225 Bush Street
Suite 1700
San Francisco, CA 94104
415.896.5900 phone
415.896.0332 fax
www.esassoc.com

DRAFT memorandum

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

from Annika Fain, ESA; Eric Zigas, ESA

subject San Luis Obispo County Water Demand Analysis Methodology (Task C.4)

Background

San Luis Obispo County (County) has experienced multiple droughts, degradation of groundwater, and limited water supplies. The San Luis Obispo County Flood Control and Water Conservation District (District) is preparing an updated County Master Water Plan (MWP). The previous version of the MWP was completed in 1998. Since then, there have been many changes in the water resources in the County, including the completion of local and regional water management plans, formation of the Integrated Regional Water Management Plan (IRWMP), new water sources, new water users, and new water regulations.

The updated MWP will incorporate these changes and provide all entities in the County with information to help effectively and efficiently manage water resources to protect ecosystems, public health and safety, and agriculture. The water supply and water demand is being calculated for the entire County for existing and future conditions. The following document includes a methodology summary for the water demand analysis. The description of water resources management and water supply inventory is being prepared in a separate document. We will utilize input from the WRAC, regional, sub-regional, and other stakeholders related to all categories of the water demand methodology.

Total Water Demand

Definition

The total water demand is split into four categories: urban, rural, agricultural, and environmental. Total demand will be defined as the sum of all categories.

Method

The total water demand will be calculated for existing and future conditions throughout the County. For calculating the existing water demand we will utilize the most recent available data, consistent with the timeframe used for water supply calculations. For future water demand we will provide “build-out” in the context of future demands in the foreseeable future, consistent with the timeframe used for water supply calculations. We will create a geodatabase which includes all four categories of water demand for existing and future conditions, as well as the total water demand, for each of the water planning areas. The data will be compiled into “look up tables” that are either linked to/generated by GIS layers or are independent of GIS and based on adopted plans (pending their areal/spatial application). This will allow any of the parameters to be revised as they are updated; or in order to test the sensitivity of the estimate to changing conditions; or to provide the ability to explore “what if” development were to happen differently, or what if there is a pending development for which water availability needs to be verified. We will utilize input from the WRAC, regional, sub-regional, and other stakeholders related to the total water demand methodology.

Assumptions

Calculating the existing total water demand and projecting the future total water demand requires a number of assumptions, review and analysis of existing data for each of the categories. A couple of the general assumptions are outlined below and assumptions specific to each of the individual water demand categories are discussed within the individual category section:

- Existing demands represent average annual demand, in acre-feet (AFY). The demand can vary widely on smaller timescales, such as a daily or monthly demand.
- Future water demand will be shown as a range whenever possible. For urban areas, the range of the future water demand represents projected 2025 demand and build-out demand. The build-out demand is not associated with a particular year because this is unknown and will vary between water planning areas. For agricultural demand, the range represents the difference between using low and high end of variables. For rural demand, the range represents the difference between using low and high water duty factors

Urban Water Demand

Definitions

Urban water demand refers to residential, commercial, industrial, parks, institutions, and golf courses water demand within the unincorporated communities and incorporated cities in the County, and will include. The water demand in other unincorporated areas in the County is included in the rural water demand, agricultural water demand, and environmental demand.

Sources

Primary sources of data include the water system master plans (WSMP) and urban water management plans (UWMP) prepared by water purveyors, incorporated cities, and unincorporated communities. All of the urban areas, incorporated cities and unincorporated communities have adopted a WSMP or UWMP during the last 10 years. Additionally, the County’s *Annual Resource Summary Report* 2008 (ARS) provides existing projected water demand and population for these areas.

Method/Assumptions: Existing and Future Water Demand

Existing water demand calculations and future water demand projections from WSMP’s and UWMP’s will be used. UWMP’s are available for all incorporated cities and include existing and future water demand. WSMP’s are available for all of the unincorporated communities, which are serviced by Community Services Districts (CSD), or County Service Areas (CSA), and include water demand information. The Wallace Group has reviewed all of the UWMP and WSMP's and provided a summary of the available urban water demand presented in these documents. Table 1 includes a list of some of the WSMP's and UWMP's developed for unincorporated communities and incorporated cities in the County. These plans include water demand information. We will utilize input from the WRAC, regional, sub-regional, and other stakeholders related to the urban water demand methodology.

TABLE 1
URBAN WATER MANAGEMENT PLANS (UWMP) AND WATER SYSTEM MASTER PLANS (WSMP) AVAILABLE FOR URBAN WATER DEMAND ANALYSIS

Urban Areas	UWMP	WSMP	Year
San Simeon		X	2007
Cambria	X	X	2005; 2004
Cayucos	X	X	2008; 2003
Morro Bay*	X		2006
Los Osos CSD	X	X	2000; 2002
San Luis Obispo City*	X		2005
Pismo Beach*	X		2007
Arroyo Grande*	X		2000
Grover Beach*	X		2006
Oceano CSD		X	2004
Avila Beach CSD			2007
Nipomo CSD	X	X	2007
Atascadero (AMWC)*	X	X	2005; 2009 (in progress)
Templeton CSD		X	2005
Paso Robles*	X		2005
Shandon (CSA 16)		X	2004
San Miguel		X	2002
Santa Margarita (CSA 23)		X	2003

*Includes incorporated city

The WSMP's and UWMP's describe existing and future demand in various units such as gpcd (gallons per capita per day), AFY, or average day demand (ADD). For purposes of this analysis, the annual urban water demand will be presented in AFY. The urban water demand for individual areas in the County will be associated with a GIS layer which will include the existing and future urban demand for each unincorporated community and incorporated city.

Rural Water Demand

Definitions

Rural water demand refers to water demand in unincorporated areas of the County that are not considered agricultural or urban.

Sources

The County GIS land use data, including vacant and developed properties and potential subdivisions and units, in the unincorporated areas of the County will be used to calculate a rural water demand. Additional sources include information from purveyors, water management plans, and the County's ARS.

Method/Assumptions: Existing and Future Rural Demand

A water duty factor will be applied to the acreage and dwelling units of unincorporated areas. A water duty factor is an estimated average volume of water used annually by a particular activity and is represented in AFY/acre and AFY/dwelling unit (DU).

Due to different climates and types of water usage, the water duty factors can vary widely between region and time of year. The water duty factor varies with the number of persons in each DU and the amount of landscaping, as well as the climate. Coastal rural areas will require less water than inland rural areas due to greater evapotranspiration in the inland areas and more precipitation in the coastal areas. The water duty factor for each of the areas will be determined by using information available related to rural interior and exterior water usage in San Luis Obispo County, as well as adjacent counties, from purveyors and other sources. We will account for the exterior water usage varying more than the interior water usage by establishing a range for each region for existing and future rural demand.

We will utilize the County GIS layer which includes land use and DU for all unincorporated areas of the County. We will calculate a rural water demand for each area by multiplying the number of dwelling units or acreage for a particular land use by a water duty factor. For future rural water demand, initially the residential potential demand will be multiplied by a factor, such as 90%, to account for physical and environmental constraints on development. The rural demand for individual areas in the County will be associated with a GIS layer which will include the number of dwelling units, water duty factor, and rural water demand for all unincorporated areas in the County that are not considered agricultural or urban. We will utilize input from the WRAC, regional, sub-regional, and other stakeholders related to the rural water demand methodology.

Agricultural Water Demand

Definitions

Agricultural water demand refers to water demand in all agricultural areas in the County. The following definitions are related to factors related to agricultural water demand:

- GIWR: Gross Irrigation Water Requirement (GIWR) represents the quantity of applied irrigation water. For San Luis Obispo County, the GIWR is primarily a function of crop evapotranspiration (Etc), effective rainfall (EF), leaching requirement (LR), irrigation efficiency (IE), and frost protection (FP).

- Eto: Reference evapotranspiration (Eto) represents the approximate theoretical water use of a well watered, cool-seasoned grass , 4 – 6 inches tall, under full cover. This varies with changing weather conditions throughout the County.

- Kc: The crop coefficient (Kc) refers to a dimensionless number, specific to a particular crop, that is related to the Eto of grass (1.0). Kc is used to estimate plant water use for a particular plant in a particular region.

- Etc: Crop Evapotranspiration (Etc) is estimated by multiplying Eto and Kc. Etc is the quantity (depth) of water transpired by plants, retained in plant tissue, and evaporated from adjacent soil surfaces during a specific time.

- EF: Effective rainfall (EF) is the amount of rain used by crops and is influenced by a variety of factors including frequency, intensity, and total amount of rainfall; percentage of ground cover, rate of evapotranspiration, and rooting depth of the crop; and soil water holding capacity, infiltration rate, and moisture at the time of rainfall.

- FP: Frost protection (FP) refers to the amount of water used to protect plants from frost. The FP is based on the approximate number of nights per year, hours per night, and applied water flow rate for crops which are prone to damage

- LR: Leaching requirement (LR) refers to the amount of extra irrigation water necessary to remove salts from the soils.

- IE: Irrigation efficiency (IE) represents the ratio of irrigation water beneficially used vs. total irrigation water applied.

Sources

The Agriculture/Crop GIS layer for the County from August 2008 will be used, as well as other information provided by the Agricultural Commissioner's office. This layer is updated yearly with information from the pesticide use records obtained by the San Luis Obispo Department of Agriculture. The pesticide use records are forecasts and are approximately 80% accurate (Isensee, 2009). The number of crop rotations varies and is not identified in the Agriculture/Crop GIS layer. Therefore, we will estimate these parameters based on any available information.

CIMIS data will be used as reference evapotranspiration (ETo) and crop coefficients (Kc) for areas where data are available, as well as relevant University of California Cooperative Extension Leaflets 21426 to 21428. (Snyder et al., 1987, 1989a, 1989b). The rainfall data will be used from a variety of sources including SLO County gages, SLO County Hydrology Report, SLO County Flood Control and Water Conservation District maps, CDEC, CIMIS, NWS, and NOAA Rainfall Maps. ESA has contacted a UC Farm Advisor (Mark Battany) in San Luis Obispo County and obtained information on frost protection in the County. Irrigation information has been obtained from a Cachuma Resource Conservation District (CRCD) Irrigation Specialist (Kevin Peterson), as well as from the Central Coast Vineyard Team (CCVT) Executive Director (Kris O'Connor). Additionally, a DWR model is available to calculate applied water (AW; the quantity of water applied to a specific crop per unit area) for areas where sufficient data is available (http://www.water.ca.gov/landwateruse/anaglwu.cfm#).

Method/Assumptions: Existing Agricultural Demand

We will utilize input from the WRAC, regional, sub-regional, and agricultural stakeholders related to the agricultural water demand methodology. Additionally, we will utilize the agricultural crop GIS data from 2008 to determine types of crop for areas throughout the County, as well as other information provided by the Agricultural Commissioner's office and other organizations. In some areas of the County we will need to look closely at aerial photos, to check the accuracy of the agricultural data. We will calculate a Gross Irrigation Water Requirement (GIWR) by utilizing information on crop evapotranspiration, contribution from rain or shallow water table, leaching requirements, irrigation efficiency, and frost protection. The following equation will be used to calculate annual GIWR in AFY for each of the water planning areas:

$$\text{Annual GIWR} = \frac{\text{ETc} - \text{EF}}{(1 - \text{LR}) \text{ x IE}} + \text{FP}$$

This formula was modified from a general formula for GIWR, which was established in 1997 (Burt). In areas where CIMIS DWR has established rain gages, we will utilize the DWR irrigation model that calculates water demand for areas where gaged precipitation data exists. This model takes into consideration the irrigated crop area, irrigated land area, multi-cropping, evapo-transpiration, effective precipitation, and consumed fraction to calculate the applied water (acre-foot per acre). This can be multiplied by acreage for crop type to calculate agricultural water demand (AFY). The applied water in San Luis Obispo and Kern County has been calculated from 1998 to 2001 at select gages and can be updated by utilizing one of the online models (Consumptive Use Program [CUP] or SIMETAW).

Crop Evapotranspiration

Reference Crop Evapotranspiration (Eto). Crop evapotranspiration for four CIMIS weather stations in San Luis Obispo County, two in Kern County (to the east), and one in Santa Barbara County (to the South) will be used. The CIMIS stations in San Luis Obispo County include two in San Luis Obispo, one in Atascadero, and one in Nipomo. Additionally, there are two CIMIS stations in Kern County which can be used to estimate Eto in Eastern San Luis Obispo County.

Crop coefficients (Kc). The crops in San Luis Obispo County will be assigned crop coefficients based on the crop type and location. These crops include nursery, orchard, pasture vegetable vineyard, seed, grass oat, and berry. The spreadsheet and GIS model will be set-up so these numbers can be easily updated with new crop coefficients and crop evapotranspiration.

Crop Evapotranspiration (Etc). Crop evapotranspiration will be calculated by multiplying the reference crop evapotranspiration by the crop coefficients for each agricultural crop and area.

Effective Rainfall (ER)

The effective rainfall will be calculated for each area by utilizing historical monthly precipitation in San Luis Obispo County and effective precipitation based on crop type.

Frost Protection (FP)

The frost protection water requirement will be calculated for grapes and strawberries, as well as other crops where frost protection is applied. This will be based on information provided by the UC Farm Advisors and input from the WRAC and other agricultural stakeholders.

Leaching Requirements (LR)

The leaching requirements, amount of over watering necessary to remove salts from the soil, will be assumed to be satisfied by rainfall for much of the area, with the exception of some dryer areas where a percentage will be assigned for the deciduous crop groups. This will be based on information provided by agricultural stakeholders.

Irrigation Efficiencies (IE)

Irrigation efficiencies will be calculated by utilizing distribution uniformity and losses provided by the San Luis Obispo County/Santa Barbara County Cachuma Resource Conservation District, San Luis Obispo County Coastal Resources Conservation District, vineyard owners, and recent studies. Additionally, we will incorporate input from the WRAC and other agricultural stakeholders.

Method/Assumptions: Future Agricultural Demand

Similar methods and equations will be used as above to calculate the future irrigation water requirements. The calculation of GIWR will be different due to changes in cropping patterns, weather patterns, and irrigation methods. Where appropriate, general plan land use data will be utilized to predict areas where agricultural lands could change in the future. We will utilize the most recent climate change information in our analysis. For future agricultural water demand we may include a decrease in rainfall and higher evapotranspiration, based on predicted climate change in the area.

Environmental Water Demand

Definitions

Environmental water demand refers to the amount of water needed in an aquatic ecosystem, or released into it, to sustain aquatic habitat and ecosystem processes.

Sources

There are six active USGS streamflow gages and 68 inactive USGS streamflow gages in San Luis Obispo County (USGS, 2009). Information on location, site details, drainage, and available data was obtained for all United States Geological Survey (USGS) sites and imported into GIS. There are 18 active San Luis Obispo County streamflow gages. We obtained similar information from Sylas Cranor in the San Luis Obispo Water Resources Department for all active and inactive gages and imported into GIS.

Method/Assumptions: Existing and Future Environmental Demand

We will quantify and qualify existing and future environmental water demands for areas where data are available and unimpaired runoff data can be obtained or calculated. We will utilize USGS and County existing stream gage data and develop a plan for obtaining the critical stream flow data. Unimpaired runoff estimates will be calculated by developing regional, multiple regression relationships that will predict runoff as a function of two or more factors (e.g. drainage area, precipitation, topography, or land cover) or one that would predict runoff at an ungaged, or partially gaged, location as a function of runoff at a gaged location. Once the estimated unimpaired runoff has been established, numerous methodologies for calculating environmental water demand may be applied. We will likely use methods such as the February median flow (FMF) methodology (California Department of Fish and Game [CDFG] and National Marine Fisheries Service [NMFS], 2002), the "Montana Method" (Tennant, 1976), or the median annual discharge methodology (Hatfield and Bruce, 2000). We will select an appropriate methodology for the environmental demand analysis based on target species, data availability, consensus from the WRAC and other stakeholders, as well as time and budget constraints.

Unimpaired Runoff

As part of the Environmental Water Demand analysis, annual unimpaired (i.e., unregulated by impoundments or dams and not substantially effected by the diversion or pumping of water) flow statistics (e.g., mean, median, FMF) will be calculated for select locations throughout San Luis Obispo County. The flow statistic(s) ultimately selected for the analysis will be determined through coordination with a fisheries biologist. The following outlines the approach and methods proposed for the estimation of unimpaired runoff within San Luis Obispo County. Generally, the method followed will be similar to methods described by Mann et al. (2004) and Ries and Friesz (2000). In the most basic sense, the record/flow statistic(s) at long-term gaging stations will be used to extend the record/flow statistic(s) of short-term gaging stations, and these will in turn be used to estimate the flow statistic(s) at ungaged locations. Below is a description of methods we are using to calculate unimpaired runoff.

We will develop a base map in AcrGIS; gather and process relevant spatial data (e.g., topography, soils data, geology, mean annual rainfall). We will determine which USGS and County gages represent predominantly unimpaired flow conditions:

- For active and recently discontinued USGS gages, this information has already been obtained (available online);
- For older USGS gages, the hard copy Water Data Reports (WDR) need to be consulted (available at UC Berkeley or the USGS Water Science Center in Sacramento, CA); and
- For select County gages, this will need to be verified by County staff and/or through analysis of aerials and water rights information.

We will select “Index Stations” (i.e., those stations with records comprising 30 years or more), summarize mean daily flow data, and calculate the flow statistic for the assessment period (likely to be Water Year 1972-2008, as this period is common to most of the candidate Index Stations). We will test for trends, qualitatively (i.e., plotting vs. time) and/or quantitatively (correlation test, Kendall’s tau), in the Index Station data. We will discard Index Stations that exhibit significant trend and use “de-trending” methods if trend is exhibited at regional scale.

We will use Index Stations and regression analysis to adjust (extend) the record of “Study Stations” (i.e., those with records comprising less than 30 years); Index Station-Study Station pairing will be informed by regional characteristics (e.g., topography, geology, etc.) but ultimately determined by proximity and the value of the regression coefficient of determination (R^2). For each regression, we will plot computed residuals and evaluate (qualitatively and/or quantitatively) possible issues (e.g., non-constant variance with time). We will calculate the flow statistic(s) for the Study Stations over the assessment period.

Based upon the flow statistic(s) calculated for the gaged locations (i.e., the Index Stations and the record-extended Study Stations), estimate the flow statistic(s) for selected ungaged locations. We will select ungaged locations of interest (some locations may be ruled out all together due to differences in watershed characteristics as compared to any of the gaged locations). We will determine appropriate station(s) (Index and/or Study Station) for each ungaged location of interest; this will be based upon proximity, mean annual rainfall, drainage area size, watershed relief/topography, geology, and soil characteristics. We will calculate the flow statistic(s) for the ungaged locations using A) the drainage basin area-ratio method or B) multiple regression (note: the latter will not likely be an option given budget and time constraints). We will summarize the flow statistics and unimpaired runoff estimates for all Index Stations, Study Stations, and ungaged locations.

References

Burt, C.M. Irrigation Water Management, Agricultural Engineering Department, Cal Poly San Luis Obispo.

Department of Fish and Game, California (DFG) and National Marine Fisheries Service (NMFS), *Guidelines for maintaining instream flows to protect fisheries resources downstream of water diversions in mid-California coastal streams.* Draft guidelines with errata note dated August 19, 2002, NOAA Fisheries, Santa Rosa, CA, CDFG, Region 3, Yountville. 19 pp, 2002.

Hatfield, T. and J. Bruce., *Predicting salmonid habitat-flow relationships for streams from western North America.* N. Amer. J. Fish. Management. 20: 1005-1015, 2000.

Isensee, Michael, GIS Coordination Meeting, May 4, 2009.

Mann, M.P., Rizzardo, J. and Satkowski R., *Evaluation of Methods Used for Estimating Selected Streamflow Statistics, and Flood Frequency and Magnitude, for Small Basins in North Coastal California*, USGS Scientific Investigations Report 2004-5068, 2004.

Ries, K.G., III, and Friesz, P.J., *Methods for estimating low-flow statistics for Massachusetts streams,* U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p, 2000.

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

Snyder, R.L., W.O. Pruitt, and D.A. Shaw, *Determining daily reference evapotranspiration (Eto).* UC 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.

Tennant, D. L, ‘Instream flow regimens for fish, wildlife, recreation, and related environmental resources’, in Orsborn, J. F. and Allman, C. H. (Eds), Proceedings of the Symposium and Specialty Conference on Instream Flow Needs II. American Fisheries Society, Bethesda, Maryland. pp. 359–373, 1976.

USGS, USGS Water Data for California, http://waterdata.usgs.gov/ca/nwis/, accessed June 29, 2009.