,472	381,955
2006	8,751	13,119	49,650	1,320	4,744	5,607	1,162	84,351	600	60,000	15,665	11,213	2,323	4,615	94,416	-10,065	371,890
2007	3,510	0	1,500	1,343	4,604	5,707	1,213	17,876	600	61,026	15,904	11,415	2,426	1,592	92,962	-75,086	296,805
2008	6,499	312	41,834	1,365	4,675	5,808	1,264	61,756	600	62,052	16,143	11,616	2,528	3,316	96,255	-34,498	262,306
2009	4,691	0	19,386	1,388	4,620	5,909	1,315	37,308	600	63,077	16,382	11,817	2,631	2,273	96,781	-59,473	202,834
Minimum	3,510	0	1,500	1,139	4,102	4,801	751	17,876	600	51,794	13,752	9,601	1,503	1,592	81,352	-75,086	--
Maximum	13,033	321,785	103,408	1,388	4,862	5,909	1,315	448,814	600	63,077	16,382	11,817	2,631	7,085	96,781	364,779	--
Average	6,729	46,652	40,700	1,264	4,497	5,355	1,033	106,231	600	57,436	15,067	10,709	2,067	3,449	89,328	16,903	--

Table 5. Water Balance for the Atascadero Groundwater Subbasin from 1998 to 2009 for Rural Domestic Water Duty Factor Set No. 1

Water Year	Subsurface Inflow (acre-feet)	Precipitation Percolation (acre-feet)	Streambed Percolation (acre-feet)	Irrigation Return Flow (acre-feet)	Urban Wastewater Discharge (acre-feet)	Rural\Small Community Wastewater Discharge (acre-feet)	Small Commercial Wastewater Discharge (acre-feet)	Total Inflow (acre-feet)	Subsurface Outflow (acre-feet)	Agricultural Groundwater Pumping (acre-feet)	Urban Groundwater Pumping (acre-feet)	Rural\Small Community Groundwater Pumping (acre-feet)	Small Commercial Groundwater Pumping (acre-feet)	Phreatophyte Extraction (acre-feet)	Total Outflow (acre-feet)	Annual Storage Change (acre-feet)	Cumulative Storage Change (acre-feet)
1998	1,273	16,803	16,994	23	1,334	530	157	37,115	150	1,059	10,500	1,061	314	320	13,404	23,711	23,711
1999	538	4	8,320	24	1,040	531	164	10,621	150	1,095	10,635	1,063	329	119	13,391	-2,769	20,941
2000	711	519	10,323	25	1,030	532	172	13,312	150	1,131	10,771	1,065	343	166	13,626	-314	20,627
2001	780	1,549	9,285	26	1,103	533	179	13,456	150	1,167	10,906	1,066	358	185	13,832	-377	20,250
2002	386	0	6,922	26	1,032	534	186	9,087	150	1,204	11,041	1,068	372	77	13,912	-4,826	15,424
2003	483	0	9,965	27	1,268	535	193	12,473	150	1,240	11,176	1,070	387	104	14,127	-1,653	13,771
2004	418	0	6,748	28	1,188	536	201	9,118	150	1,276	11,311	1,072	401	86	14,296	-5,178	8,593
2005	1,325	18,478	16,408	29	1,423	537	208	38,408	150	1,312	11,446	1,074	416	334	14,732	23,676	32,269
2006	898	5,195	10,920	30	1,272	538	215	19,067	150	1,348	11,582	1,076	430	217	14,803	4,265	36,534
2007	375	0	5,071	30	1,102	539	222	7,339	150	1,384	11,717	1,078	444	74	14,847	-7,508	29,026
2008	673	332	10,036	31	1,152	540	229	12,994	150	1,420	11,852	1,080	459	156	15,116	-2,122	26,904
2009	493	0	7,500	32	1,195	541	237	9,997	150	1,456	11,987	1,082	473	106	15,255	-5,258	21,646
Minimum	375	0	5,071	23	1,030	530	157	7,339	150	1,059	10,500	1,061	314	74	13,391	-7,508	--
Maximum	1,325	18,478	16,994	32	1,423	541	237	38,408	150	1,456	11,987	1,082	473	334	15,255	23,711	--
Average	696	3,573	9,874	28	1,178	536	197	16,082	150	1,258	11,244	1,071	394	162	14,278	1,804	--

Table 6. Water Balance for the Atascadero Groundwater Subbasin from 1998 to 2009 for Rural Domestic Water Duty Factor Set No. 2

Water Year	Subsurface Inflow (acre-feet)	Precipitation Percolation (acre-feet)	Streambed Percolation (acre-feet)	Irrigation Return Flow (acre-feet)	Urban Wastewater Discharge (acre-feet)	Rural\Small Community Wastewater Discharge (acre-feet)	Small Commercial Wastewater Discharge (acre-feet)	Total Inflow (acre-feet)	Subsurface Outflow (acre-feet)	Agricultural Groundwater Pumping (acre-feet)	Urban Groundwater Pumping (acre-feet)	Rural\Small Community Groundwater Pumping (acre-feet)	Small Commercial Groundwater Pumping (acre-feet)	Phreatophyte Extraction (acre-feet)	Total Outflow (acre-feet)	Annual Storage Change (acre-feet)	Cumulative Storage Change (acre-feet)
1998	1,273	16,803	16,994	23	1,334	902	157	37,486	150	1,059	10,500	1,803	314	320	14,147	23,339	23,339
1999	538	4	8,320	24	1,040	903	164	10,993	150	1,095	10,635	1,806	329	119	14,135	-3,141	20,198
2000	711	519	10,323	25	1,030	905	172	13,685	150	1,131	10,771	1,810	343	166	14,371	-686	19,511
2001	780	1,549	9,285	26	1,103	906	179	13,829	150	1,167	10,906	1,813	358	185	14,579	-750	18,761
2002	386	0	6,922	26	1,032	908	186	9,461	150	1,204	11,041	1,816	372	77	14,660	-5,200	13,562
2003	483	0	9,965	27	1,268	910	193	12,848	150	1,240	11,176	1,819	387	104	14,876	-2,028	11,533
2004	418	0	6,748	28	1,188	911	201	9,494	150	1,276	11,311	1,823	401	86	15,047	-5,553	5,980
2005	1,325	18,478	16,408	29	1,423	913	208	38,783	150	1,312	11,446	1,826	416	334	15,484	23,300	29,280
2006	898	5,195	10,920	30	1,272	915	215	19,444	150	1,348	11,582	1,829	430	217	15,556	3,888	33,169
2007	375	0	5,071	30	1,102	916	222	7,716	150	1,384	11,717	1,832	444	74	15,602	-7,885	25,283
2008	673	332	10,036	31	1,152	918	229	13,372	150	1,420	11,852	1,836	459	156	15,872	-2,500	22,783
2009	493	0	7,500	32	1,195	919	237	10,376	150	1,456	11,987	1,839	473	106	16,012	-5,636	17,147
Minimum	375	0	5,071	23	1,030	902	157	7,716	150	1,059	10,500	1,803	314	74	14,135	-7,885	--
Maximum	1,325	18,478	16,994	32	1,423	919	237	38,783	150	1,456	11,987	1,839	473	334	16,012	23,339	--
Average	696	3,573	9,874	28	1,178	910	197	16,457	150	1,258	11,244	1,821	394	162	15,028	1,429	--

Table 7. Land Use Categorization in the Paso Robles Groundwater Basin from 1998 to 2009 for use by the Blaney Method

Water Year	Grasses, Weeds (acres)	Truck, Alfalfa Misc. Crops (acres)	Non-irrigated Grain (acres)	Deciduous Trees (acres)	Total Area (acres)
1998	436,966	4,984	44,603	18,448	505,000
1999	437,404	5,074	41,974	20,548	505,000
2000	437,841	5,165	39,345	22,649	505,000
2001	438,279	5,255	36,716	24,750	505,000
2002	438,717	5,346	34,087	26,851	505,000
2003	439,155	5,436	31,458	28,951	505,000
2004	439,593	5,527	28,829	31,052	505,000
2005	440,030	5,617	26,200	33,153	505,000
2006	440,468	5,707	23,571	35,253	505,000
2007	440,906	5,798	20,942	37,354	505,000
2008	441,344	5,888	18,314	39,454	505,000
2009	441,782	5,978	15,685	41,555	505,000

Note: As described in the text, acreages were estimated by straight-line interpolation using reported pumped values for 1997 and 2006.

Table 8. Land Use Categorization in the Atascadero Groundwater Subbasin from 1998 to 2009 for use by the Blaney Method

Water Year	Grasses, Weeds (acres)	Truck, Alfalfa Misc. Crops (acres)	Non-irrigated Grain (acres)	Deciduous Trees (acres)	Total Area (acres)
1998	11,892	75	1,958	652	14,577
1999	11,912	90	1,968	608	14,577
2000	11,931	105	1,978	563	14,577
2001	11,950	120	1,988	518	14,577
2002	11,969	136	1,999	473	14,577
2003	11,989	151	2,009	428	14,577
2004	12,008	166	2,019	384	14,577
2005	12,027	182	2,029	339	14,577
2006	12,046	197	2,040	294	14,577
2007	12,065	212	2,050	250	14,577
2008	12,085	227	2,060	205	14,577
2009	12,104	243	2,070	160	14,577

Note: As described in the text, acreages were estimated by straight-line interpolation using reported pumped values for 1997 and 2006.

Table 9. Agricultural Groundwater Pumping and Irrigation Return Flows from 1998 to 2009

	Paso Robles Groundwater Basin			Atascadero Groundwater Subbasin		
Water Year	Gross Agricultural Groundwater Pumping (acre-feet)	Irrigation Return Flows (acre-feet)	Net Agricultural Groundwater Pumping (acre-feet)	Gross Agricultural Groundwater Pumping (acre-feet)	Irrigation Return Flows (acre-feet)	Net Agricultural Groundwater Pumping (acre-feet)
1998	51,794	1,139	50,654	1,059	23	1,036
1999	52,820	1,162	51,658	1,095	24	1,071
2000	53,845	1,185	52,661	1,131	25	1,106
2001	54,871	1,207	53,664	1,167	26	1,142
2002	55,897	1,230	54,667	1,204	26	1,177
2003	56,923	1,252	55,670	1,240	27	1,212
2004	57,948	1,275	56,674	1,276	28	1,248
2005	58,974	1,297	57,677	1,312	29	1,283
2006	60,000	1,320	58,680	1,348	30	1,318
2007	61,026	1,343	59,683	1,384	30	1,354
2008	62,052	1,365	60,686	1,420	31	1,389
2009	63,077	1,388	61,690	1,456	32	1,424

Note: As described in the text, gross agricultural pumping figures were estimated by straight-line interpolation using reported values for 1997 and 2006.

Table 10. Discharge of Treated Urban Wastewater from 1998 to 2009

Water Year	City of Paso Robles (acre-feet)	City of Atascadero (acre-feet)	Templeton CSD (acre-feet)	San Miguel CSD (acre-feet)	Atascadero Subbasin (acre-feet)	Paso Robles Basin (acre-feet)
1998	2,969	1,334	--	115	1,334	4,418
1999	2,948	1,040	--	115	1,040	4,102
2000	3,094	1,030	--	115	1,030	4,239
2001	3,174	1,103	--	115	1,103	4,393
2002	3,180	1,032	--	115	1,032	4,327
2003	3,097	1,125	144	121	1,268	4,487
2004	3,187	1,021	166	125	1,188	4,500
2005	3,303	1,241	182	137	1,423	4,862
2006	3,296	1,037	235	176	1,272	4,744
2007	3,342	965	137	160	1,102	4,604
2008	3,389	1,018	134	134	1,152	4,675
2009	3,291	1,050	144	134	1,195	4,620
Minimum	2,948	965	134	115	1,030	4,102
Maximum	3,389	1,334	235	176	1,423	4,862
Average	3,189	1,083	163	130	1,178	4,497

Note: A complete data set of annual discharge was not available for San Miguel CSD for 1998 through 2001; data shown for 1998 through 2001 are estimated values.

Table 11. Urban Groundwater Pumping from 1998 to 2009

	Atascadero Subbasin Urban Pumping				Paso Robles Basin Urban Pumping		
Water Year	**City of Paso Robles (Thunderbird wells) (acre-feet)**	**Atascadero MWC (acre-feet)**	**Templeton CSD (acre-feet)**	**Total Atascadero Subbasin (acre feet)**	**City of Paso Robles (all wells excluding Thunderbird wells) (acre feet)**	**San Miguel CSD (acre-feet)**	**Total Paso Robles Basin (acre-feet)**
1998	3,013	6,307	1,181	10,500	3,013	239	13,752
1999	3,104	6,296	1,235	10,635	3,104	251	13,991
2000	3,195	6,285	1,290	10,771	3,195	264	14,230
2001	3,287	6,275	1,345	10,906	3,287	277	14,469
2002	3,378	6,264	1,399	11,041	3,378	290	14,709
2003	3,469	6,253	1,454	11,176	3,469	303	14,948
2004	3,560	6,242	1,509	11,311	3,560	315	15,187
2005	3,651	6,232	1,563	11,446	3,651	328	15,426
2006	3,743	6,221	1,618	11,582	3,743	341	15,665
2007	3,834	6,210	1,673	11,717	3,834	354	15,904
2008	3,925	6,200	1,727	11,852	3,925	367	16,143
2009	4,016	6,189	1,782	11,987	4,016	379	16,382
Minimum	3,013	6,189	1,181	10,500	3,013	239	13,752
Maximum	4,016	6,307	1,782	11,987	4,016	379	16,382
Average	3,515	6,248	1,481	11,244	3,515	309	15,067

Note: As described in the text, urban pumping figures were estimated by straight-line interpolation using reported pumped volumes for 1997 and 2006. Additionally, pumping for the City of Paso Robles was assumed, for the purposes of this analysis, to be split 50/50 between pumping from the Thunderbird wells and pumping from all other City wells. The locations of the Thunderbird wells overlie the Atascadero Subbasin; all other City wells overlie the Basin.

Table 12. Rural Domestic Pumping in the Paso Robles Groundwater Basin and the Atascadero Groundwater Subbasin for Water Duty Factor Set No. 1

Water Year	Atascadero Subbasin Rural Parcel Dwelling Units (DU)	Atascadero Subbasin Rural Parcel Water Duty Factor (acre-feet/DU)	Atascadero Subbasin Rural Parcel Groundwater Pumping (acre-feet)	Atascadero Subbasin Rural Parcel Wastewater Return Flows (acre-feet)	Seven Sub-areas Rural Parcel Dwelling Units (DU)	Seven Sub-areas Rural Parcel Water Duty Factor (acre-feet/DU)	Seven Sub-areas Rural Parcel Groundwater Pumping (acre-feet)	Paso Robles Basin Rural Parcel Groundwater Pumping (acre-feet)	Paso Robles Basin Rural Parcel Wastewater Return Flows (acre-feet)
1998	1,061	1.0	1,061	530	4,587	1.0	4,587	5,648	2,824
1999	1,063	1.0	1,063	531	4,704	1.0	4,704	5,766	2,883
2000	1,065	1.0	1,065	532	4,820	1.0	4,820	5,885	2,942
2001	1,066	1.0	1,066	533	4,937	1.0	4,937	6,003	3,002
2002	1,068	1.0	1,068	534	5,054	1.0	5,054	6,122	3,061
2003	1,070	1.0	1,070	535	5,170	1.0	5,170	6,240	3,120
2004	1,072	1.0	1,072	536	5,287	1.0	5,287	6,359	3,179
2005	1,074	1.0	1,074	537	5,403	1.0	5,403	6,477	3,239
2006	1,076	1.0	1,076	538	5,520	1.0	5,520	6,596	3,298
2007	1,078	1.0	1,078	539	5,637	1.0	5,637	6,714	3,357
2008	1,080	1.0	1,080	540	5,753	1.0	5,753	6,833	3,416
2009	1,082	1.0	1,082	541	5,870	1.0	5,870	6,951	3,476

Table 13. Rural Domestic Pumping in the Paso Robles Groundwater Basin and the Atascadero Groundwater Subbasin for Water Duty Factor Set No. 2

Water Year	Atascadero Subbasin Rural Parcel Dwelling Units (DU)	Atascadero Subbasin Rural Parcel Water Duty Factor (acre-feet/DU)	Atascadero Subbasin Rural Parcel Groundwater Pumping (acre-feet)	Atascadero Subbasin Rural Parcel Wastewater Return Flows (acre-feet)	Seven Sub-areas Rural Parcel Dwelling Units (DU)	Seven Sub-areas Rural Parcel Water Duty Factor (acre-feet/DU)	Seven Sub-areas Rural Parcel Groundwater Pumping (acre-feet)	Paso Robles Basin Rural Parcel Groundwater Pumping (acre-feet)	Paso Robles Basin Rural Parcel Wastewater Return Flows (acre-feet)
1998	1,061	1.7	1,803	902	4,587	1.7	7,798	9,601	4,801
1999	1,063	1.7	1,806	903	4,704	1.7	7,996	9,803	4,901
2000	1,065	1.7	1,810	905	4,820	1.7	8,195	10,004	5,002
2001	1,066	1.7	1,813	906	4,937	1.7	8,393	10,206	5,103
2002	1,068	1.7	1,816	908	5,054	1.7	8,591	10,407	5,204
2003	1,070	1.7	1,819	910	5,170	1.7	8,789	10,609	5,304
2004	1,072	1.7	1,823	911	5,287	1.7	8,988	10,810	5,405
2005	1,074	1.7	1,826	913	5,403	1.7	9,186	11,012	5,506
2006	1,076	1.7	1,829	915	5,520	1.7	9,384	11,213	5,607
2007	1,078	1.7	1,832	916	5,637	1.7	9,582	11,415	5,707
2008	1,080	1.7	1,836	918	5,753	1.7	9,780	11,616	5,808
2009	1,082	1.7	1,839	919	5,870	1.7	9,979	11,817	5,909

Table 14. Projected Water Balance for the Paso Robles Groundwater Basin from 2010 to 2025

Water Year	Subsurface Inflow (acre-feet)	Precipitation Percolation (acre-feet)	Streambed Percolation (acre-feet)	Irrigation Return Flow (acre-feet)	Urban Wastewater Discharge (acre-feet)	Rural\Small Community Wastewater Discharge (acre-feet)	Small Commercial Wastewater Discharge (acre-feet)	Total Inflow (acre-feet)	Subsurface Outflow (acre-feet)	Agricultural Groundwater Pumping (acre-feet)	Urban Groundwater Pumping (acre-feet)	Rural\Small Community Groundwater Pumping (acre-feet)	Small Commercial Groundwater Pumping (acre-feet)	Phreatophyte Extraction (acre-feet)	Total Outflow (acre-feet)	Annual Storage Change (acre-feet)	Cumulative Storage Change (acre-feet)
2010	3,746	0	14,664	1,388	4,961	5,909	1,315	30,667	600	63,077	14,720	11,817	2,631	1,728	94,574	-63,907	-63,907
2011	11,810	339,592	108,688	1,388	5,062	5,909	1,315	472,449	600	63,077	13,970	11,817	2,631	6,390	98,486	373,963	310,055
2012	7,577	321	51,092	1,388	5,111	5,909	1,315	71,398	600	63,077	14,606	11,817	2,631	3,938	96,670	-25,272	284,784
2013	8,828	3,373	68,771	1,388	5,194	5,909	1,315	93,463	600	63,077	13,677	11,817	2,631	4,660	96,463	-3,000	281,783
2014	12,511	318,645	103,408	1,388	5,317	5,909	1,315	447,177	600	63,077	15,141	11,817	2,631	6,784	100,051	347,126	628,909
2015	5,142	0	26,644	1,388	5,437	5,909	1,315	44,519	600	63,077	15,107	11,817	2,631	2,533	95,766	-51,246	577,663
2016	6,876	12	44,369	1,388	5,561	5,909	1,315	64,114	600	63,077	16,066	11,817	2,631	3,536	97,727	-33,613	544,050
2017	7,573	8,986	35,181	1,388	5,687	5,909	1,315	64,724	600	63,077	13,503	11,817	2,631	3,936	95,565	-30,841	513,210
2018	3,626	0	14,269	1,388	5,817	5,909	1,315	31,008	600	63,077	12,860	11,817	2,631	1,659	92,645	-61,637	451,572
2019	4,599	0	41,206	1,388	5,950	5,909	1,315	59,052	600	63,077	14,859	11,817	2,631	2,220	95,205	-36,154	415,418
2020	3,943	0	12,734	1,388	6,085	5,909	1,315	30,059	600	63,077	14,528	11,817	2,631	1,842	94,496	-64,437	350,981
2021	13,033	214,856	98,220	1,388	6,225	5,909	1,315	339,631	600	63,077	15,230	11,817	2,631	7,085	100,441	239,190	590,171
2022	8,751	12,997	49,650	1,388	6,368	5,909	1,315	85,062	600	63,077	15,699	11,817	2,631	4,615	98,440	-13,378	576,792
2023	3,510	0	1,500	1,388	6,515	5,909	1,315	18,821	600	63,077	15,922	11,817	2,631	1,592	95,640	-76,819	499,974
2024	6,499	316	41,834	1,388	6,665	5,909	1,315	62,611	600	63,077	15,244	11,817	2,631	3,316	96,686	-34,076	465,898
2025	4,691	0	19,386	1,388	6,820	5,909	1,315	38,193	600	63,077	16,750	11,817	2,631	2,273	97,149	-58,956	406,943
Minimum	3,510	0	1,500	1,388	4,961	5,909	1,315	18,821	600	63,077	12,860	11,817	2,631	1,592	92,645	-76,819	
Maximum	13,033	339,592	108,688	1,388	6,820	5,909	1,315	472,449	600	63,077	16,750	11,817	2,631	7,085	100,441	373,963	
Average	7,045	56,194	45,726	1,388	5,798	5,909	1,315	122,059	600	63,077	14,868	11,817	2,631	3,632	96,625	25,434	

Note: Projected inflow estimates including subsurface inflow, percolation of precipitation, and streambed percolation are based on a repeat of the rainfall pattern from 1994 to 2009.
Water balance projections assume no increases from 2009 pumping levels in agricultural pumping, rural residential growth, and small commercial pumping. This does not reflect past growth trends in these outflow components to the water balance, and could understate future pumping.

Table 15. Projected Water Balance for the Atascadero Groundwater Subbasin from 2010 to 2025

Water Year	Subsurface Inflow (acre-feet)	Precipitation Percolation (acre-feet)	Streambed Percolation (acre-feet)	Irrigation Return Flow (acre-feet)	Urban Wastewater Discharge (acre-feet)	Rural\Small Community Wastewater Discharge (acre-feet)	Small Commercial Wastewater Discharge (acre-feet)	Total Inflow (acre-feet)	Subsurface Outflow (acre-feet)	Agricultural Groundwater Pumping (acre-feet)	Urban Groundwater Pumping (acre-feet)	Rural\Small Community Groundwater Pumping (acre-feet)	Small Commercial Groundwater Pumping (acre-feet)	Phreatophyte Extraction (acre-feet)	Total Outflow (acre-feet)	Annual Storage Change (acre-feet)	Cumulative Storage Change (acre-feet)
2010	398	0	6,966	32	1,542	919	237	10,095	150	1,456	10,673	1,839	473	81	14,672	-4,577	-4,577
2011	1,203	14,712	17,591	32	1,547	919	237	36,241	150	1,456	10,306	1,839	473	301	14,525	21,715	17,138
2012	781	1,548	11,083	32	1,554	919	237	16,153	150	1,456	11,385	1,839	473	185	15,489	664	17,802
2013	905	5,439	13,080	32	1,560	919	237	22,173	150	1,456	10,362	1,839	473	219	14,500	7,672	25,475
2014	1,273	16,893	16,994	32	1,571	919	237	37,919	150	1,456	11,692	1,839	473	320	15,930	21,989	47,464
2015	538	11	8,320	32	1,577	919	237	11,634	150	1,456	11,519	1,839	473	119	15,556	-3,922	43,541
2016	711	509	10,323	32	1,583	919	237	14,313	150	1,456	12,337	1,839	473	166	16,421	-2,108	41,433
2017	780	1,537	9,285	32	1,588	919	237	14,378	150	1,456	10,629	1,839	473	185	14,732	-355	41,079
2018	386	0	6,922	32	1,593	919	237	10,089	150	1,456	9,837	1,839	473	77	13,833	-3,744	37,334
2019	483	0	9,965	32	1,599	919	237	13,236	150	1,456	11,683	1,839	473	104	15,706	-2,470	34,865
2020	418	0	6,748	32	1,603	919	237	9,957	150	1,456	11,195	1,839	473	86	15,200	-5,243	29,622
2021	1,325	18,515	16,408	32	1,607	919	237	39,043	150	1,456	11,736	1,839	473	334	15,989	23,055	52,676
2022	898	5,198	10,920	32	1,611	919	237	19,814	150	1,456	12,040	1,839	473	217	16,176	3,639	56,315
2023	375	0	5,071	32	1,615	919	237	8,250	150	1,456	12,093	1,839	473	74	16,085	-7,836	48,479
2024	673	332	10,036	32	1,619	919	237	13,849	150	1,456	11,241	1,839	473	156	15,315	-1,466	47,013
2025	493	0	7,500	32	1,623	919	237	10,804	150	1,456	12,567	1,839	473	106	16,592	-5,789	41,224
Minimum	375	0	5,071	32	1,542	919	237	8,250	150	1,456	9,837	1,839	473	74	13,833	-7,836	--
Maximum	1,325	18,515	17,591	32	1,623	919	237	39,043	150	1,456	12,567	1,839	473	334	16,592	23,055	--
Average	727	4,043	10,451	32	1,587	919	237	17,997	150	1,456	11,331	1,839	473	171	15,420	2,577	--

Note: Projected inflow estimates including subsurface inflow, percolation of precipitation, and streambed percolation are based on a repeat of the rainfall pattern from 1994 to 2009.
Water balance projections assume no increases from 2009 pumping levels in agricultural pumping, rural residential growth, and small commercial pumping. This does not reflect past growth trends in these outflow components to the water balance, and could understate future pumping.

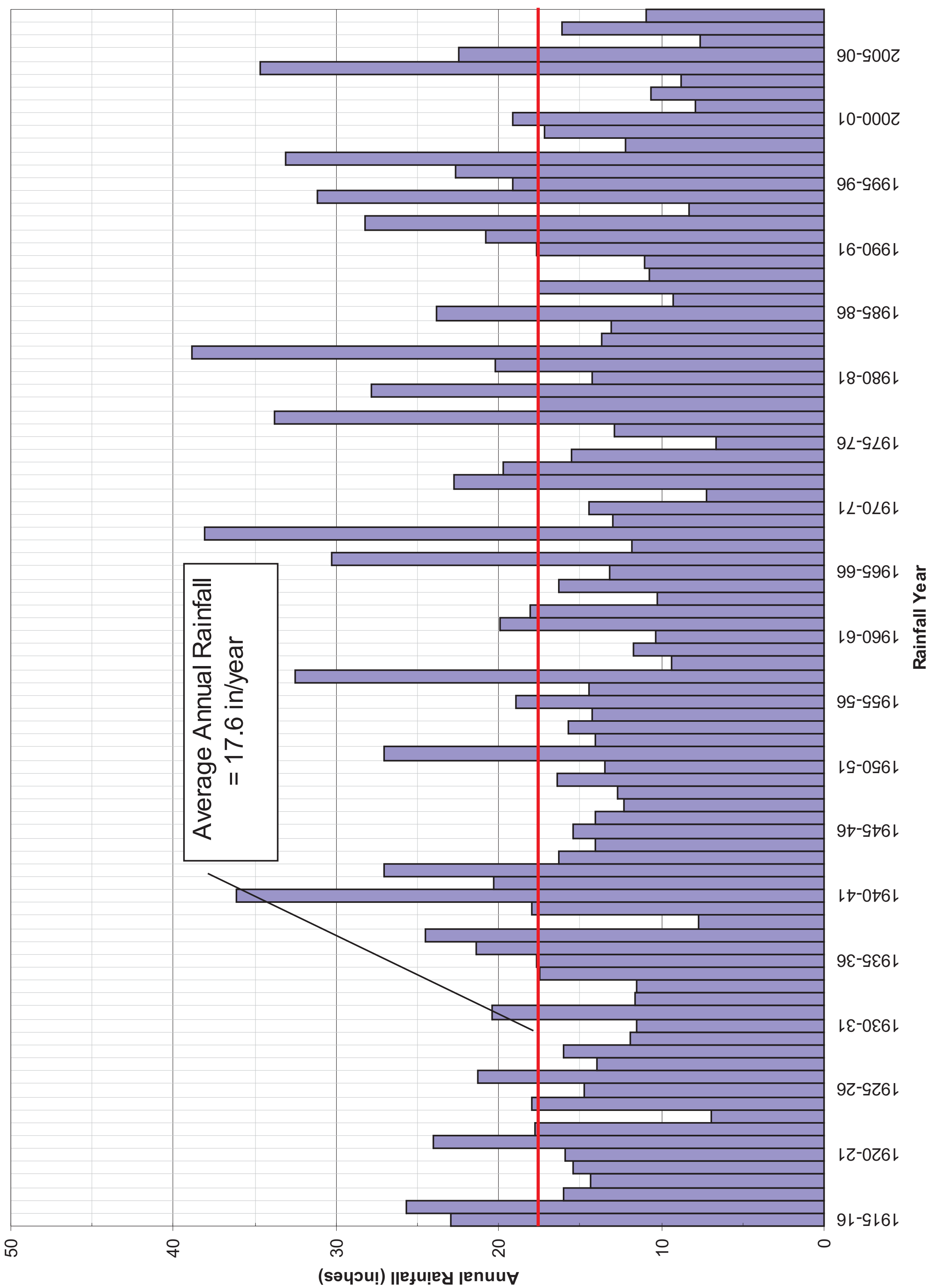
Table 16. Projected Urban Groundwater Pumping and Nacimiento Water Project Deliveries from 2010 to 2025

	City of Paso Robles			Atascadero MWC			Templeton CSD			San Miguel CSD		
Water Year	Groundwater Pumping (acre-feet)	Nacimiento Project Water (acre-feet)	Total Water Demand (acre-feet)	Groundwater Pumping (acre-feet)	Nacimiento Project Water (acre-feet)	Total Water Demand (acre-feet)	Groundwater Pumping (acre-feet)	Nacimiento Project Water (acre-feet)	Total Water Demand (acre-feet)	Groundwater Pumping (acre-feet)	Nacimiento Project Water (acre-feet)	Total Water Demand (acre-feet)
2010	7,299	0	7,299	5,557	2,000	7,557	1,467	250	1,717	398	0	398
2011	6,496	1,000	7,496	5,567	2,000	7,567	1,491	250	1,741	416	0	416
2012	5,571	2,000	7,571	7,075	500	7,575	1,524	250	1,774	435	0	435
2013	5,723	2,000	7,723	5,944	1,639	7,583	1,558	250	1,808	454	0	454
2014	5,955	2,000	7,955	7,091	498	7,589	1,624	250	1,874	472	0	472
2015	6,193	2,000	8,193	6,765	828	7,593	1,657	250	1,907	491	0	491
2016	6,439	2,000	8,439	7,427	170	7,597	1,690	250	1,940	509	0	509
2017	4,692	4,000	8,692	6,559	1,040	7,599	1,724	250	1,974	528	0	528
2018	4,953	4,000	8,953	5,604	1,996	7,600	1,757	250	2,007	547	0	547
2019	5,221	4,000	9,221	7,276	324	7,600	1,797	250	2,047	565	0	565
2020	5,498	4,000	9,498	6,623	975	7,598	1,823	250	2,073	584	0	584
2021	5,783	4,000	9,783	6,988	607	7,595	1,856	250	2,106	603	0	603
2022	6,077	4,000	10,077	7,112	479	7,591	1,890	250	2,140	621	0	621
2023	6,379	4,000	10,379	6,980	605	7,585	1,923	250	2,173	640	0	640
2024	6,690	4,000	10,690	5,940	1,639	7,579	1,956	250	2,206	658	0	658
2025	7,011	4,000	11,011	7,073	498	7,571	1,989	250	2,239	677	0	677

Table 17. Projected Urban Discharge of Treated Urban Wastewater from 2010 to 2025

Water Year	Treated Wastewater Discharge					
	City of Paso Robles (acre-feet)	City of Atascadero (acre-feet)	Templeton CSD (acre-feet)	San Miguel CSD (acre-feet)	Atascadero Subbasin (acre-feet)	Paso Robles Basin (acre-feet)
2010	3,212	1,285	258	207	1,542	4,961
2011	3,298	1,286	261	216	1,547	5,062
2012	3,331	1,288	266	226	1,554	5,111
2013	3,398	1,289	271	236	1,560	5,194
2014	3,500	1,290	281	246	1,571	5,317
2015	3,605	1,291	286	255	1,577	5,437
2016	3,713	1,291	291	265	1,583	5,561
2017	3,825	1,292	296	275	1,588	5,687
2018	3,939	1,292	301	284	1,593	5,817
2019	4,057	1,292	307	294	1,599	5,950
2020	4,179	1,292	311	304	1,603	6,085
2021	4,305	1,291	316	313	1,607	6,225
2022	4,434	1,290	321	323	1,611	6,368
2023	4,567	1,290	326	333	1,615	6,515
2024	4,704	1,288	331	342	1,619	6,665
2025	4,845	1,287	336	352	1,623	6,820

FIGURES



ANNUAL RAINFALL AT THE ATASCADERO MWC
STATION NO. 34 FROM 1916 TO 2009

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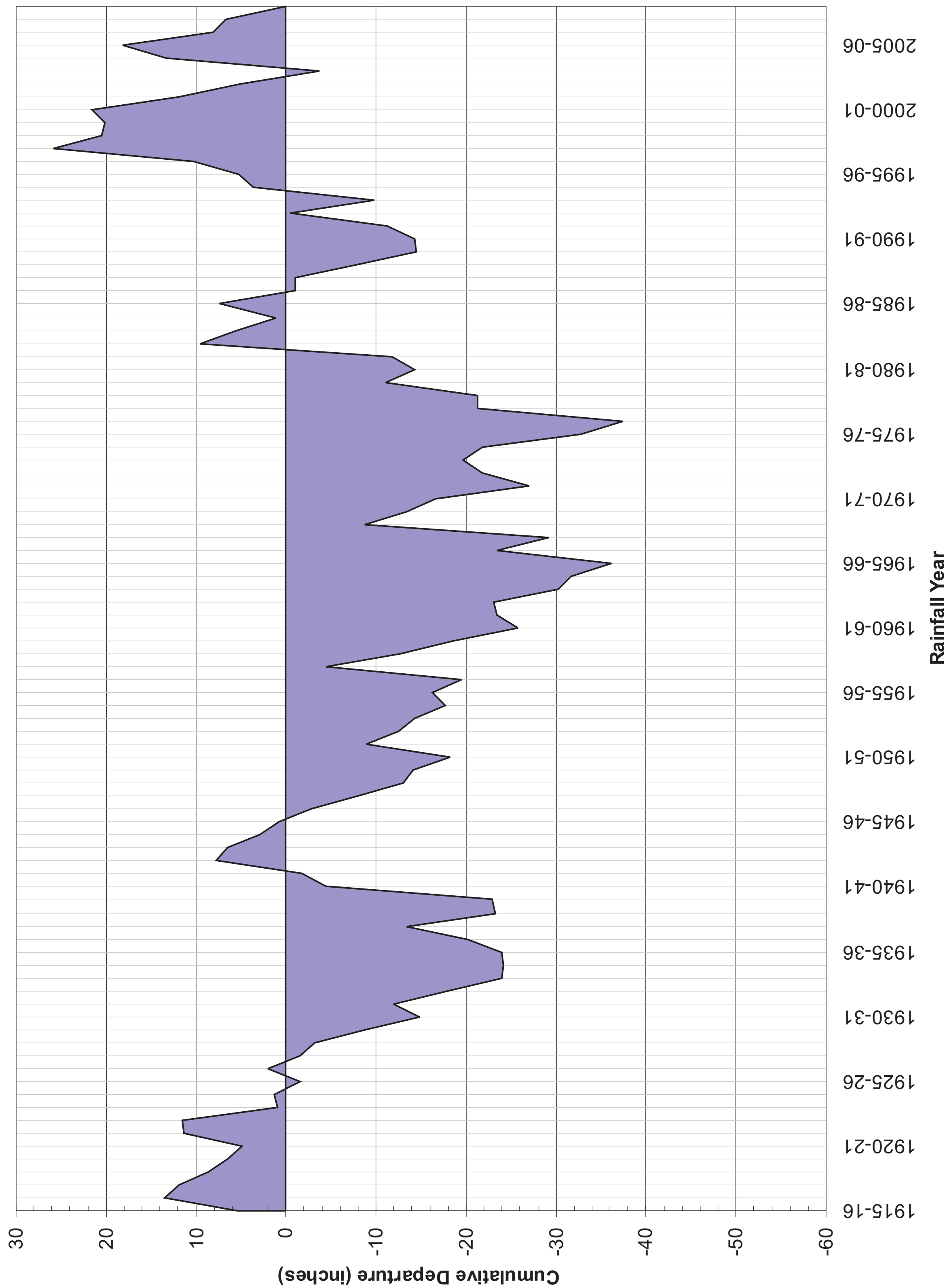
FIGURE 1.



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CUMULATIVE DEPARTURE OF ANNUAL RAINFALL AT THE ATASCADERO MWC STATION NO. 34 FROM AVERAGE ANNUAL RAINFALL FROM 1916 TO 2009

FIGURE 2.

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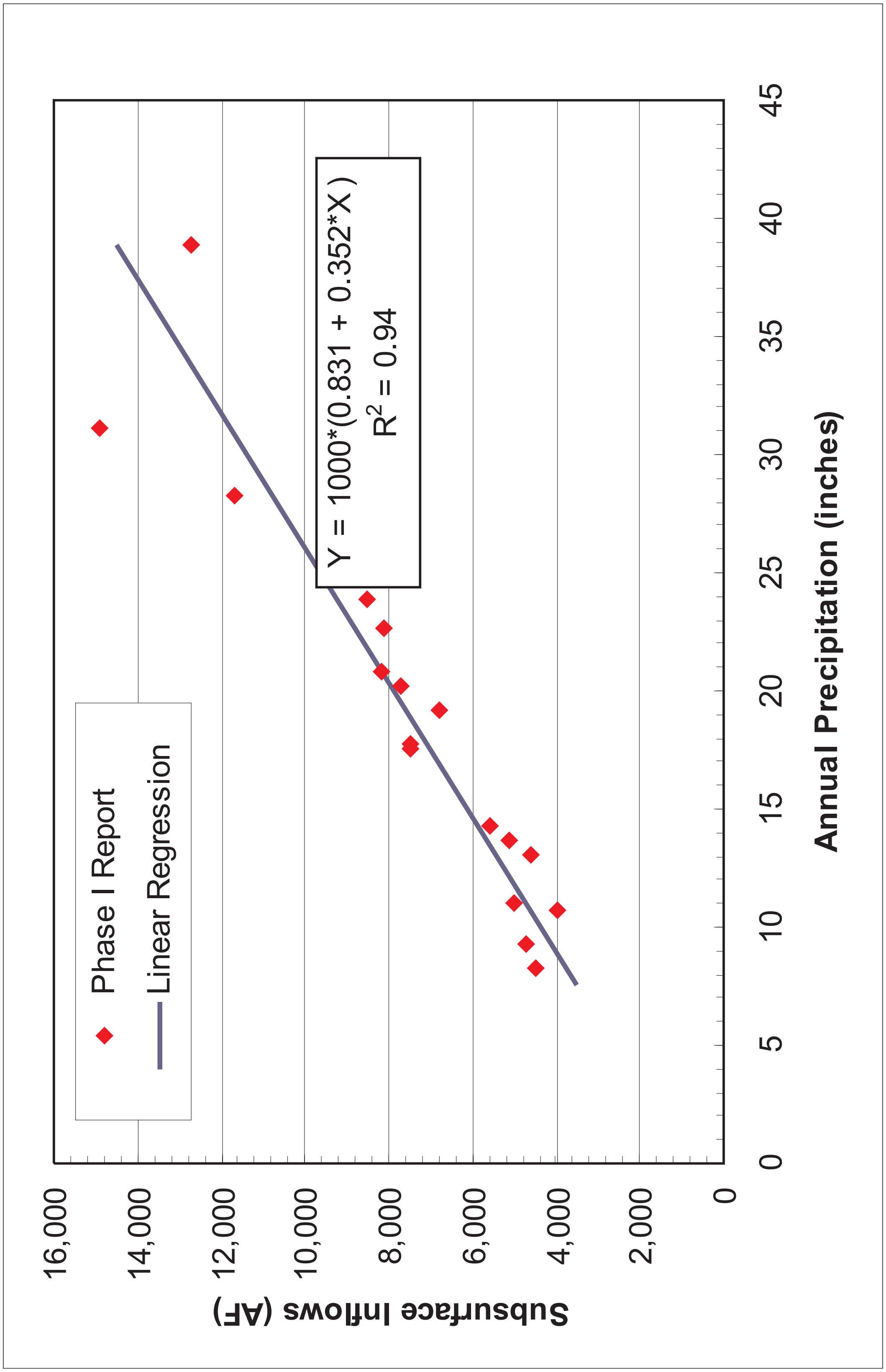

LINEAR REGRESSION OF ESTIMATED SUBSURFACE INFLOW ON MEASURED PRECIPITATION IN THE PASO ROBLES GROUNDWATER BASIN FROM 1981 TO 1997

FIGURE 3.

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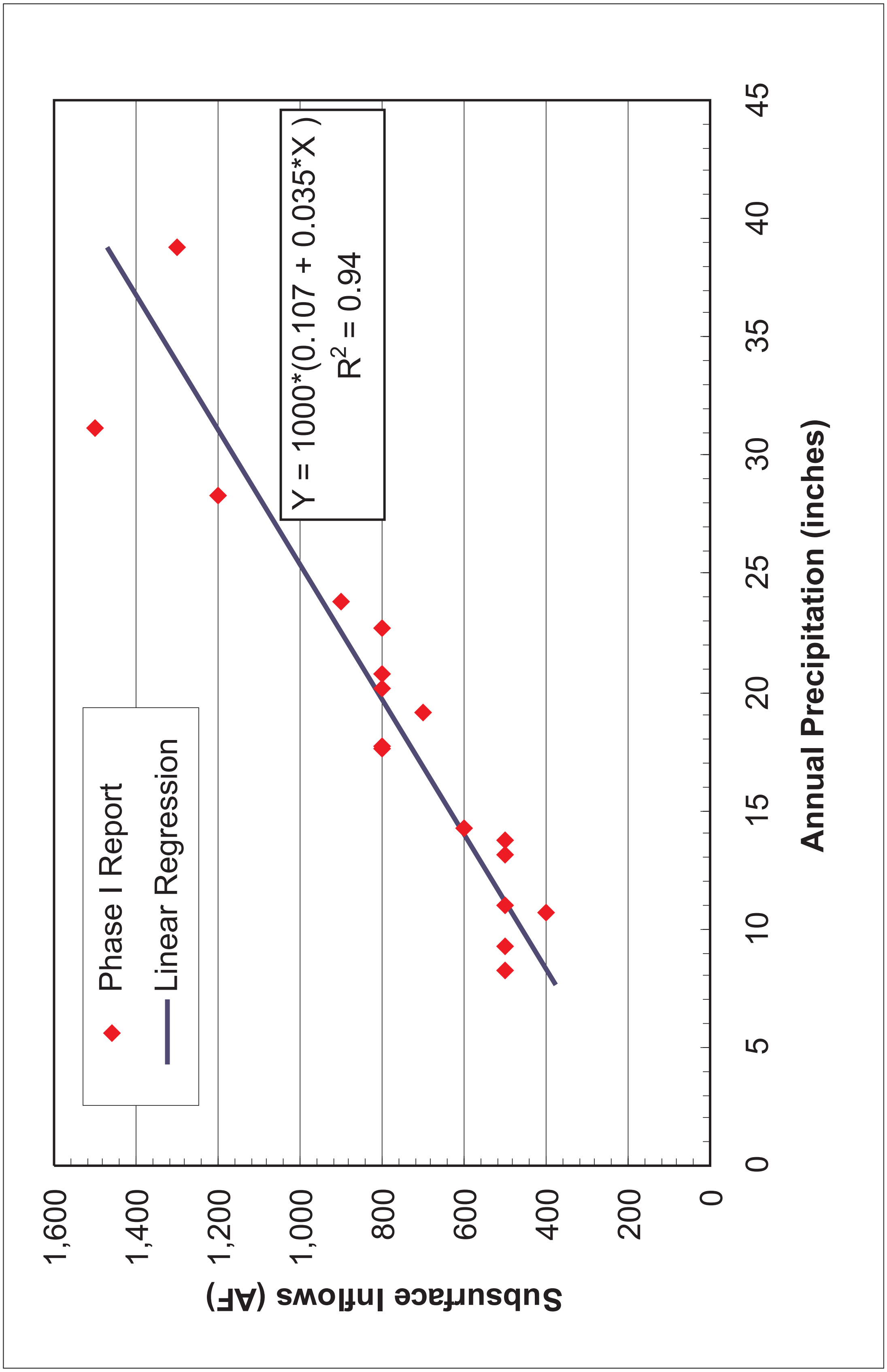
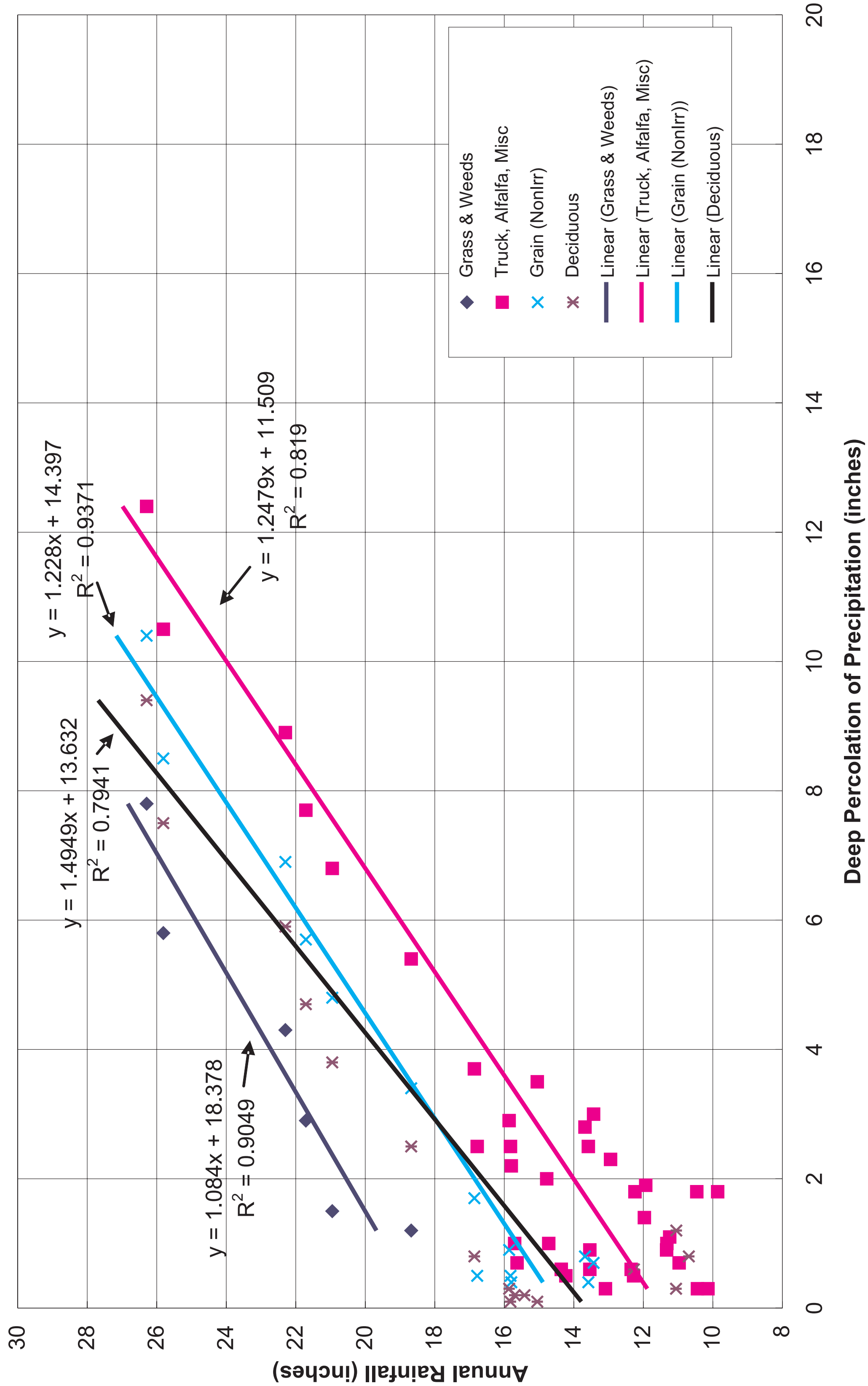


LINEAR REGRESSION OF ESTIMATED SUBSURFACE INFLOW ON MEASURED PRECIPITATION IN THE ATASCADERO SUBBASIN FROM 1981 TO 1997

FIGURE 4.



LINEAR REGRESSION OF DEEP PERCOLATION OF PRECIPITATION ON MEASURED RAINFALL FOR FOUR DIFFERENT LAND USE CATEGORIES

FIGURE 5.

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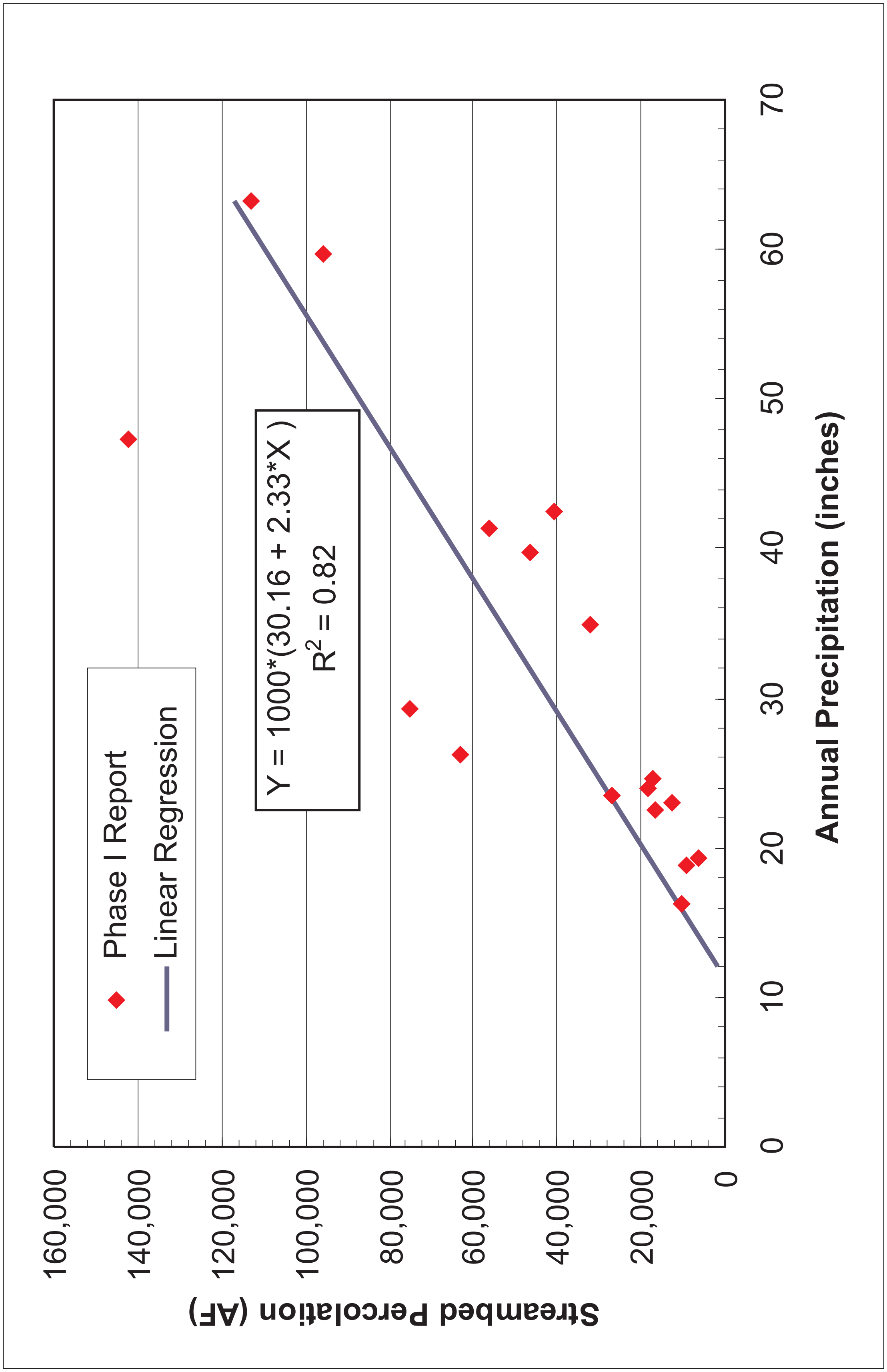
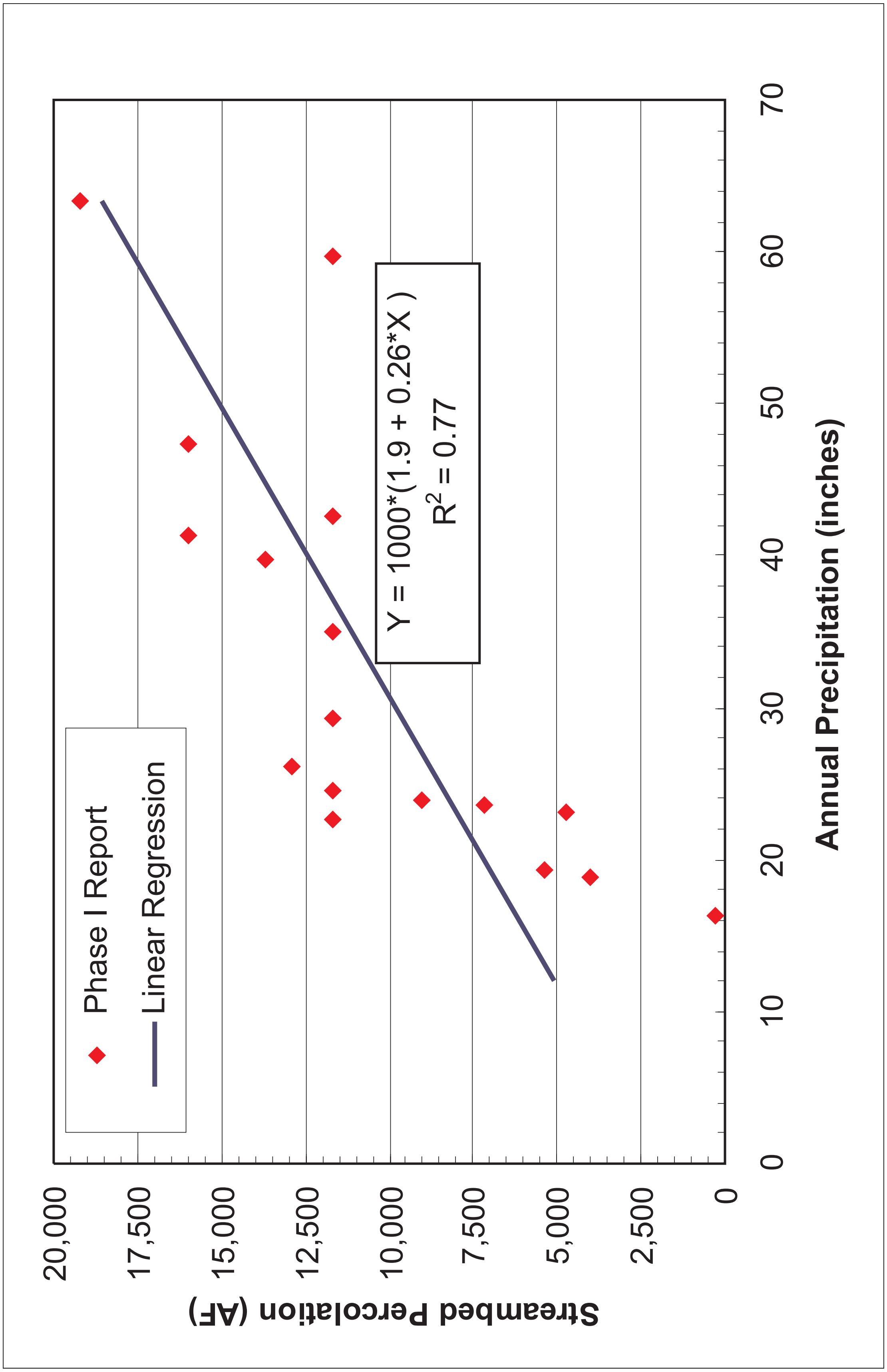


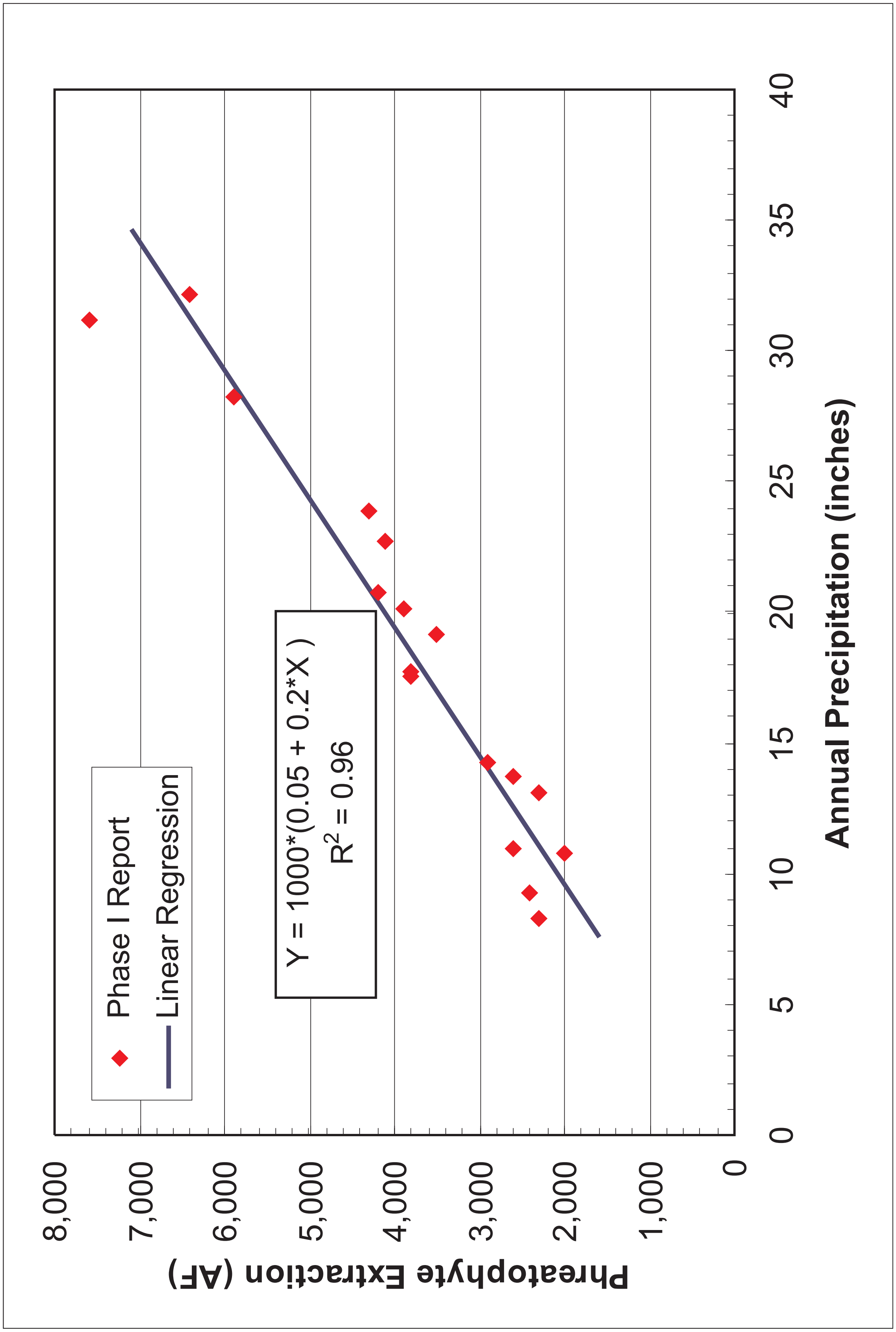
LINEAR REGRESSION OF STREAMBED PERCOLATION ON MEASURED PRECIPITATION IN THE PASO ROBLES GROUNDWATER BASIN FROM 1981 TO 1997

FIGURE 6.



LINEAR REGRESSION OF STREAMBED PERCOLATION ON MEASURED PRECIPITATION IN THE ATASCADERO SUBBASIN FROM 1981 TO 1997

FIGURE 7.



LINEAR REGRESSION RELATIONSHIP BETWEEN MEASURED PRECIPITATION AND PHREATOPHYTE EXTRACTION IN THE PASO ROBLES GROUNDWATER BASIN FROM 1981 TO 1997

FIGURE 8.

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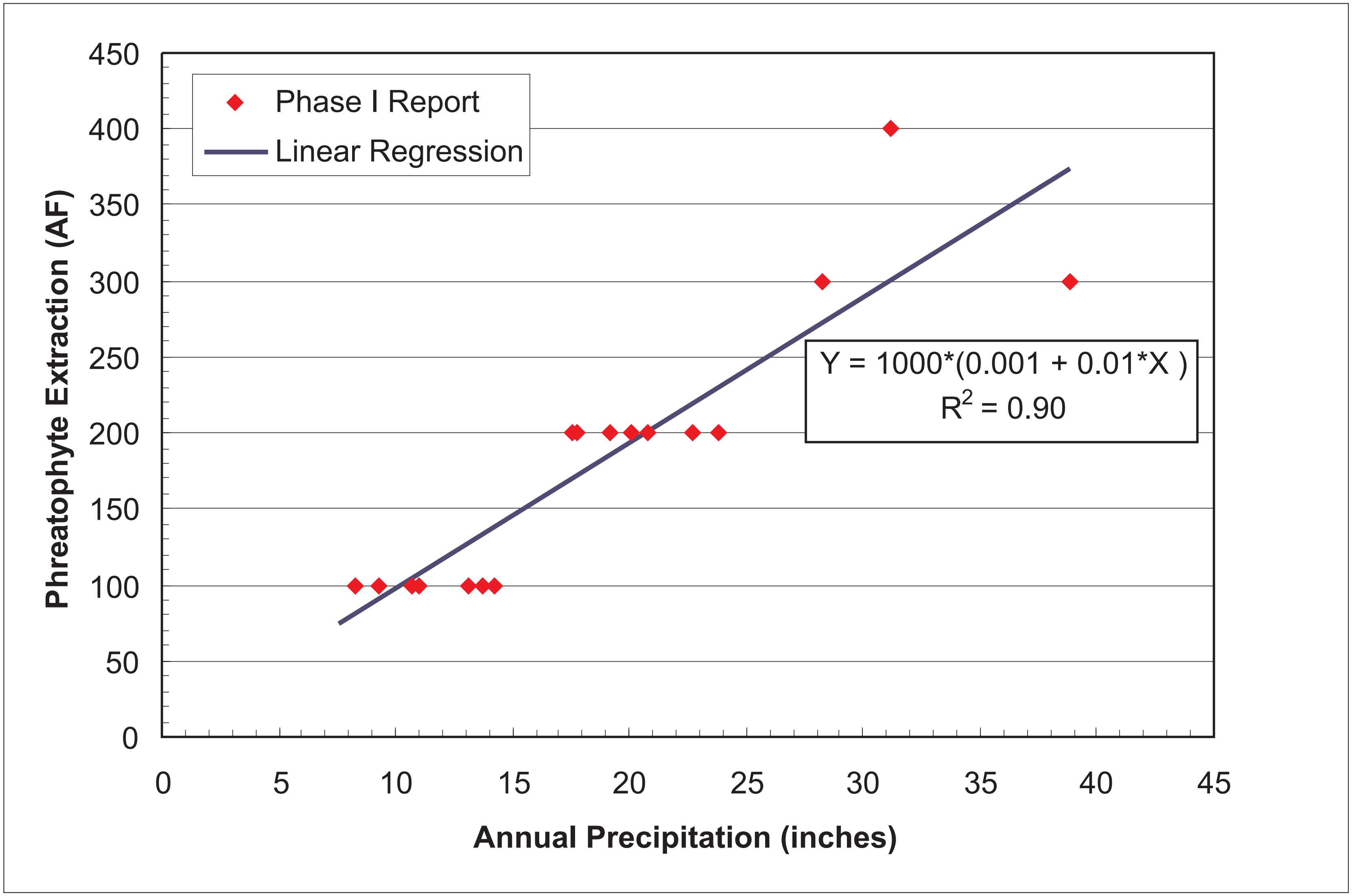
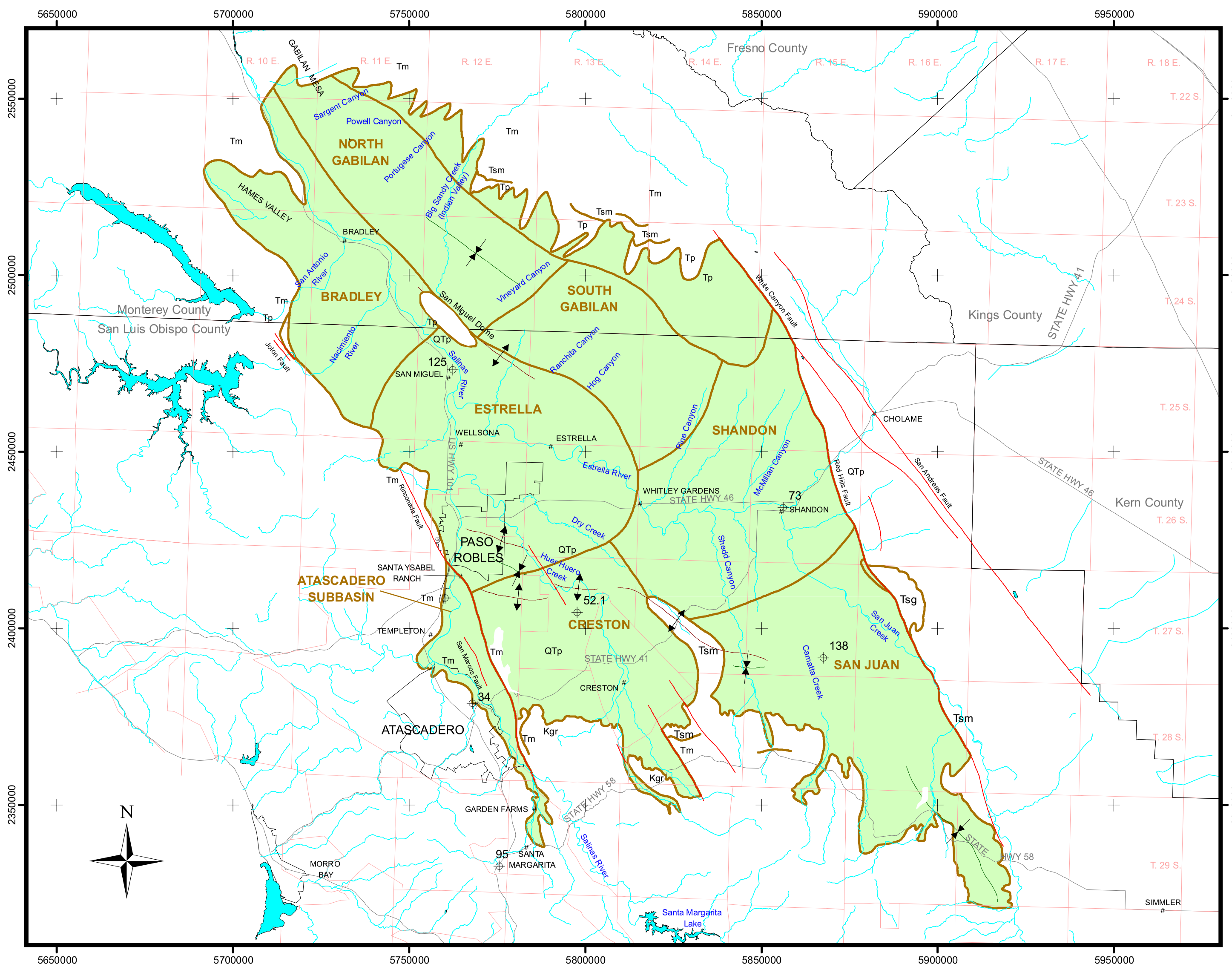


LINEAR REGRESSION RELATIONSHIP BETWEEN MEASURED PRECIPITATION AND PHREATOPHYTE EXTRACTION IN THE ATASCADERO SUBBASIN FROM 1981 TO 1997

FIGURE 9.

PLATES

March 2010
Project No. 3014.036



Legend

- 101 Precipitation Station
- City
- Basin Outline
- Fault
- Anticline
- Syncline
- Streams
- Highways
- County Line
- Township and Range Grid

Geologic Units		
Paso Robles Groundwater Basin Sediments	Qa	Alluvium
	Qoa	Older Alluvium
	Qls	Landslide
	QTp	Paso Robles Formation
Other Geologic Units	Tp	Pancho Rico Formation
	Tsm	Santa Margarita Sandstone
	Tm	Monterey Shale
	Tv	Vaqueros Formation
	Ts	Simmler Formation
	Tsg	unnamed (maroon) conglomerate
	Kgr	granite rocks

Notes:
1. Geologic units shown on base map around basin boundary are for reference only. For a geologic map of the basin see Figure 5.
2. Township and Range grid reference: Federal Township and Range System, Mt. Diablo Baseline and Meridian

30,000 15,000 0 30,000 Feet

Paso Robles Groundwater Basin Location Map

Paso Robles Groundwater Basin Water Balance Review and Update

Fugro West, Inc.

Plate 1

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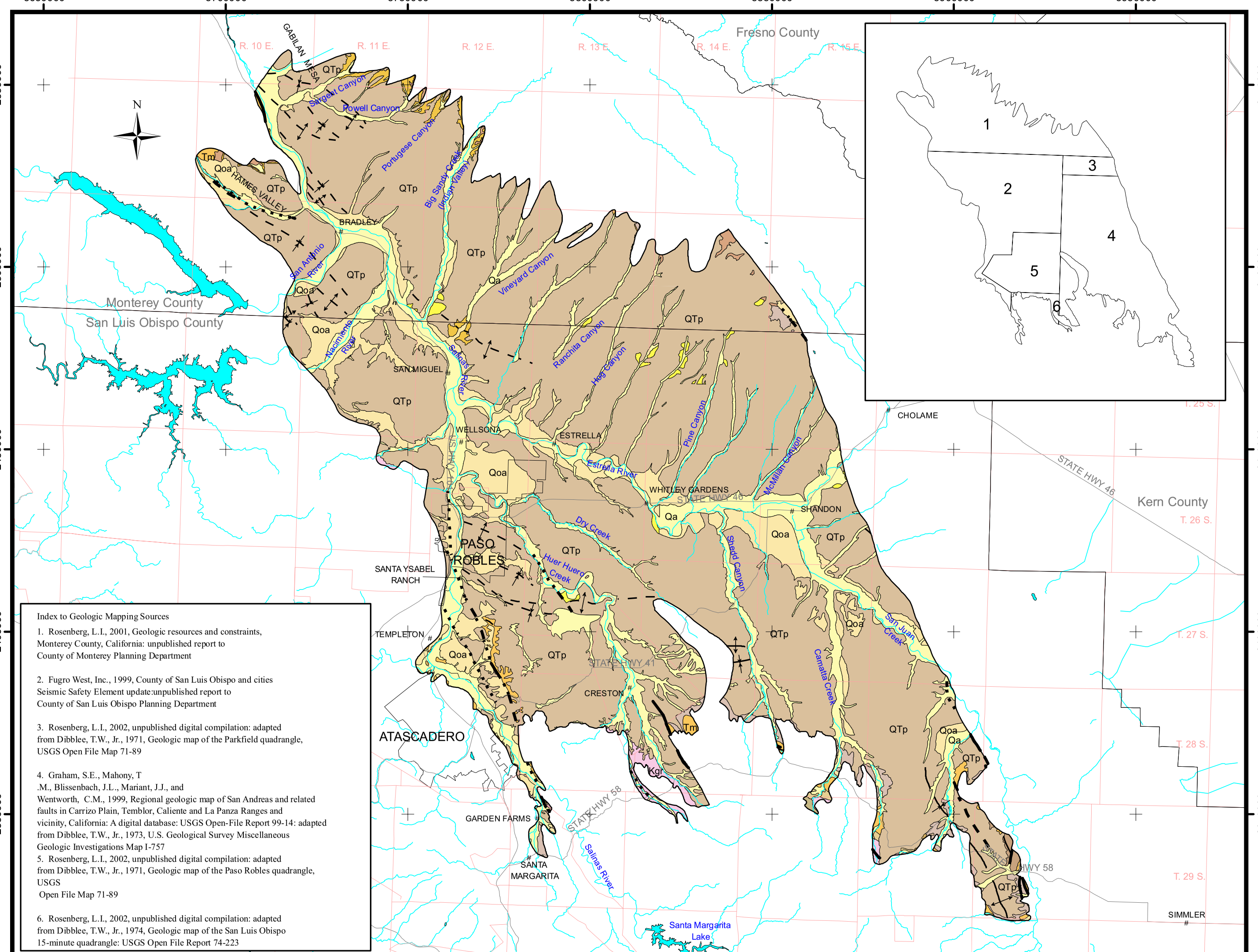
March 2010
Project No. 3014.036



Legend

Geologic Units

Paso Robles Groundwater Basin Sediments

- Qa — Quaternary alluvium, undifferentiated (Holocene)
- Qoa — Older alluvium, undifferentiated (Pleistocene)
- Qls — Landslide deposits (Holocene-Pleistocene)
- QTp — Paso Robles Formation, undifferentiated (Pliocene-Pleistocene)

Other Geologic Units

- Tuc — Unnamed clastic sedimentary unit (probably Pliocene)
- Tp — Pancho Rico Formation, undifferentiated (late Miocene to early Pliocene)
- Tsm — Santa Margarita Sandstone (late Miocene)
- Tbs — Branch Canyon Sandstone (middle to late Miocene)
- Tm — Monterey Shale, undifferentiated (middle Miocene)
- Tv — Vaqueros Formation, undifferentiated (Oligocene)
- Ts — Simmler Formation, undifferentiated (Oligocene?)
- Tsg — unnamed conglomerate (Oligocene or Miocene)
- Kgr — Granitic rocks (Cretaceous)

- Fault, certain
- Fault, approximately located
- Fault, concealed
- Anticline, certain
- Anticline, approximately located
- Syncline, certain
- Syncline, approximately located
- Streams
- Highways
- County Line
- Township and Range Grid

Note:
1. Township and Range grid reference: Federal Township and Range System, Mt. Diablo Baseline and Meridian

30,000 15,000 0 30,000 Feet

Geologic Map of the Paso Robles Groundwater Basin

Paso Robles Groundwater Basin Water Balance Review and Update

Fugro West, Inc.

Plate 2

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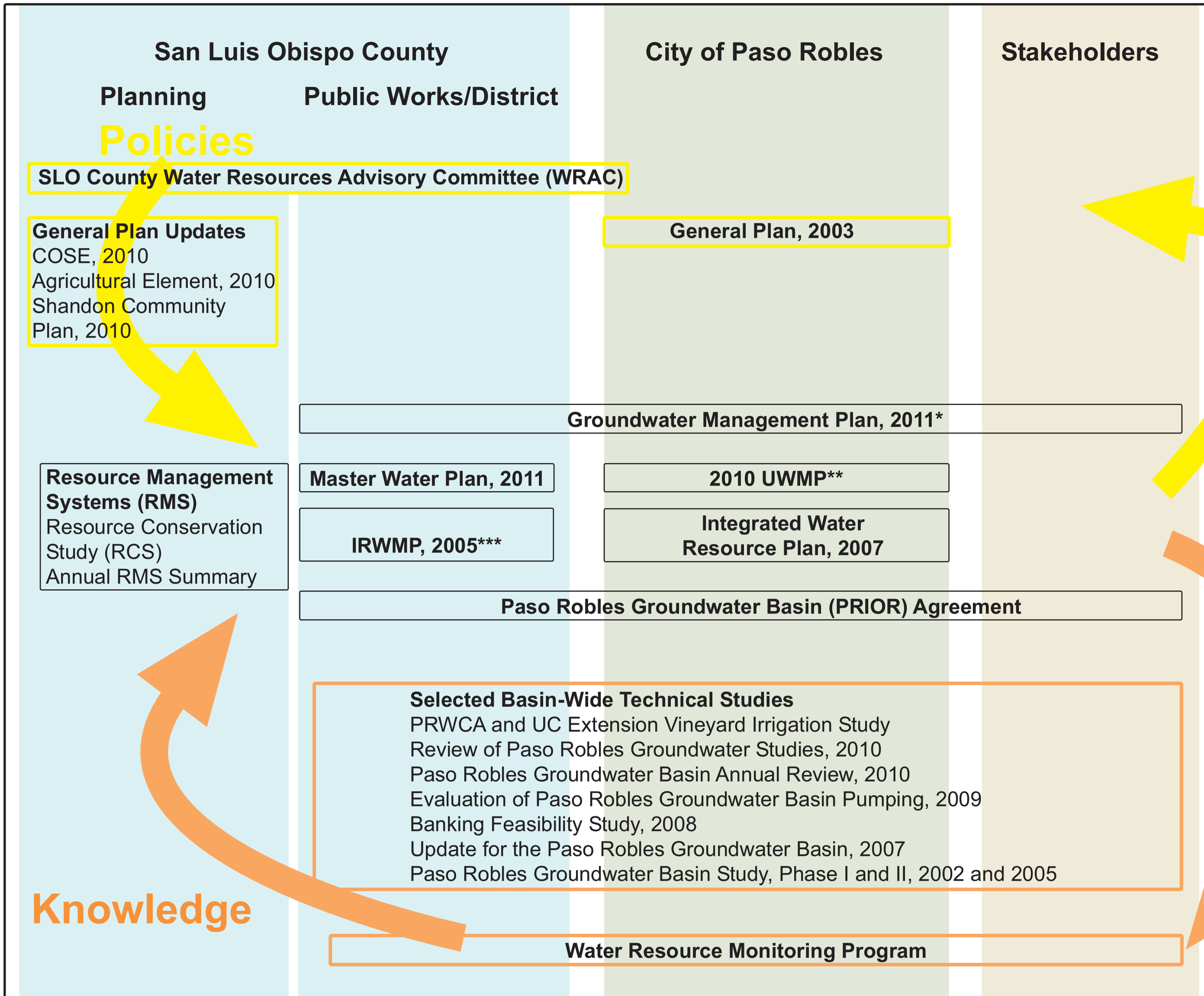
Attachment E
Peer Review of Paso Robles Groundwater Basin Studies
Executive Summary

Attachment F
Matrix of Recent Water Management Plans and Studies, Paso Robles Groundwater Basin

Recent Water Management Plans and Studies
Paso Robles Groundwater Basin



* Authorized by California State Groundwater Management Planning Act
** Required by California Urban Water Management Planning Act
*** Authorized by California Integrated Regional Water Management Act

CITY OF EL PASO DE ROBLES

"The Pass of the Oaks"

July 15, 2010

Peer Review of Paso Robles Groundwater Basin Studies
Executive Summary

In the 8 years since publication of the "Paso Robles Groundwater Basin Study" (Fugro), two updates have been prepared (2009 – Todd and 2010 – Fugro); perplexingly, their basin status findings differ. Consequently, the City of Paso Robles commissioned a peer review of the updates to examine the differences, as well as indentify steps to enhance future groundwater analysis.

Key report conclusions:

- The 2002 Groundwater Study (Fugro) concluded that perennial yield of the Paso Robles Basin is 94,000 acre feet per year (AFY), and Atascadero's sub-basin yield is 16,500 AFY.

- The 2002 baseline study, as well as the 2009 Todd and 2010 Furgo updates estimated total demand:

	2002 Fugro	2009 Todd	2010 Fugro
Groundwater Basin	82,600 AFY	88,154 AFY	92-97,000 AFY
Atascadero Sub-Basin	11,100 AFY	15,545 AFY	15-16,000 AFY

- The 2009 and 2010 updates also estimated groundwater storage:

  Todd found *declines* in basin and sub-basin storage between 2000 and 2006

  Fugro found *increases* in basin and sub-basin storage between 1998 and 2009

Consulting Hydrologist Gus Yates, PG, CHg, was engaged to conduct a peer review of the Todd & Fugro updates. In evaluating the assumptions and methods employed, he:

- Questions the hydrologic distinction of the Atascadero Sub-basin.
- Questions stream recharge estimation method.
- Argues that (a) the presumption that recharge occurs only after the plant root zone is fully saturated, and (b) using a single, averaged rainfall value over the entire basin (Fugro, 2002) is not sound.
- Suggests that calibrating water balance based upon limited well level records is not entirely accurate.
- Suggests increased modeling and data collection to improve accuracy of future evaluations.

Summary:

There is general agreement that groundwater pumping is nearing perennial yield, and that efforts to supplement supplies (including the Nacimiento Water Project, State Water Project, conservation, and recycling) will help maintain balance. However, just a 10% increase in basin-wide pumping could negate those benefits.

The best course of action is to:

- MONITOR - Establish the 40+ recommended monitoring wells across the Paso Robles Groundwater Basin and Atascadero Sub basin[1]. Use the improved well monitoring system to regularly analyze changes in water levels (as an indicator of basin conditions).
- MODEL – Update and enhance the model to cross-check and integrate water level data, water balance calculations, rainfall, recharge, in and out flows for more reliable yield and storage estimates.
- SUPPLEMENT – Secure supplemental water (Nacimiento Water Project, State Water Project, recycled water, etc.) in lieu of groundwater to meet demands.
- MANAGE – Achieve cooperative groundwater management.

[1] See SLO County analysis of well measurement program dated 2008 by Cleath & Associates.

MEMORANDUM

Gus Yates, PG, CHg, Consulting Hydrologist
1809 California Street, Berkeley CA 94703 • Tel/Fax 510-849-4412 • gusyates@earthlink.net

Date: June 29, 2010
To: Christopher Alakel, City of Paso Robles
From: Gus Yates, consulting hydrologist
Cc:
Subject: Peer Review of Paso Robles Groundwater Studies

I have completed a review of five major studies of the Paso Robles groundwater basin completed since 2002, as well as several key reports cited in those studies.[1]. My review focused on discrepancies and sources of uncertainty in the previous studies. In some cases, discrepancies arose from differences in assumptions and methods, and in other cases from a cumulative evolution in conceptual understanding of the basin. In addition, I occasionally thought that alternative data or methods would have improved the accuracy or consistency of previous studies.

This memorandum documents the results of my review. It describes in detail discrepancies, uncertainties, weaknesses and possible improvements, grouped by major topic areas. It concludes with recommendations for future data collection and analysis activities that would be of greatest value in reducing uncertainty and supporting management of water resources.

Discrepancies Stemming from Geographic Scale of Analysis

Different scales of analysis have led to conflicting conclusions in previous studies. Local groundwater conditions can deviate substantially from average conditions for the basin as a whole. For example, a recent study concluded that "the basin should be considered to be essentially in balance by a small margin" (Fugro 2010). But hydrographs of some wells exhibit unmistakable long-term declines, such as the one for well 26S/13E-30B2 in the Estrella subarea shown in **Figure 1**. This discrepancy can be attributed to a difference in scale of analysis.

Previous studies consistently divided the basin into two parts for quantitative analysis, separating the Atascadero subbasin from the main Paso Robles basin. Subareas of the main basin were identified early on for qualitative discussion purposes, but complete water balances have not been calculated on a subarea basis.

Figure 2 shows the subareas of the Paso Robles basin originally delineated by Fugro and Cleath (2002). Among the main basin subareas, the Estrella subarea has groundwater

[1] See 'References Cited" section at the end of the memo for a list of reports that were reviewed.

conditions that most clearly differ from basin-wide average conditions. A pumping trough—or depression in the groundwater surface—has steadily developed over the past 20 years. **Figure 3** shows contours of cumulative water level decline in the Estrella subarea during 1997-2009, which is in addition to the decline during 1981-1997 previously documented by Fugro and Cleath (2002).

Ironically, the hydrologic separation of the Atascadero subbasin from the main basin was overemphasized in previous studies. The difference in water level between a warm water spring and a well on opposite sides of the Rinconada Fault were cited as evidence that the fault is a barrier to flow, at least in the Paso Robles Formation (Fugro and Cleath, 2002, p. 19). Aside from the questionable assumption that a thermal spring is representative of ambient groundwater conditions, hydrographs of a larger set of wells on either side of the fault reveal substantial variation in water level with well depth and very little difference between the two sides of the fault (monitoring wells 26S/12E-33 Q1, 33Q4, 27S/12E-4K2, 9N2 and 9N3). Furthermore, the river alluvium is much more permeable than the Paso Robles Formation (800 times more permeable in the calibrated groundwater model), and it reportedly is unaffected by the fault. Because of this permeability contrast, the fault probably has little effect on groundwater to flow between the Atascadero and main basin areas in any case. Finally, any shift in groundwater balance in the Atascadero subbasin would be absorbed by a change in river-aquifer exchange and be conveyed across the fault as surface flow.

The advantage of dividing the basin into subareas for analysis is that local problems can be identified and more effectively managed. However, local water balances are more complex because they include additional terms representing groundwater flows between subareas. Nevertheless, understanding the dependence of yield in one subarea on recharge in another subarea is very useful for planning and management purposes.

The greatest drawback to subarea analysis is that it can undermine political support for management measures that encompass the entire basin. Water users in subareas with few local groundwater problems may be disinclined to help pay for regional solutions. In reality, the subareas are all hydrologically connected, and solutions with the lowest overall cost may involve the entire basin. It should be emphasized that all users have an interest in maintaining the integrity of the whole basin.

Rainfall Recharge

Infiltration of rainfall is the largest source of recharge to the groundwater basin, so uncertainty in the estimate of this flow has a major impact on uncertainty in the overall water balance. Two previous studies estimated rainfall recharge using a method that produces infrequent, large pulses of recharge (Fugro and others, 2002; Fugro, 2010). For example, rainfall recharge in only two years (1998 and 2005) contributed 43% of total basin recharge for the 12-year analysis period (1998-2009) (Fugro [2010] Tables 3 and 4). Therefore, errors in this flow heavily influence errors in the overall water balance and in basin yield.

The rainfall recharge estimates in those studies relied entirely on linear regressions of rainfall penetration studies by Blaney (1933). However, Blaney's estimates of rainfall recharge in areas of natural vegetation were supported by measurements at only two sites in a single year (grass-weed sites A and G in the Ventura basin in 1932). Extrapolations to other year types, root depths and soil conditions were based on modeling and assumptions.

Blaney's approach to rainfall recharge is commonly referred to as a "bathtub model". It assumes that deep percolation beneath the root zone (i.e. groundwater recharge) does not commence until the available water capacity of the root zone is fully saturated. I have used this approach many times in my own studies. In some cases, I have had other information to help corroborate the recharge estimates, such as groundwater hydrographs, stream baseflow data, or joint calibration of a groundwater model with the soil moisture budget model. My general experience has been that the bathtub approach can produce reasonable long-term average recharge rates but that simulated recharge is commonly too sporadic. This appeared to be the case for the Paso Robles basin, also. In order to calibrate the groundwater model, the original time series of annual recharge values estimated using Blaney's method was redistributed more uniformly over the calibration period (Fugro and others [2005] pp. 29-30).

The sporadic time series of annual rainfall recharge produced by the Blaney method may also be inconsistent with measured groundwater levels. The Blaney method predicts rainfall recharge only in exceptionally wet years. In contrast, hydrographs generally show little response to wet years. If rainfall recharge truly occurs as large infrequent pulses, it should be noticeable in the hydrographs. An example of the discrepancy arising from the Blaney recharge method is that Fugro (2010) estimated an increase of 391,174 acre-feet (AF) in groundwater storage from 1997 to 2006 using the Blaney method, whereas Todd Engineers (2007) estimated a decrease of 29,767 AF using a water level approach. Some of the discrepancy could arise from uncertainty in water levels, which is discussed more fully in the section on "Uncertainty in Water Levels", below.

Blaney's 1933 study and the regression equations developed from that study by Fugro and Cleath (2002) are not as solid a basis for estimating recharge as previous reports implied. For example, the threshold of 11.5 inches of cumulative seasonal rainfall to initiate deep percolation beneath typical, shallow-rooted crops (for example, truck crops) in Figure 5 of Fugro (2010) is too high. The regression equations all trace back to Blaney (1933), which had internal inconsistencies. Blaney's 16 sites included only two sites with irrigated annual crops (beans) and four additional sites with relatively shallow-rooted evergreen tree crops (oranges and lemons). In all of those sites, rainfall penetrated beyond the root zone in the one year that soil moisture was monitored. Blaney did not measure how much water percolated beyond the root zone. Using numerous assumptions, Blaney then **simulated** the soil moisture balance for various crops over a period of five years. The simulated results are the basis for Fugro's regression equations, and they appear to underestimate deep percolation, particularly for annual cropland that is bare in winter. The errors are as follows:

- The initial soil moisture deficits at the start of the rainy season are reasonable for truck crops (2.5 inches, corresponding to a root depth of 30 inches, available water capacity of 0.16, and 50% moisture depletion), but they are too high for vineyards and deciduous trees (10 inches). Vine roots extend to a depth of 6 feet. Assuming a typical loamy soil with an available water capacity of 0.15 in/in, total soil moisture storage capacity between field capacity and wilting point would be 10.8 inches for vines. For natural vegetation, it is reasonable to assume soil moisture is nearly fully depleted, but not for irrigated crops. Irrigated truck crop soils rarely if ever fall below 50% of moisture capacity (or yield would be adversely affected). Drought-stressed vineyards might end up at less than 50% of moisture capacity, but probably not close to zero. Assumptions regarding initial soil moisture are important because they strongly influence simulated rainfall recharge.

- The estimates of bare soil evaporation are too high. Blaney assumed evaporation equaled one-half inch following each winter storm, for a seasonal total of 5.8 inches on a site that received 17.54 inches of rain (Blaney's Table 17). Applying the more modern approach presented in FAO Bulletin 56 (pages 144-146) using daily rainfall and ETo data from the Atascadero CIMIS station for May 2009 through April 2010 obtained an estimated annual soil evaporation of only 2.8 inches, even after scaling rainfall up by a factor of 1.16 to equal the same annual total as in Blaney's study.

- It is unclear how Blaney obtained such low estimates of deep percolation for truck crops shown in Table 57 of his report, which are the basis for the regression equations in Fugro and Cleath (2002) and Fugro (2010). Assuming an initial soil moisture deficit of 2.5 inches (see above), Blaney's assumption of zero runoff, and an estimate of 2.8 inches of bare-soil evaporation in winter suggests that deep percolation should have been initiated when seasonal rainfall reached 5.3 inches, not 11.5 inches. Even using Blaney's estimate of 5.8 inches of bare-soil evaporation should have resulted in a threshold for deep percolation of 8.3 inches of seasonal rainfall.

- An evaluation of vineyard deep percolation is particularly relevant to the Paso Robles basin because it is now the dominant crop. For vineyards, a reasonable estimate of initial soil moisture deficit might be 8 inches for vines managed under regulated deficit irrigation (80% depletion of available water). Combining this with the FAO estimate of 2.8 inches of bare soil evaporation and assuming zero runoff obtains a threshold for deep percolation of approximately 10.8 inches of seasonal rainfall, not the 13.6 inches indicated by the regression equation on Figure 5 of Fugro (2010) (deciduous tree category).

The assumed distribution of rainfall across the basin is another source of uncertainty in previous studies. Fugro and Cleath (2002, p. 99) used a single, averaged value of rainfall for the entire basin each year. Todd (2007, Figure 2) prepared an isohyetal map showing that average annual rainfall varies from 10 in/yr to 16 in/yr. This amount of variation would significantly affect average annual deep percolation, which is approximately proportional to rainfall once the seasonal soil moisture deficit has been refilled.

The authors of previous studies were aware of the limitations of the methods they applied. For example, Fugro and Cleath (2002, pp. 124-127) emphasized that “any estimates of effective rainfall for a study of this sort are extremely gross”. Given the importance of rainfall recharge in the basin water balance, improvement of the recharge estimation method is warranted.

A more systematic multi-year simulation of daily soil moisture budgets for various combinations of vegetation, soil and annual rainfall would be useful for refining the rainfall recharge estimates. The soil-moisture-budget model could be jointly calibrated with the groundwater flow model, because errors in simulated water levels can sometimes be traced to systematic errors in estimated recharge.

Vineyard Irrigation

Vineyard irrigation accounted for 76% of agricultural pumping and 51% of total pumping in 2006 (Todd 2007). Therefore, errors in this budget item strongly influence the accuracy of the overall water balance and basin yield estimates.

The vineyard irrigation estimates rely on letter reports of two experts: Mark Battany (2004) and Frank Honeycutt (2004). Battany estimated a +/- 50% uncertainty in estimated average vineyard irrigation (“somewhere around 1.25 ft/yr, plus or minus 50%”). Applied to a basin-wide vineyard irrigation estimate of 60,000 AFY, this corresponds to an uncertainty of +/- 30,000 AFY.

Honeycutt presented three estimates of basin-wide irrigation pumping (including Battany's estimate) representing a range of +/-10,000 AFY (17%) around an average of approximately 60,000 AFY. This estimate assumed a “maximum reasonable future irrigated acreage” of 45,000 acres planted 100% to vineyard.

Todd (2007) tabulated actual 2006 irrigated acreage (40,836 ac, 84% vineyard). In spite of less acreage and a different crop mix, Todd's estimate of total irrigation pumping exactly equaled Honeycutt’s long-term estimate of 60,000 AFY (Table 5). This presumably was achieved by adjusting the water duties for the other crops, because Todd kept Honeycutt’s 1.25-1.5 ft/yr duty for vineyard (Table 3). This appears to indicate some uncertainty in crop coefficients, irrigation efficiency, or both.

Honeycutt's estimate of irrigation pumping incorporated an assumption that crop water demand in Shandon (the eastern part of the basin) is 20% to 50% greater than in Paso Robles and applied that higher irrigation demand to 30% of the basin-wide cropland. This geographic difference is overstated. Spatial modeling of reference ET (ETo) by the California Irrigation Management Information System indicates that ETo in Shandon is only 5% greater than in Paso Robles (http://wwwcimis.water.ca.gov/cimis/cimiSatSpatialCimis.jsp). Assuming the true difference is 5% not 50%, the original basin-wide irrigation estimate could be as much as 13.5% too high (45% ET error x 30% of basin area). For a base value of 60,000 AFY, this equals an error of 8,100 AFY.

Vineyard water use depends on a number of factors, including vine spacing, vine pruning (as it affects the percent canopy cover at midday), grape variety, and the degree of planned soil moisture depletion during the growing season (regulated deficit irrigation). Most growers now calculate irrigation demand in gallons per vine per week rather than inches per acre per month. Additional data from a variety of vineyards could substantially narrow the range of uncertainty in agricultural irrigation demand.

Crop Water Demand and Irrigation Efficiency

There appear to be discrepancies within Fugro and Cleath (2002) regarding irrigation efficiency and gross versus net pumping. Irrigation efficiencies were assumed to increase from 63% in 1980 to 70-75% in 1997 (see Table 58). Also, excess applied water to manage soil salinity was estimated to equal 2-16% of base irrigation demand for various crops (Table 56). But the water budget (Table 72) shows irrigation deep percolation equaling only 2-4% of gross irrigation pumping, equivalent to 96-98% efficiency. An earlier discussion indicates that "irrigation losses" are in the range of 18-38% (Table 42). Table 42 also indicates "irrigation return flows" equal to 2.1-4.5% of gross pumping, but the text describing the table states that deep percolation below the root zone is 2-17%. The discussion of irrigation efficiency (p. 129) states that the irrigation efficiency is calculated over an entire growing season. Normally, the seasonal efficiency accounts for irrigation return flow (deep percolation in this case) that is re-pumped for irrigation use the same season. This approach is inconsistent with the estimates of gross pumping based on total applied water with no adjustments for return flow component. It is also inconsistent with a layered model where pumping derives from deep layers while irrigation return flow accrues to the top layer. The most recent study (Fugro, 2010) assumed an average efficiency of 2.2 % (p. 6, section 3.1.4). Some of the apparent discrepancy among these numbers could be the result of unclear documentation. They were presented in various places in the 2002 report in discussions of disparate topics.

There is also an inconsistency between the discussion of salt leaching requirements (Fugro 2002, pages 54-55 and 127-128) and the Blaney (1933) estimates of rainfall recharge. If Blaney is correct and significant recharge occurs only once every 3-4 years, rainfall percolation would not be frequent enough to provide adequate leaching. Fugro (2002) Table 13 shows that grapes are relatively sensitive to salt and have the highest leaching requirement among crops commonly grown in the region. Soil salinity typically increases substantially during the course of a single irrigation season. It is unlikely that vines could wait 4 years between salt-flushing events. Thus, the estimated frequency of rainfall recharge influences irrigation efficiency as constrained by the need for salt management.

The most unambiguous approach to calculating applied water and deep percolation would be to use a per-irrigation efficiency to convert consumptive use to gross irrigation pumping. If the efficiency did not appear sufficient to achieve an adequate leaching ratio (on an annual basis, in conjunction with deep percolation of winter rainfall), then a lower efficiency could be assumed.

Several other apparent discrepancies or conceptual inconsistencies related to agricultural water use were identified during my review of previous studies. These included:

- Todd (2009, Table 12) subtracted irrigation return flow to obtain net agricultural pumping in a water balance calculation, but did not subtract WWTP and septic percolation to get net municipal and rural residential pumping. This seems inconsistent.

- There appears to be a discrepancy between the estimated water balance and observed water-level trends in Fugro and Cleath (2002). The water balance calculations (Table 71) indicated that annual groundwater pumping decreased during 1981-1997 because much of the cropland shifted to vineyard, which has a smaller water duty than pasture and other crops. The regression slope for annual pumping during 1981-1997 was -498 AFY per year for Estrella subarea pumping and -3,470 AFY per year for the entire basin. In spite of the decrease in pumping, groundwater levels declined during that period, in some cases at an increasing rate.

- The historical trend in agricultural water use is considerably different from the future irrigation trend assumed in the most recent study (Fugro, 2010). As noted above, estimated irrigation water use in the Estrella subarea and the basin as a whole decreased substantially and steadily during 1981-1997, reaching a basin-wide level of about 50,000 AFY in 1997 (Fugro and Cleath [2002] Table 71). In contrast, Fugro (2010) assumed irrigation pumping in 2010 was 63,077 AFY (26% higher than in 1997) and that it would remain constant during 2010-2025. The basis for this assumed change in pumping amount and trend was not explained in the report.

- Two estimates of future water demand used quite different assumptions regarding future rural residential pumping. Todd (2009, Table 14) estimated that rural groundwater pumping in 2025 would be 44% greater than in 2006 (16,504 AFY versus 11,485 AFY). Fugro (2010, Table 13) assumed rural residential pumping would remain constant at the 2009 level (11,817 AFY). In addition to this range of uncertainty in the number of rural residences, there is uncertainty in the amount each residence uses. Fugro (2010) tested water use factors ranging from 1.0 to 1.7 AFY per residence. In both instances, the assumptions appeared to come from planning agencies, not the report authors. For example, Todd (2009) explored the maximum "buildout" water use for rural residential development based on a San Luis Obispo County inventory of potentially developable rural residential parcels. The resulting estimate of potential water use is probably high because some of that development would likely require permits that local agencies would be reluctant to issue given the continuing water-level declines in the Estrella and Shandon subareas.

WATER LEVELS ARE A MAJOR SOURCE OF UNCERTAINTY

Trends in measured water levels are critical to evaluating the sustainability of pumping. Regardless of what water balances and groundwater models might show, chronically declining water levels at multiple wells are a certain indication of excessive pumping. However, water level hydrographs in the Paso Robles basin can be difficult to interpret because in many cases they do not respond clearly and consistently to changes in recharge or pumping. Theoretically, both factors should strongly influence water levels, but empirically the relations are weak. This somewhat counterintuitive condition probably results from layering within the basin, which slows and attenuates recharge pulses as they percolate down to the aquifers tapped by water supply wells. Layering also creates confined aquifer conditions, in which water levels fluctuate widely in response to individual pumping cycles, which can result in large and apparently random fluctuations in quarterly or semiannual water level data.

The hydrographs in **Figure 4** illustrate the connection—or lack thereof—between water levels and pumping or recharge. If groundwater levels responded strongly to recharge, they should trend noticeably upward during wet periods and downward during droughts. A cumulative departure analysis of annual rainfall at Paso Robles indicates that the 1984-1992 period was dry, as indicated by the downward trend in the red line in **Figure 5**. The 1993-1998 period was wet (upward trend), and the 1999-2009 period consisted of mostly below-average rainfall years except for wet years in 2005 and 2006. The groundwater hydrographs show little or no response to these trends in rainfall. The declining trend evident in all of the hydrographs commenced in the mid-1990s in most cases, when climatic conditions were still wet. An exception is the temporary increase in water levels in 2005-2006 at wells 16P2 and 29N1. These wells apparently responded to above average recharge from nearby creeks.

The hydrographs also do not correlate with the expected effects of seasonal pumping. Spring water levels are indicated on the hydrographs by pink dots. Given that the vast majority of groundwater pumping in the area is for irrigation, the spring water levels should be higher than the fall water levels every year, but in many wells and years this is not the case. Although the hydrographs do not respond entirely as expected to recharge and pumping, the ubiquitous long-term declining trend can only be the result of an imbalance between the two.

Another potential source of error in interpreting hydrographs is mixing data for shallow wells tapping younger alluvium with data for deeper wells tapping the Paso Robles Formation. **Figure 6** shows hydrographs for two wells located less than 2,000 feet apart along the Estrella River in the Estrella subarea. The well with steady, high water levels

(5F1) probably draws from the alluvium, while the well with large, long-term declines (5D2) is deeper and draws from the Paso Robles Formation.

These examples support a conclusion that interpretation of water level trends is best done by examining a large number of hydrographs, identifying general trends common to most of them, and looking for hydrogeologic or other physical circumstances to explain wells that deviate from the norm. Also, comparing water levels between two particular dates—by hydrographs or contours—can lead to conclusions that are not representative of long-term trends. Trend analysis that includes all years is more robust.

Streamflow and Stream-Aquifer Interaction

Several methods were used in previous studies to estimate groundwater recharge from stream percolation, including groundwater modeling and calculations based on gauged streamflows and measured groundwater levels. One method suffered from conceptual limitations, and other aspects of the analyses are not sufficiently well documented to enable a systematic comparison of results.

Fugro and Cleath (2002) calculated stream recharge based on vacant alluvial storage capacity, with no limitation related to streambed infiltration capacity. This approach probably overestimates recharge from high, brief flow events, when infiltration capacity may limit the percolation rate. Conversely, the method probably underestimates recharge from sustained flows after vacant storage capacity in the alluvium has already been refilled. Under those circumstances, the stream can keep the alluvial aquifer continuously full as water percolates from the alluvium into the underlying Paso Robles Formation. Furthermore, it appeared that vacant storage capacity may have been estimated in some cases from deep wells completed in the Paso Robles Formation, but deep water levels are poorly correlated with recharge, pumping and shallow water levels. Therefore, they are not reliable indicators of available storage at the water table.

Fugro and Cleath (2002) included no discussion of groundwater discharge into streams, and it's not listed in Table 71 or 72. Groundwater discharge into streams is a substantial part of the water budget. Subsequent groundwater modeling indicated that this flow was approximately 29,000 AFY, or 42% as large as seepage from streams (ZoneBudget output for 1981-1997).

The MODFLOW model (Fugro and others, 2005) overcame some of the limitations of the earlier study. Stream percolation is governed by available storage capacity in shallow aquifers near the stream as well as by the stage, permeability and wetted area of the streambed. The model also simulates groundwater discharge into streams where groundwater levels are higher than the stream surface. In all these respects, the MODFLOW approach is conceptually correct. Documentation of the MODFLOW results in the report was somewhat complicated, however, so it was difficult to compare them with the prior study. Table 3 of the modeling report shows 46,000 AFY of percolation from streams. However, this includes WW percolation and excludes percolation from streams other than Salinas River (per e-mail from Nels Ruud 4/27/10). Therefore, the total is not directly comparable to Table 41 of Fugro and Cleath (2002), which listed 41,800 AFY of seepage from streams.

When the MODFLOW model was reactivated for the present review, the ZoneBudget results showed total percolation from all streams of 68,400 AFY. This estimate is 26,600 AFY (64%) larger than the 2002 estimate. A possible explanation for the discrepancy is that the vacant-storage-capacity method used in 2002 omits ongoing percolation from the alluvium to the Paso Robles Formation when the alluvium is "full".

The MODFLOW model requires estimates of streamflow at model boundaries, not at gage locations. The method for extrapolating flow from the gauge locations to the model boundaries is not documented, either for streams with downstream gauges (Salinas and Estrella Rivers) or for ungauged streams (all others)(Fugro and others [2005] pp. 15-16). This is not a trivial exercise, given that flow depletions along ungauged streams and upstream of gages are unknown. The method used by the modeling team to estimate these inflows is unclear (P. Sorensen, pers. comm. 4/29/10).

Finally, the 6-month stress periods used in the model are too long to accurately represent stream-aquifer interaction. Stream recharge is quite nonlinear, especially for flashy flows in broad sandy channels with variable flow width. If average streamflow over the 6-month period is entered into the model it will grossly overestimate stream recharge (which is a large percentage of small steady flows and a smaller percentage for flashy high flows). This issue is not discussed in the model documentation.

Subsurface Inflow

Groundwater inflow from areas adjacent to the modeled area were supposedly estimated using the Darcy equation, but no data were available for the three factors in that equation: hydraulic gradient, flow depth and hydraulic conductivity. The hydraulic gradient was assumed to equal the topographic slope of the overlying ground surface (Fugro and Cleath [2002] p. 94). In reality, there is no physical mechanism requiring that the two gradients be similar. No well data were used to estimate saturated thickness, and the hydraulic conductivity was similarly assumed (Fugro and Cleath [2002] Table 34).

Furthermore, groundwater inflow was assumed to vary substantially from year to year, which is improbable. This variability was justified by reference to a tunnel seepage study in Santa Barbara County that documented pulses of tunnel inflow following rain storm events (Fugro and Cleath [2002] p. 95). This conceptual model of groundwater flow pulses rapidly following rainfall events contradicts the Blaney (1933) data used to estimate rainfall recharge for the groundwater model. Blaney's studies indicated that deep percolation beneath the root zone occurred only in wet years (Fugro and Cleath [2002], pp. 96-99). If the Blaney concept is correct, there would be surges in groundwater inflow across the model boundaries during wet years followed by a recession during subsequent normal and dry years. Table 35 of Fugro and Cleath (2002) does not closely follow this pattern.

The estimated annual variation in subsurface inflow seems too high. The estimates of annual subsurface inflow to the basin during 1981-1997 vary by more than a factor of two (Fugro and Cleath [2002] Table 35). This is implausible, because 1) it implies that groundwater gradients across basin boundaries fluctuate by a factor of more than two, and 2) it implies that large pulses of rainfall recharge cause large fluctuations in water levels adjacent to the basin, which is not a pattern observed in monitoring wells within the basin.

The estimates of annual variability in inflow are presented as fact in Figure 3 of Fugro (2010), which shows a regression of annual subsurface inflow versus rainfall for 1981-1997. It implies that subsurface inflow was actually measured, when in fact the inflow data are entirely synthetic, as described above. Apparently, the regression equation shown on the figure reflects nothing more than the assumptions underlying the inflow estimates. After deriving an estimate of average gradient and flow across the basin boundary, annual variations in this flow were then estimated by assuming that inflow varies as a percentage of annual rainfall (Fugro and Cleath [2002] p. 95 and Table 35). This assumption contradicts the Blaney approach used for rainfall recharge, which estimates recharge as a highly nonlinear function of annual rainfall (i.e. very threshold-dependent).

A better approach to estimating boundary inflows would be to delineate external upland areas likely to contribute inflow to the basin (bounded by faults, flow divides beneath ridges, or distance from other discharge boundaries such as upland creeks). The same procedures used to estimate rainfall recharge within the basin should be applied to the external areas and assumed to become inflow to the basin. Finally, inflow is probably fairly constant from year to year due to the attenuating effects of flow through the relatively impermeable geologic materials present in the external upland areas.

During model calibration, subsurface inflows were substantially increased along selected boundary segments "where insufficient inflow was available to simulate the measured groundwater elevations" (Fugro and others [2005] p. 18). Adding water to a groundwater model without a plausible physical source—especially by means of a general head boundary capable of supplying unlimited quantities of water—is always suspect. That approach to fixing a calibration problem is typically non-unique. Errors in recharge, pumping or hydraulic conductivity might also overcome the problem, and in some cases the water level data themselves might not be representative of ambient groundwater conditions. In this case, lower hydraulic conductivity might have elevated groundwater levels in the problem areas as much as increased boundary inflow.

Recharge to the South Gabilan area was further boosted by increasing stream recharge. The stream channel density in the model for the South Gabilan area was more than two times greater than in the North Gabilan area, in spite of similar terrain, rainfall and geology. As a result, stream recharge in the South Gabilan area was 1.9 times greater. The extra boundary inflow (2,800 AFY) and extra stream recharge (3,000 AFY) contributed to the 10,400 AFY of outflow to the Estrella area, averaged over the 1981-1997 calibration period. This flow comprised nearly half of the total inflow to the Estrella area and therefore substantially influenced model calibration in that area. It is not clear whether a smaller storativity value in the Estrella area could have achieved an equally acceptable simulation of long-term water level declines.

Groundwater Storage

Two of the previous studies mention the total volume of groundwater in storage in the basin (Fugro and Cleath [2002] p. 143; Fugro [2010] p. 14). In my opinion, this number is of little practical value and can be misleading for lay audiences. It would be physically impossible to pump a basin dry (some saturated thickness is required to convey groundwater to wells), and a host of adverse effects would intervene long before that endpoint were reached (for example: pumping costs, dry wells, elimination of baseflow in rivers, subsidence, mortality of riparian vegetation). A more useful storage volume for management purposes is the volume defined by minimum and maximum desirable water level surfaces. This range of water levels is much smaller than the total basin thickness; perhaps 100 feet in some areas and much less near sensitive habitats. The volume of storage between the upper and lower water level surfaces constrains the calculations of perennial yield because it defines the volume of water that can be borrowed from storage during droughts. Groundwater management should be based on this operable storage range and not on total basin storage.

There is some discrepancy among previous studies regarding storativity values. Fugro and Cleath (2002, Table 68) assumed a range of specific yields (0.08-0.11) for the basin areas (0.08 for Estrella).The groundwater model (Fugro and others [2005] Figs. 33-36) used 0.17 for alluvium (layer 1). Most of layer 2 (where the water table is located for most of the Estrella area) has a specific yield of only 0.01. Specific yield in layer 3 closely matches the values in the 2002 report, and that is the layer in which the water table occurs throughout the largest part of the basin. The low specific yield value for layer 2 creates a discrepancy between simulated storage changes in the Estrella subarea and storage changes estimated independently of the model (for example, Todd [2007], Table 1).

There appears to be an error in one or more entries in Table 9 of Fugro and others (2005), which shows the simulated average annual change in storage by subarea during the calibration period. For example, the value for the San Juan subarea is four times greater than for the Estrella subarea, when Estrella experienced much larger water level declines. Also, the Shandon subarea should not have a large increase in storage, because water levels did not rise (see Figure 34 of Fugro and Cleath (2002) for contours of 1997 minus 1980 water levels).

Similarly, storage and water level information seem inconsistent in Todd (2007). Referring to the hydrograph for well 26S/15E-18J001 (Todd Figure 11) as representative of groundwater conditions in the Shandon area, the text asserts that “water levels appear to have decreased beginning in 2003, suggesting increased local pumping in the area" (page 9, bottom of 2nd paragraph). However, a declining trend is inconsistent with the increase in storage listed for the Shandon subarea in Table 1 (page 10).

Basin Yield

Three estimates of perennial yield have been presented in previous studies, all of them remarkably similar. Fugro and Cleath (2002) used the practical rate of withdrawal method in which annual change in storage is plotted against annual groundwater pumping. The expected relationship is that storage change would be negative in years with high pumping and positive in years with low pumping. The method was applied twice: once with storage changes calculated using the inventory method (total inflows minus total outflows) and once with changes calculated using the specific yield method (water levels). Linear regression of the scatterplot data resulted in a line, and the perennial yield was the amount of pumping corresponding to the point where the line crossed the x axis (zero storage change). The two estimates of perennial yield were 93,500 ac-ft/yr and 94,600 ac-ft/yr, respectively (Fugro and Cleath, 2002).

The similarity of the two estimates is not an indication of high accuracy, however. The two scatterplots without the trend lines are reproduced in **Figure 7**. There is a large amount of scatter in the data, especially when storage changes are estimated using the specific yield method (lower plot). Individual years plot in quite different locations in the two plots, relative to the other data points. Examples are highlighted in color. This suggests that the two methods do not strongly confirm one another and that the similarity in x-axis intercepts is merely a coincidence. The low precision of the slopes is also indicated by the low r-squared values (0.256 and 0.039 for the two plots, respectively). Finally, the very shallow slope of the regression line for the lower plot turns out not to be significantly different from zero at even a 60% confidence level. Thus, the perennial yield estimate based on the specific yield method is meaningless.

The third estimate of perennial yield was obtained using the groundwater model. All types of pumping throughout the basin were adjusted by a uniform percentage until the average annual storage change over the calibration period was zero. This occurred at an average annual basin-wide pumping rate of 97,700 ac-ft/yr, or 2.4% less than the estimated historical pumping (Fugro and others, 2005).

The two valid estimates of yield differ by 4,200 ac-ft/yr, or slightly more than 4%. Both methods were based on basin-wide averages and could include localized storage depletion. A broader range of estimates could undoubtedly be obtained with different data and assumptions, particularly if the geographic distribution of pumping were rearranged. This is because perennial yield is influenced by the location of pumping relative to head-dependent boundaries such as creeks and rivers.

There may be a discrepancy between these estimates of yield and an independent comparison of pumping and water levels. Todd (2009, Table 12) completed a detailed inventory of pumping in the basin, which totaled 88,154 AFY. This total is well below the prior range of yield estimates (93,500 – 97,700 AFY), yet water levels continue to decline in the Estrella and Shandon areas. While these declines may be local, they would have to be more than offset by increases in other areas to be consistent with the basin yield estimates.

RECOMMENDATIONS

- Collect vineyard irrigation data from a large sample of growers to improve estimates of salt leaching needs, irrigation pumping and irrigation efficiency.

- Monitor groundwater levels at selected locations on a frequent basis and at multiple depths. This information could substantially improve our understanding of basin storage, relationships between pumping, recharge and water levels, and rates of flow between the alluvium and Paso Robles Formation. The data would also reveal the amount of error in quarterly and semiannual water level data sets caused by short-term drawdown in response to pumping cycles in a confined aquifer. In practice, this program may require installation of additional monitoring well clusters and deployment of data loggers at selected wells to measure water levels frequently.

- Update the groundwater model to facilitate further analysis of water balance and water management issues. It provides the best available tool for analysis because it enforces consistency between water balances and water levels and because it provides a means of testing alternatives. Specific improvements include:

    - Simulate rainfall recharge using a daily model of soil moisture balance. Test the sensitivity of simulated recharge to key input parameters. Apply the recharge model to zones representing various combinations of soil type, rainfall, slope, land use, crop type and irrigation status. Continuous simulation of a multi-year period eliminates errors associated with estimating soil moisture status at the beginning of each rainy season. Compare the results with the Blaney method.

    - Estimate groundwater inflow around the perimeter of the model by applying the rainfall recharge model to adjacent upland areas that plausibly contribute inflow to the basin. Assume the inflow is relatively constant from year to year.

    - Use the model to define physically realistic upper and lower water level surfaces defining a range of operable storage for basin management purposes.

    - Calculate and interpret subarea water budgets using the MODFLOW ZoneBudget post-processor.

- Use the model to investigate yield issues on a subarea basis, including possible changes in the locations and depth of well production.

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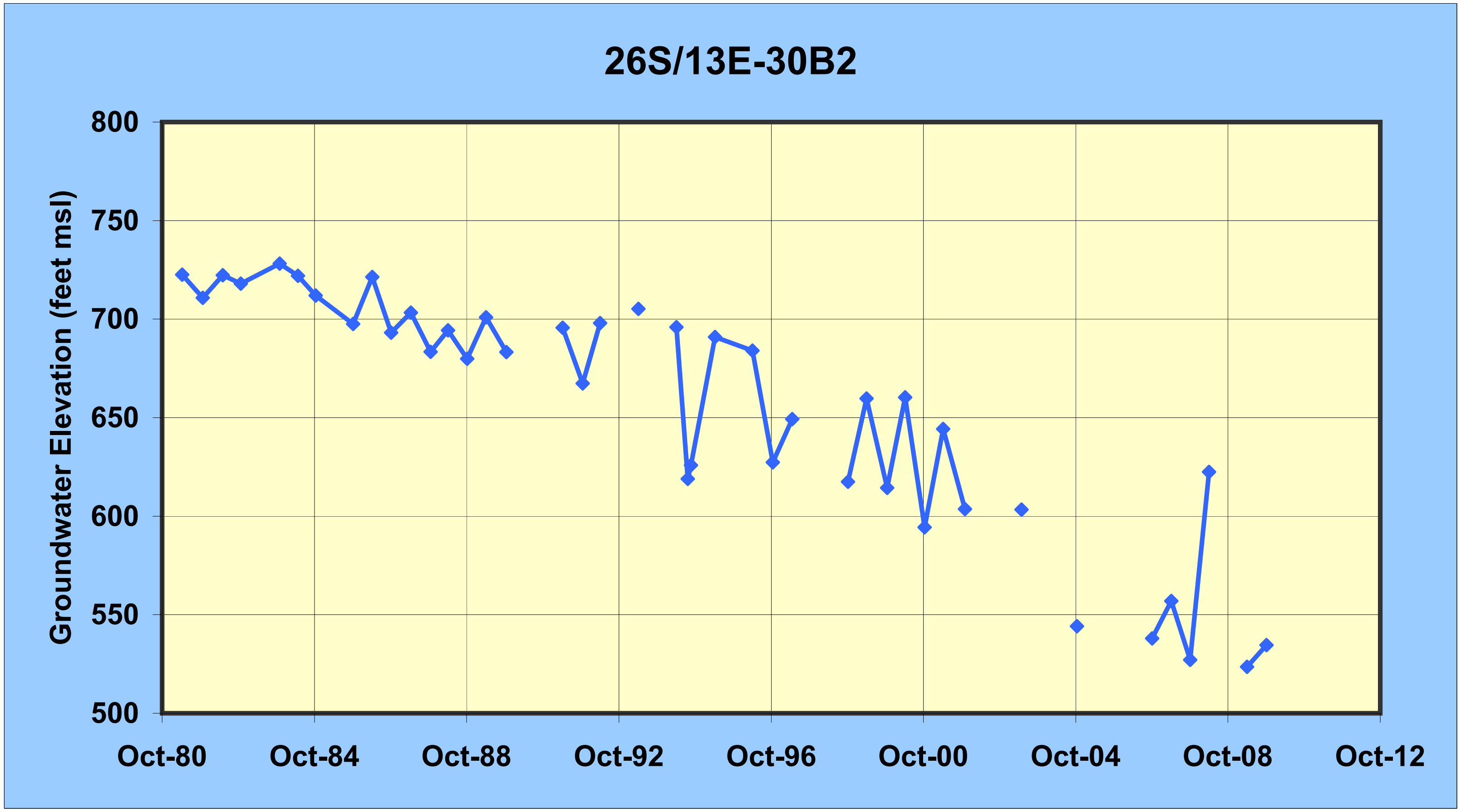


Figure 1. Hydrograph of Water Levels at Well 26S/13E-30B2 in the Estrella Subarea

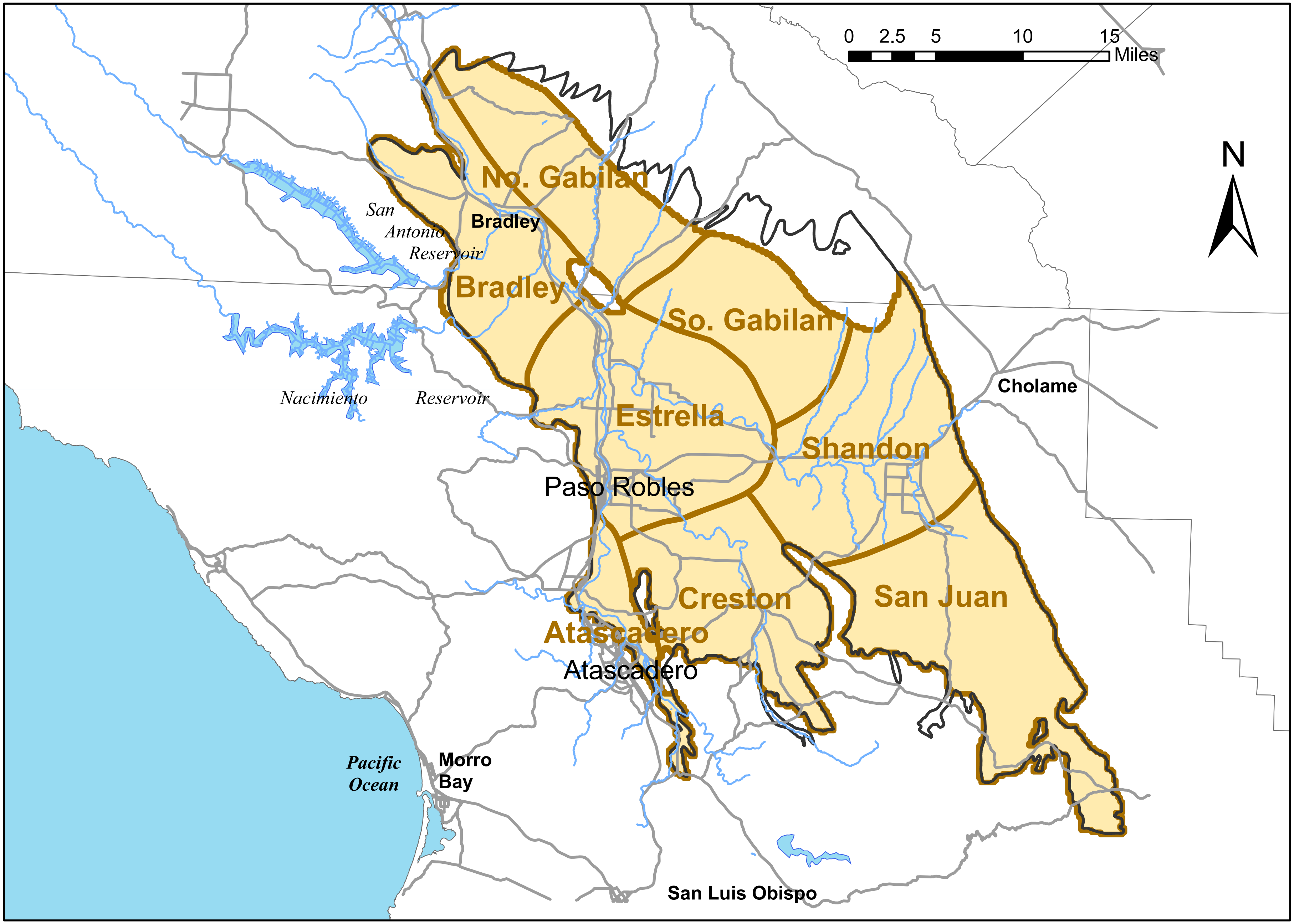


Figure 2. Paso Robles Groundwater Basin and Subarea Boundaries

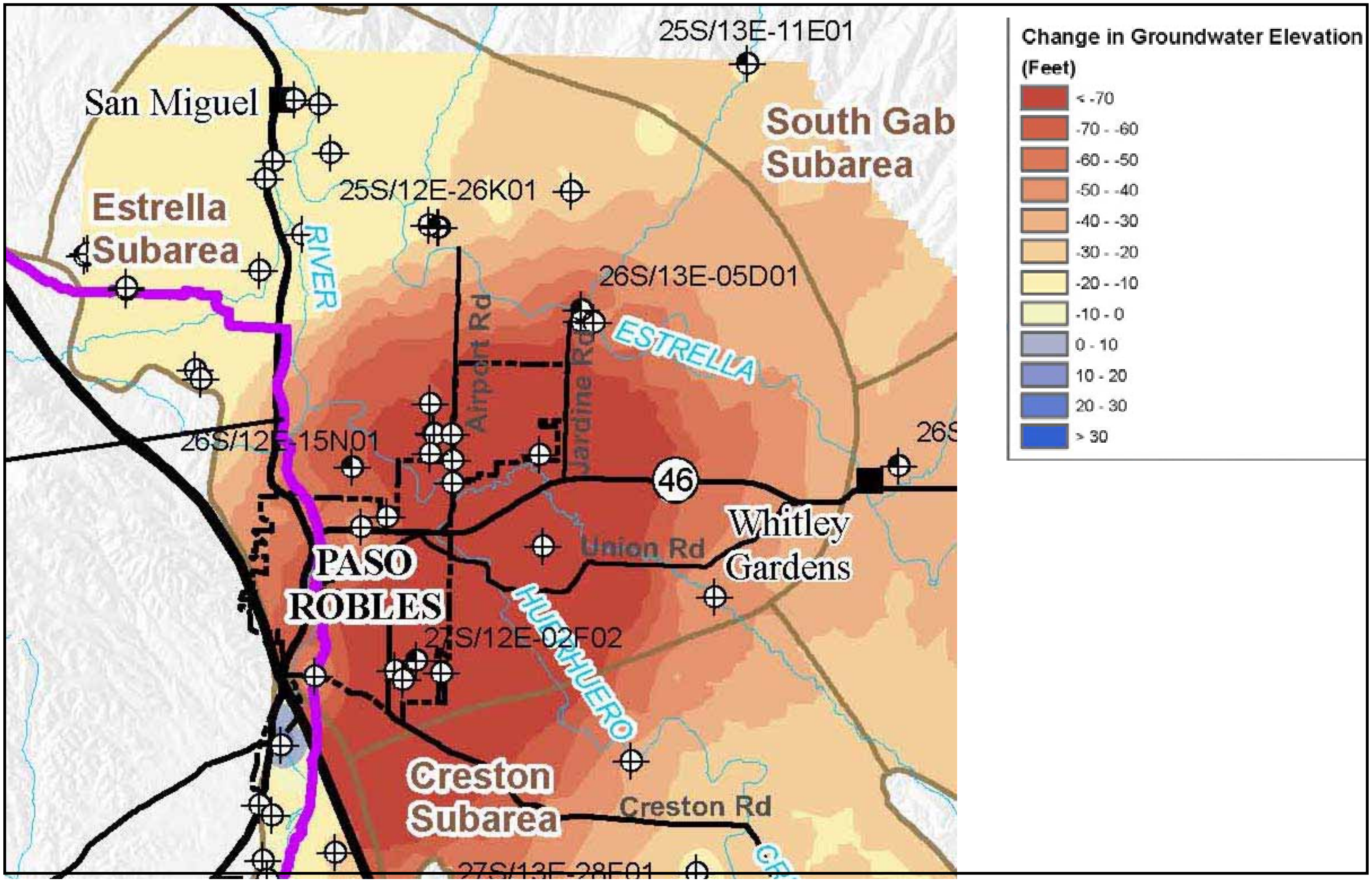


Figure 3. Map of Change in Groundwater Levels in the Estrella Subarea, 1997-2009

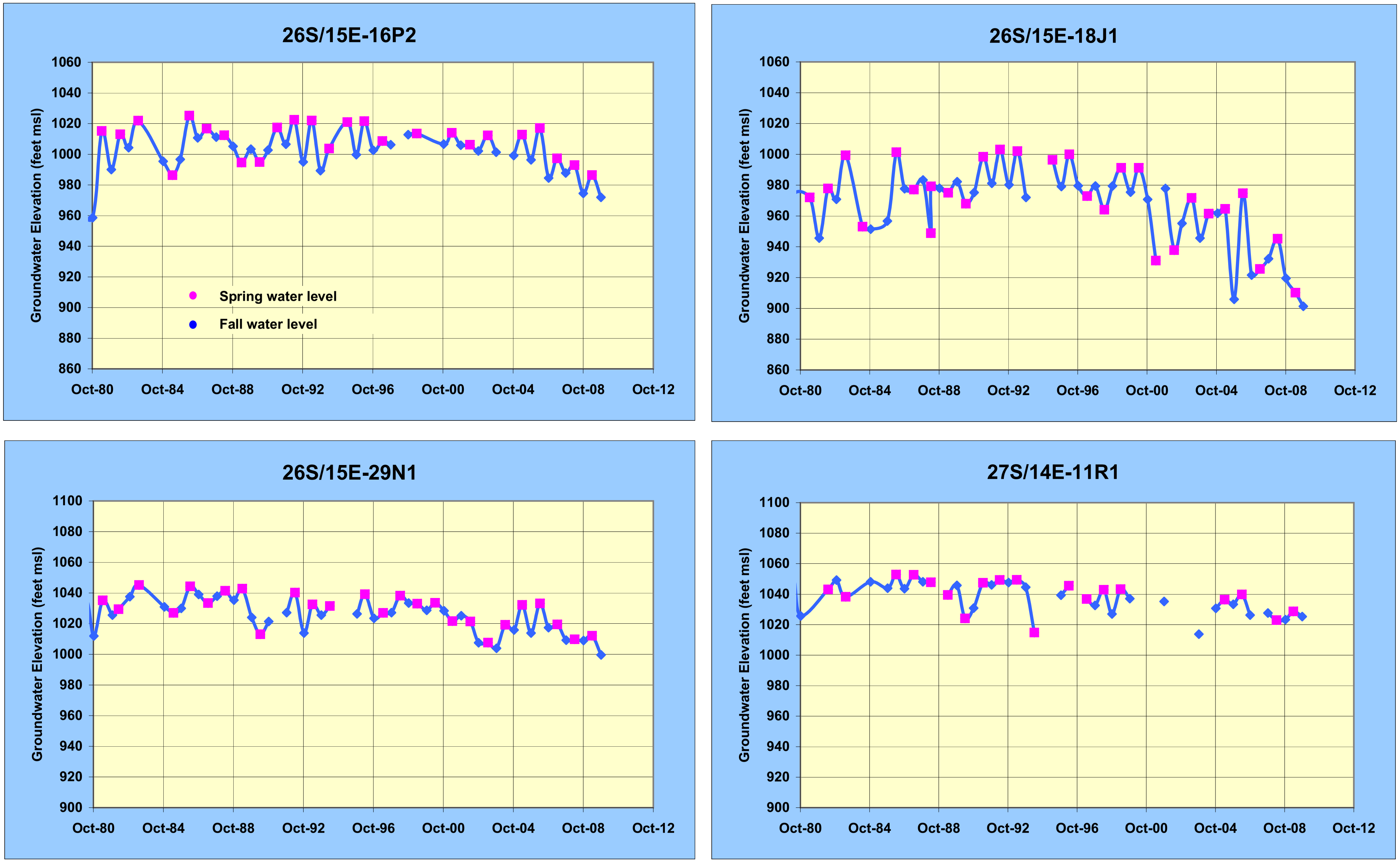


Figure 4. Hydrographs of Selected Wells in the Shandon Subarea

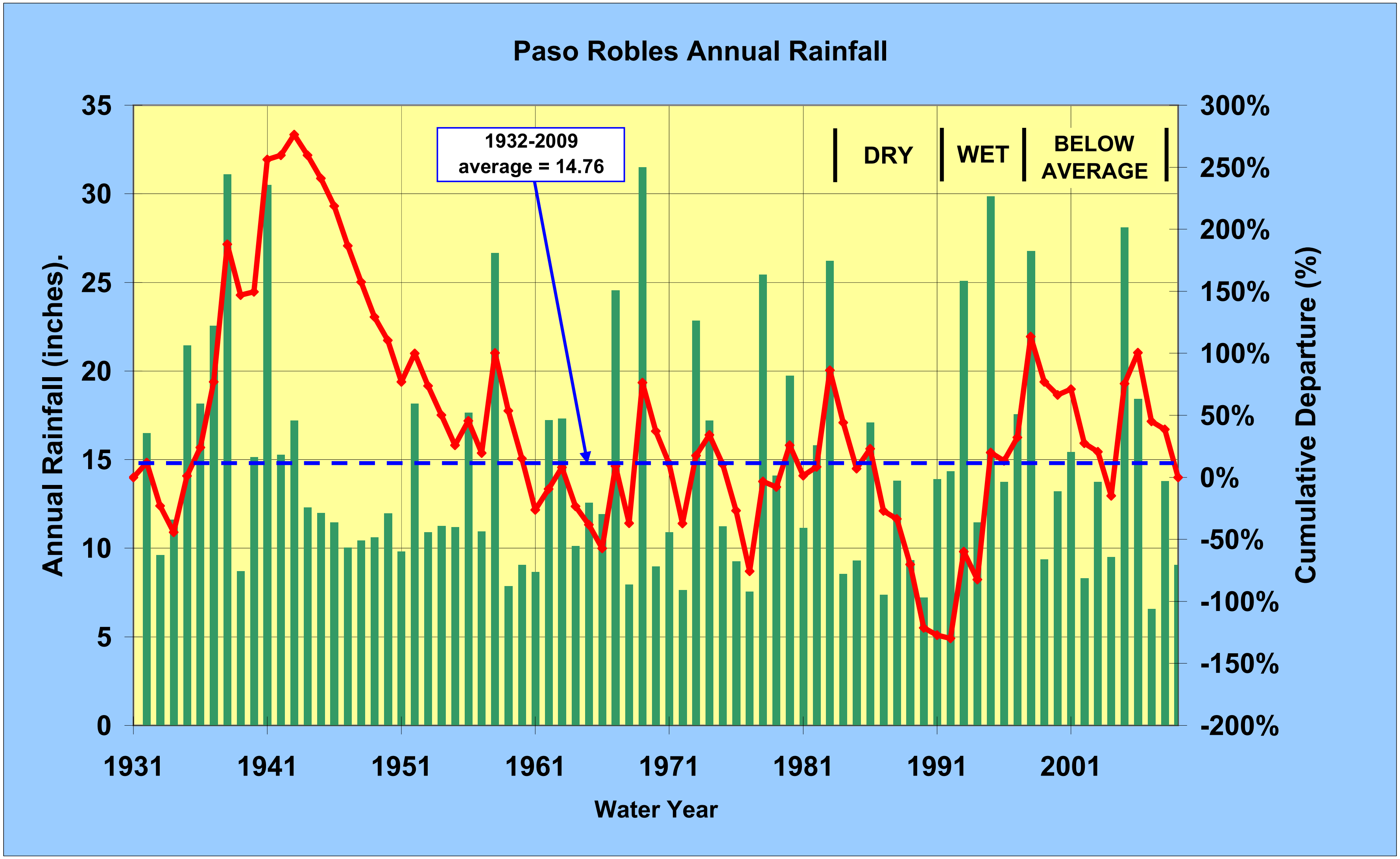
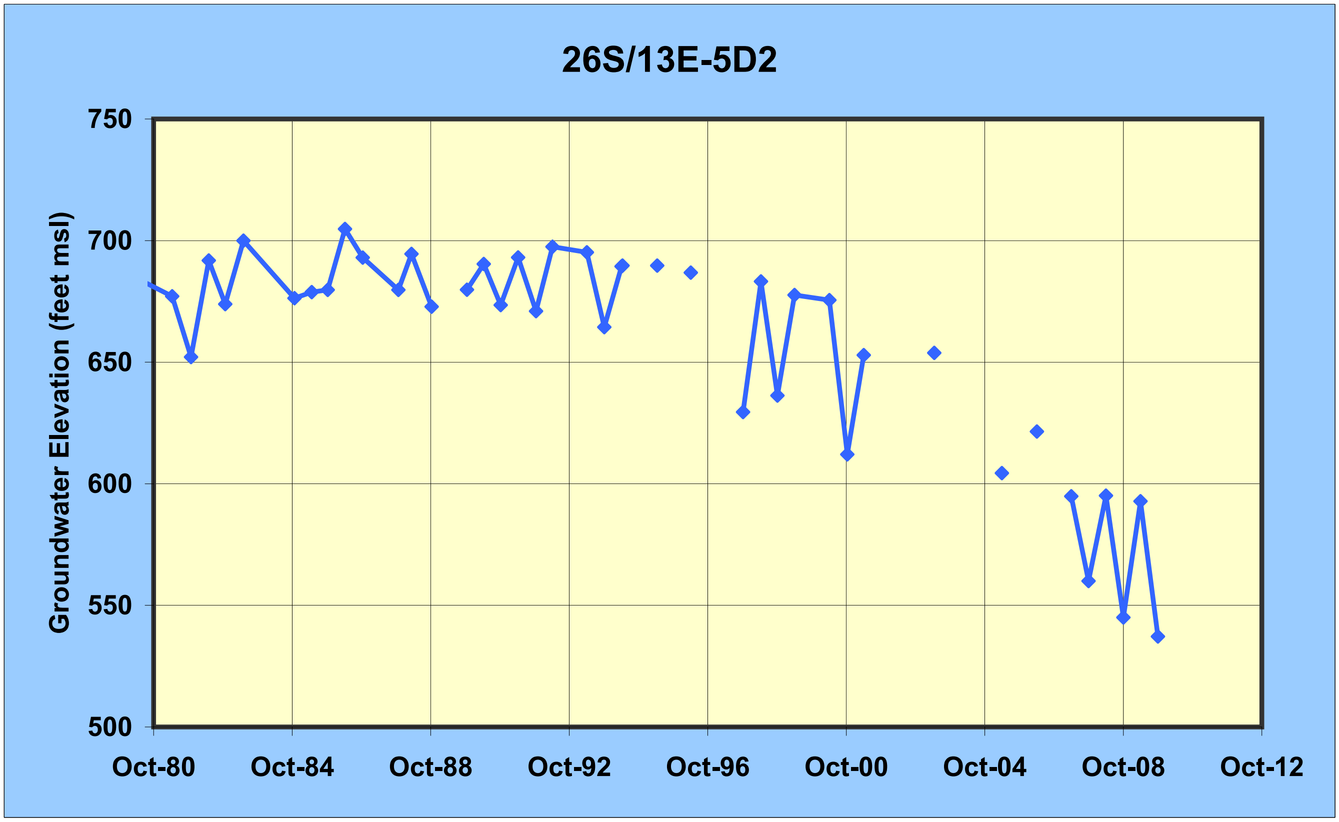


Figure 5. Annual Rainfall and Cumulative Departure of Annual Rainfall at Paso Robles, 1932-2009



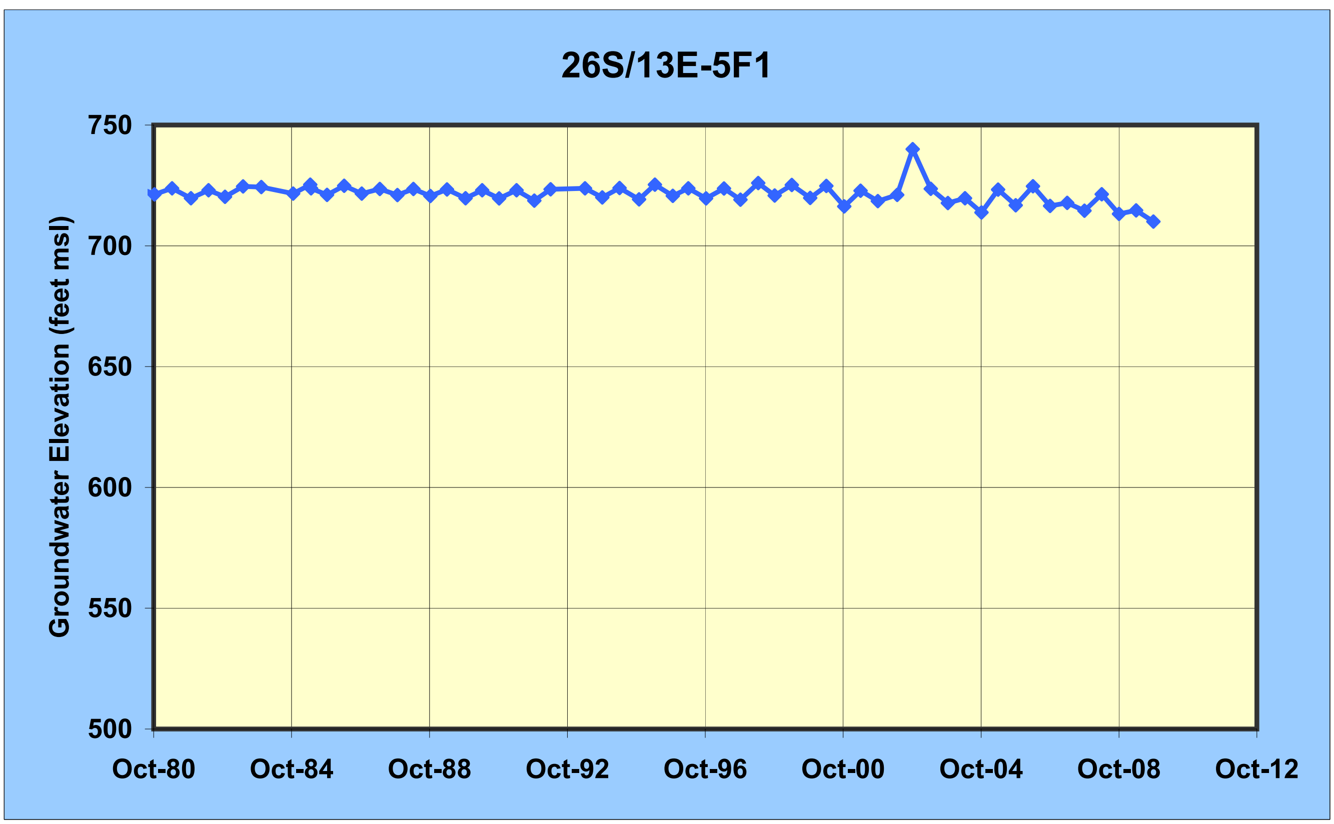
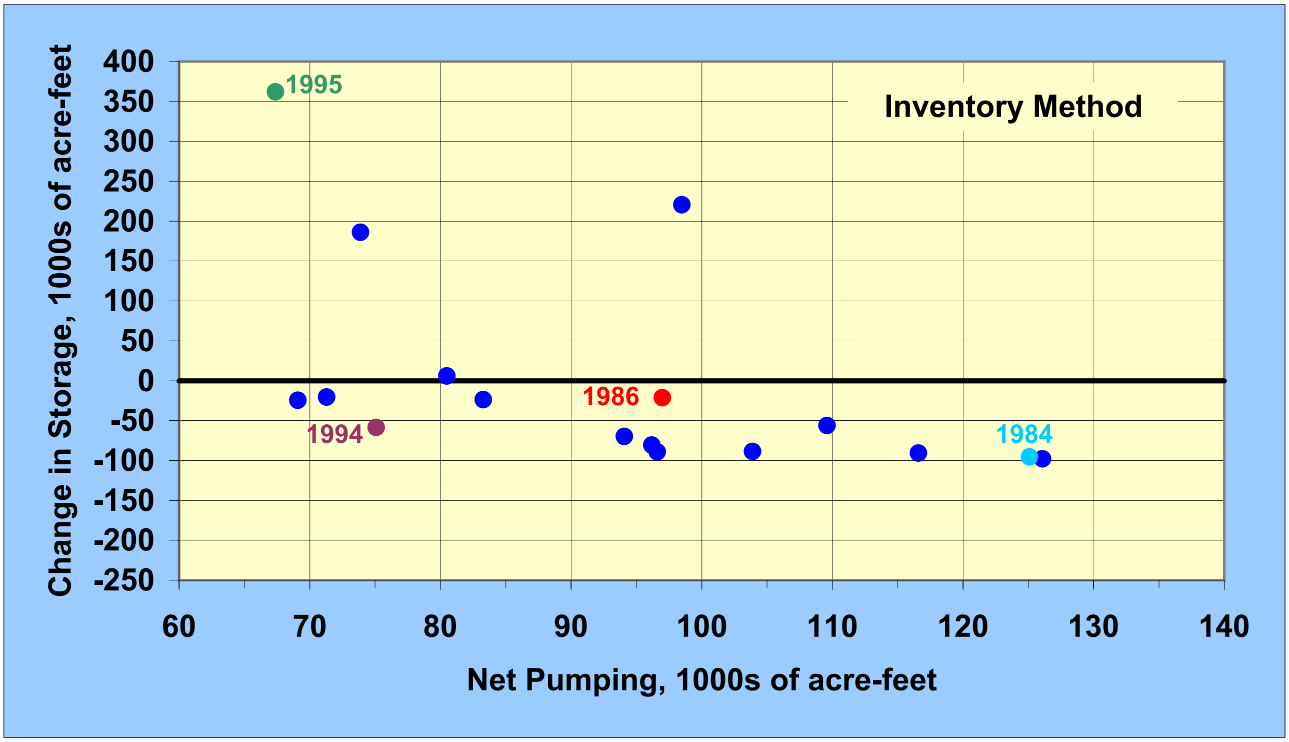


Figure 6. Hydrographs of Two Nearby Wells in the Estrella Subarea



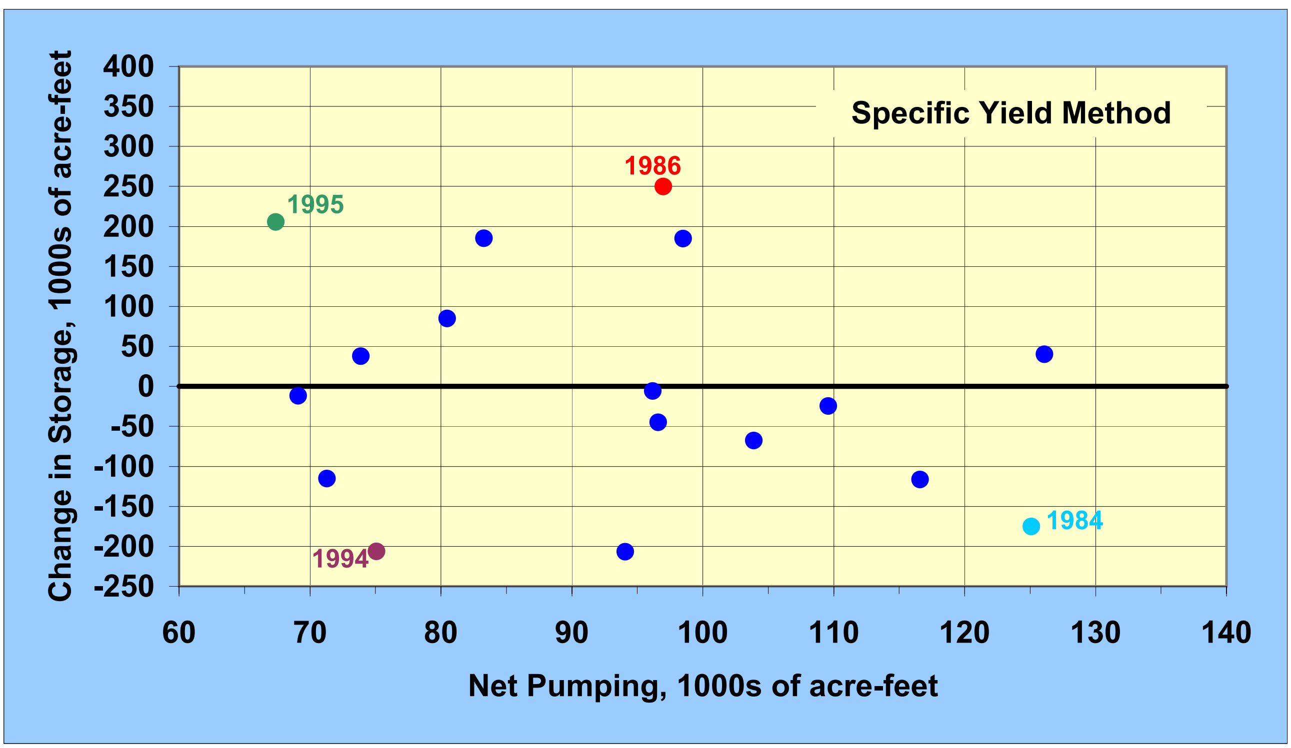


Figure 7. Relation of Annual Basin-Wide Change in Storage to Annual Groundwater Pumping, 1981-1997

Comments

TODD ENGINEERS

GROUNDWATER · WATER RESOURCES · HYDROGEOLOGY · ENVIRONMENTAL ENGINEERING

MEMORANDUM

Date: July 30, 2010

To: Christopher Alakel

From: Iris Priestaf, PhD, President

Re: Observations on Gus Yates, Peer Review of Paso Robles Groundwater Studies, June 29, 2010

I appreciate the opportunity to comment on Gus Yates' peer review. Yates' review has been thoughtful, has involved significant in-depth analysis, and has yielded useful findings and recommendations. While some findings may be subjective or not definitive, the peer review is useful in spotlighting critical uncertainties and pointing the way to improved water management. Our focus here is on application of Yates' memo to ongoing and future management.

1. Yates indicates that the hydrologic separation of the Atascadero subbasin is overstated.

The City has a unique position in straddling the Atascadero-Estrella boundary, with wells in each subarea. The degree of hydrologic separation of the Atascadero subbasin has been a long-standing issue, marked by determined advocacy by some parties for separation. Yates' opinion is an important reminder that the hydrogeologic evidence is insufficient and that future decisions (for example, regarding groundwater development, Nacimiento storage, and wastewater disposal) should not assume separation. If the Paso Robles basin is adjudicated in the future, this will be a primary issue.

Also important is Yates' emphasis on the need for all stakeholders to recognize a shared interest in maintaining groundwater supply throughout the basin. This unity of the basin needs to be recognized in County planning, including the Resource Capacity Study (which initially was focused on a limited area of concern) and Master Water Plan. It should also be reinforced during development of the Groundwater Management Plan (GMP), which by necessity is addressing the basin on a subarea basis. The City's active participation in management of the Atascadero and Estrella subareas can be an important unifying factor.

2. Yates indicates that the available water level data is a major source of uncertainty. He warns against use of groundwater level change maps to assess the overall state of the basin in terms of perennial yield and recommends analysis of numerous hydrographs.

I agree that groundwater level data should be considered with everyone's recognition of the limitations of the data and monitoring network. This is important because the City, County, and stakeholders are developing a GMP and planning on annual "state of the basin" reports. Such documents typically include change maps and key hydrographs that are selected to represent an area. While Yates has identified legitimate problems with groundwater level change maps, they are useful to show where declines are occurring. However, given the uneven distribution of monitoring wells (particularly in marginal recharge areas of the basin) and uncertain reliability of some deep monitoring wells as indicators of storage, they do not currently give us the whole picture. Hydrographs from selected wells also do not give the whole picture.

In the short term, the GMP and annual reports should be explicit about the data shortcomings and in the long term, the monitoring network needs to be improved. Consideration should be given to increasing the frequency of monitoring from semi-annual to quarterly, at least for the purposes of investigation. Yates mentioned the possibility of dedicated new monitoring well clusters; if given three choices, where would he put them? In regional terms and focusing on the groundwater level decline, it would be useful to bracket the area of decline with a well cluster in eastern Estrella near the Estrella River, central-western Estrella near the Salinas River, and near the Atascadero-Estrella boundary. An updated and improved numerical groundwater flow model would be useful in defining optimal locations for well cluster sites.

3. Yates indicates that stakeholders should focus on operable storage instead of total storage.

In the Paso Basin, total storage is not relevant to basin management. Operable storage is the groundwater storage located between minimum and maximum desirable water levels. Yates provides good reinforcement for the current GMP discussion of Basin Management Objectives (BMOs), which is focused on establishing those desirable water levels for each subarea.

4. Yates points out significant uncertainties in important water balance elements, including agricultural water consumption, rainfall recharge, subsurface inflow, and stream-aquifer interaction.

To varying degree, these have been the subject of discussion and in fact, vineyard water consumption is being investigated now by the University of California Cooperative Extension. (Yates' queries about vine spacing, canopy cover, deficit irrigation and salt leaching should be forwarded to UC.) While recognizing the benefits of focused studies and updates, I am concerned about a piecemeal approach to the water balance in the Paso Robles basin. Accordingly, I concur with Yates' recommendation to update the numerical groundwater model, including the water balance that is an integral part of the model. I have discussed the Paso Robles Basin numerical model with Dan Craig, Senior Hydrolgeologist/Modeler with Todd Engineers, who is an original MODFLOW modeler with more than 20 years experience. We recommend that the City, County and other stakeholders plan for update of the model within three years. This would make appropriate use of the UC Extension findings in the context of the entire water balance. The numerical model update should involve re-evaluation of rainfall recharge and subsurface inflow using soil-moisture balances, reconsideration and more robust simulation of stream-groundwater interactions, and a rigorous water-level trend analysis. The numerical model should be shifted to a monthly time step to better simulate the known dynamic conditions and to provide improved predictions of groundwater levels, in and outflow rates, and storage.

5. To support the model and water balance update, Yates provides recommendations for improving specific water balance estimates, including soil moisture balances to investigate rainfall recharge and subsurface inflow.

Soil moisture balances are a practical methodology to provide an independent check on these two inflows. Given the apparent importance of subsurface inflow from the South Gabilan to the Estrella subarea, application of a soil moisture balance to the South Gabilan tributary uplands and valley areas would be especially revealing. Increased understanding of the sources of Estrella subarea inflow has practical application in terms of monitoring (where should we expand the monitoring system) water balance (what is the sustainable yield), and management (where and how should we protect recharge areas).

6. Yates recommends application of the model to explore alternatives for the location and depth of well production.

This is a practical recommendation that could allow the City and other stakeholders to make better use of available groundwater resources.

I concur with Yates that improvements should be made to the groundwater monitoring program, elements of the water budget, and groundwater flow model. Improvement of the groundwater monitoring program is an important part of the ongoing GMP and should account for the recommendations provided by Yates in addition to those in the County's Data Enhancement Plan, and the Cleath & Associates' 2003 memorandum. A focused program improvement would address rainfall and stream flow in addition to groundwater; identify locations, methods, frequency of monitoring of both existing wells and potential new monitoring wells; describe data compilation, organization, and reporting; and discuss data evaluation methods (hydrographs, trend evaluations, storage calculation methodologies) to achieve monitoring program objectives.

The water balance/numerical model should be improved and updated within the next three years. It should have improved soil-moisture, recharge, and subsurface inflow rates, and it should be updated with current groundwater level data and well pumping rates. This will allow both an improved estimate of basin-wide sustainable yield, and refined assessments of local-scale flow and storage conditions around pumping centers and other critical areas.

FUGRO WEST, INC.

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August 11, 2010

City of El Paso de Robles
1000 Spring Street
Paso Robles, California 93446

Attention: Mr. Christopher Alakel
Water Resources Manager

Comments on Peer Review of Paso Robles Groundwater Basin Studies

Dear Mr. Alakel:

Thank you very much for providing Fugro the opportunity to review the comments of Gus Yates relative to water supply, water balance, and groundwater management objectives for the Paso Robles Groundwater Basin. Mr. Yates makes many excellent points regarding how the accuracy of and uncertainty associated with estimates of components of recharge to the basin might be improved as well as how estimates of groundwater use and annual changes in the amounts of groundwater in the basin could be better determined. These are many of the same comments we have suggested over the past few years in support of an effort to update the Basin model.

Although it has not occurred to any significant degree in the past with regard to the Paso Robles Groundwater Basin, peer reviews are common in water supply studies. It is important to recognize that in virtually all peer reviews, certain aspects of the work under review can be criticized and made to appear flawed, should the reviewer be so inclined. Groundwater and hydrogeology studies involve many parameter estimates and assumptions because it is not physically and/or financially possible to measure all the components and variables needed in water balance and groundwater modeling studies. Thus, the peer reviewer can always say that a given assumption or parameter estimate is flawed and that another assumption or methodology should be used, even though there is no immediate means of measuring if the alternative would yield a better result. It is not difficult to find a hydrogeologist that will proffer an opinion that disagrees on the approach or methodologies used for a given component of a groundwater study due largely to the inability to directly measure that component. Alternative methodologies or results provided by the peer reviewer can usually be equally criticized by another peer reviewer.

It is important to recognize that the hydrogeologic understanding of a groundwater basin (including perennial yield) tends to evolve over time as more studies are completed and more data collected. Confidence in water balance estimates and groundwater models generally improves with additional data collection and data analysis; however, it is important to understand that there will always be some amount of uncertainty in water balance and groundwater modeling results

In light of the above, decision makers should recognize that while hydrogeologic consultants may strongly disagree with each other on certain components of the work/results, the best approach is to evaluate recommendations made in the past by Fugro and other consultants in the Basin in conjunction with some of the recommendations made by Mr. Yates to decide on how best to allocate the available financial resources to improve the hydrogeologic understanding of Paso Robles Groundwater Basin.

Again, we appreciate the opportunity to review the comments of Mr. Yates on our past work and the work of others and look forward to continuing our technical relationship with all stakeholders in the basin as future studies are conducted.

Sincerely,
FUGRO WEST, INC.

Paul A. Sorensen, PG, CHg
Principal Hydrogeologist

Christopher Alakel

From: Timothy Cleath [timothycleath@sbcglobal.net]
Sent: Tuesday, August 10, 2010 5:03 PM
To: Christopher Alakel
Cc: Paul Sorensen
Subject: Comments on Yates Peer Review of Paso Basin Updates

Mr. Alekal:

Mr. Sorensen of Fugro shared with me Gus Yates' peer review of the Paso Robles Groundwater Basin Updates. Cleath-Harris Geologists (formerly Cleath & Associates) participated in the earlier groundwater basin studies. There are some review comments that relate to the earlier work and the groundwater flow characterization based on the initial study.

Mr. Yates' statement that "Ironically, the hydrologic separation of the Atascadero subbasin from the main basin was overemphasized in previous studies." is an opinion that I do not share. There are geologic structural features that control the groundwater flow within the basin sediments underlying the alluvium. For further reference, the Dibblee geologic map and the DWR 1981 study "Water Quality in the Paso Robles Basin" show that there are folds as well as faults that have deformed the pre-Holocene sedimentary beds. As a result, groundwater flow into the main basin from the Atascadero sub-basin is restricted to the alluvial deposits where the Salinas River alluvium passes over the Rinconada fault. This restriction greatly impacts groundwater flow from the higher rainfall/runoff area recharge west of the Salinas River and it's importance should be recognized.

Improvements in groundwater monitoring are recommended by Gus Yates as well as every purveyor and active consultant. It has been recognized in every management study workshop and by County Public Works. CHG has been working for the County recently on ways to incorporate more good data monitoring wells into the program that they have been doing for more than 40 years.

Cleath-Harris Geologists recognizes that this model can be a valuable tool and increasingly improved as it is modified for future work. Future efforts to utilize the groundwater model locally or regionally will do well to modify the model appropriately. Many of Mr. Yates' recommendations could be incorporated into those efforts.

Sincerely,
CLEATH-HARRIS GEOLOGISTS, INC.

Timothy S. Cleath, CHg #81
President