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KERN GROUNDWATER AUTHORITY COORDINATION AGREEMENT COMPONENTS WHITE PAPER SERIES

Item E
Change in Groundwater Storage

Introduction

There are seven components to Groundwater Sustainability Plan (GSP) coordination agreements. The coordination components are further described in the Department of Water Resources (DWR)'s GSP regulations, which were released in draft form in February, 2016. The seven components are:

a. **Groundwater Elevation Data.**
b. **Groundwater Extraction Data.**
c. **Surface Water Supply.**
d. **Total Water Use.**
e. **Change in Groundwater Storage.**
f. **Water Budget.**
g. **Sustainable Yield.**

The Coordination Committee of the Kern Groundwater Authority (KGA) is preparing a series of white papers addressing each of the coordination elements identified above. This white paper addresses ***Item e) Change in Groundwater Storage.*** The information presented in this white paper provides a suggested methodology and protocols for consistent change in groundwater storage data throughout the Kern Subbasin. The intent of this white paper is to advance the dialogue between participating members of the KGA on the development of a coordination agreement required under the Sustainable Groundwater Management Act (SGMA). The information presented herein is draft and subject to the input and revision from members of the Coordination Committee.

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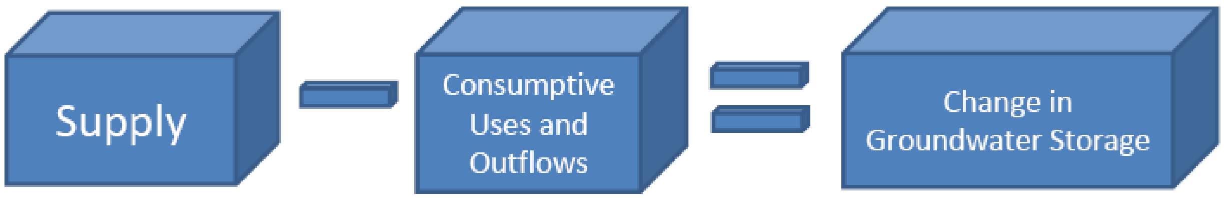
Water Budget Components

Water budgets estimate change in groundwater storage by comparing supplies to consumptive uses and outflows. This section explains the supply and consumptive use components that need to be considered when developing a water budget for the Kern Subbasin. Figure 1 shows the summary equation.



Supply can be calculated by documenting and adding together water supply inputs into the Kern Subbasin, which include:

- Kern River.
- Minor streams.
- CVP imports.
- SWP imports.
- Precipitation.
- Groundwater inflows from small watersheds.
- Groundwater inflows from the Tule Subbasin.
- Groundwater inflows from Tulare Lake Subbasin.
- Produced water from oil extraction.
- Withdrawals from groundwater storage (groundwater extractions).

Consumptive use can be calculated by documenting and adding together consumptive uses and outflows, which include:

- Managed habitat evapotranspiration.
- Undeveloped land evapotranspiration.
- Soil moisture evapotranspiration.
- Agriculture evapotranspiration.
- Groundwater outflows to small watersheds.
- Groundwater outflows to Tule Subbasin.
- Groundwater outflows to Tulare Lake Subbasin.
- Municipal consumptive use (municipal use minus municipal discharge).
- Evaporation during energy production.
- Contributions to groundwater storage (deep percolation).

This white paper discusses methods that can be used to measure or estimate change in groundwater storage. Other components of the water budget are discussed in other white papers.

Definition of Change in Groundwater Storage

Change in Groundwater Storage is defined as "the annual change in volume of groundwater in storage between seasonal high conditions."

Data and Monitoring Protocols

This white paper proposes a single method for the calculation of change in storage within the Kern Subbasin, comprised of two elements:

- Change in groundwater surface elevation.
- Porosity.

The change in groundwater elevation, multiplied by a porosity factor, across a given basin surface area, can be used to calculate an estimate of the volumetric change in storage. This estimate can be cross-checked with the water balance method for verification of results. Protocols for collecting adequate data to make the calculation are described below.

Groundwater Elevation

Monitoring data from the monitoring program established by the GSP will be used to identify groundwater levels for the seasonal high time period (spring monitoring cycle) in each aquifer in the subbasin. The groundwater elevation in each aquifer will be contoured under supervision of a certified hydrogeologist. The contours for consecutive years will be compared to generate a change in groundwater levels map, which illustrates the spatial distribution of water level change, for each aquifer. The resulting contour map would be similar to the one shown in Figure 1, but would calculate the change from one sequential year to another instead of multiple years.

Porosity

Spatial and vertical porosity are required to calculate groundwater storage. Porosity data can be compiled from several different sources. Porosity is a calibrated parameter in C2VSIM (DWR, 2013), the United States Geological Survey (USGS) developed a robust texture model for the Central Valley Hydrologic Model (CVHM), which characterizes aquifer system deposits and lithologic data based on drillers' logs (USGS 2015). An example of the USGS's texture data is shown in Figure 2. Data from both models can be extracted, compared, and used to establish a baseline of spatial and vertical porosity in the Kern Subbasin. As data gaps in porosity information are identified, those gaps can be filled by local data sources such as pre-existing studies and drillers log data.

The change in storage contour map for each aquifer measured would then be multiplied with the spatial and vertical porosity data, using GIS software to calculate change in storage for a given year or series of years. Change in storage can be calculated for the basin and for smaller geographies, so that chapter GSPs can report their change in storage in their area as part of the chapter's water budget.

Figure 1. Spring Groundwater Elevation Change 1995 to 2002

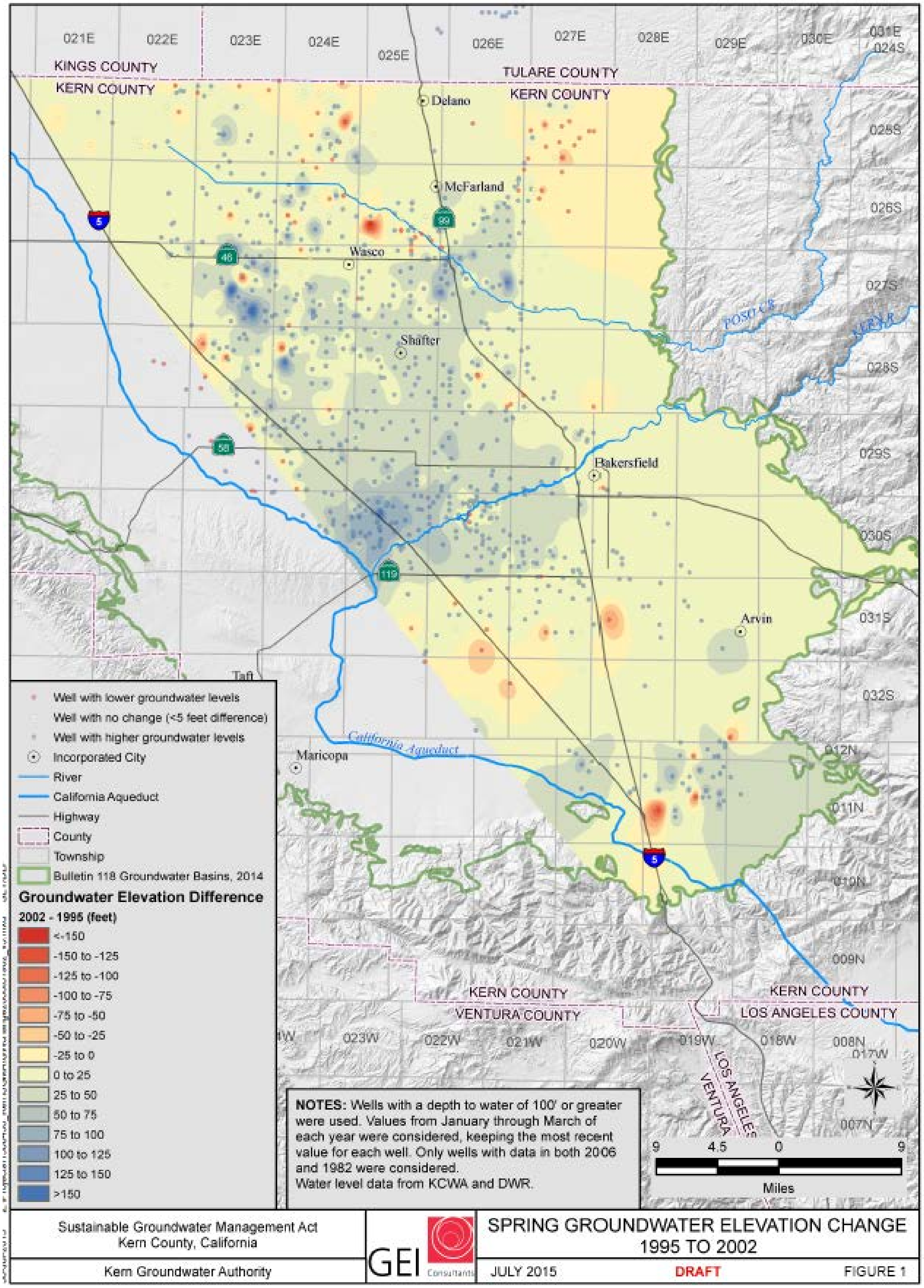
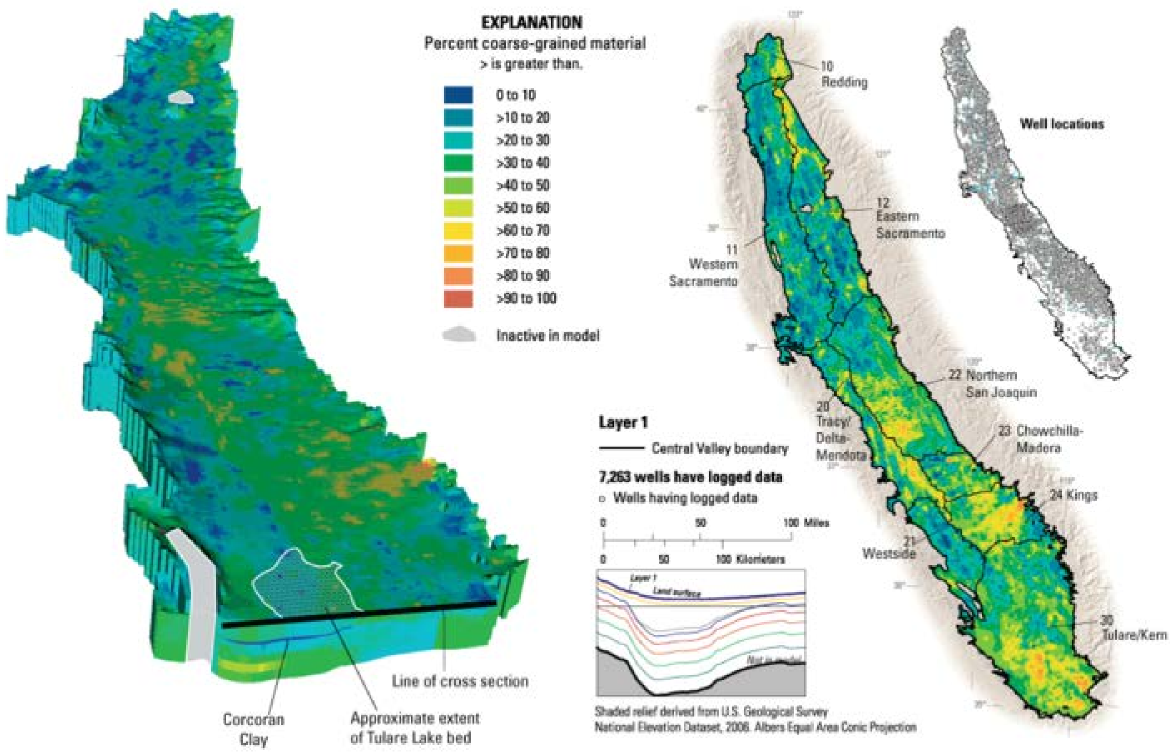


Figure 2. USGS Texture Model Representation



Reporting of Change in Storage Data

SGMA requires annual reporting of groundwater elevation data, groundwater extraction, surface water use, total water use, and change in groundwater storage. Results of the change in storage data can be calculated and reported annually, both for the entire Sub-basin and for smaller management areas or GSAs within the basin.

Quality Control and Assurance

The entire Kern Subbasin's change in storage is planned to be calculated using this method, and therefore the accuracy of the calculation can be evaluated by comparing the results to a water budget approach using total water use and surface water deliveries. The calculated amount of water extracted can be compared to the calculated change in storage; both results should be similar.

References

California Department of Water Resources. 2013. *The California Central Valley Groundwater-Surface Water Simulation Model*. Accessed on March 2, 2016. Available from: https://msb.water.ca.gov/documents/86728/156883/C2VSim_Workshop-2-C2VSim.pdf

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