

ATTACHMENT 5: WORK PLAN

The detailed Work Plan includes the following activities and has been organized into seven project tasks, described in detail in this Work Plan:

Task 1 – Data Review and Modeling

Task 2 - Monitoring Well Siting and Design

Task 3 - Environmental Compliance and Permitting

Task 4 - Well Drilling/Well Construction/Development/Instrumentation

Task 5 - Monitoring Well Data Transmittal

Task 6 - Project Management/Coordination and *QA/QC*

Detailed Work Plan

Task 1 – Data Review and Modeling

The overall objective of this effort is to investigate the current hydrologic conditions in the western portions of Glenn County, where recent groundwater level declines have been observed, and to utilize existing groundwater flow models of the area to evaluate the potential benefits that may be realized by the implementation of a focused groundwater recharge program. This will also assist in meeting the Preliminary Plan goals by using a predictive modeling tool to help provide data that will aid in the examination of the assumptions made during the development of the current BMOs, enhance the background information for decisions relating to GWMP and BMOs, and help identify sensitive areas with regard to monitoring for BMO compliance.

The first phase of this effort consists of the collection and evaluation of groundwater use and groundwater elevation data for areas of concern within Glenn County. These areas generally lie in the western portions of the County. Groundwater level data collected over the last 15-20 years will be collected and reviewed to identify seasonal fluctuations in groundwater levels as well as the degree of groundwater level recovery over the winter-spring period, and how these trends change in different hydrologic year types. These data will also be used to identify any recent groundwater level trends that indicate longer-term overdraft of particular portions of the groundwater basin. Rates of groundwater level changes will be used to develop preliminary estimates of the required volume of recharge water required to stabilize groundwater levels. Groundwater use data as well as any recent land use changes, where available, will also be considered in the analysis.

The second phase of this effort is to evaluate the potential benefits that could be realized by the implementation of an induced groundwater recharge program in this area. An existing regional scale groundwater flow model, such as SACFEM (See **Attachment 5.1** SACFEM excerpt from the CA Central Valley Groundwater Modeling Workshop, July 2008), will be used to investigate the

groundwater conditions that would result from implementation of a groundwater recharge project. The first step in this process is to develop a baseline scenario that defines the groundwater conditions that will result in the area over the next several years assuming groundwater production rates are similar to those occurring today. Then a series of predictive simulations will be performed assuming the implementation of a groundwater recharge project with several different assumed recharge capacities. This suite of simulations will likely evaluate a 5,000 ac-ft/yr, 10,000 ac-ft/yr, and a 15,000 ac-ft/yr recharge project. It will be assumed that the recharge will be accomplished using near surface methods, such as flooded recharge basins or utilization of existing gravel quarries or other surficial features that could be utilized for this purpose. Simulated groundwater elevations assuming the implementation of several active recharge projects will be compared with the baseline simulation to quantify the benefits that could be realized by implementation of a successful recharge program in the area. The benefits of a particular recharge program will be evaluated by comparing both groundwater levels and the volume of groundwater in storage with and without the implementation of the project.

Deliverables from this task include a technical memorandum documenting the results of the geologic assessment as well as the model simulations performed to evaluate the potential benefits of the implementation of groundwater recharge projects in the area. The memorandum will include geologic cross-sections that show the thickness and distribution of aquifers in the area and the location of any potential perching layers that could impede groundwater flow. Maps of soil properties will also be presented to identify favorable locations for surface recharge sites. The results of the model simulations will be summarized by comparing maps of groundwater levels under current hydrologic conditions with those showing simulated groundwater levels forecast to occur with groundwater recharge facilities in operation. These comparisons will be made for several different recharge facilities with varying magnitudes of groundwater recharge capacity. Model output will also be used to compute the increase in the volume of groundwater in storage over time resulting from the operation of the recharge facilities. This data will also be used in the examination of the BMOs and GWMP and sensitive areas regarding monitoring for BMO compliance.

The investigation and installation of the potential recharge facility will be undertaken in a subsequent grant or local effort and is not part of this task.

Task Deliverables: The deliverable associated with this task will be a determination of the feasibility of constructing a viable recharge facility in the areas currently being considered also detailed maps of time predicted drawdown associated with 1) Current and projected changes in land and water use, 2) Benefits that can realized from additional surface water applications and the consequences of decreased surface water delivery.

Future proposals that may be developed by performing this task may be:

- Determine the annual demand for recharge water. The annual recharge demand will play a large part in defining the total area of basins within a project.
- Identify and quantify a source of water for recharge. This would include determining the volume and availability schedule of the water source as well as the quality of that source.
- Determine favorable locations where the infiltration capacity of the surface soils is high enough for recharge to be feasible
- Determine the fate of the recharged water after infiltrating the surface soils. This would include confirming that there will be sufficient volume in the unsaturated zone to accept the recharged water and that the recharged water will not flush salts or other contaminants into the deeper aquifers. In addition, the potential for impeding the downward flow of recharged water on low permeability perching layers needs to be evaluated.
- Determine the rise of groundwater levels that would occur due to recharge. As the recharged water reaches the water table, groundwater levels will rise until the rate of lateral groundwater flow away from the recharge area is equal to the rate of recharge at the surface.

Task 2: Monitoring Well Siting and Design

In an effort to remain consistent with previous investigations and with consultation of DWR Northern Region Office staff, the County has selected preliminary well locations on public lands or with landowners willing to participate. These preliminary locations are shown on **Figure 5.1** and will be finalized based on further coordination with DWR Northern Region Office staff and the landowners. Right-of-entry agreements (See **Attachment 5.2**, Draft Sample right-of-entry agreement) with the landowners will be completed.

Where applicable, the selected contractor will be responsible for any necessary public notification procedures, notification of the Underground Service Alert (Dig Alert) 48 hours before the start of drilling operations, site access and traffic controls for construction and monitoring, and responsibility for maintenance of monitoring facilities.

Monitoring well designs are based on the design as shown in **Figure 5.2** titled *Proposed Monitoring Well Design* and **Figure 5.3** *Surface Completion for Dedicated Monitoring Well*. The design will be prepared/reviewed by a consulting geologist and additionally reviewed by DWR Northern Region Office staff for consistency. Final monitoring well designs will be provided to the drilling contractor at the time of geophysical log interpretation. Based on the results of exploratory drilling and lithologic/geophysical logging, the County may modify the well design (screened interval and slot size) as deemed necessary by the staff field geologist. All monitoring well zones will be constructed with schedule 80, 2.5-inch nominal diameter polyvinyl chloride (PVC) casing, screen and end cap material. The conceptual design illustrates:

- Borehole diameter

- Screen and casing diameter
- Screen interval
- Seal depth and thickness
- Depth and thickness of transition sand, and
- Structure of surface completion

Task Deliverables

- Final design for multi-completion monitoring well.
- A map showing the final and potential site locations for the monitoring well, and completed right-of-entry agreements where applicable.

Task 3: Environmental Compliance and Permitting

The primary objective of this task is to prepare environmental compliance documentation and obtain permits required for the construction of a monitoring well. In compliance with the California Environmental Quality Act (CEQA) Glenn County staff will complete an appropriate level of environmental review prior to constructing the monitoring well. For purposes of this work plan it is assumed that CEQA compliance will not necessitate development of an Environmental Impact Statement/Environmental Impact Report (EIS/EIR), and that construction for the monitoring well is categorically exempt from such requirements. Documentation will be filed with the County Recorder and the State Clearinghouse where the documents will be made available for a 30-day public comment period. (See **Attachment 5.3**, CEQA Example)

Individual permits will be required for the construction of the monitoring well from the Glenn County Environmental Health Department.

Task Deliverables

- A statement of categorical exemption or a negative declaration for the monitoring well.
- Well permit(s) issued by the County.

Task 4: Well Drilling/Construction/Development/Instrumentation

The monitoring well will be drilled and constructed by a C-57, California State Licensed Well Drilling Contractor using the monitoring well design specified in Task 3. Similar to past monitoring well construction efforts in Glenn County, a qualified consulting geologist will provide onsite construction management services during the drilling and construction of the proposed monitoring well. Drilling and construction activities are expected to include:

- Testhole drilling/ Borehole drilling: All monitoring well will be drilled solely using direct mud rotary drilling techniques
- Geophysical logging: Samples will be collected for visual inspection every 10 feet during drilling and a suite of geophysical logs will be run on all boreholes (to include short and long normal resistivity, gamma, spontaneous potential logs, and caliper logs)
- Disposal of cuttings: it is assumed that mud and cuttings will be disposed of on-site

- Monitoring well construction and geologic oversight
- Monitoring well development consistent with DWR (state) and local standards
- Construction of above ground surface well completions: The completion will consist of a lockable standpipe of special design on a 4ft x 4ft x 6 inch concrete pad with four (4) traffic bollards around the completion
- When completed, well will be equipped with continuous data loggers (See **Figure 5.4**)

Task Deliverables

- Copies of field logbook entries
- Copies of construction documentation
- Copies of inspection documentation

Task 5: Prepare Monitoring Well Completion Data Transmittal

The County will direct the consulting geologist to prepare and submit to DWR a Monitoring Well Completion Data Transmittal detailing the activities during monitoring well drilling, construction, and development. The transmittal will include the following items:

- Summary documentation of major activities
- Lithologic log prepared from descriptions of drill cuttings
- Geophysical logs
- Well development data
- As-built well construction diagrams, and
- Locations where data loggers are placed
- Well Completion Report
- Information necessary for CASGEM database

Task Deliverables

- Monitoring Well Completion Data Transmittal
- State well number
- Permit number
- Date of installation
- Drilling method

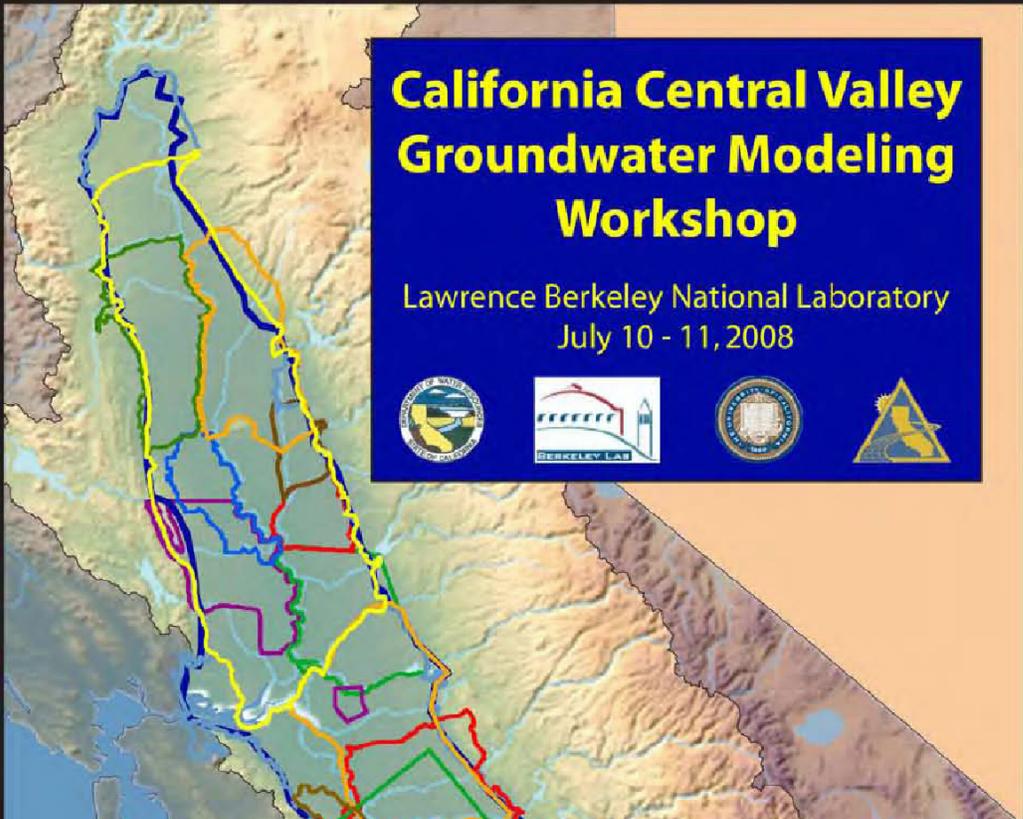
Task 6: Project Management and QA/QC

The County will communicate with DWR regarding project status throughout the preparation of monitoring well design and during construction. DWR will be provided an opportunity to review and comment on all project deliverables. Progress reports will be submitted to DWR quarterly. The progress reports will include a summary of activities for the last quarter, activities for the upcoming quarter, and a review of budget and schedule. The final project documentation and all data collected will be submitted to DWR in written and electronic format at the conclusion of the project.

County of Glenn/Colusa Basin Drainage District
Modeling/Monitoring
July 13, 2012 LGA Grant Application

Task Deliverables

- Agendas and minutes for all meetings focused on this project
- Quarterly progress reports to DWR
- Consistency with Budget and Schedule
- Final Report



California Central Valley Groundwater Modeling Workshop

Lawrence Berkeley National Laboratory
July 10 - 11, 2008



SACFEM: A Land Use Based Transient Finite-Element Groundwater Flow Model of the Sacramento Valley

Peter Lawson, P.G., C.HG., Heather Perry, Lee G. Bergfeld, P.E., and Walter Bourez, P.E.

A finite-element groundwater flow model of the Sacramento Valley has been developed, linking a relatively high resolution groundwater flow model (89,000 surface nodes, 7 layers) with an external surface water budgeting tool to provide transient surface water budget terms. Monthly estimates of the deep percolation of applied water and precipitation were computed according to current land use, crop type, location, and water year type. Agricultural pumping quantities were computed as the difference between applied water demand and available surface water for irrigation. The linked models can be used to compute well-field-scale impacts on groundwater levels and surface water flows due to groundwater substitution and conjunctive water management type projects.

Introduction

Implementation of conjunctive water management within the Sacramento Valley is one strategy being used to enhance the reliability of the existing water supply, as well as potentially improve water quality, within the San Francisco Bay Delta. However, the operation of conjunctive water management, or groundwater substitution projects, can result in adverse impacts on water resources within the valley. The two most critical potential impacts of additional groundwater production are depression of local groundwater levels, with associated impacts on well yields from nearby water supply wells, and changes in the hydraulic relationship between the surface water and groundwater systems in the area. To support the evaluation of these potential impacts, a high-resolution, numerical groundwater modeling tool was developed to estimate the impacts of potential future conjunctive water management projects on surface water and groundwater resources within the Sacramento Valley. Specific objectives of the modeling effort included the following:

Development of a regional-scale, water-budget-based numerical model covering the Sacramento Valley Groundwater Basin. This model will utilize a transient surface water budget based on land use, water district operations, cropping patterns, surface water availability,

and required supplementary groundwater pumping to meet agricultural demands.

Quantification of the transient impacts to streams resulting from the implementation of various alternative conjunctive water management projects within the northern Sacramento Valley.

Calculation of transient valley-wide and project-specific drawdown in groundwater levels resulting from the implementation of various water management projects.

Consideration of the effects of operating conjunctive water management projects in both wet and dry hydrologic periods, and the effects of operating projects only in certain selected years within a longer hydrologic period.

Model Code Description

MicroFEM© (Hemker, 1997), an integrated groundwater modeling package developed in The Netherlands, was chosen to simulate the groundwater flow systems in the Sacramento Valley Groundwater Basin. The current version of the program (3.60) has the ability to simulate up to 25 layers and 250,000 surface nodes. MicroFEM© is capable of modeling saturated, single-density groundwater flow in layered systems. Horizontal flow is assumed in each layer, as is vertical flow between adjacent layers.

MicroFEM© was the chosen modeling platform for both basins for the following reasons:

- The finite-element scheme allowed the construction of model grids covering large geographic areas (over 5,955 square miles in the Sacramento Valley Groundwater Basin) with coarse node spacings outside of the simulated project areas and finer node spacings in areas of interest (e.g., near potential project areas). The finer node spacing near simulated production wells provides greater resolution of simulated groundwater levels and stream impacts.
- The graphical interface allows rapid assignment of aquifer parameters and allows proofing of these values by graphical means.
- The flexible post-processing tools allow rapid evaluation of transient water budgets for model simulations and identification of changes to stream discharges and other water fluxes across the model domain.

SACFEM Model Development

Spatial Grid

The Sacramento Valley Groundwater Model grid consists of 88,922 nodes and 177,095 elements. Nodal spacing varies from as large as 5,800 feet (1,750 meters) near the model boundary to as small as 500 feet (150 meters) in areas where groundwater production is simulated (Figure 1). The finer spacing in these areas of interest allow for more refined estimates of the groundwater levels and the magnitude of groundwater/surface water interaction that would occur due to project pumping. The model boundary represents the extent of the fresh water aquifer in the Sacramento Valley.

Vertical Layering

The total model thickness represents the thickness of the fresh water aquifer (less than 3,000 micromhos) as defined by Berkstresser (1973) and subsequently refined in the northern portion of the valley by the California Department of Water Resources (DWR) (DWR, 2002). For the southern portion of the model area, defined by Berkstresser data, elevation contour lines of the base of fresh water, along with information from boring locations (point measurements of the elevation of the base of fresh water), were used to define the elevation of the base of fresh water. For the northern portion of the model area, the depth to fresh water defined on DWR geologic cross-sections was utilized. These data sets were then merged to yield a single interpretation of the structural contour map of the base of fresh water across the Sacramento Valley.

Total Aquifer Thickness

To develop a total aquifer thickness distribution, and therefore a total model thickness distribution, it was necessary to develop a groundwater elevation contour map and then subtract the depth to the base of fresh water from the groundwater elevation contour map. As will be discussed in more detail below, the water level calibration targets for this groundwater modeling tool are the steady-state groundwater heads measured in calendar year 2000. Therefore, to develop a target groundwater elevation contour map, all available groundwater elevation measurements in the DWR Water Data Library were obtained from DWR central and northern district staff. These measurements were primarily collected bi-annually, during the spring and fall periods, and these values were averaged at each well location to compute an average water level at each well point. These values were then contoured, in conjunction with the streambed elevations for the 37 major streams included in the model, to develop a target groundwater elevation contour map for the year 2000. As described above, the distribution of the elevation of the base of fresh water was subtracted from this groundwater elevation contour map to yield an estimate of the distribution of the total aquifer thickness across the model domain.

Model Layer Thickness

Layers 1 through 5 represent shallower producing zones within the valley. The thicknesses of these layers were assigned based on a specified percentage of the available aquifer thickness at a given location, to provide multiple depth zones within which to assign regional pumping. The assumed layer thicknesses for Layers 1 through 5 were also selected to reflect typical screened intervals of production wells in the Sacramento Valley. Layer 1 represents approximately 6 percent of the total aquifer thickness, except along certain portions of the model perimeter where the total aquifer thickness becomes very small. In these areas, Layer 1 thickness was increased to up to 24 percent of the total aquifer thickness to improve numerical stability of the flow calculation. The thicknesses of Layers 2 through 4 each represent approximately 10 percent of the total aquifer thickness, and the thickness of Layer 5 represents approximately 15 percent of the total aquifer thickness. Layers 6 and 7 represent the Lower Tuscan aquifer, where present, or the lower Tehama Formation. These two layers represent the remaining thickness of the fresh water aquifer in the model.

Boundary Conditions

A combination of head-dependent, specified flux, and no-flow boundary conditions were used to simulate the groundwater flow system within the Sacramento Valley. Each of these boundary conditions will be discussed in more detail below.

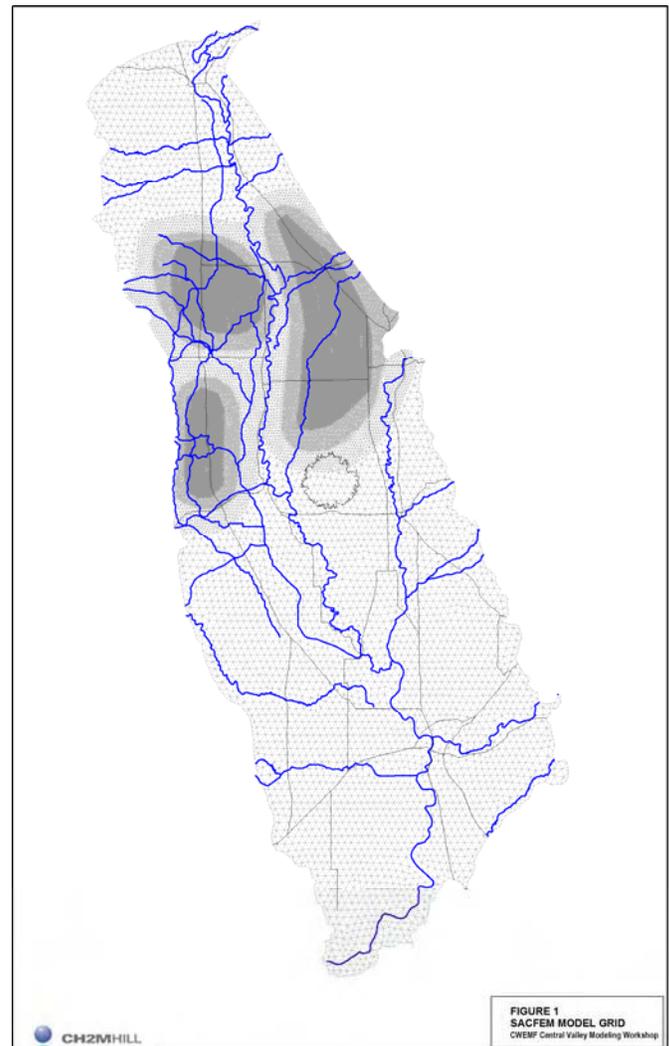


Figure 1. SACFEM model grid.

Head-Dependent Boundaries

A head-dependent boundary condition was chosen to simulate the streams within the Sacramento Valley. The MicroFEM© wadi system was used to implement streams within the model domain.

MicroFEM©'s wadi package calculates the magnitude and direction of nodal fluxes based on the relative values of the user specified stream stage and the calculated head in the upper aquifer, but is limited by a critical depth. When calculated groundwater elevations fall below this critical depth, it is assumed that the water table decouples from the river system, and the leakage rate from the river to the aquifer becomes constant.

Most major streams in the Sacramento Valley were included in the groundwater flow model. A total of 37 streams are represented. Stream locations and elevations were digitized from existing base maps and U.S. Geologic Survey (USGS) topographic quad sheets and imported into the model domain. Stream length within a given node is a grid-dependent variable calculated by MicroFEM© at each river node.

Specified Flux Boundaries

There are two sets of specified flux boundaries used in the SCAFEM model. The first set reflects aurally distributed stresses applied to every node within the model domain. These include: deep percolation of precipitation, deep percolation of applied water, agricultural groundwater pumping, and urban groundwater pumping. The deep percolation flux values were applied to surface nodes located in Layer 1. The pumping stresses due to agricultural and urban groundwater production are applied to nodes within Layers 2 through 4 of the SCAFEM model, with pumping quantity apportioned between the layers based on relative layer transmissivity. Layers 2 through 4 were chosen for agricultural pumping because these layers represent a depth interval of between 200 and 500 feet below ground surface, which is the depth at which a significant quantity of the regional agricultural pumping across the valley occurs. The spatial distribution and magnitudes of these specified flux boundaries were derived from the surface water budget calculations described in the Surface Water Budget section below.

The second set of specified flux boundaries represent aurally distributed stresses applied to surface nodes located along the SCAFEM model boundary. The subsurface inflow of precipitation falling within the Sacramento River watershed but outside the extent of the model domain, mountain front recharge, was estimated for streams not explicitly simulated in the SCAFEM model. To estimate these flux values, the USGS 10-meter Digital Elevation Model (DEM), along with existing hydrography Geographic Information System coverages for the Sacramento Valley, were used to delineate the drainage areas for these tributary streams. It is these watershed areas that can contribute water to the model domain but are not accounted for in the wadi boundary conditions defined in the model. Once the extent of these watershed areas were defined, they were intersected with PRISM (Daly et al. 2008) rainfall data using Geographic Information System tools, and the volume of precipitation falling on the watershed computed. Based on the computed total volume of precipitation, the deep percolation to the groundwater system was calculated using the empirical relationship developed by Turner (1991). The computed annual deep percolation volume (converted to a flux) was then imposed at the model boundary coincident with the drainage area of interest.

No-Flow Boundaries

A no-flow boundary was specified across the bottom boundary of the model, representing the fresh water/brackish water interface.

Surface Water Budget

One of the most critical components to the successful operation of the SCAFEM model is the computation of the transient surface water budget components. These water budget components were

estimated based on a variety of spatial information including land use, cropping patterns, source of irrigation water, surface water availability in different year types and locations, and the spatial and temporal distribution of precipitation.

A root zone model is used to track soil moisture accounting and calculate monthly requirements for applied irrigation water and quantities of deep percolation that recharge the underlying aquifer. DWR extracted the root zone component of their Integrated Water Flow Model (IWFEM) to simulate the physical processes of the root zone in a stand-alone model. The IWFEM Demand Calculator (IDC) combines data on precipitation, land use, crop evapotranspiration, irrigation efficiencies, and soil parameters to simulate the root zone and calculate a time-series of applied water requirements and deep percolation. These calculations were performed for each node in SCAFEM based on the land use mix within the individual nodes. The quantity of deep percolation estimated by the IDC model was modified during the calibration process to improve agreement between simulated and measured groundwater levels across the valley. These calibration adjustments are described more completely in the Model Calibration section of this document. These refined monthly estimates of deep percolation of applied water and precipitation at each model node were used as specified flux boundary conditions for the SCAFEM model.

Applied water demands for each node are evaluated based on the location of the element, computing whether the element falls within a water district with known water rights and availability for a given water year type, or outside of a district in areas known to be irrigated from groundwater. The availability of surface water in a given month of a given year type is then determined for each element. In areas where the source of irrigation water is groundwater only, or mixed source, the crop demand is compared to the availability of surface water for irrigation. Any deficit in available surface water to meet crop requirements is assumed to be provided by agricultural pumping. The spatial and temporal distribution of this agricultural groundwater production, estimated on a nodal basis by this methodology, was implemented in the SCAFEM model as a specified flux boundary, as described above.

The final component of the water budget that required estimation was the quantity of urban pumping. The population data from the year 2000 census were used to estimate urban groundwater pumping quantities for all cities within the model domain that rely on groundwater as a drinking water source and have populations greater than 5,000. It was assumed that urban pumping in communities with a population of less than 5,000 was insignificant compared to the agricultural pumping that occurs in those areas. A per capita water use estimate of 200 gallons per capita per day was applied to the census population data to estimate pumping quantities for each city. The total estimated urban groundwater demand for each city was apportioned to all nodes falling within the city municipal boundaries based on relative nodal area. During the calibration process, it was necessary to increase the per capita water use factor for both the Chico and Sacramento urban areas. These higher per capita use rates resulted in significant improvement in the match between simulated and observed groundwater levels in these areas.

Aquifer Properties

The distribution of aquifer properties across the Sacramento Valley is poorly understood. In certain areas with significant levels of groundwater production, the collection of aquifer test data, and the measurement of historic groundwater level trends in response to known groundwater production rates has provided valuable information on aquifer properties. However in the majority of the valley, these data are not available.

To estimate the spatial distribution of aquifer properties across the model domain for this numerical modeling effort, a database of well productivity information was used. In consultation with DWR staff, a database was obtained that included all of the pump efficiency

testing data collected by Pacific Gas and Electric over the last several decades. When pump efficiency tests are conducted, the static groundwater elevation in the well along with the dynamic groundwater level at a known pumping rate is measured; typically while the well is operating at a rate that reflects normal operating conditions. These data were compiled along with well construction information for each production well to yield a representative data set of well productivity across the valley. Wells that did not have available construction data were omitted from further consideration.

The intent of the modeling analysis described herein is to simulate the operation of high productivity irrigation wells screened within the major producing zones in the valley to support conjunctive water management projects. Therefore, the aquifer properties that are of primary interest are those of the major aquifer zones tapped by large diameter irrigation wells. The well database described about was filtered to remove data obtained from tests on low yield or shallow domestic type wells. All test data from wells that reported a well yield below 100 gallons per minute (gpm) were eliminated from consideration as was the test data from wells with a total depth of less than 100 feet. The only exception to this second consideration was for wells located along the basin margins, where aquifers are thin, that reported what appeared to be valid test results. Data from these wells was considered as they were often the only data available in the basin margin areas. The total number of wells that remained in the database for consideration was approximately 1,000 wells.

Once the data set for consideration was finalized, the reported specific capacity data for each well was used to estimate an aquifer transmissivity for that location. The relationship used to estimate aquifer transmissivity was the following form of a simplified version of the Jacob non-equilibrium equation:

$$Sc = T/2000 \quad (1)$$

Where:

- Sc = specific capacity of an operating production well (gpm per foot of drawdown)
- T = aquifer transmissivity (gallons per day per foot)

Once a transmissivity estimate was computed for each location, the transmissivity value was then divided by the screen length of the production well to yield an estimate of the aquifer hydraulic conductivity. The final step in the process was to smooth the hydraulic conductivity field to provide regional scale information. Individual well tests produce aquifer productivity estimates that are local in nature, and may reflect small scale aquifer heterogeneity that is not necessarily representative of the basin as a whole. To average these smaller scale variations in the data set, a FORTRAN program was developed that evaluated each independent hydraulic conductivity estimate in terms of the available surrounding estimates. When this program is executed, each hydraulic conductivity value was considered in conjunction with all other values present within a user-specified critical radius, and the geometric mean of the available hydraulic conductivity values calculated. This geometric mean value is then assigned as the representative regional hydraulic conductivity value for that location. The critical radius used in this analysis was 10,000 meters, or approximately 6 miles. The point values obtained by this process were then kriged to develop a hydraulic conductivity distribution across the model domain.

Model Calibration

The calibration approach used to develop this modeling tool was significantly influenced by the resources available to fund the project. While a fully transient calibration approach, in which the model is used to replicate groundwater levels and flow conditions throughout some period of record, would be the more desirable approach, the resources were not available to fund such an effort. Instead, a more limited steady-state calibration approach was implemented. In a steady-state calibration process, the monthly water budget components for a selected period are averaged, and the model is calibrated to both

average groundwater levels and stream discharges that occur during the calibration period. The calibration selected for this effort was calendar year 2000, the most recent year for which water budget information is available that was characterized by average hydrologic conditions. A calendar year instead of a water year was used to facilitate the development of average groundwater elevation calibration targets. The available water level data was obtained from DWR, and much of that data is collected in the spring and the fall. If a water year was used, the cut-off between water years is the end of September, which coincides with the mid-point of the fall sampling event. The result would be that when average groundwater elevation values were calculated, some of the measurements would be from October of the previous year and some would be from September of the subsequent year, which would introduce error in the data set, especially if the year types were different. The use of a calendar year eliminates this potential for error.

Calibration Targets

Several quantitative and qualitative calibration targets were used in the calibration process. These calibration targets are:

- Average year 2000 groundwater elevations (257 wells used as calibration targets)
- Areas of gaining and losing streams (approximate)
- Approximate water budget quantities (order of magnitude comparison as no precise estimates are available)

Water Budget Modification

During the calibration process, it was anticipated that some adjustment to the water budget components computed using the methodology described above would be necessary to obtain an acceptable degree of calibration. A water budget analysis performed on the raw input data provided by the IDC root zone model, combined with simulated groundwater heads from model runs using that deep percolation data, suggested that the prescribed percolation rates in the north (Red Bluff area) and south (Davis/Woodland area) were too

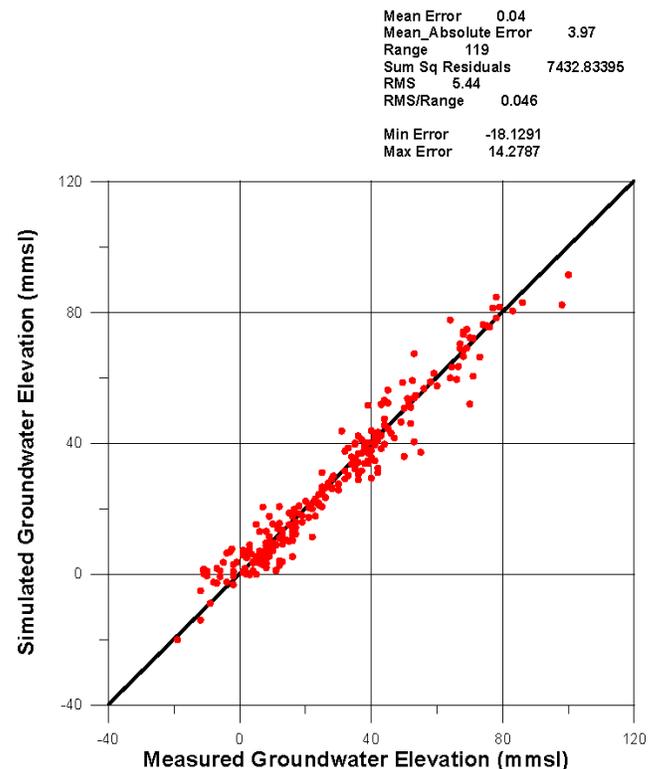


Figure 2. SACFEM calibration scattergram.

high. Percolation rates were reduced in these areas resulting in a significant improvement in calibration residuals.

Calibration To Groundwater Elevations

A scattergram, which plots the simulated versus the measured groundwater elevation at each target calibration well, is a graphical measure of the state of calibration. A plot of this type is shown on Figure 2. A perfect fit between simulated and observed groundwater elevations would plot as a 45 degree line (slope = +1.0, Y-intercept = 0). As can be seen in Figure 2, the model shows good agreement between simulated and observed groundwater levels. Another quantitative measure of calibration that is commonly used is to calculate the root mean square error (RMS) divided by the range of observations. As a rule of thumb, a well calibrated regional model will have an RMS/Range of less than 10 percent, and a well calibrated local scale mode will have an RMS/Range of less than 5 percent. The RMS/Range of the steady state calibration presented here is 4.6 percent, well below the 10 percent criteria.

Calibrations To Gaining And Losing Stream Segments

In the Sacramento Valley, a further qualitative calibration target is the identification of stream segments that are gaining flow through groundwater discharge versus losing flow to groundwater recharge. While the exact stream reaches that gain or lose flow due to surface water/groundwater interaction are not fully delineated, and this relationship changes seasonally with fluctuating groundwater levels and stream stages, the general pattern observed in the valley is that the major trunk streams such as the Sacramento, Feather, and American rivers tend to gain flow, while the smaller upper tributaries near the basin margin tend to lose flow to the groundwater system. The pattern predicted by the calibrated groundwater flow model is reasonably consistent with the generally accepted pattern described above. The calibrated model indicates the upper reaches of the Sacramento River gain flow from groundwater discharge, but further south in the Yolo-Zamora and Sacramento areas, the depressed groundwater levels result in the Sacramento River losing flow to the aquifer system. The model further suggests that the smaller tributaries to the Sacramento River lose flow in their upper reaches, and in many cases transition to gaining flow nearer their confluence with the Sacramento River, especially in the northern portion of the valley.

Calibration To Steady-State Water Budget

The magnitude of the water budget components derived from the steady-state calibration run are summarized in Table 1. While exact comparative estimates are not available for most of these components, rough estimates are. For example the 2002 calibration simulation estimates a combined 2.9 million acre-feet of groundwater pumping

within the model domain, which agrees reasonable well with the generally accepted value of between 2.5 and 3.0 million acre-feet of groundwater withdrawal in an average year. Similarly, while no independent estimates of the quantity of groundwater that discharges to the Sacramento River are available, given the average flows that are observed in the Sacramento River, an average value of 975 cubic feet per second of groundwater discharge seems reasonable.

Conclusions

The SACFEM model represents a new high resolution groundwater modeling tool to support the evaluation of various groundwater related projects within the Sacramento Valley. The surface water budgeting tool was constructed using detailed spatial information regarding water source, crop type, district water rights holdings, and soil moisture accounting to develop a node-specific (89,000 surface nodes) representation of deep percolation and agricultural pumping throughout the Sacramento Valley. The model grid has sufficient resolution (150 meters) to accurately depict well field scale effects due to the implementation of conjunctive water management projects, while the seven layer construction allows assignment of groundwater stresses to appropriate aquifer zones within the valley. Overall, the SACFEM model represents a significant contribution to the suite of modeling tools available for the Sacramento Valley offering coverage of the entire valley at higher resolution than is available with existing models of this scale.

References

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Table 1. Model Simulated Water Budget Components

	Acre-Feet	CFS
Recharge		
Deep Percolation of Precipitation	1,398,461	1,932
Deep Percolation of Applied Water	865,131	1,195
Mountain Front Recharge	495,507	684
Seepage from Streams to Groundwater	816,848	1,128
Total Recharge	3,575,947	4,939
Discharge		
Agricultural Pumping	2,417,506	3,339
Urban Pumping	451,507	624
Groundwater Discharge to Streams	705,999	975
Total Discharge	3,575,012	4,938

WATER ADVISORY COMMITTEE
Glenn County Department of Agriculture

() Exploration () Survey () Construction () Monitoring

Project Name: _____ Parcel No.: _____

TEMPORARY ENTRY PERMIT and LICENSE

The undersigned PERMITTOR hereby grants permission to the Water Advisory Committee/Glenn County Department of Agriculture, hereinafter referred to as PERMITTEE, and its officers, employees, agents and contractors, to enter, with all necessary equipment, upon PERMITTOR's land in the County of Glenn, State of California, described as that portion of Assessor's Parcel No. _____, and marked on the attached map, for the purpose of installing a monitoring well, installation of appurtenances, and for such other incidental purposes as may be required, subject to the following provisions:

1. Reasonable precautions will be exercised to avoid damage and protect persons or property.
2. PERMITTOR assumes no liability for loss or damage to property or injuries to or deaths of agents, contractors or employees of PERMITTEE by reason of the exercise of privileges given under this permit.
3. Nothing in this permit shall preclude PERMITTOR from filing a claim(s) with the County of Glenn for any loss or expense which PERMITTOR or its tenant may suffer caused by or due to exercise by PERMITTEE of the rights granted by this permit.
4. PERMITTEE agrees to indemnify and hold PERMITTOR harmless from any damage caused by PERMITTEE's activities authorized by this permit. PERMITTEE agrees also to either reimburse PERMITTOR for any damage to PERMITTOR's roads and fences, or other property, occurring by reason of the exercise of rights granted herein, or to replace or restore said property.
5. Motorized vehicle access will be limited to existing roads. PERMITTOR'S authorization under this provision does not relieve PERMITTEE from any liability or obligation of indemnity under any other provision herein.
6. The Water Advisory Committee will provide telephone notice of intent to access the property at least 48 hours prior to such access. The PERMITTOR should respond immediately with any concerns or request for postponement.
7. The initial term of this permit shall expire upon completion of the well installation to the satisfaction of the County. Thereafter, the property owner grants a license to the permittee for the purpose of monitoring and maintenance in accordance with the Glenn County Groundwater Management Plan. The license will be reviewed and renewed on a no less than five (5) year basis.

PERMITTOR'S Name and Address: _____

Recommended for Acceptance: _____

ACCEPTED:
Water Advisory Committee/
Glenn County Department of Agriculture

Phone No. _____

Signature _____ Date _____

Signature _____ Date _____

CONSENT OF TENANT (S)

We, the Tenants of land described in this Temporary Entry Permit and License are under lease with Lessor, whose name is subscribed to this contract as PERMITTOR, do hereby consent to the execution of said Temporary Entry Permit and License and agree that all reimbursements shall be paid to said PERMITTOR as herein set forth.

Date _____

Attachments: 1. Map

County of **Glenn**

Mark D. Black, Agricultural Commissioner
Sealer of Weights & Measures

Department of Agriculture

Jean S. Miller, Assistant Agricultural Commissioner
Sealer of Weights & Measures

Date: May 28, 2007

To: Colusa Basin Drainage District
ATTN: Gene Massa
P.O. Box 390
Willows, CA 95988

From: Glenn County Department of Agriculture
P. O. Box 351
720 N. Colusa Street
Willows, CA 95988

RE: Notice of Exemption for Dedicated Monitoring Well

The project involves the installation of one multi-completion groundwater well by Glenn County in cooperation with the Colusa Basin Drainage District. The well will be located south Wilson Creek in Glenn County. The project purpose is basic data collection related to groundwater monitoring and recharge.

Enclosed is a filed exemption for such projects in the County and a site specific project description.

If you have any questions concerning this project, please contact me at (530) 934-6501 or at wateradv@countyofglenn.net.

Sincerely,

Lester Messina
Water Resources Coordinator

Attachment 1: Notice of Exemption
Figure 1: Site Map

720 N. Colusa Street
P.O. Box 351
Willows, CA 95988

Phone: (530) 934-6501
Fax: (530) 934-6503
Email: agcommr@countyofglenn.net

ATTACHMENT 1

NOTICE OF EXEMPTION

To: Colusa Basin Drainage District
ATTN: Gene Massa
P.O. Box 390
Willows, CA 95988

From: Glenn County Department of Agriculture

Project Title: Dedicated Monitoring Well Installation

Project Location: Glenn County (see attached figure)

Project Location: Specific location: ½ mile south of County Road 35, east of County Road D
Section 7, T 20 N, R 3 W

Description of Nature, Purpose, and Beneficiaries of Project:

The construction portion of proposed project will involve the drilling of a test hole to at least 1000 feet. Required permits have been secured. After the bore hole is e-logged, a construction design will be decided which will incorporate at least four screened intervals to capture specific aquifer properties. Drilling and construction will take place in May/June 2007. No improvements to site access will be required. No sump excavation will be required. With landowners permission all drill wastes (rock cuttings and inert bentonite clay) will be spread and left on-site upon well completion. A small 5-foot by 5-foot concrete pad with protective steel bollards will be installed over the monitoring well to protect the well head.

Potential site impacts include minor disturbance of the ground surface within and adjacent to the drill location and a temporary increase in noise levels during drilling and installation of the well. Once the well is completed, it will be used for monitoring of groundwater levels with continuous level loggers. No impacts associated with monitoring of these wells have been identified.

The project purpose is basic data collection related to groundwater production, recharge, and long-term ground water level fluctuations. Project beneficiaries include the Colusa Basin Drainage District, Glenn County, California Department of Water Resources, the Bureau of Reclamation, local water districts, and all Glenn County water users.

Name of Public Agency Approving Project: Glenn County Planning Division, #2001-07

Name of Person or Agency Carrying Out Project: Glenn County Department of Agriculture for the Glenn County Water Advisory Committee

Exempt Status: Categorical exemption for basic data collection (Section 15306)

Reasons Why the Project Is Exempt: Section 15306 -basic data collection, research, experimental management, and resource evaluation activities, which do not result in a serious or major disturbance to an environmental resource.

Contact Person:

Signature: _____

SAMPLE

