Geosyntec consultants

1111 Broadway, 6th Floor
Oakland, California 94607
PH 510.836.3034
FAX 510.836.3036
www.geosyntec.com

Shawna Scott
Planning Program Manager
SWCA Environmental Consultants
1422 Monterey Street C200
San Luis Obispo, CA 93401

18 April 2012

Subject: Baseline Water Demand
Proposed Laetitia Agricultural Cluster Subdivision
San Luis Obispo County

Dear Shawna,

As requested this letter presents a summary evaluation of baseline water demand for the proposed Laetitia Agricultural Cluster Subdivision (Proposed Project) in San Luis Obispo County.

Background

As described in the Draft EIR (DEIR, SWCA Morro Group, 2008), the Proposed Project includes development of 102 one-acre residential lots and four buildable open space lots totaling approximately 1,787 acres, construction of approximately 25 acres of internal residential roads, removal of approximately 113 acres of existing vineyards, and replanting of approximately 140 acres of vineyard. Development proposed within the open space lots includes a homeowner's association facility, recreation center, and a community center ("ranch headquarters").

The estimated total water demand of the Proposed Project reported in the DEIR (SWCA Morro Group, 2008) was 143 acre-feet per year (AF/Y) based on analysis by Cleath and Associates[1] (C&A, 2005). However, with required water conservation measures such as limitations on area of turf and residential irrigation and removal of the equestrian center, C&A (November 2008) reported that the project water demand was reduced nearly 50 percent to 73.7 AF/Y, which is equivalent to 45.7 gallons per minute (gpm). With additional limitations on landscape irrigation, the estimated project demand was further reduced to a total of 46.3 AF/Y, which is equivalent to 29 gpm (CHG, 2010).

[1] Subsequent references to Cleath and Associates are abbreviated C&A. In 2009, the name Cleath and Associates was changed to Cleath Harris Geologists, which is abbreviated as CHG.

Groundwater pumped from four wells completed in fractured bedrock (Wells 10, 11, 14, and 15) in the eastern portion of the property (Figure 1) is proposed as the sole water supply for the 102 residential lots and community facilities. Three phases of cyclic pumping from the four wells were conducted from the period from October 2009 through December 2010 by CHG. Results of the well testing and updated assessments of sustainable yield from the wells were prepared by CHG after the second and third phases of testing (CHG, July 2010 and March 2011). This evaluation of baseline water demand is provided as a supplement to our Review of Well Testing and Sustainable Yield Assessment (Geosyntec, October 2011).

Available Data on Baseline Water Demand for Laetitia Vineyards

The existing and additional vineyards, and existing winery and ranch facilities will continue the historical use of groundwater from existing wells on the western portion of the property (Figure 1). Historical water use for these facilities as reported by C&A (2004, 2005) and the DEIR, based on evaluation of available records for 1994 and 2003, is 168 acre feet per year (AF/Y), of which 161 AF/Y is used for irrigation of 620 acres of vineyards and 4.9 acres of irrigated lemon orchards, and 7 AF/Y is used for the winery and the winery, service building and residence. Not accounting for the small orchard, 161 AF/Y for 620 acres of vineyards equates to 0.26 AF/Y per acre of vineyards. C&A (2005) reported that the vineyards and orchards were irrigated by Wells 1, 3, 4, 5, and 9, and the winery, residences and facilities used Wells 2 and 7.

Laetitia reported[2] that 208 AF of water were pumped from Wells 1, 4, and 9 during 2011 for vineyard irrigation (33, 94, and 81 AF from Well 1, 4 and 9, respectively), and 5.3 AF of water were used for the winery production operations. In addition, metering of the primary domestic well from 18 April 2011 to 3 January 2012 indicated total pumping of 10.9 AF, however 4.3 AF of this was used for winery production. The remaining 6.6 AF for the period of 270 days equates to 8.9 AF/Y for the two residences, offices, tasting room, landscaping and shop. Metering of the backup domestic well indicated a total 0.027 AF for a period of 190 days from 27 June 2011 to 3 January 2012, which equates to an annual rate of 0.05 AF. Water use by the main estate residence, however, is not metered.

Assuming 619.8 acres of vineyards, the 2011 irrigation rate equates to approximately 0.34 AF/Y per acre of vineyards, substantially higher than the estimates for 1994 and 2003 discussed above.

[2] Email correspondence from S. Harris (CHG) to S. Scott (SWCA) 24 & 25 January 2012, and additional Email correspondence from S. Harris (CHG) to G. Thrupp (Geosyntec) and S. Scott (SWCA) 18 April 2012.

Calculations of Vineyard Water Demand from the County MWP

The most recent Draft Master Water Plan for San Luis Obispo County (Carollo, January 2012)[3] presents a compilation of calculated crop-specific agricultural annual water demand for each geographical water planning area (WPA) and a range of crop types (ESA Draft Memorandum dated 7 January 2010 included in Appendix D of the January 2012 Draft MWP). A map of the County WPAs and the ESA Draft Memo from the Draft MWP are provided as attachments to this letter.

The crop-specific values of agricultural water demand presented in the ESA Draft Memo are calculated using the method summarized below:

$$\text{The Annual Crop-Specific Water Demand} = \frac{ETc - ER}{(1 - LR)(IE)} - FP$$

ETc = Crop Evapotranspiration

ER = Effective Rainfall

LR = Leaching Requirements: amount of excess irrigation needed to remove salts from the soil. ESA used a value of 11% for WPA 7.

IE = Irrigation Efficiency: 70 to 85% for existing vineyards, which typically have drip irrigation systems, and 75 to 90% for furture vineyards.

FP = Frost Protection: Water is commonly applied to vineyards with sprinklers for frost protection (FP) on an as needed basis from January to March to help reduce damage to crops by freezing. Reported typical water useage for FP in San Luis Obispo County is 0.5 AF/Y per acres of vineyards. However, ESA used a FP value of 0.25 AF/Y per acre of vineyards for the entire County based on the assumption that only 50% of the vineyards use water for frost protection.

Further explanation and tables of values for each of these parameters are provided in the ESA Draft memo in Appendix D of the Draft MWP for the County.

---

[3] http://www.slocountywater.org/site/Frequent%20Downloads/Master%20Water%20Plan/index.htm

For WPA 7 (South Coast), which includes the Proposed Project, Table A1 of the ESA Draft Memo indicates that water demand of existing vineyards ranges from 0.7 to 1.3 with a middle value of 1.0 AF/Y per acre of vineyards. Table A2 indicates water demand of future vineyards is nearly the same: 0.7 to 1.2 with a middle value of 0.9 AF/Y per acre of vineyards.

Based on the method presented in Appendix D of the County's Draft MWP, the expected vineyard water demand at Laetitia are substantially greater than the reported values of 0.26 and 0.34 AF/Y per acre at the Laetitia vineyards discussed above. However, C&A (2004) reported that all the Laetitia vineyards have drip irrigation and that the vineyard manager indicated that there had not been any need for a frost protection spray system. The vineyard water demand numbers in the ESA memo include 0.25 AF/Y per acre for frost protection. If water is not used for frost protection at the Laetitia vineyards, then subtracting 0.25 AF/Y per acre from the low end of vineyard water demand numbers (Tables A1 and A2), results in adjusted water demand values of 0.45 AF/Y per acre of vineyards for existing or future vineyards in WPA 7, which is still substantially more than reported values at Laetitia of 0.26 and 0.34 AF/Y per acre of vineyards.

Note, however, that adjusted *middle* water demand values for existing vineyards in WPA 2 (Cambria) and WPA 3 (Cuyucos) are 0.15 and 0.25 AF/Y per acre after subtraction of 0.25 AF/Y per acre that is assigned for frost protection (Table A1). Furthermore, subtracting the assigned 0.25 AF/Y per acre of water for frost protection from *low* demand values in Table A1, which are all 0.5 AF/Y per acre for existing vineyards in WPA 1 (San Simeon), WPA 4 (Morro Bay), WPA 5 (Los Osos), and WPA 6 (San Luis Obispo/Avila), result in adjusted water demand values of 0.25 AF/Y per acre of vineyards. Thus, although the reported vineyard water demand values of 0.26 to 0.34 AF/Y per acre for the Laetitia vineyards are substantially lower than predicted for WPA 7 based on calculated water demands (ESA, 2010) presented in Appendix D of the County MWP (Corollo, 2012), the Laetitia vineyard reported values are similar to predicted values for other WPAs in the County if indeed no water is used for frost protection.

Calculation of Laetitia Agricultural Demand

Because available records of irrigation rates for the Laetitia vineyards are apparently limited to three years (1994, 2003, and 2011) and rainfall in 1994 and 2011 was well above the estimated average[4] for the Project Area (Geosyntec, 2010), we have used a reasonable conservative approach to calculate baseline water demand of the Laetitia vineyards based on the low water demand value of 0.7 AF/Y per acre for WPA 7 in Table A1 and subtraction of the assumed 0.25 AF/Y per acre for frost protection, which is included in the 0.7 value: 0.7 – 0.25 = 0.45 AF/Y per acre.

Conservative Calculated Baseline Water Demand of Laetitia Vineyards
= (620 acres) (0.45 AF/Y per acre) = 279 AF/Y

Conservative Calculated Water Demand of Proposed Project Vineyards
(removal of 113 acres of vineyard, but replanting of 140 acres: net gain of 27 acres)
= (647 acres) (0.45 AF/Y per acre) = 291.2 AF/Y

Based on the middle demand value for citrus in Table A1 (1.8 AF/Y per acre), the calculated additional water demand for the 4.9 acres of lemon tree orchards is

(4.9 acres) (1.8 AF/Y per acre) = 8.8 AF/Y

As a comparison, based on the reported 2011 irrigation rate of 0.34 AF/Y per acre:

Baseline Water Demand of Laetitia Vineyards
= (620 acres) (0.34 AF/Y per acre) = 208 AF/Y, and

Water Demand of Proposed Project Vineyards
= (647 acres) (0.34 AF/Y per acre) = 220 AF/Y

Confirmation that no water is used for frost protection and continued metering of the Laetitia vineyard irrigation rates is recommended to provide a more robust basis for site-specific vineyard water demand.

[4] Based on rainfall records for the Mehlschau Station, rainfall was 31.97 inches in 1994, 13.35 inches in 2003. And based on online data for the Nipomo station, rainfall in 2011 was 47.84 inches in 2011. Estimated average annual rainfall for the project area is approximately 17 inches (e.g. Geosyntec, 2011).

Viable Long-Term Groundwater Production Rate

Estimated sustainable yield totaling 87 AF/Y (54 gpm) from the four project wells (CHG, 2010), was scaled down to 65 AF/Y (40 gpm)[5] based on compensation for continued drop of water levels at three of the four wells (Wells 10, 14, and 15) during the Phase three testing (Geosyntec, 2011). Further revision to 62.4 AF/Y (38.7 gpm) with a 25% increase of pumping at Well 15 and reduction of pumping from Well 11 was recommended to protect Los Berros Creek baseflow (Table 4, Geosyntec, 2011).

We consider 62.4 AF/Y (38.7 gpm) a viable long-term production rate based on the water levels recorded in the four wells for the period from October 2009 to March 2011, which included several months of pumping. We reiterate a note of caution that rainfall during the testing program was 138 percent of average, and also that long-term yields of water wells producing from bedrock aquifers, which may have linear fracture systems, commonly are substantially less than short-term yields. However, we also reiterate that long-term groundwater production rates of 21 AF/Y reported by CHG (July 2010) for each of two irrigation wells[6] at the Project Site provide an additional line of evidence, that 62 AF/Y is a viable long-term groundwater production rate for the four project wells combined.

Project Demand Relative to Baseline Demand

This summary evaluation of baseline water demand facilitates consideration of the proposed project demand in context of the baseline demand on groundwater resources. The proposed project water demand of 46.3 AF/Y for the residential development and net gain of 27 acres of vineyards represents a 20% increase in water demand relative to the baseline demand based on the vineyard water demand adopted by the County's MWP (ESA 2010 in Carollo, 2012), or a 26% increase based on a lower vineyard water demand from reported 2011 irrigation for the Laetitia vineyards. The calculations are provided below.

---

[5] Page 15 of the Geosyntec 2011 report has a typo: 65 AF/Y equates to 40 gpm, not 42 gpm. The correct equivalent AF/Y and gpm values are provided in Table 4.

[6] CHG, July 2010, page 9 reports that Well 5 produced 540 AF over 26 years, and Well 9 produced 230 AF over 11 years. Each equates to approximately 21 AF/Y. Both of the wells are screened in the Obispo Formation fractured bedrock and their locations are shown on Figures 3 and 7.

Version 1. County MWP vineyard water demand value of 0.45 AF/Y per acre

Baseline Water Demand
= (620 acres vineyards)(0.45 AF/Y per acre) + (4.9 acres citrus)(1.8 AF/Y per acre)
+ (14.3 AF/Y winery, residential etc)
= 302.1 AF/Y

Baseline + Project Water Demand
= (647 acres vineyards)(0.45 AF/Y per acre) + (4.9 acres citrus)(1.8 AF/Y per acre)
+ (14.3 AF/Y winery, residential, etc) + 46.3 AF/Y
= 364.8 AF/Y

Increase from Baseline = (100)(364.8/302.1) = 119.3%

Version 2. Laetitia data vineyard demand value of 0.34 AF/Y per acre (2011 data)

Baseline Water Demand
= (620 acres vineyards)(0.34 AF/Y per acre) [Assumed to include citrus orchard]
+ (14.3 AF/Y winery, residential, etc)
= 222.3 AF/Y

Baseline + Project Water Demand
= (647 acres vineyard)(0.34AF/Y per acre) + (14.3AF/Y winery, residential etc) + 46.3 AF/Y
= 280.6 AF/Y

Increase from Baseline = (100)(280.6/222.3) = 126.2%

A 20 to 26% increase in groundwater production rates from the Laetitia property is viable particularly since, with the exception of Well 9 and some contribution from springs, the historical water supply for the vineyards and existing facilities has been from wells in the lower western portion of the Laetitia property—more than a mile away from the new wells in the upper portion of the property that would be used for the proposed residential development. Relatively close proximity of Well 9, which is used for vineyard irrigation, to Development Project Wells 10 and 11 (less than 0.5 mile separation), and the fact that all three of these wells tap groundwater within fractures in the Obispo Tuff, is cause for concern that the long-term production rate from Well 9 may decrease with operation of Wells 10 and 11. However, a potential decrease in production from Well 9 can be made up by minor increases in pumping from other wells in the western portion of the property.

In the long term, a 20 to 26% increase in total groundwater production at the Laetitia Property may decrease baseflow of Los Berros Creek. However, as previously recommended, curtailment of pumping from Well 11 during the months of August through November (Table 4 and Figure 19, Geosyntec 2011) will help to mitigate potential impacts to Los Berros Creek of groundwater pumping for the proposed residential development.

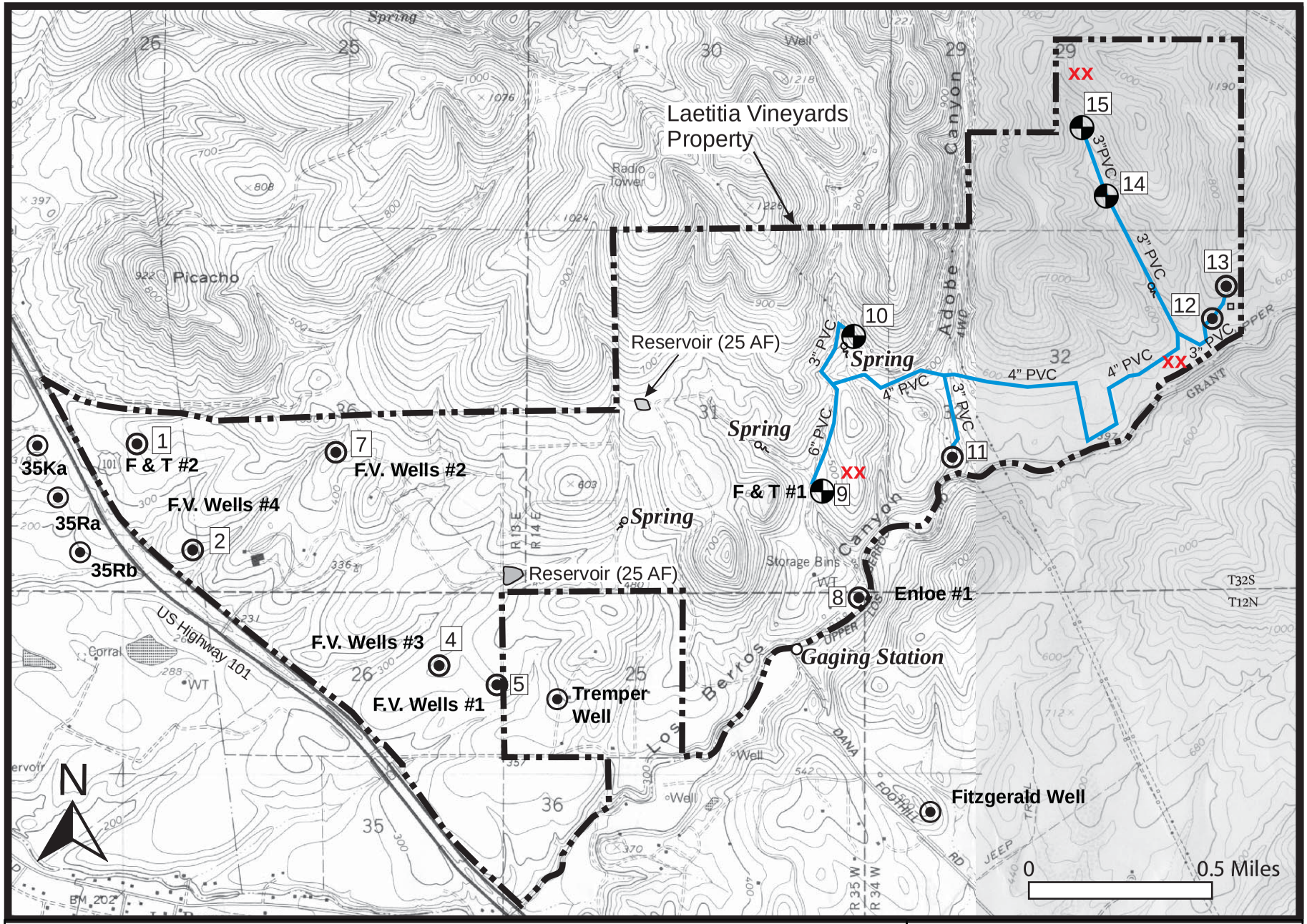
Sincerely,

Gordon Thrupp, PhD, PG, CHg
Associate Hydrogeologist

Nicole Gotberg, PG
Senior Staff Geologist

Attachments:

Figure 1. Site map with well locations
References
Map of San Luis Obispo Water Planning Areas
Draft ESA Memo on Crop-Specific Water Demand from Appendix D of the Draft MWP



Base map: U.S.G.S. 7.5 minute topographic, Oceano and Nipomo Quadrangles, CA
Base map scale: 1 inch = 2000 feet
Well locations approximate
Adapted from CHG memo, 4 Jan 2011

Explanation

15 Well Location and number

Well discharge piping

XX Weather recording station

Water Supply Well for Proposed Subdivision

Topographic Map of the Laetitia Site Showing Well Locations
Baseline Water Demand
Proposed Laetitia Agricultural Cluster Subdivision
San Luis Obispo, California

April 2012	Figure 1	Geosyntec consultants

P:\GIS\Latetia\AI\2012Apr\TopoWells.ai

References

Carollo, 2012, San Luis Obispo County Master Water Plan, Draft January 2012.

Cleath Associates (C&A), 2004. Water Supply Assessment for Laetitia Vineyard and Winery, Arroyo Grande, California, January 27.

Cleath Associates (C&A), 2005, Water Resources Studies for Laetitia Vineyard Property, Arroyo Grande, San Luis Obispo County, October 6.

Cleath Associates (C&A), 2008, Response to County Comments on Water Resources, Laetitia Agricultural Cluster EIR, Arroyo Grande, San Luis Obispo County, March 28.

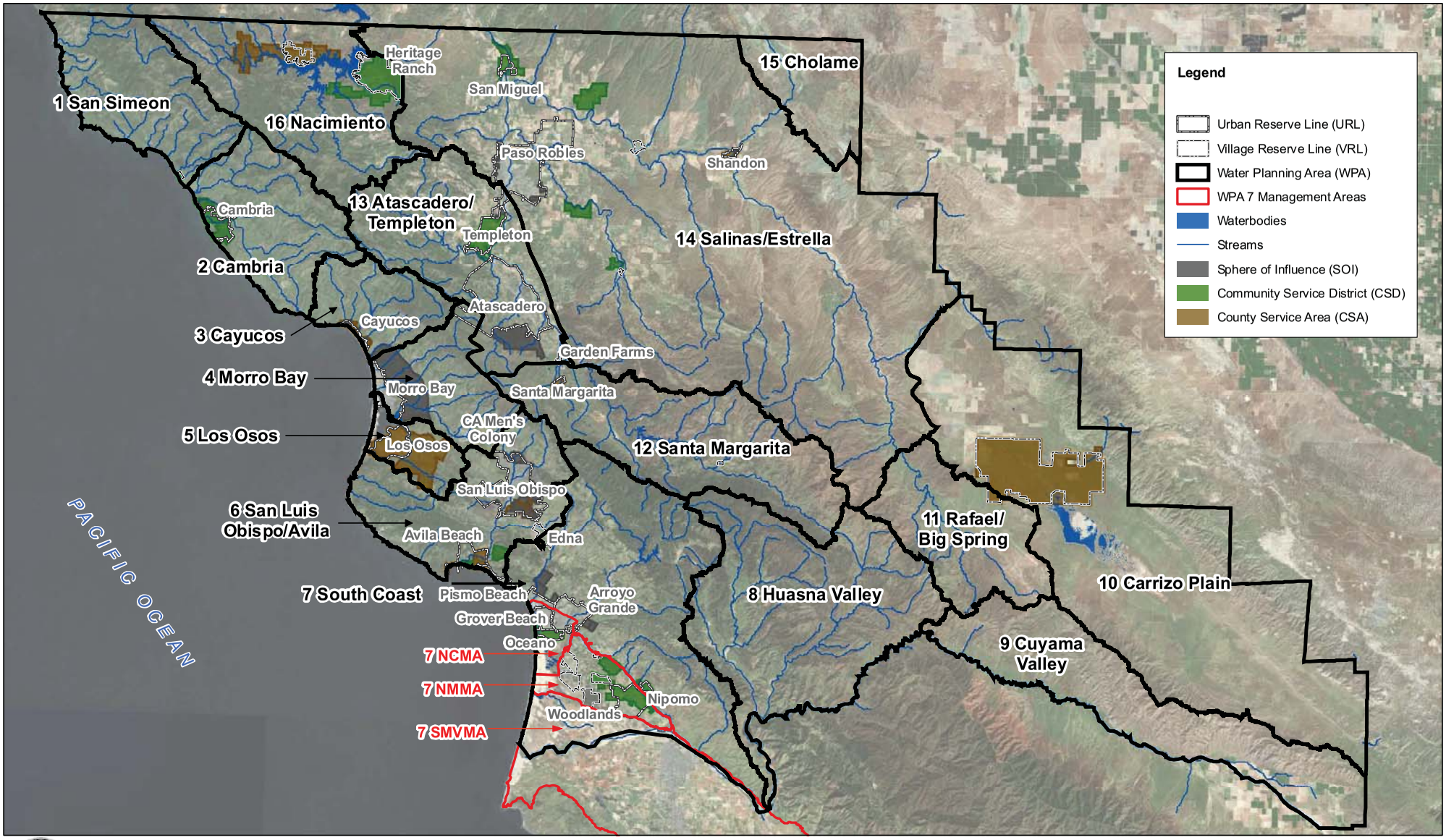
Cleath Harris Geologists (CHG), 2010, Laetitia Well Testing and Sustainable Yield Assessment, Los Berros Canyon, San Luis Obispo County, prepared for Laetitia Vineyard and Winery, July 2010.

Cleath Harris Geologists (CHG), 2011, Phase 3 Addendum, Laetitia Agricultural Cluster Project Well Testing and Sustainable Yield Assessment, Los Berros Canyon, San Luis Obispo County, prepared for Laetitia Vineyard and Winery, March 2011.

ESA, 2010, DRAFT Memorandum, San Luis Obispo County Annual Crop-Specfic Applied Water Variables, prepared for San Luis Obispo County Water Resources Advisory Committee (WRAC), 7 January 2010; included in Appendix D of the Corollo Draft January 2012 Master Water Plan.

Geosyntec, 2011, Review of Well Testing and Sustainable Yield Assessment, Proposed Laetitia Agricultural Cluster Subdivision, San Luis Obispo, California; prepared for SWCA Environmental Consultants, October 2011.

SWCA Morro Group, 2008. Draft Environmental Impact Report (DEIR) for the Laetitia Agricultural Cluster Subdivision, Tentative Tract Map and Conditional Use Permit, prepared for County of San Luis Obispo, September.



San Luis Obispo County Flood Control and Water Conservation District

MASTER WATER PLAN

San Luis Obispo County

Figure 1 Water Planning Areas in San Luis Obispo County

ESA

225 Bush Street
Suite 1700
San Francisco, CA 94104
415.896.5900 phone
415.896.0332 fax

www.esassoc.com

DRAFT memorandum

date January 7, 2010

to Courtney Howard, San Luis Obispo County; Water Resources Advisory Committee (WRAC)

from Annika Fain, ESA; Eric Zigas, ESA

subject San Luis Obispo County Annual Crop-Specific Applied Water Variables (Appendix A)

Agricultural Demand

ESA calculated the crop-specific applied water for these crop groups by utilizing information on crop evapotranspiration, effective rainfall, leaching requirements, irrigation efficiency, and frost protection. The following equation was used to calculate the annual crop-specific applied water (AF/Ac/Yr) for each of the water planning areas:

$$\text{Annual Crop - Specific Applied Water (AF/Ac/Yr)} = \frac{\text{ETc} - \text{ER}}{(1 - \text{LR}) \text{ x IE}} + \text{FP}$$

This formula was modified from a general formula for irrigation water requirements, which was established in 1997 (Burt, 1997). A detailed discussion and summary tables of each of the parameters in the above equation is presented below. **Table A1** presents a range of values for the existing annual crop-specific applied water (AF/Ac/Yr) for all crop groups and water planning area. **Table A2** presents a range of values for the projected future crop-specific applied water (AF/Ac/Yr) for all crop groups and water planning area. The annual crop-specific applied water is multiplied by crop acreage to determine an agricultural water demand (AFY). **Table A3** presents a range of values for the agricultural water demand for all crop groups and water planning area. **Table A4** presents a range of values for the agricultural water demand for all crop groups and water planning area.

Reference Crop Evapotranspiration (Eto). Crop evapotranspiration for CIMIS weather stations in San Luis Obispo County and in Kern County (to the east) was used. The CIMIS stations in San Luis Obispo County include two in San Luis Obispo, one in Atascadero, and one in Nipomo. Additionally, Blackwells Corner, in Kern County was used to estimate Eto in Eastern San Luis Obispo County. The water planning areas were grouped according to the reference crop evapotranspiration climate groups (**Table A5**). Due to substantial variability within WPA 7, ESA used an average crop evapotranspiration of Arroyo Grande and Nipomo for this area. A summary of the estimated reference crop evapotranspiration used for the analysis is shown in **Table A6**.

Crop coefficients (Kc). The crops in San Luis Obispo County were assigned crop coefficients based on the crop type and location. These crops include alfalfa, nursery, irrigated pasture, citrus, deciduous, vegetable, and

vineyard. The spreadsheet and ArcGIS® model is set-up so these numbers can be easily updated with new crop coefficients and crop evapotranspiration. The crop coefficients for this analysis are summarized in **Table A7**.

TABLE A1
EXISTING CROP-SPECIFIC APPLIED WATER (AF/AC/YR) BY CROP GROP AND WATER PLANNING AREA

WPA #	WPA Name	Alfalfa (AF/Ac/Yr)			Citrus (AF/Ac/Yr)			Deciduous (AF/Ac/Yr)			Nursery (AF/Ac/Yr)			Pasture (AF/Ac/Yr)			Vegetable (AF/Ac/Yr)[a]			Vineyard (AF/Ac/Yr)		
		Low	High	Med	Low	High	Med	Low	High	Med	Low	High	Med	Low	High	Med	Low	High	Med	Low	High	Med
1	San Simeon	1.4	2.5	2.0	0.5	1.2	0.9	1.3	2.2	1.8	0.6	1.5	1.1	1.6	2.7	2.1	1.2	1.4	1.3	0.5	1.0	0.8
2	Cambria	1.4	2.5	2.0	0.5	1.2	0.9	0.9	1.8	1.4	0.6	1.5	1.1	1.6	2.7	2.1	1.0	1.4	1.2	0.0	0.6	0.4
3	Cayucos	1.6	2.7	2.2	0.6	1.4	1.0	1.1	1.9	1.5	0.7	1.6	1.2	1.7	2.9	2.3	1.0	1.4	1.2	0.1	0.7	0.5
4	Morro Bay	2.2	3.3	2.7	1.1	1.8	1.5	1.6	2.4	2.0	1.2	2.0	1.6	2.3	3.4	2.9	1.2	1.7	1.4	0.5	1.0	0.8
5	Los Osos	2.2	3.3	2.7	1.1	1.8	1.5	1.6	2.4	2.0	1.2	2.0	1.6	2.3	3.4	2.9	1.2	1.7	1.4	0.5	1.0	0.8
6	San Luis Obispo/Avila	2.3	3.5	2.9	1.1	1.9	1.5	1.7	2.6	2.1	1.2	2.1	1.7	2.5	3.7	3.1	1.4	1.8	1.6	0.5	1.1	0.8
7	South Coast	2.7	3.9	3.3	1.5	2.2	1.8	2.7	3.7	3.2	1.6	2.4	2.0	2.9	4.1	3.5	1.5	1.9	1.7	0.7	1.3	1.0
8	Huasna Valley	4.8	6.4	5.6	2.5	3.4	3.0	4.2	5.4	4.8	2.6	3.7	3.1	4.8	6.5	5.7	2.0	2.6	2.3	1.8	2.6	2.2
9	Cuyama Valley	4.8	6.4	5.6	2.5	3.4	3.0	3.8	5.0	4.4	2.6	3.7	3.1	4.8	6.5	5.7	2.0	2.6	2.3	1.8	2.6	2.2
10	Carrizo Plain	5.1	6.7	5.9	2.8	3.6	3.2	4.1	5.3	4.7	2.9	3.9	3.4	5.2	6.8	6.0	2.1	2.7	2.4	2.0	2.7	2.4
11	Rafael/Big Spring	4.8	6.4	5.6	2.5	3.4	3.0	3.8	5.0	4.4	2.6	3.7	3.1	4.8	6.5	5.7	2.0	2.6	2.3	1.8	2.6	2.2
12	Santa Margarita	3.2	4.5	3.9	1.4	2.2	1.8	2.5	3.5	3.0	1.5	2.4	2.0	4.8	6.5	5.7	1.4	1.9	1.6	1.1	1.8	1.4
13	Atascadero/Templeton	3.2	4.5	3.9	1.4	2.2	1.8	2.5	3.5	3.0	1.5	2.4	2.0	4.8	6.5	5.7	1.4	1.9	1.6	1.1	1.8	1.4
14	Salinas/Estrella	3.8	5.2	4.5	1.9	2.7	2.3	3.4	4.5	4.0	2.0	2.9	2.5	5.2	6.8	6.0	1.6	2.2	1.9	1.4	2.1	1.7
15	Cholame Valley	4.9	6.5	5.7	2.5	3.3	2.9	3.9	5.1	4.5	2.6	3.6	3.1	4.8	6.5	5.7	1.9	2.4	2.1	2.0	2.7	2.3
16	Nacimiento	3.2	4.5	3.9	1.4	2.2	1.8	2.5	3.5	3.0	1.5	2.4	2.0	3.3	4.6	3.9	1.4	1.9	1.6	1.1	1.8	1.4

[a] Accounts for multi-cropping (assumes 3 vegetable crops planted per acre per year for WPA 1-7; assumes 2 vegetable crops planted per acre per year for WPA 8-16)

TABLE A2
PROJECT FUTURE CROP-SPECIFIC APPLIED WATER (AF/AC/YR) BY CROP GROP AND WATER PLANNING AREA

WPA #	WPA Name	Alfalfa (AF/Ac/Yr)			Citrus (AF/Ac/Yr)			Deciduous (AF/Ac/Yr)			Nursery (AF/Ac/Yr)			Pasture (AF/Ac/Yr)			Vegetable (AF/Ac/Yr)[a]			Vineyard (AF/Ac/Yr)		
		Low	High	Med	Low	High	Med	Low	Low	High	Med	Low	High	Med	Low	Low	High	Med	Low	High	Med	Low
1	San Simeon	1.3	2.4	1.8	0.5	1.2	0.8	1.3	2.1	1.7	0.6	1.4	1.0	1.5	2.5	2.0	0.9	1.3	1.1	0.0	0.6	0.3
2	Cambria	1.3	2.4	1.8	0.5	1.2	0.8	0.9	1.7	1.3	0.6	1.4	1.0	1.5	2.5	2.0	0.9	1.3	1.1	0.0	0.6	0.3
3	Cayucos	1.5	2.5	2.0	0.6	1.3	0.9	1.0	1.8	1.4	0.7	1.5	1.1	1.6	2.6	2.1	1.0	1.3	1.2	0.2	0.7	0.4
4	Morro Bay	2.1	3.0	2.5	1.1	1.7	1.4	1.5	2.2	1.9	1.1	1.9	1.5	2.2	3.2	2.7	1.2	1.5	1.4	0.5	1.0	0.7
5	Los Osos	2.1	3.0	2.5	1.1	1.7	1.4	1.5	2.2	1.9	1.1	1.9	1.5	2.2	3.2	2.7	1.2	1.5	1.4	0.5	1.0	0.7
6	San Luis Obispo/Avila	2.2	3.2	2.7	1.0	1.7	1.4	1.6	2.4	2.0	1.1	2.0	1.5	2.3	3.4	2.9	1.3	1.7	1.5	0.5	1.0	0.7
7	South Coast	2.6	3.6	3.1	1.4	2.1	1.7	2.6	3.5	3.1	1.5	2.3	1.9	2.7	3.8	3.3	1.4	1.8	1.6	0.7	1.2	0.9
8	Huasna Valley	4.6	6.1	5.3	2.4	3.3	2.8	4.1	5.2	4.6	2.5	3.5	3.0	4.6	6.1	5.4	1.9	2.5	2.2	1.7	2.5	2.1
9	Cuyama Valley	4.6	6.1	5.3	2.4	3.3	2.8	3.7	4.8	4.2	2.5	3.5	3.0	4.6	6.1	5.4	1.9	2.5	2.2	1.7	2.5	2.1
10	Carrizo Plain	4.9	6.3	5.6	2.7	3.5	3.1	4.0	5.0	4.5	2.7	3.7	3.2	4.9	6.4	5.7	2.1	2.6	2.3	2.0	2.6	2.3
11	Rafael/Big Spring	4.6	6.1	5.3	2.4	3.3	2.8	3.7	4.8	4.2	2.5	3.5	3.0	4.6	6.1	5.4	1.9	2.5	2.2	1.7	2.5	2.1
12	Santa Margarita	3.1	4.3	3.7	1.4	2.1	1.7	2.4	3.4	2.9	1.5	2.3	1.9	3.1	4.3	3.7	1.3	1.8	1.6	1.1	1.7	1.4
13	Atascadero/Templeton	3.1	4.3	3.7	1.4	2.1	1.7	2.4	3.4	2.9	1.5	2.3	1.9	3.1	4.3	3.7	1.3	1.8	1.6	1.1	1.7	1.4
14	Salinas/Estrella	3.7	4.9	4.3	1.8	2.6	2.2	3.3	4.3	3.8	1.9	2.8	2.3	3.7	5.0	4.3	1.6	2.1	1.8	1.4	2.0	1.7
15	Cholame Valley	4.7	6.1	5.4	2.4	3.2	2.8	3.8	4.9	4.4	2.5	3.4	2.9	4.8	6.2	5.5	1.8	2.3	2.0	1.9	2.6	2.2
16	Nacimiento	3.1	4.3	3.7	1.4	2.1	1.7	2.4	3.4	2.9	1.5	2.3	1.9	3.1	4.3	3.7	1.3	1.8	1.6	1.1	1.7	1.4

[a] Accounts for multi-cropping (assumes 3 vegetable crops planted per acre per year for WPA 1-7; assumes 2 vegetable crops planted per acre per year for WPA 8-16)

TABLE A3
EXISTING AGRICULTURAL WATER DEMAND (AFY) BY CROP GROP AND WATER PLANNING AREA

WPA #	WPA Name	Alfalfa (AFY)			Citrus (AFY)			Deciduous (AFY)			Nursery (AFY)			Pasture (AFY)			Vegetable (AFY)[a]			Vineyard (AFY)		
		Low	High	Med	Low	High	Med	Low	High	Med	Low	High	Med	Low	High	Med	Low	High	Med	Low	High	Med
1	San Simeon	0	0	0	9	24	17	0	0	0	0	0	0	0	0	0	0	0	0	33	65	49
2	Cambria	0	0	0	165	424	295	24	47	36	1	2	2	0	0	0	248	343	295	3	30	17
3	Cayucos	0	0	0	220	471	345	0	0	0	0	0	0	0	0	0	146	198	172	1	4	2
4	Morro Bay	0	0	0	753	1,206	979	0	0	0	0	0	0	82	120	101	796	1,038	917	43	81	62
5	Los Osos	0	0	0	0	0	0	6	8	7	125	209	167	1,176	1,725	1,451	1,444	1,883	1,664	1	1	1
6	San Luis Obispo/Avila	0	0	0	241	408	324	304	466	385	48	85	67	515	773	644	1,512	1,991	1,752	279	594	436
7[b]	South Coast	0	0	0	5,892	8,886	7,389	68	89	78	324	510	417	1,539	2,190	1,864	5,974	7,718	6,846	2,458	4,192	3,325
8	Huasna Valley	0	0	0	48	65	56	18	23	20	0	0	0	0	0	0	392	508	450	845	1,206	1,026
9	Cuyama Valley	0	0	0	0	0	0	2,448	3,236	2,842	0	0	0	0	0	0	22,287	28,861	25,574	377	538	457
10	Carrizo Plain	0	0	0	693	911	802	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	Rafael/Big Spring	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	Santa Margarita	48	68	58	0	0	0	18	25	21	0	0	0	266	358	312	0	0	0	1,055	1,709	1,382
13	Atascadero/Templeton	0	0	0	46	70	58	1,799	2,516	2,158	123	194	159	2,851	3,827	3,339	28	38	33	3,718	6,026	4,872
14	Salinas/Estrella	3,053	4,182	3,617	607	859	733	1,981	2,672	2,327	151	223	187	7,447	9,770	8,609	4,160	5,463	4,812	38,080	56,562	47,321
15	Cholame Valley	0	0	0	65	87	76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	Nacimiento	0	0	0	65	99	82	1,970	2,755	2,362	0	0	0	33	46	39	0	0	0	1,054	1,709	1,381
Total		**3,101**	**4,250**	**3,676**	**8,804**	**13,509**	**11,157**	**8,636**	**11,837**	**10,237**	**773**	**1,224**	**998**	**13,908**	**18,808**	**16,358**	**36,988**	**48,043**	**42,515**	**47,946**	**72,716**	**60,331**

[a] Accounts for multi-cropping (assumes 3 vegetable crops planted per acre per year for WPA 1-7; assumes 2 vegetable crops planted per acre per year for WPA 8-16)

[b] The agricultural demand for WPA 7 in this table only includes areas outside of the NCMA, NMMA, and SMVMA.

TABLE A4
PROJECT FUTURE AGRICULTURAL WATER DEMAND (AFY) BY CROP GROP AND WATER PLANNING AREA

WPA #	WPA Name	Alfalfa (AFY)			Citrus (AFY)			Deciduous (AFY)			Nursery (AFY)			Pasture (AFY)			Vegetable (AFY)[a]			Vineyard (AFY)		
		Low	High	Med	Low	High	Med	Low	High	Med	Low	High	Med	Low	High	Med	Low	High	Med	Low	High	Med
1	San Simeon	0	0	0	9	22	16	0	0	0	0	0	0	0	0	0	0	0	0	5	42	23
2	Cambria	0	0	0	185	472	329	25	47	36	1	2	1	0	0	0	493	672	582	35	298	166
3	Cayucos	0	0	0	288	608	448	0	0	0	0	0	0	0	0	0	139	187	163	3	10	6
4	Morro Bay	0	0	0	764	1,208	986	0	0	0	0	0	0	76	110	93	797	1,027	912	52	96	74
5	Los Osos	0	0	0	22	35	29	5	8	7	117	193	155	1,103	1,592	1,347	1,502	1,937	1,720	1	1	1
6	San Luis Obispo/Avila	0	0	0	233	390	311	287	435	361	45	78	62	483	713	598	1,490	1,939	1,715	272	567	420
7[b]	South Coast	0	0	0	5,606	8,355	6,981	121	155	138	304	471	388	1,914	2,681	2,297	5,899	7,531	6,715	2,767	4,638	3,703
8	Huasna Valley	0	0	0	46	62	54	17	22	20	9	13	11	448	592	520	379	485	432	1,166	1,644	1,405
9	Cuyama Valley	0	0	0	0	0	0	2,366	3,090	2,728	0	0	0	0	0	0	22,506	28,802	25,654	366	516	441
10	Carrizo Plain	0	0	0	672	872	772	4	5	5	0	0	0	0	0	0	7	9	8	0	0	0
11	Rafael/Big Spring	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	Santa Margarita	46	64	55	5	8	7	21	29	25	0	0	0	296	410	353	0	0	0	1,356	2,169	1,762
13	Atascadero/Templeton	0	0	0	75	113	94	1,898	2,624	2,261	118	183	151	2,539	3,515	3,027	74	99	87	5,040	8,062	6,551
14	Salinas/Estrella	2,925	3,946	3,436	700	978	839	2,569	3,423	2,996	150	217	183	6,969	9,366	8,167	4,060	5,270	4,665	43,365	63,625	53,495
15	Cholame Valley	0	0	0	63	83	73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	Nacimiento	0	0	0	66	99	83	2,064	2,853	2,459	0	0	0	31	43	37	0	0	0	2,577	4,122	3,350
Total		**2,972**	**4,011**	**3,491**	**8,733**	**13,306**	**11,020**	**9,376**	**12,690**	**11,033**	**744**	**1,158**	**951**	**13,858**	**19,024**	**16,441**	**37,346**	**47,957**	**42,652**	**57,005**	**85,790**	**71,397**

[a] Accounts for multi-cropping (assumes 3 vegetable crops planted per acre per year for WPA 1-7; assumes 2 vegetable crops planted per acre per year for WPA 8-16)
[b] The agricultural demand for WPA 7 in this table only includes areas outside of the NCMA, NMMA, and SMVMA.

TABLE A5
CLIMATE GROUP FOR CROP EVAPOTRANSPIRATION BY WPA

WPA#	WPA	Assigned Climate Group
1	San Simeon	San Simeon
2	Cambria	San Simeon
3	Cayucos	San Simeon
4	Morro Bay	Morro Bay
5	Los Osos	Morro Bay
6	San Luis Obispo/Avila	San Luis Obispo
7	South Coast	Arroyo Grande/Nipomo
8	Huasna Valley	Cuyama
9	Cuyama Valley	Cuyama
10	Carrizo Plain	Cuyama
11	Rafael/Big Spring	Cuyama
12	Santa Margarita	Atascadero
13	Atascadero/Templeton	Atascadero
14	Salinas/Estrella	Paso Robles
15	Cholame Valley	Blackwells Corner
16	Nacimiento	Atascadero

[a] Climate Groups were determined by looking at available Eto by WPA

TABLE A6
REFERENCE CROP EVAPOTRANSPIRATION (inches/month)[a]

Month	Arroyo Grande	Blackwells Corner	Morro Bay	Paso Robles	San Luis Obispo	San Simeon	Nipomo	Atascadero	Cuyama
January	2.0	1.4	2.0	1.6	2.0	2.0	2.2	1.2	2.1
February	2.2	2.1	2.2	2.0	2.2	2.0	2.5	1.5	2.4
March	3.2	3.8	3.1	3.2	3.2	2.9	3.8	2.8	3.8
April	3.8	5.4	3.5	4.3	4.1	3.5	5.1	3.9	5.4
May	4.3	7	4.3	5.5	4.9	4.2	5.7	4.5	6.9
June	4.7	7.8	4.5	6.3	5.3	4.4	6.2	6	7.9
July	4.3	8.5	4.6	7.3	4.6	4.6	6.4	6.7	8.5
August	4.6	7.7	4.6	6.7	5.5	4.3	6.1	6.2	7.7
September	3.6	5.8	3.8	5.1	4.4	3.5	4.9	5	5.9
October	3.2	3.9	3.5	3.7	3.5	3.1	4.1	3.2	4.5
November	2.4	1.9	2.1	2.1	2.4	2.0	2.9	1.7	2.6
December	1.7	1.2	1.7	1.4	1.7	1.7	2.3	1	2
Total (in/yr)	40.0	56.5	39.9	49.2	43.8	38.2	52.2	43.7	59.7

[a] The ETo values in this table were derived from: CIMIS, 2009; DWR, 1999; University of California, 1987; Snyder et al., 1987

TABLE A7
CROP COEFFICIENTS FOR EACH CROP GROUP

Month	Alfalfa	Citrus	Deciduous	Nursery	Pasture	Vegetables	Vineyard
January	0.00	0.56	0.00	0.50	0.00	0.00	0.00
February	0.00	0.56	0.00	0.50	0.00	0.00	0.00
March	0.90	0.56	0.60	0.50	1.00	0.00	0.00
April	0.90	0.56	0.70	0.50	1.00	0.00	0.00
May	0.90	0.56	0.80	0.50	1.00	0.00	0.60
June	0.90	0.56	0.90	0.50	1.00	0.00	0.70
July	1.00	0.56	1.00	0.50	1.00	0.00	0.60
August	1.00	0.56	1.00	0.50	1.00	1.00	0.50
September	1.10	0.56	0.90	0.50	1.00	1.00	0.30
October	1.00	0.56	0.80	0.50	1.00	1.00	0.10
November	0.00	0.56	0.00	0.50	0.00	1.00	0.00
December	0.00	0.56	0.00	0.50	0.00	1.00	0.00

[a] Adapted from DWR 113-3 (DWR, 1974), UC Leaflet 21427 (Snyder et al., 1989a), UC Leaflet 21428 (Snyder et al., 1989b)

Crop Evapotranspiration (Etc). Crop evapotranspiration was calculated by multiplying the reference evapotranspiration and for each agricultural crop and area. Annual Crop evapotranspiration (AF/Ac/Yr) for each crop group and WPA is summarized in **Table A8**.

TABLE A8
ANNUAL CROP EVAPOTRANSPIRATION [a] (AF/Ac/Yr)
FOR EACH CROP GROUP AND WPA

WPA #	WPA Name	Alfalfa	Citrus	Deciduous	Nursery	Pasture	Vegetable	Vineyard
1	San Simeon	2.4	1.8	2.2	1.6	2.5	1.2	1.0
2	Cambria	2.4	1.8	2.2	1.6	2.5	1.2	1.0
3	Cayucos	2.4	1.8	2.2	1.6	2.5	1.2	1.0
4	Morro Bay	2.6	1.9	2.3	1.7	2.7	1.3	1.0
5	Los Osos	2.6	1.9	2.3	1.7	2.7	1.3	1.0
6	San Luis Obipso/Avila	2.8	2.0	2.5	1.8	3.0	1.5	1.2
7	South Coast	3.0	2.2	2.6	1.9	3.1	1.5	1.2
8	Huasna Valley	4.1	2.8	3.7	2.5	4.2	1.9	1.7
9	Cuyama Valley	4.1	2.8	3.7	2.5	4.2	1.9	1.7
10	Carrizo Plain	4.1	2.8	3.7	2.5	4.2	1.9	1.7
11	Rafael/Big Spring	4.1	2.8	3.7	2.5	4.2	1.9	1.7
12	Santa Margarita	3.1	2.0	2.8	1.8	3.2	1.4	1.3
13	Atascadero/Templeton	3.1	2.0	2.8	1.8	3.2	1.4	1.3
14	Salinas/Estrella	3.4	2.3	3.0	2.1	3.5	1.6	1.4
15	Cholame Valley	4.0	2.6	3.6	2.4	4.2	1.7	1.7
16	Nacimiento	3.1	2.0	2.8	1.8	3.2	1.4	1.3

[a] Crop evapotranspiration is equal to the product of crop coefficients and reference crop evapotranspiration

Effective Rainfall (ER). The effective rainfall was calculated for each area by utilizing historical annual precipitation in San Luis Obispo County and effective precipitation based on crop type and water planning area.

The historical yearly precipitation gages that were used for the water demand analysis are listed in **Table A9**. The rainfall from each of these gages was assigned to a particular water planning area. Due to substantial variability

TABLE A9
SAN LUIS OBISPO COUNTY RAINFALL STATIONS USED FOR ANALYSIS

Rainfall Station	Average (Inches/Yr)	County Gage #	Record
Santa Rosa Creek	27.5	169	1964-2003
Cayucos Creek	24.8	173.1	1965-2003
Baywood Park/Camp SLO	18.2	177/224	1967-2003
CalPoly	22.2	1	1870-2003
Lopez Dam	19.6	178.1	1968-2003
Nipomo	16.6	38	1921-2003
Santa Maria Valley	15.3	23	1910-2003
Paso Robles	15.2	10	1887-2003
AMWC	17.4	34	1916-2003
Santa Margarita	24.3	9a	1972-2003
Carrizo Plain	10.9	151.2	1966-2003
White Ranch	12.3	93	1931-2008
Oceano CSA #13	16.1	157.1	1959-2006

SOURCE: San Luis Obispo County, 2005 & 2009 http://www.slocountywater.org/site/Water%20Resources/Data/maps/data.htm

within WPA 7, ESA used an average precipitation of Nipomo and Lopez Dam gages for this area. **Table A10** lists the range of effective rainfall percentage for each crop group.

TABLE A10
EFFECTIVE RAINFALL PERCENTAGE FOR EACH CROP GROUP[a]

Range	Alfalfa	Citrus	Deciduous	Nursery	Pasture	Vegetable[b]	Vineyard
Low	40%	40%	40%	30%	40%	15%	30%
High	60%	60%	60%	50%	60%	25%	50%

[a] Effective rainfall general ranges from 29% to 59% (Burt et al., 2002)
[b] Accounts for multi-cropping by reducing vegetable effective rainfall in half.

Frost Protection (FP). The sprinkler frost protection water requirement was estimated for grapes (throughout the County), as well as strawberries and blueberries (WPA 1, 7, 8, and 14). For vineyards, the frost threat occurs from March to April in San Luis Obispo County. For strawberries and blueberries in San Luis Obispo County, primarily in WPA 7 and 14, respectively the frost threat occurs from January to March. Sprinkler frost protection requires a large amount of water, which may be higher than a typical groundwater well can produce (Battany, 2009). Therefore, growers that use sprinkler frost protection will generally have large reservoirs on site or nearby. The frost protection values ESA used were 0.25 AF/Ac/Yr for vineyards throughout the County and 0.4 AF/Ac/Yr for strawberries and blueberries in WPA 1, 7, 8, and 14. This was based on information provided by the

UC Farm Advisors and input from the WRAC and other agricultural stakeholders. Details on how the numbers were determined for vineyards and strawberry frost protection are shown below.

Grapes

Sprinkler frost protection on vineyards will only occur where growers have access to a large reservoir onsite or nearby (Battany, 2009). Overhead sprinklers may operate from 4-6 hours per evening for 10-12 nights per year (San Luis Obispo County, 1998). System flow rates generally range from 40 to 50 gallons per minute per acre (gpm/Ac), 0.09 inches per hour (in/hr) and 0.11 in/hr, respectively. **Table A11** shows an example of yearly applied water for frost protection on a vineyard depending on minutes of runtime and a system flow rate of 50 gpm/Ac. To determine the percentage of acreage that uses sprinkler frost protection would require a detailed look at all vineyards on aerial photography and/or discussions with all vineyard owners. The amount of frost protection on vineyards varies from year to year and farm to farm. For purposes of this analysis, ESA has assumed that approximately 50% of the vineyards use frost protection. Therefore, ESA used 0.25 AF/Ac/Yr for frost protection on grapes throughout the County.

TABLE A11
RANGE OF ANNUAL APPLIED WATER FOR FROST PROTECTION ON A TYPICAL VINEYARD (AF/AC/YR)

Hours per night	Nights per year	Annual Applied Water (AF/Ac/Yr)
4	10	0.34
	11	0.38
	12	0.41
5	10	0.43
	11	0.47
	12	0.52
6	10	0.52
	11	0.57
	12	0.62

SOURCE: San Luis Obispo County, 1998

Strawberries and Blueberries

The amount of frost protection on strawberries varies from year to year and farm to farm. Sprinklers typically operate for 6 to 10 hours a night for 8-12 nights per year (San Luis Obispo County, 1998). System flow rates for frost protection of strawberries are approximately 45 gpm/Ac (0.10 in/hr). **Table A12** shows an example of yearly applied water for frost protection on strawberries depending on minutes of runtime and a system flow rate of 45 gpm/Ac. For purposes of the agricultural water demand analysis, strawberries and blueberries are grouped in the deciduous group. To account for the frost protection of strawberries and blueberries on some of the crops, 0.4 AF/Ac/Yr was added to the deciduous crop in WPA 1, 7, 8, and 14.

TABLE A12
RANGE OF ANNUAL APPLIED WATER FOR FROST PROTECTION ON STRAWBERRIES (AF/AC/YR)

Hours per night	Nights per year	Annual Applied Water (AF/Ac/Yr)
6	8	0.48
	10	0.60
	12	0.72
8	8	0.64
	10	0.80
	12	0.96
10	8	0.80
	10	1.00
	12	1.20

SOURCE: San Luis Obispo County, 1998

Leaching Requirements (LR). Leaching requirements, amount of over watering necessary to remove salts from the soil, were assumed to be satisfied by rainfall in the majority of the coastal areas (WPA 1 to WPA 6). Leaching requirements for the Paso Robles Basin were presented by Fugro and Cleath (2002). ESA used these estimates, approximately 5 percent to 16 percent, to identify existing LR for inland areas. **Table A12** includes the leaching requirement percentage used for crop groups located in inland WPAs (WPA 8-16). Mark Gaskell, UC Farm Advisor, stated that strawberries may have a leaching requirement of 10 to 20 percent (Gaskell, 2009). Therefore, ESA used a leaching requirement of 11 percent for existing demand in WPA 7. The future leaching requirements may be greater based on a build-up of salts in the soil (Battany, 2008; Gaskell, 2009). Therefore, the future leaching requirements were assumed to be 1 to 2 percent higher than existing leaching requirements.

TABLE A12
LEACHING REQUIREMENTS FOR INLAND AREAS IN SAN LUIS OBISPO COUNTY

Crop Group	Leaching Requirements (%)	
	Existing	Future
Alfalfa	8%	10%
Nursery	5%	7%
Pasture	8%	10%
Citrus	5%	7%
Deciduous	11%	13%
Vegetable	8%	10%
Vineyard	16%	18%

SOURCE: Existing leaching requirements were adapted from Fugro and Cleath, 2002 (Table 13)

Irrigation Efficiencies (IE). Irrigation efficiencies were calculated by utilizing distribution uniformity and losses provided by the San Luis Obispo County/Santa Barbara County Cachuma Resource Conservation District

(CRCD), San Luis Obispo County Coastal Resources Conservation District, vineyard owners, and recent studies. Additionally, ESA incorporated input from the WRAC and other agricultural stakeholders.

Higher irrigation efficiencies depend primarily on improving system distribution uniformity, decreasing surface losses, and reducing scheduling errors. Irrigation efficiencies are difficult to measure and are often estimated according to the system type, special practices, and distribution uniformities. Micro irrigation systems include micro-sprinklers, drip emitters, and drip tape. Micro systems tend to have higher irrigation efficiencies than sprinkler systems (**Table A13**). Regardless, there is a range between potential and actual performances of irrigation systems.

TABLE A13
ESTIMATED IRRIGATION EFFICIENCY RANGES BASED ON SYSTEM TYPE

	Estimated Irrigation Efficiency (IE) (%)		
Irrigation System Type	**Maximum Potential IE (includes excellent design and excellent management)**	**Average IE (includes excellent design and average management)**	**Low IE (includes average design and below average management)**
Sprinkler	80-85	75	50-60
Micro	90-95	85	60-70

SOURCE: Peterson, 2009a

Local farm advisors were contacted regarding the types of irrigation systems on crop groups. **Table A14** summarizes the type of irrigation systems used on specific crops. In 1998 MWP, the majority of vegetables were irrigated with surface systems. Over the last 10 years, surface irrigation systems have been converted to micro and sprinkler irrigation systems (Peterson, 2009a).

TABLE A14
ESTIMATES OF CURRENT IRRIGATION SYSTEM TYPES BY CROP GROUP

	Percentage of Acreage with Irrigation System Type (%)		
Crop Group	**Surface**	**Sprinkler**	**Micro**
Alfalfa	0	100	0
Citrus (permanent)	0	20	80
Deciduous (permanent)	0	20	80
Nursery	0	50	50
Pasture	0	100	0
Permanent	0	20	80
Vegetable	0	40	60
Vineyard	0	0	100

[a] Acreage was placed in a particular category according to the system they use most of the season.

SOURCE: Peterson, 2009b

Although measuring irrigation efficiency is difficult, a system's distribution uniformity can be quantified and measured in the field. The relationship between distribution uniformity and irrigation efficiency can be expressed as follows:

Irrigation Efficiency=Distribution Uniformity x (1-Losses)

The CRCD conducts irrigation evaluations with the Mobile Irrigation Lab. The CRCD has completed more than 325 evaluations related to irrigation efficiencies throughout San Luis Obispo and Santa Barbara Counties. The irrigation specialists provided estimates presented in Table A9 and Table A10, as well as information on distribution uniformity. Recent evaluations have shown that the distribution uniformity is approximately 75%, which is 5% higher than in 1998 (Peterson, 2009a). This change is primarily due to the change from surface to micro and sprinkler systems.

The sprinkler systems are associated with distribution uniformities of approximately 75% and micro systems are associated with distribution uniformities of 85%. For the purposes of estimating applied water, irrigation efficiencies were assigned to crop group according to the primary irrigation system type. **Table A15** includes existing irrigation efficiencies for crop groups**.** Irrigation efficiencies are likely to continue to improve in the future, due to improvements in equipment, economic pressure (increased electricity costs if groundwater levels decline), or have economic incentives (Isensee, 2009). **Table A16** includes projected future irrigation efficiencies for crop groups.

TABLE A15
EXISTING IRRIGATION EFFICIENCIES FOR CROP GROUPS

	Existing Irrigation Efficiency Range (%)	
Crop Group	**Low**	**High**
Alfalfa	60%	75%
Nursery	60%	75%
Pasture	60%	75%
Citrus & Deciduous	70%	85%
Vegetable	70%	85%
Vineyard	70%	85%

SOURCE: Peterson, 2009a and 2009b

TABLE A16
FUTURE PROJECTED IRRIGATION EFFICIENCIES FOR CROP GROUPS

	Projected Future Irrigation Efficiency Range (%)	
Crop Group	**Low**	**High**
Alfalfa	65%	80%
Nursery	65%	80%
Pasture	65%	80%
Citrus & Deciduous	75%	90%
Vegetable	75%	90%
Vineyard	75%	90%

SOURCE: Peterson, 2009a and 2009b

References

Battany, M., Paso Robles Soil Salinity Survey, Part II, Grape Notes, San Luis and Santa Barbara Counties, June 2008.

Battany, M., personal communication, e-mail, December 10, 2009.

Burt, C.M., Mutziger, A., Howes, D.J., and Solomon, K.H., Evaporation from Irrigated Agricultural Land in California, January 2002.

California Irrigation Management Information System (CIMIS), http://wwwcimis.water.ca.gov/cimis/welcome.jsp accessed September 30, 2009.

Department of Water Resources (DWR), Vegetative Water Use in California, Bulletin 113-3, 1974

Department of Water Resources (DWR) and UC Dept. of Land, Air & Water Resources, Reference Evapotranspiration Zones Map, 1999.

Fugro West, Inc., Cleath and Associates, Final Report Paso Robles Groundwater Basin Study, 2002.

Gaskell, M., e-mail, personal communication, December 11, 2009.

Isensee, Michael, San Luis Obispo County Agricultural Commissioner, personal communication, e-mail, November 9, 2009.

Peterson, Kevin, Irrigation Specialist, Personal Communication, e-mail, CRCD, 12 November, 2009a.

Peterson, Kevin, Irrigation Specialist, Personal Communication, e-mail, CRCD, 28 September, 2009b.

San Luis Obispo County, 1998 Master Water Plan, 1998.

San Luis Obispo County, Water Years 2001-2002 and 2002-2003 Hydrologic Report, 2005

San Luis Obispo County, San Luis Obispo County Water Resources Division of Public Works Water Resources Data, www.slocountywater.org/site/Water%20Resources/Data/maps/data.htm, accessed December 8, 2009.

Snyder, R.L., W.O. Pruitt, and D.A. Shaw, *Determining daily reference evapotranspiration (Eto)*, Cooperative Extension, Univ. California, Berkeley, CA, Leaflet 21426, 12 pp., 1987.

Snyder, R. L., Lanini, B. J., Shaw, D. A., and Pruitt, W. O. *Using reference evapotranspiration (ETo) and crop coefficients to estimate crop evapotranspiration (ETc) for agronomic crops, grasses, and vegetable crops*, Cooperative Extension, Univ. California, Berkeley, CA, Leaflet No. 21427, 12 p., 1989a.

Snyder, R. L., Lanini, B. J., Shaw, D. A., and Pruitt, W. O. *Using reference evapotranspiration (ETo) and crop coefficients to estimate crop evapotranspiration (ETc) for trees and vines.* Cooperative Extension, Univ. California, Berkeley, CA, Leaflet No. 21428, 8 p, 1989b.

University of California, Reference Evapotranspiration (ETo) for California, (Bulletin 1922), W.O. Pruitt, et al., Division of Agricultural and Natural Resources, 1987.