Memorandum

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Date: June 29, 2018

Re: Expert Panel Review of Version 1.0 of the
Ventura Regional Groundwater Flow Model (VRGWFM)
(Ventura County, California)

1.0 Introduction

The United Water Conservation District (UWCD) has developed a numerical groundwater flow model of a series of interconnected groundwater basins in Ventura County, California where UWCD is charged with managing, protecting, conserving, and enhancing the region's water resources. The model, which is called the Ventura Regional Groundwater Flow Model (VRGWFM) currently simulates groundwater flow in the Oxnard Plain, Oxnard Forebay, Pleasant Valley, West Las Posas, and Mound groundwater basins. UWCD identifies this model as Version 1.0 of the VRGWFM, and has documented the model's development in a report being issued concurrently with this memorandum (UWCD, 2018). Later versions of the model will be issued that will add three other adjoining basins (Santa Paula, Fillmore, and Piru). Figure 1 shows the extent of the model grid, the locations of the groundwater basins described above, and the locations of three other adjoining groundwater basins (East Las Posas, South Las Posas, and Arroyo Santa Rosa) that lie outside of UWCD's jurisdictional area.

The VRGWFM has been developed to provide a new management tool to guide future policy decisions regarding groundwater management at local and regional scales and potentially in various aquifers or groups of aquifers. Among the many anticipated uses of the model is the analysis of groundwater budgets and management alternatives during the development of

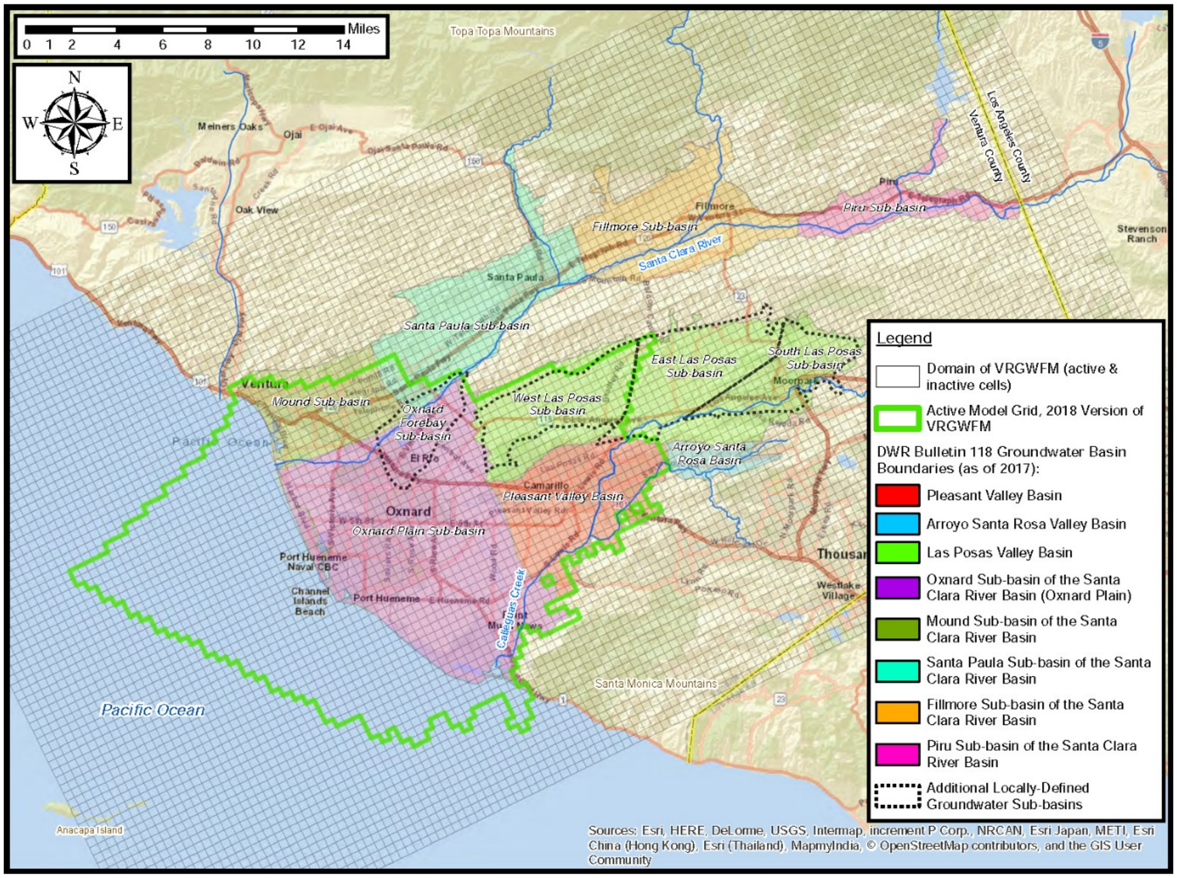

Figure 1. Ventura Regional Groundwater Flow Model Domain (map prepared by United Water Conservation District)

Groundwater Sustainability Plans (GSPs) for the Oxnard and Pleasant Valley groundwater basins, as required under the State of California's Sustainable Groundwater Management Act (SGMA). Aspects of GSP development and implementation that are anticipated to make use of the model include (1) establishing sustainability goals and criteria in critical regions of the local groundwater basins and (2) developing numerical thresholds for evaluating compliance with the goals and criteria during the ensuing 20-year period for implementing each GSP.

UWCD has retained the services of an expert review panel consisting of the three groundwater modeling consultants who are the co-authors of this memorandum. Working individually and collectively, this panel has conducted a review of the model's construction, calibration, and simulation performance, with a focus on evaluating (1) the suitability of the overall modeling approach and model design to meet the GSP objectives, (2) the conceptualization, construction, and simulation techniques by which the geologic and hydrologic attributes of the multi-aquifer groundwater system are represented in the model, and (3) the quality of the model's calibration. The panel also has considered the model's suitability for a variety of anticipated future uses, as well as potential limitations on its use.

The panel's review effort began in March 2016, and a first comprehensive review of the model was issued by the panel in June 2016 (GSI Water Solutions and others, 2016). Several rounds of model revisions by UWCD and subsequent reviews by the panel occurred during the ensuing two years, leading to UWCD's issuance of the model development report (UWCD, 2018) and the panel's issuance of this memorandum. UWCD has implemented many of the expert panel's suggestions and recommendations and plans to further refine the model as needed to support future specific applications of the tool. Accordingly, this memorandum provides a summary of the panel's evaluation of Version 1.0 of the model as documented in the model development report (UWCD, 2018), with the recognition that the model is likely to evolve through a series of refinements as it is applied to specific projects and planning efforts in the region.

In summary, the expert panel finds the model to be a well-designed and well-calibrated tool, and a tool that is a substantial enhancement and upgrade over previously available tools. Version 1.0 of the VRGWFM provides a newly robust and detailed method of evaluating how the multiple aquifers in the region behave and how they might respond to the design and implementation of specific regional management programs and specific projects in the five groundwater basins that the model currently simulates in southern Ventura County.

Groundwater models commonly contain a very large amount of data and can be extremely complex. This model is no exception, and in some respects is more complicated and detailed than other regional-scale or locally-focused groundwater models. While the review team has spent considerable time working with the model and discussing its underlying assumptions with UWCD, future reviews of the model's applications and its expansion into the groundwater basins of the Santa Clara River Valley may turn up further recommendations and suggested changes to the model.

This memorandum is organized into six sections as follows:

- Introduction (Section 1)
- Descriptions of the model and the model development process (Section 2)
- The expert panel's evaluation methods and activities (Section 3)
- The expert panel's assessment of the model's calibration quality (Section 4)
- The model's uses and potential enhancements (Section 5)
- A list of reference documents cited in this memorandum (Section 6)

2.0 Model Description and the Model Development Process

2.1 Model Description

The current version of the model uses 13 layers to simulate the groundwater resources of southern Ventura County. The current model layering, which was expanded from 8 layers to 13 layers in early 2016, is shown in Figure 2. In general, the layering in the current model is as follows:

Model Layer	Mound Basin	Forebay area	Oxnard Plain Basin	Pleasant Valley Basin	West Las Posas Sub-basin
1	Shallow alluvial aquifer	*layer inactive*	Semi-perched Aquifer	Semi-perched Aquifer	Shallow alluvial aquifer
2	Fine-grained Pleistocene deposits (Layers 2 through 4)	*layer inactive*	Clay Cap	Clay Cap	Layers 2 through 5 are each 1 foot thick in this basin, and assigned similar properties as the shallow alluvial aquifer
3		Oxnard Aquifer	Oxnard Aquifer	Oxnard Aquifer	
4		Oxnard-Mugu Aquitard	Oxnard-Mugu Aquitard	Oxnard-Mugu Aquitard	
5	Mugu Aquifer	Mugu Aquifer	Mugu Aquifer	Mugu Aquifer	
6	Mugu-Hueneme Aquitard	Mugu-Hueneme Aquitard	Mugu-Hueneme Aquitard	Mugu-Hueneme Aquitard	unnamed aquitard
7	Hueneme Aquifer	Hueneme Aquifer	Hueneme Aquifer	Hueneme Aquifer	Upper San Pedro Formation (Layers 7 and 8)
8	Hueneme-Fox Cyn Aquitard	Hueneme-Fox Cyn Aquitard	Hueneme-Fox Cyn Aquitard	Hueneme-Fox Cyn Aquitard	
9	Fox Cyn-main Aquifer	Fox Cyn-main Aquifer	Fox Cyn-main Aquifer	Fox Cyn-main Aquifer	Fox Cyn-main Aquifer
10	Mid-Fox Cyn Aquitard	Mid-Fox Cyn Aquitard	Mid-Fox Cyn Aquitard	Mid-Fox Cyn Aquitard	Mid-Fox Cyn Aquitard
11	Fox Cyn-basal Aquifer	Fox Cyn-basal Aquifer	Fox Cyn-basal Aquifer	Fox Cyn-basal Aquifer	Fox Cyn-basal Aquifer
12	*layer inactive*	*layer inactive*	Fox-Grimes Aquitard	Fox-Grimes Aquitard	Fox-Grimes Aquitard
13	*layer inactive*	*layer inactive*	Grimes Canyon Aquifer	Grimes Canyon Aquifer	Grimes Canyon Aquifer

Note: *This diagram is conceptual, and does not reflect all of the details incorporated in the VRGWFM regarding changes in thickness or character of hydrostratigraphic units occurring in each basin or area.*

Figure 2. Conceptual Diagram Illustrating Relationships between Model Layers and Hydrostratigraphic Units (prepared by United Water Conservation District)

- The upper two layers of the model simulate the semi-perched aquifer and aquitard respectively.
- Model layers 3 and 5 simulate the Oxnard and Mugu aquifers, which together comprise the Upper Aquifer System (UAS).
- Model layers 7, 9, 11, and 13 simulate the Hueneme Aquifer, the upper and basal portions of the Fox Canyon Aquifer, and the Grimes Canyon Aquifer, respectively, which together represent the Lower Aquifer System (LAS).
- The intervening layers (model layers 4, 6, 8, 10, and 12) simulate the aquitards that lie between the primary aquifers of the UAS and LAS.

The model currently simulates the Oxnard Plain, Oxnard Forebay, Pleasant Valley, West Las Posas, and Mound groundwater basins, which have been the focus of calibration efforts to date. Certain outer boundaries of the active model domain have been extended beyond these five basins to reflect the locations of natural hydrologic boundaries, rather than simply the boundaries of the groundwater basins themselves (to avoid creating artificial boundaries and artificial numerical effects on the model). For example, the model extends offshore to simulate the submarine water exchanges with offshore outcrop areas for each principal aquifer system. Also, the model includes a small portion of the Santa Paula basin to account for groundwater exchanges across the northern limits of the Oxnard Plain and Forebay and with the Santa Clara

River (which meanders across these basin boundaries). UWCD has stated that it intends to soon begin a second phase of model development that will extend the model upstream along the Santa Clara River, to include the entire Santa Paula basin plus the Fillmore and Piru basins.

The model uses the MODFLOW-NWT groundwater modeling software (Niswonger and others, 2011) and has been imported into Version 7 of the Groundwater Vistas graphical user interface (ESI, 2017) by the expert panel. The model uses a uniform grid of square cells that are 2,000 feet long on a side. The model grid is oriented at North 26° West to align the model's principal axes with the dominant flow directions along the ocean shore and along the Santa Clara River.

UWCD is also considering the use of the MODFLOW-USG software (Panday and others, 2013) as recommended by the panel. MODFLOW-USG allows nested grids to be inserted into localized areas in the model and turned on and off as needed, according to the needs of future studies requiring predictive simulations with the model. This allows refined grids to be developed only where needed, which avoids creating finer grid spacing throughout the model and thereby reduces run-times and file sizes. Also, only one model needs to be maintained instead of separate models that have fine and coarse grid sizes. Additionally, the use of MODFLOW-USG allows multi-layer wells to be represented fully implicitly (as connected linear networks [CLNs]) and allows lateral pinch-outs of hydrostratigraphic units to be explicitly modeled (to better honor the geology and provide more robustness to the simulation). Initial testing of the VRGWFM by the panel indicates that model run times and file sizes may be improved by moving the model into the MODFLOW-USG environment in the future.

2.2 Summary of the Model Development Process

UWCD developed the model by conducting four core activities during the course of the nearly 5-year period that became necessary to develop this detailed tool:

- **Step 1: Development of the Conceptual Model.** This effort focused on developing the detailed hydrostratigraphic unit (HSU) model that defines the number of aquifers and aquitards; developing the elevation surfaces of the lithologic contacts for the top and bottom of each HSU across the region; defining the locations and offsets of faults and the outer bedrock boundaries of each aquifer system; and defining the offshore extent of each aquifer and aquitard, including the locations of two submarine canyons along the coast. In addition to the hydrostratigraphic model, the conceptual model identifies groundwater recharge and discharge processes and provides estimates of the magnitudes of those processes, as understood from both the numerical model development work and the various independent data sources that were available to UWCD. See Section 2 of the model development report (UWCD, 2018) for details.

- **Step 2: Construction of the Numerical Model.** UWCD selected the modeling platform (software), which consists of the MODFLOW family of groundwater flow models and specifically uses a version of MODFLOW (MODFLOW-NWT; Niswonger and others, 2011) that was developed to provide more accurate and robust solution methods for simulating (where needed) the drying and rewetting of aquifer layers in response to the temporal variation of groundwater recharge and discharge processes. UWCD also selected Groundwater Vistas (ESI, 2017) as the graphical user interface for visualizing and managing the development of the numerical model. Model construction then involved selecting the MODFLOW packages that would be required, and estimating and programming the values of aquifer parameters, boundary conditions, and the multiple hydrologic processes that affect groundwater flow (aerially-distributed recharge from precipitation and from anthropogenic uses of water; recharge of surface water runoff that flows to the margins of the aquifer system from upstream contributing watersheds; subsurface lateral inflows from some – though not all – adjoining groundwater basins; recharge from, and discharge to, streams that lie within the model domain; capture of shallow groundwater by tile drains in agricultural areas; evapotranspiration by deep-rooted phreatophytes along stream channels and in wetlands; groundwater and sea water fluxes along the offshore outcrops for each aquifer; and groundwater pumping from municipal and agricultural production wells (many of which are open to – and pump water from – multiple aquifers rather than from a single aquifer).

- **Step 3: Calibration of the Numerical Model.** UWCD has calibrated the model to historical conditions from 1985 through 2015. Hydrologic processes were varied monthly in the model during this 31-year time period. Using hydrographs and statistical methods, UWCD evaluated calibration quality by comparing on a monthly basis the simulated groundwater elevations and elevation changes with those observed in the field at various times at 639 wells. Approximately 500 of these wells are agricultural or municipal production wells, and the remaining wells are non-pumping observation wells installed at various times since the mid-1990s. For each individual well that was examined as part of the calibration process, a critical aspect of evaluating calibration quality was the selection of the model layer(s) that best represents the conditions at the well, as understood from the well's construction information, its usage, and the water level data collected over time at the well.

- **Step 4: Sensitivity Analysis.** As part of completing the final stages of the calibration process, UWCD also conducted a sensitivity analysis that involved performing more than 7,000 individual model simulations in which multiple adjustments were made to the values of (1) hydraulic parameters for the aquifers and fault systems and (2) the individual components of surface water recharge to the underlying aquifer systems. These adjustments were tested one change at a time, so that the model's sensitivity to each parameter and recharge term could be evaluated. See Section 4 of the model development report (UWCD, 2018) for details.

3.0 Expert Panel Evaluation Methods and Activities

At the beginning of its review (in the spring of 2016), the expert panel met with UWCD to discuss (1) UWCD's thoughts on its modeling progress and future model uses (including the objectives for the model, the development of the conceptual model, the approach to model construction and calibration, and UWCD's assessment of the model's calibration quality and readiness for future use), and (2) the plan and approach for the work to be conducted by the expert panel. This meeting was preceded by the panel members' review of key hydrogeologic references, including the prior regional model of the local aquifer systems (Hanson and others, 2003) and key reports on local hydrogeology (Mukae and Turner, 1975; Turner, 1975; Turner and Mukae, 1975; Brown, 2005), water quality (Izbicki, 1992; Izbicki and others, 2005), groundwater budgets (HydroMetrics and GSI, 2016a and 2016b), and groundwater conditions and management (FCGMA, 2014; ITRC, 2010; UWCD, 2014; VCWPD, 2015).

UWCD then provided the panel members with the MODFLOW input and output files, GIS shapefiles of model base maps, and post-processing files containing scatter plots and hydrographs from the monthly transient calibration simulation. At that time, the model did not include the West Las Posas basin (which was added to the model in 2017), and the calibration time period ended in December 2012 (which was later extended through December 2015). ESI imported the files for the March 2016 version of the model into Groundwater Vistas (GV) and conducted checks of the GV-generated files against those provided by UWCD. Each member of the expert panel conducted their own independent simulations and examined the model in detail to (1) verify appropriate numerical implementation of the conceptual model elements and (2) evaluate convergence and the numerical accuracy (including the mass balance) of the model. During its evaluation process, the panel focused its review on the following specific topics:

1. The model's areal extent, grid size, discretization, and orientation relative to true north
2. The model's layering and its representation of the conceptual hydrostratigraphic model
3. The time discretization for the 1985-2015 transient calibration simulation
4. The numerical convergence criteria and closure criteria
5. Aquifer parameters (spatial distribution and magnitudes)
6. Boundary conditions (types and implementation)
7. The implementation of transient stresses
8. The simulated groundwater budget produced by the 1985-2015 transient calibration simulation
9. The calibration data and the representativeness of the calibration period
10. The calibration results, the methods of evaluating calibration quality, and an assessment of spatial bias geographically and by layer
11. Consistency of the calibrated model (parameters and water budget results) with conceptual models
12. Sensitivity analysis and results

13. The overall applicability of the model for its intended purposes, and potential limitations on its use

The panel prepared a draft memorandum for UWCD in June 2016 (GSI Water Solutions and others, 2016), presenting the findings of its review of the model as it stood at that time, and also providing suggestions and recommendations for UWCD to consider implementing either as part of its continued model development efforts or after completion of Version 1.0 of the VRGWFM. While the panel concluded that the model was nearly ready for its intended uses, the panel also recommended that certain adjustments be made, including (1) localized refinements to the representation of flow in the Mound basin and the eastern portion of the Pleasant Valley basin; (2) activating the MODFLOW package that simulates evapotranspiration by deep-rooted phreatophytes; (3) refining the initial conditions for the transient simulation; and (4) reviewing various details of the simulation and calibration methods. UWCD and the panel discussed UWCD's progress with model revisions via phone and email during the ensuing two years, with day-long review meetings occurring in October 2017 and April 2018. New versions of the model also were provided to the expert panel members for their review during the 2-year period that followed the issuance of the June 2016 draft memorandum.

4.0 Assessment of Calibration Qualilty

As discussed in Section 1.0 of this memorandum, the expert panel finds Version 1.0 of the VRGWFM to be a well-designed and well-calibrated tool. During the course of its initial review during 2016 and subsequent phases of model review (in 2017 and 2018), the panel observed that the process of calibrating the VRGWFM is complicated by a number of factors. Specifically:

1. The multi-layered and faulted aquifer system is complex in structure, and the wells that penetrate these units commonly penetrate more than one aquifer system. Some wells penetrate 2 or 3 layers in the model, while other wells penetrate as many as 7 or 8 model layers. Accordingly, the water level measured in a well is the result of not only its use at the time the water level is measured, but also the large ambient (natural) differences in groundwater elevations that are commonly present in the Upper Aquifer System (UAS) versus the Lower Aquifer System (LAS).

2. As discussed in Section 2.2, the majority of the available groundwater elevation data are from production wells, with a small number (approximately 130) non-pumping observation wells also providing data for shorter time periods beginning in the mid-1990s or later. The production wells are simulated as pumping wells in the model, in order to simulate this important discharge term in the groundwater budget for each individual aquifer. Yet the water level data from these same wells consist almost exclusively of measurements that are made once a well has been off for a period of time. The use of these measurements in evaluating calibration quality is quite complicated and difficult to interpret, because (a) the hourly and daily operations of each well are unknown, and (b) the duration of time a well has been off before a water level

measurement is collected is unknown (and likely varies from well to well and over time at any individual well).

3. Large fluctuations in water levels occur in these wells because of changes in recharge and pumping. The magnitudes of both terms (recharge and pumping) can only be estimated from the available data sources, and therefore are not precisely known.

4. In the Oxnard Plain and much of Pleasant Valley, the regional aquifers that are the source of local groundwater supplies (the UAS and LAS) are overlain by a perched groundwater system. Many wells are available for calibrating the model in the UAS and LAS, but very few wells are present in the semi-perched aquifer system, thereby limiting the ability to conduct as detailed a calibration of the semi-perched aquifer system as can be done in the underlying regional aquifers.

Even with these many complexities, the expert panel concludes that Version 1.0 of the VRGWFM is very well calibrated. This assessment is based on our review of a version of the model that was provided to the panel in early 2018, for which the panel members evaluated the model's calibration both qualitatively and quantitatively. The qualitative analysis consisted of visual inspection of hydrographs prepared by UWCD, from which the panel identified the total number of wells with good versus poor matches in each groundwater basin and for the entire model domain. The quantitative assessment was accomplished by the panel using residual statistics for groundwater elevations, residual statistics of changes in groundwater elevations over time, and maps of the locations of the worst matches in each model layer (to look for any spatial bias in the locations of poorly matched wells).

Hydrographs provided by UWCD show field measurements and model-simulated water levels in each layer penetrated by the well. The panel reviewed 270 hydrographs to determine the number of good matches and poor matches. As an example of the visual inspections of each hydrographs, Figure 3 shows a good match while Figure 4 shows a poor match.

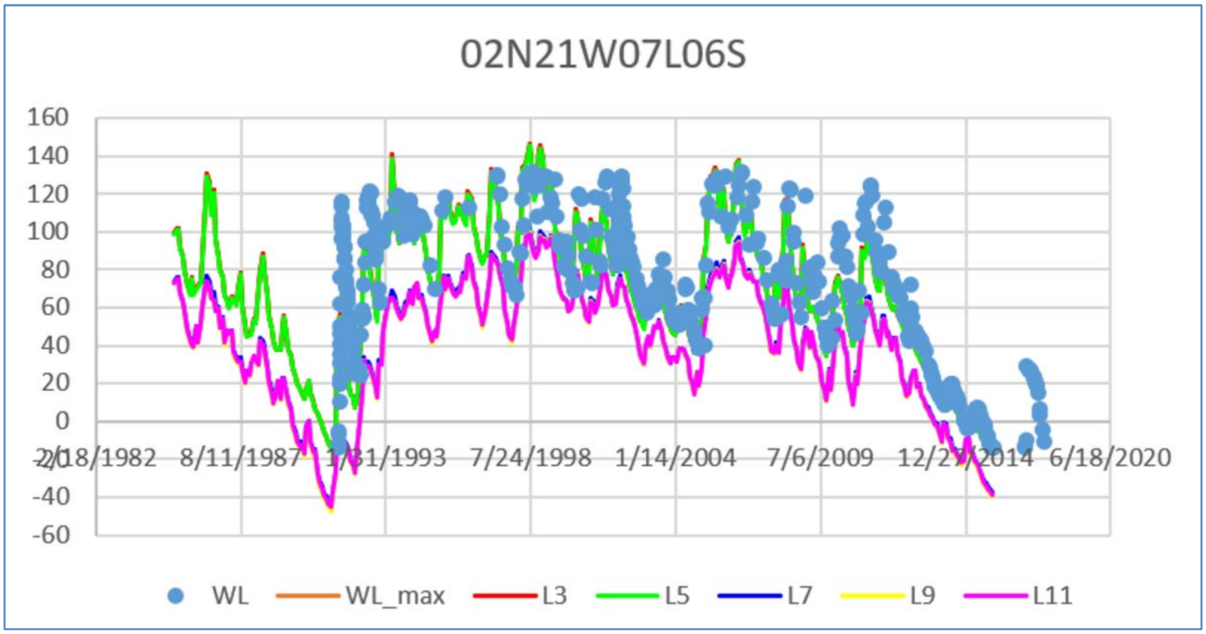

Figure 3. Example Calibration Hydrograph for a Well with a Good Match

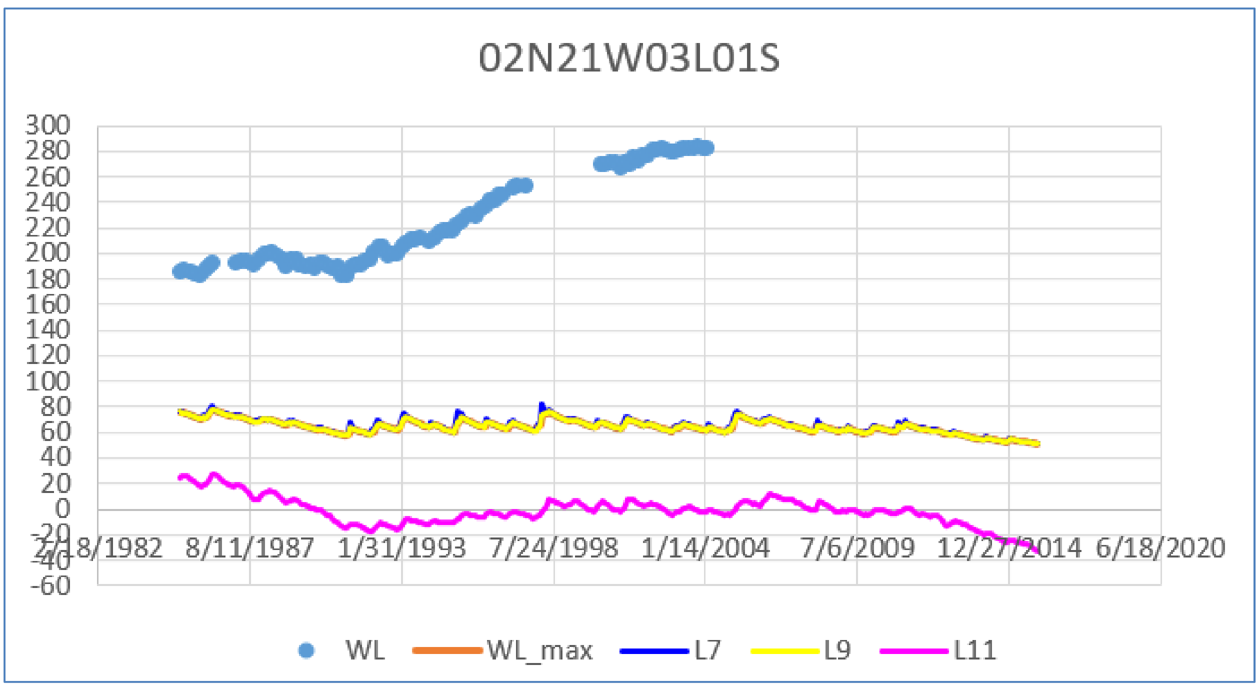

Figure 4. Example Calibration Hydrograph for a Well with a Poor Match

Of 277 hydrographs reviewed, only 34 were judged to be of poor quality and 41 were adequate. Most hydrographs (202, or 73%) showed a good match between modeled and measured values. The largest number of poor matches (14) was in West Las Posas, basin where some wells are screened in the lithologically complex San Pedro Formation, which contains lenses of unknown lateral continuity within a thick sequence of fine-grained sediments. The other basins, which have more discrete and continuous aquifers and aquitards, typically had between 0 and 3 poor matches. Table 1 shows these qualitative results for each basin. In our opinion, matching a high percentage of available hydrographs is difficult to do and means the calibration is very good.

Table 1: Qualitative Assessment of Hydrograph Calibration Quality

Basin	Total Wells	Good Match	Poor Match
FB1	15	14	0
FB2	18	17	1
FB3	15	15	0
Mount West	6	4	2
Mound South	4	4	0
Mound East	8	4	3
OP1	26	20	0
OP2	27	25	1
OP3	25	19	3
OP4	22	18	0
OP5	7	5	0
PV1	12	8	1
PV2	16	11	3
PV3	10	3	5
PV4	16	14	0
UAS	8	3	1
WLP	42	18	14
Total	277	202	34

Statistical analysis of the residuals for groundwater elevation[1] show a good match as well. Statistics were computed by the panel by finding the layer which best represents the water level response at each individual well, and then computing residuals for the hydrograph by using simulated groundwater elevations from that layer. Statistics were then divided by the range in water levels to get a scaled result. Use of scaled statistics is convenient because the results can then be compared to the calibration quality of numerical models in other settings. In our experience, scaled statistics less than 0.1 (i.e., 10 percent) are indicative of good calibration. The scaled groundwater elevation statistics for this model (for residual mean, residual standard deviation, RMS error, and absolute residual mean) are in the 2 to 4 percent range when considering groundwater elevations themselves (i.e., are water levels too high or too low) and in the 2 to 3 percent range when considering month-to-month changes in groundwater elevations over time (i.e., is the model simulating the fluctuations in water levels that occur). In

[1] The residual is the simulated error, which is defined as the measured groundwater elevation minus the modeled elevation.

our experience, having a good match to both absolute elevations and to changes in elevation is not often achieved and points again to the fact that the VRGWFM is very well calibrated (as previously suggested by the hydrographs).[2]

Another visual representation of calibration quality is a scatter plot of observed versus simulated water levels. In an ideal calibration, the values fall on a straight line at a 45 degree angle. The degree of scatter and any bias in the line of best fit provide information on the degree of regional spatial bias. The scatter plot generated by the panel for the water level elevation calibration is shown in Figure 5. Except for some outliers (shown in red ellipse) the degree of scatter about the 45 degree line is good and does not indicate the existence of any significant spatial or temporal bias.

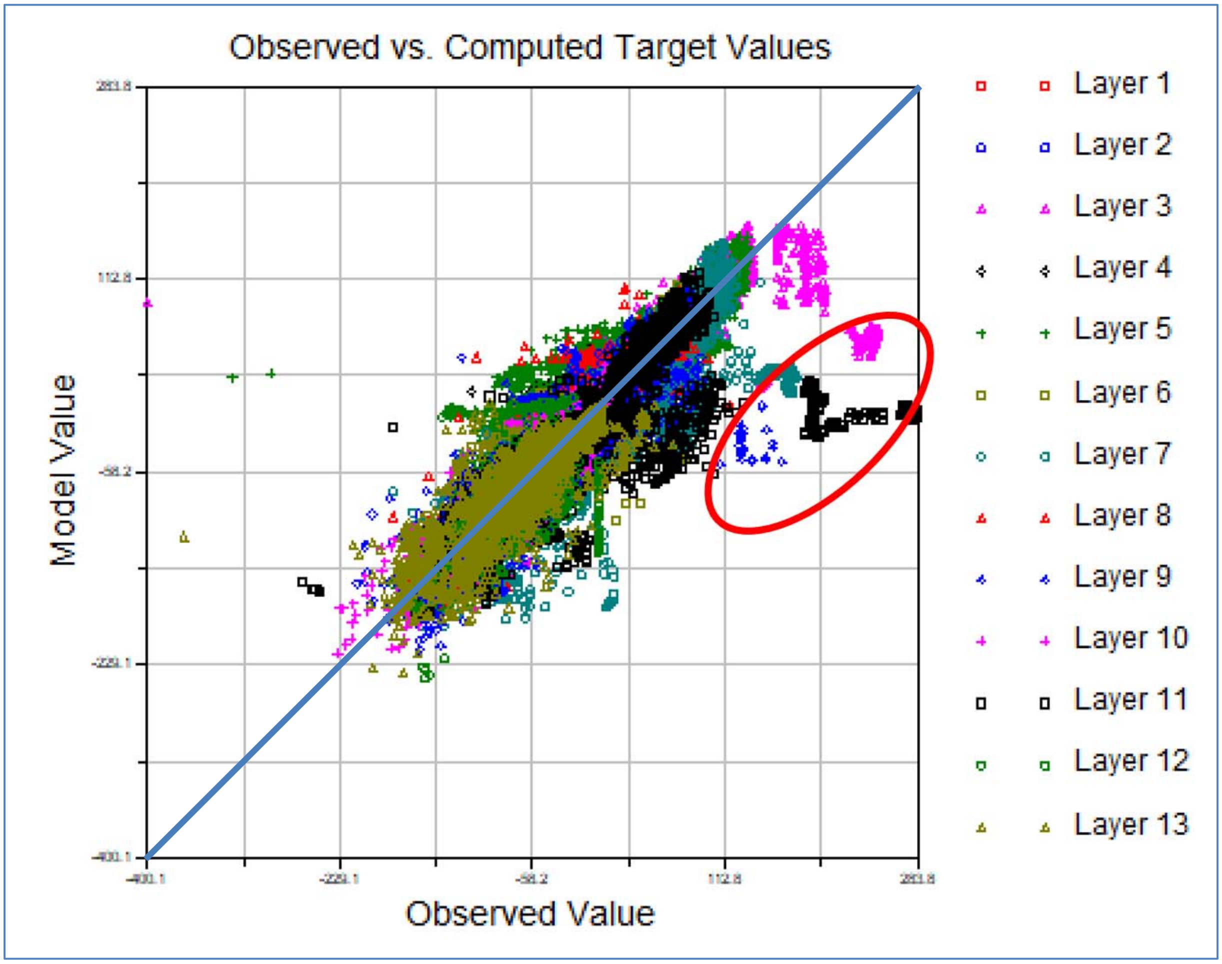

Figure 5. Scatter Plot for Groundwater Elevations

[2] The expert panel's method of selecting the simulated groundwater elevations is slightly different than the method used by UWCD. For a given well, the panel selected the simulated elevations for the model layer that appeared to best represent the water level response, based on inspection of the hydrograph at the well. UWCD uses the maximum water level simulated for all layers to which the well is open, though at some wells a different layer was chosen if large differences were visible in the hydrographs. The expert panel finds that the calibration statistics it has computed are generally similar to those computed by UWCD.

The same sort of scatter plot for change in head is shown in Figure 6. The degree of scatter is similar to that for the elevation match, and again no significant bias is shown.

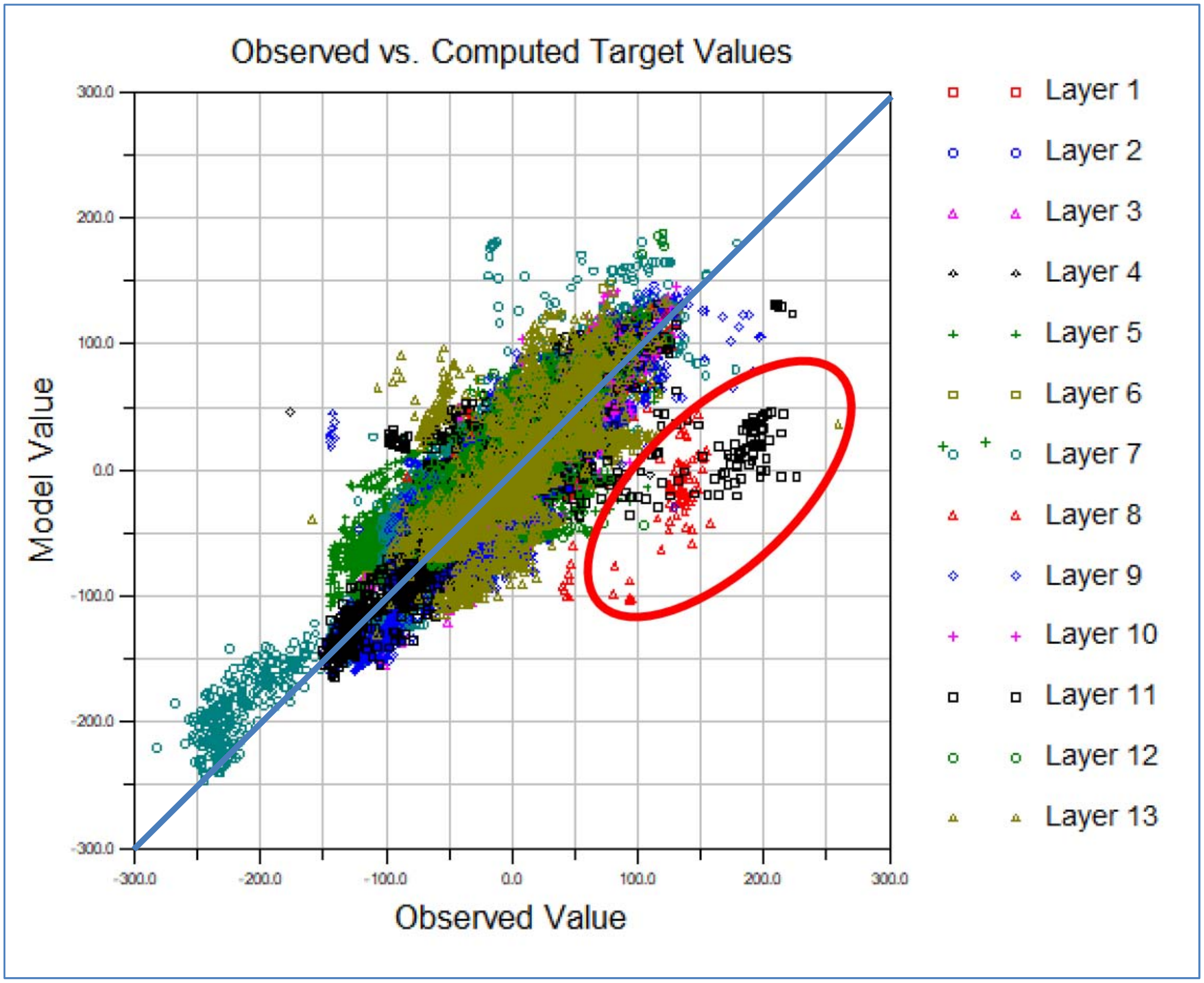

Figure 6. Scatter Plot for Changes in Groundwater Elevations

Figure 7 shows maps of the location of the worst matches in two model layers in the UAS (the Oxnard Aquifer in layer 3, and the Mugu Aquifer in layer 5). Each map uses green dots to show the locations of the five worst hydrographs in a given model layer. Figure 8 shows similar maps for the four principal aquifers in the LAS (the Hueneme Aquifer in layer 7, the Fox Canyon Aquifer's upper and basal units in layers 9 and 11, and the Grimes Canyon Aquifer in layer 13). Together, these maps provide an understanding of the spatial distribution of error by allowing for identification of the existence (or lack thereof) of spatial bias in the locations of poorly matched wells. As shown by these figures, the worst hydrographs tend to lie (1) on or near the outer boundaries of the model, where groundwater gradients are steep due to topography, faulting, and/or significant rates of recharge, and (2) at locations inside the model domain where hydraulic gradients are steep because of groundwater pumping. The occurrence of the largest errors in places with steep gradients is not surprising, given that groundwater elevations may differ by tens to hundreds of feet between the 2,000-foot wide model grid cell containing the green dot and one or more of its neighboring grid cells of equal size. The use of refined grid spacing in future applications of the model likely would cause simulated groundwater elevations (and changes in elevations) to more closely match observed conditions; accordingly, adjustments to hydraulic parameters in the model are not warranted in these areas without first conducting further testing and evaluation using refined grids.

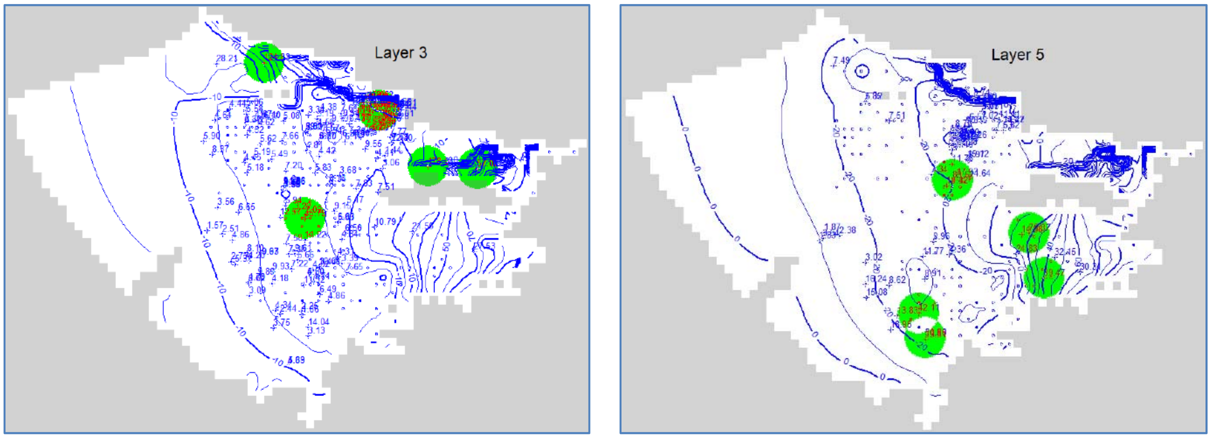

Figure 7. Locations of 5 Worst Targets in the Principal Aquifers of the UAS

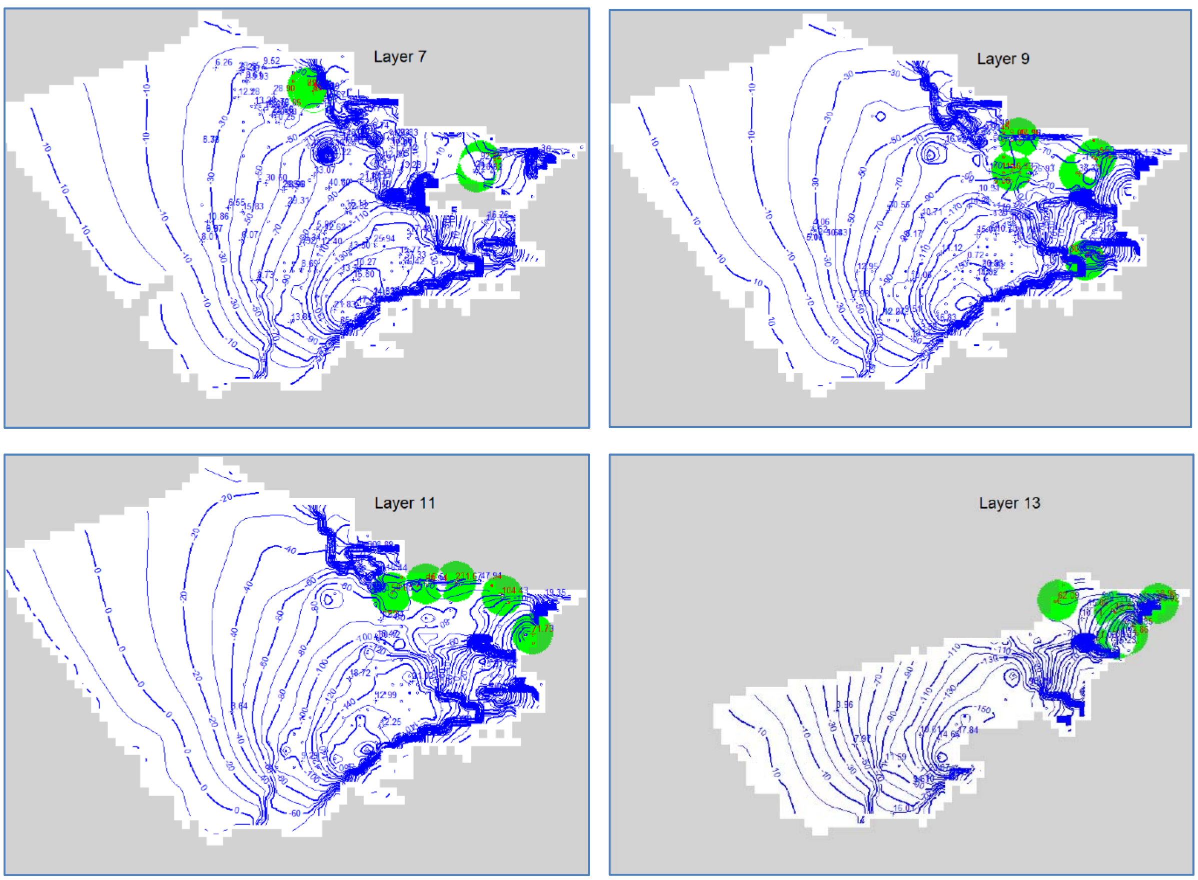

Figure 8. Locations of 5 Worst Targets in the Principal Aquifers of the LAS

5.0 Model Uses and Potential Enhancements

Version 1.0 of the VRGWFM – the groundwater flow model that UWCD has developed for the Oxnard Forebay, Oxnard Plain, Pleasant Valley, West Las Posas, and Mound groundwater basins – is viewed by the expert panel as an appropriate tool for meeting UWCD's stated objective of improving the understanding of key factors that affect the availability and usability of groundwater resources in the region. The spatial extent of the model, the use of monthly stress periods to simulate temporal variations in surface and groundwater conditions, and the use of a calibration period spanning 31 years of fluctuating weather conditions (and changing land and water uses) together make the model suitable for assisting with long-term sustainable management of the groundwater resources in these five basins. Version 1.0 of the VRGWFM is viewed by the expert panel as being ready for use in regional and local planning efforts, and is of sufficient quality to support development of GSPs under SGMA, including conducting water budget analyses, estimating the sustainable yield of the regional aquifers under various long-term management alternatives, and evaluating the ability of specific projects and management actions to meet minimum threshold levels that will be established in basin-specific GSPs. The model can evaluate these aspects of GSP planning and implementation by simulating future potential changes in groundwater pumping, natural and artificial recharge, and future land and water uses. Additionally, the availability of complementary tools such as MODFLOW-USG allows for local-scale grid refinements to be made to the VRGWFM, which can efficiently provide a representation of local-scale features and projects while also accounting for regional (basin-scale) processes and conditions. The use of MODFLOW-USG and UWCD's plans to expand the model eastward along the Santa Clara River are expected to further enhance the model's usefulness for groundwater resource planning and management in southern Ventura County.

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