

# Groundwater Model Development

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This appendix documents the construction, calibration, and application of the groundwater flow model developed to support the *North Hollywood Operable Unit (NHOU) Focused Feasibility Study (FFS)*. The model was originally developed to support various groundwater analyses performed across the San Fernando Valley (SFV) groundwater basin. The model was periodically updated as additional hydrologic information was collected throughout the basin. The history of these model updates is summarized in the following sections.

## B.1 Groundwater Flow Model History

James M. Montgomery Consulting Engineers (JMM) originally developed the groundwater flow model (JMM, 1992) for the SFV groundwater basin under cooperative agreement with the U.S. Environmental Protection Agency (EPA) and the Los Angeles Department of Water and Power (LADWP). The model was developed using the MODFLOW modeling application and was subsequently revised in 1994 by CH2M HILL (under contract with EPA) to support a feasibility study of groundwater cleanup for the San Fernando basin. This version of the model was referred to as the San Fernando Basin feasibility study (SFBFS) groundwater flow model and is documented in the *San Fernando Basin Groundwater Model Documentation* (CH2M HILL, 1994).

An updated version of the SFBFS model was developed in 1998. The resulting model was designated as the SFBFS-A model and documented in the *Draft San Fernando Basin Groundwater Model Update and Revision Report* (CH2M HILL, 1998). Updates and revisions to the original model include the following:

- Translation of the model into a graphical user interface (Visual MODFLOW)
- Enhanced particle tracking capabilities using MODPATH
- Extension of the simulation period through water year 1997
- Transition to deep percolation with temporal variability
- Changes to hydraulic conductivity in the Glendale area as a result of detailed modeling by Camp, Dresser, and McKee in the Glendale area
- Implementation of the MODFLOW rewetting package

The SFBFS-A model was revised in 2001 to yield the SFBFS-B model. Significant refinements were incorporated into the 2001 SFBFS-B model and are discussed in Sections B.1.1, B.1.2, and B.1.3. Additional refinements to the model during the FFS effort are summarized in Section B.2.1.

### B.1.1 Extension of Simulation Period through Water Year 1999

The SFBFS-B temporal data were extended through water year 1999. The following additional data were incorporated:

- Pumping data for the SFV basin were obtained from the annual Upper Los Angeles River Area (ULARA) Watermaster service area reports
- Water entering the SFV basin via spreading grounds obtained from the ULARA Watermaster (ULARA, 2000)

Pumping data were obtained from the ULARA Watermaster annually and entered into a database maintained by CH2M HILL. Data up to water year 1999 were entered into the database and subsequently into the groundwater model.

All pumping data were reviewed and amended, as appropriate, to ensure that the existing database was accurate.

### B.1.2 Conversion of SFBFS-A Model to MODFLOW-Surfact Platform

Because of the continuing problems associated with the creation of the dry cells when simulated groundwater elevations fell below the base of a particular model layer and the resulting instability of the model simulations, the SFBFS-A model was converted to run on the MODFLOW-Surfact modeling platform. MODFLOW-Surfact is a saturated/unsaturated model that solves the flow equations for saturated flow beneath the water table and unsaturated flow in areas where simulated groundwater levels fall beneath the base of a given model layer. In this way, stable solutions are obtained even when portions of model layers are dry.

### B.1.3 Recalibration of SFBFS-A Model

In an attempt to improve calibration of the SFBFS-A model, the assumed aquifer properties used in the model were adjusted, and the deviation between the simulated and observed groundwater elevations at each calibration well were assessed. A distinct improvement in model calibration was obtained by the following adjustments:

- Hydraulic conductivity was decreased in the western portion of the model.
- Hydraulic conductivity was increased in the portion of the basin near the Los Angeles River Narrows.
- Areal recharge of precipitation was decreased modelwide.

The present distribution of aquifer properties in the model are presented, by layer, in Section B.2.1.

## B.2 NHOU Focused Feasibility Study Model

The SFBFS-B groundwater flow model was further refined to evaluate the remedial alternatives evaluated in the FFS. The primary refinements include enhancing the model grid resolution near NHOU, extending the period of the model calibration data set through water year 2006, adjusting the assumed aquifer properties to achieve a more accurate

calibration, and including additional water level calibration targets at various locations within NHOU.

The analysis of groundwater extraction alternatives for NHOU required modification to the model grid of the SFBFS-B groundwater flow model. The SFBFS-B model was developed to evaluate regional groundwater flow throughout the entire SFV groundwater basin. The objectives of the present modeling effort associated with the FFS required a more detailed study of groundwater flow directions and gradients, specifically near the North Hollywood extraction wells and surrounding LADWP well fields. To facilitate this analysis, the MODFLOW grid was refined in the area of North Hollywood. The original SFBFS-B model had grid elements that were 1,000 by 1,000 feet in the NHOU area. The grid prepared for this analysis was modified so that the grid elements near NHOU measure 50 by 50 feet. The revised NHOU groundwater flow model grid is shown on Figure B-1 (figures appear at the end of this appendix). This modification to the model grid provides simulated groundwater elevation and flow direction data at a more refined scale and more accurately depicts the response of the aquifer to groundwater extraction. This allows a more accurate estimate of the extent of hydraulic containment provided by the proposed extraction wells and existing production wells within the basin. The four model layers included in the SFBFS-B model were retained in the FFS model.

### B.2.1 Extension of Calibration Data Set

The SFBFS-B model was calibrated to hydrologic data from water years 1982 through 1999. During the refinement effort to support the NHOU FFS, the model calibration period was extended through 2005. Groundwater production and spreading (artificial recharge) data for the SFV basin were obtained from the ULARA Watermaster. Groundwater elevation data provided by several parties and agencies in the SFV basin were obtained from the SFV groundwater database and used to augment the calibration target data sets. Because the current version of the model focuses primarily on simulating groundwater conditions within NHOU, groundwater elevation time-series data from numerous additional wells located within NHOU were incorporated as targets for calibration. Several of these new groundwater level data sets are from remedial investigation monitoring well clusters within NHOU that include multiple completions at various depths (i.e., completions within different hydrostratigraphic units) at a particular location. Calibration to these data sets is especially useful because it confirms that the model accurately forecasts water level trends within a particular layer, and it accurately simulates vertical gradients that exist between the model layers. The accurate depiction of vertical gradients is important when evaluating the extent of hydraulic containment provided by extraction well fields because vertical gradients can result in the migration of contamination between adjacent layers and influence the ability of a particular well field to achieve complete hydraulic containment. All previous calibration target data sets contained in the SFBFS-B model were updated and retained in the calibration process. The locations of the water level calibration wells incorporated into the FFS model calibration are shown on Figure B-2.

### B.2.2 Model Recalibration

During the recalibration process, additional groundwater elevation monitoring locations within the NHOU were included in the model as calibration targets. The locations of the calibration targets in the FFS model are shown on Figure B-2. After adding these calibration

targets within the NHOU, it was discovered that significant differences existed between water levels during the extended calibration period. To improve agreement between the simulated and observed water levels, several changes were made to the aquifer properties simulated in the most recent SFBFS-B groundwater model, including the following:

- Increased aquifer horizontal and vertical hydraulic conductivity throughout the model by 50 percent in all layers
- Increased the riverbed hydraulic conductivity by a factor of five in the vicinity of the Los Angeles River Narrows
- Eliminated a small zone of model elements with low assigned hydraulic conductivity values trending east-west within Layer 2, north of the Los Angeles River Narrows

The revised hydraulic conductivity distributions for Model Layers 1 through 4 are shown on Figures B-3 through B-6, respectively.

With these modifications to the model, a significant improvement in the match between simulated and observed water level trends in all areas of the model was obtained. A series of groundwater elevation hydrographs that compare the simulated and observed groundwater elevation over time at each calibration well in the FFS model is presented on Figure B-7.

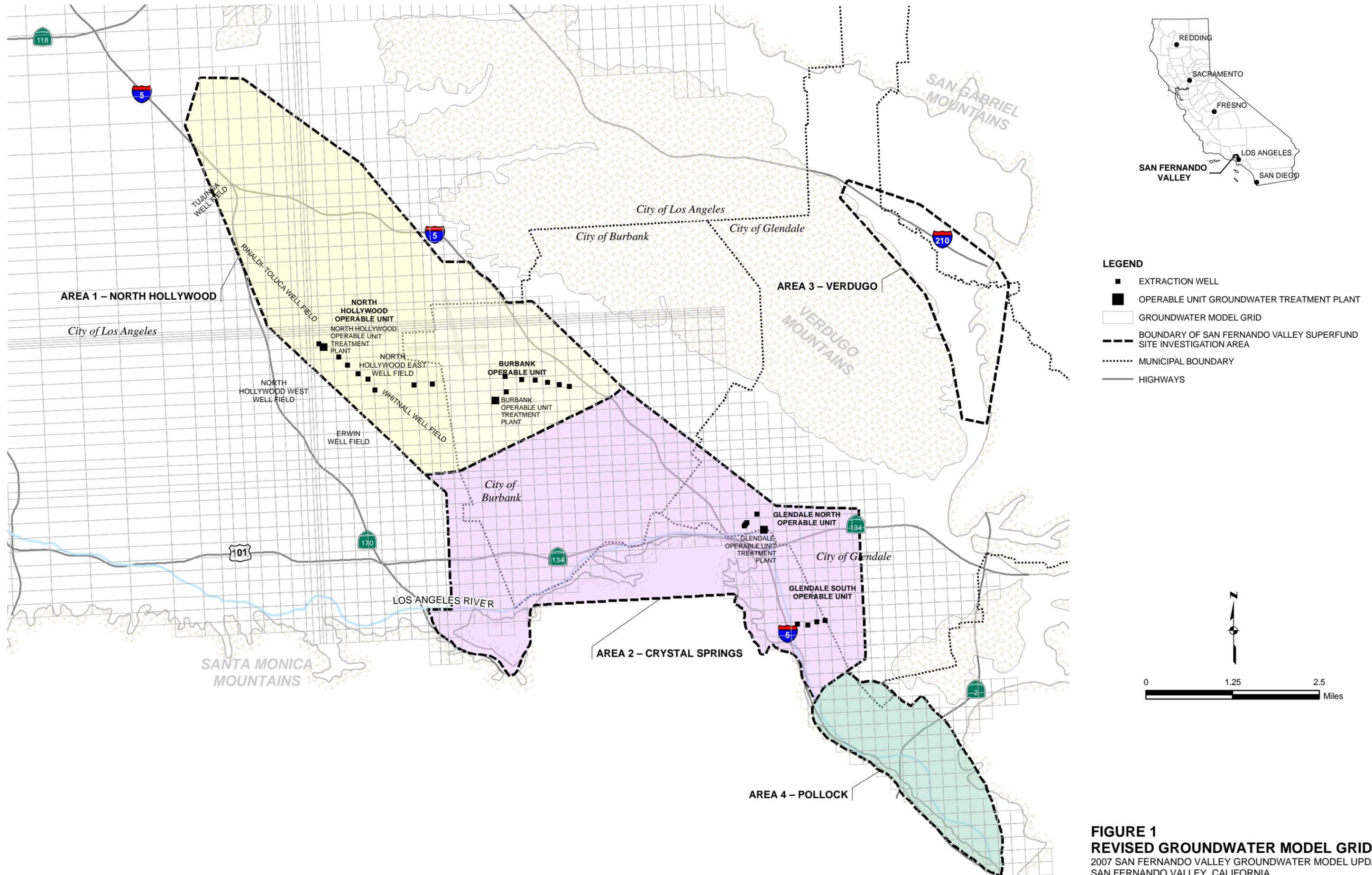
## B.3 Works Cited

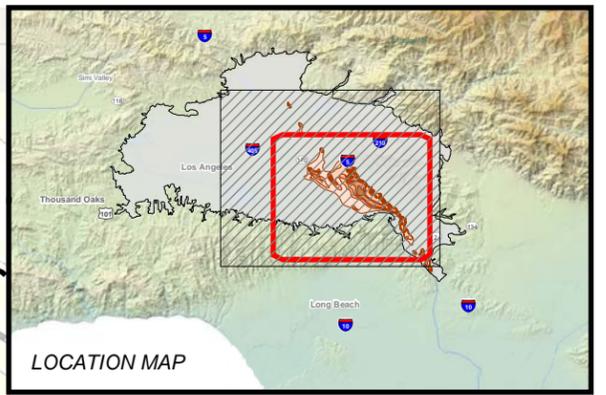
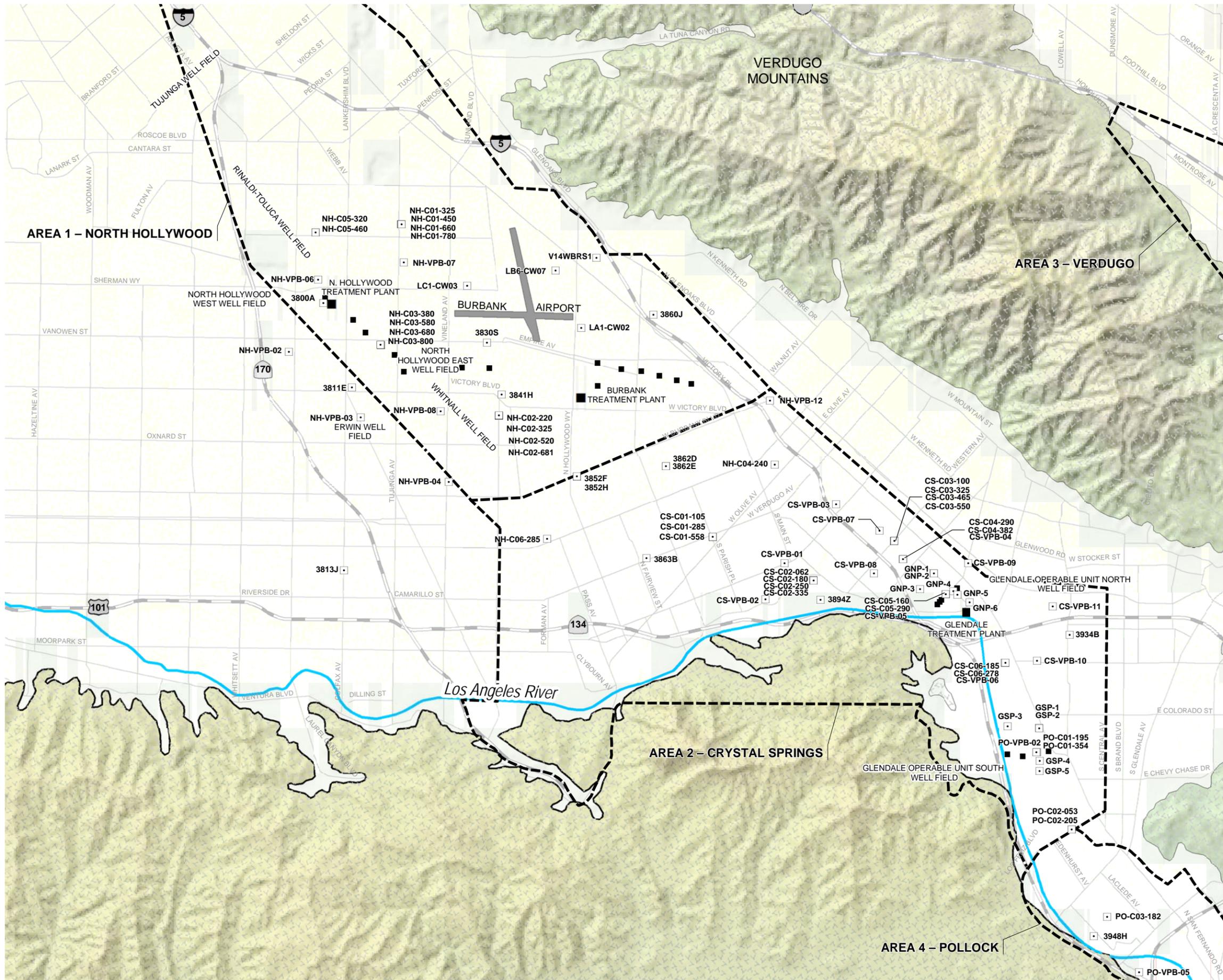
CH2M HILL. 1998. *Draft San Fernando Basin Groundwater Model Update and Revision Report, San Fernando Valley Superfund Site, Los Angeles, California*. September.

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James M. Montgomery Consulting Engineers, Inc. (JMM). 1992. *Remedial Investigation of Groundwater Contamination in the San Fernando Valley, Remedial Investigation Report*. December.

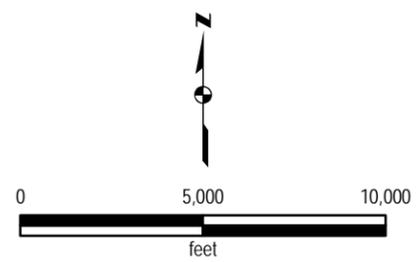
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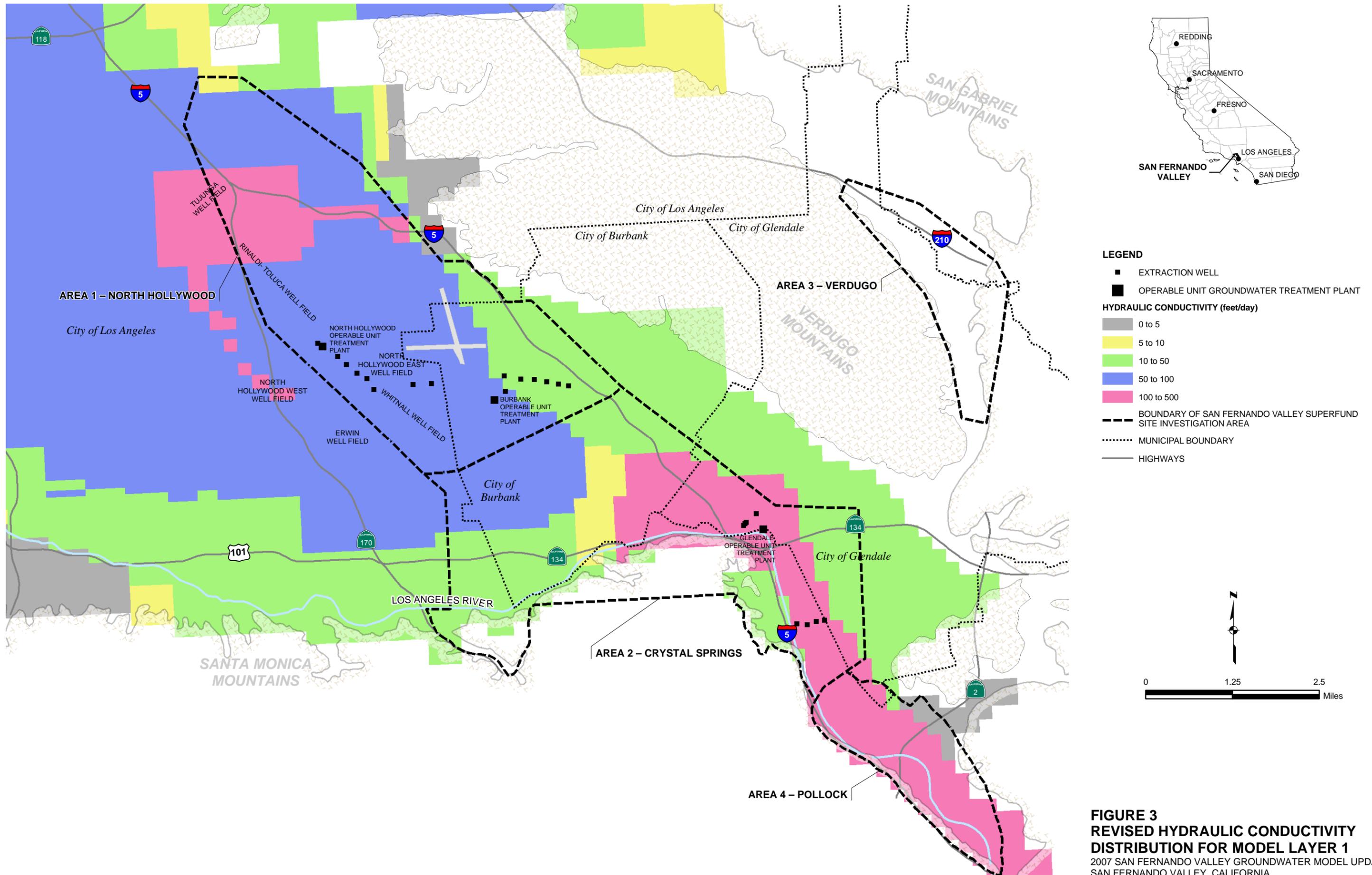


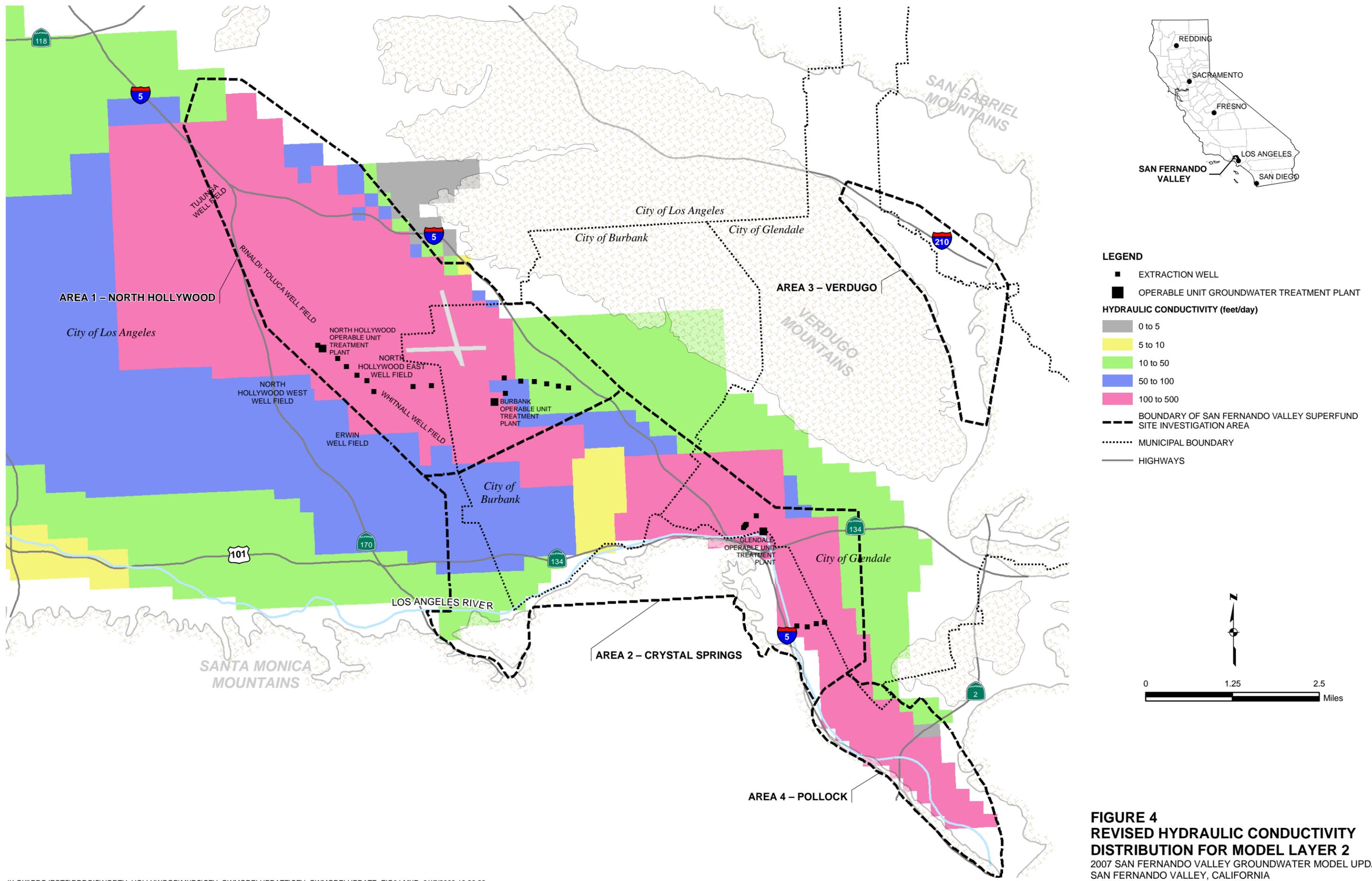
**LEGEND**

- MODEL CALIBRATION WELLS
- EXTRACTION WELL
- BOUNDARY OF SAN FERNANDO VALLEY SUPERFUND SITE INVESTIGATION AREA

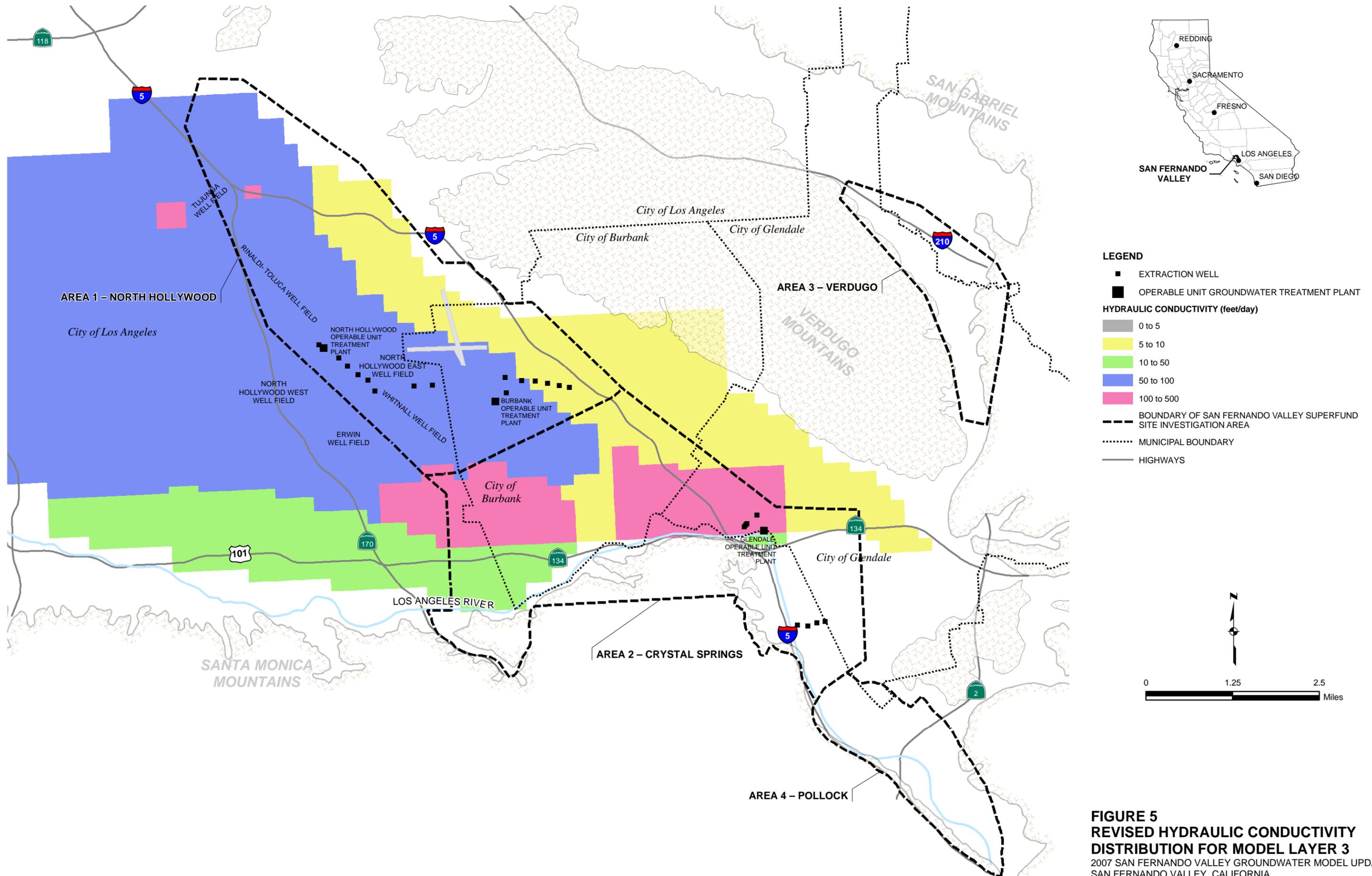


**FIGURE 2**  
**LOCATION OF MODEL CALIBRATION WELLS**  
 2007 SAN FERNANDO VALLEY GROUNDWATER MODEL UPDATE  
 SAN FERNANDO VALLEY, CALIFORNIA

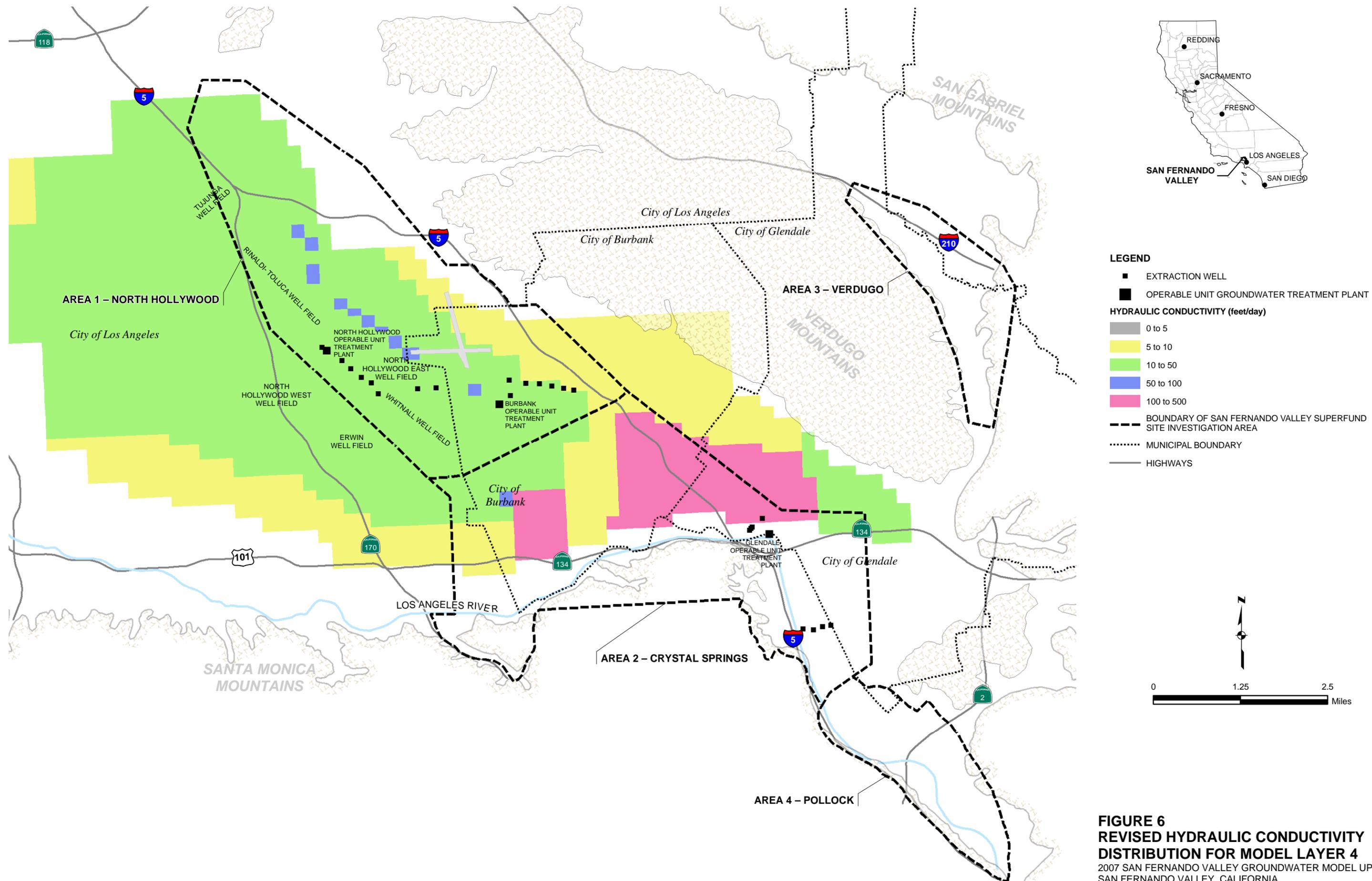


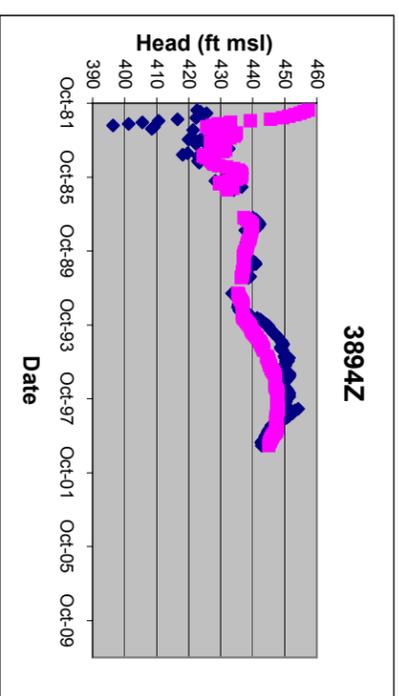
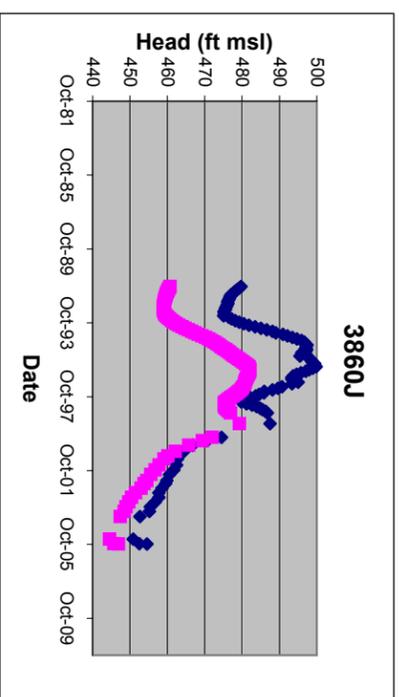
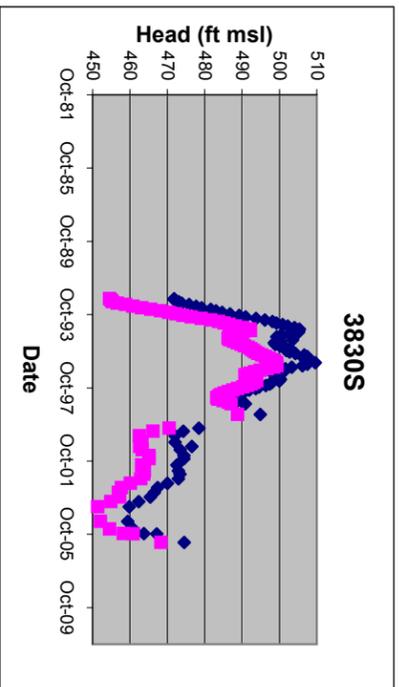
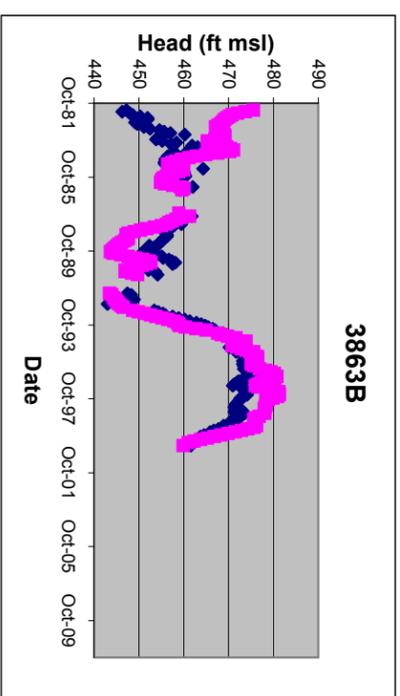
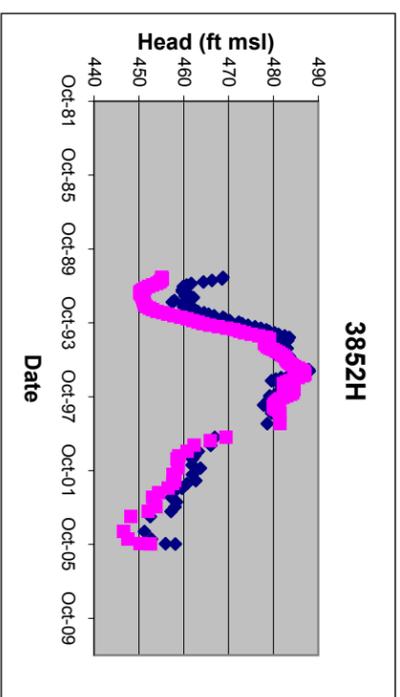
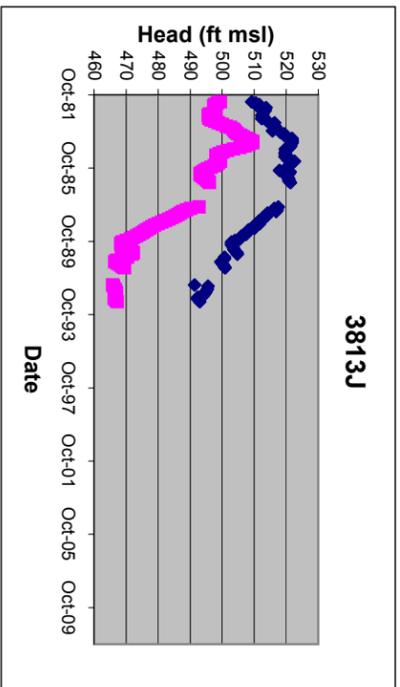
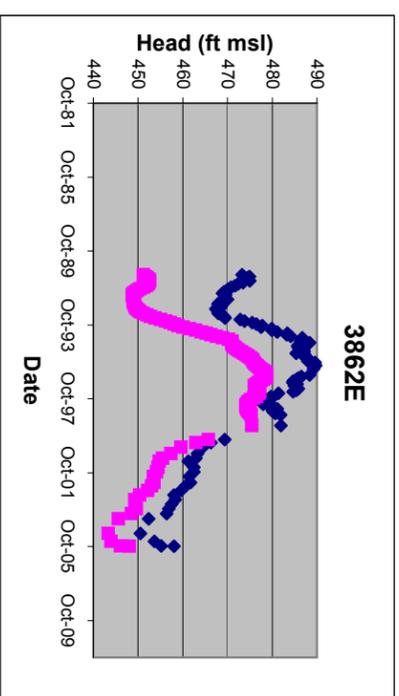
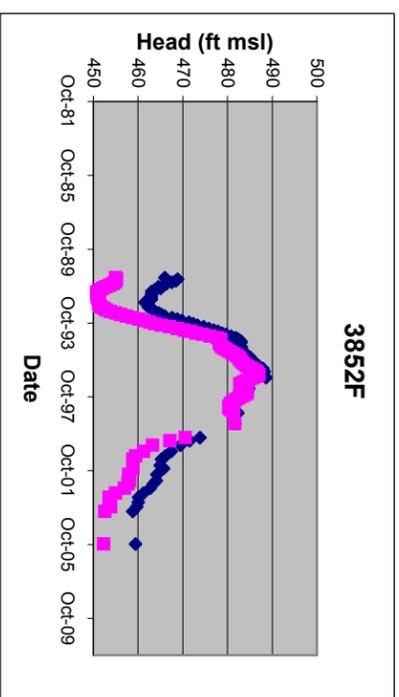
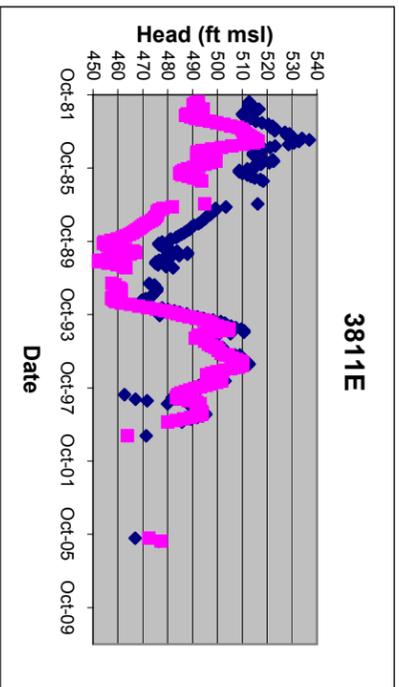
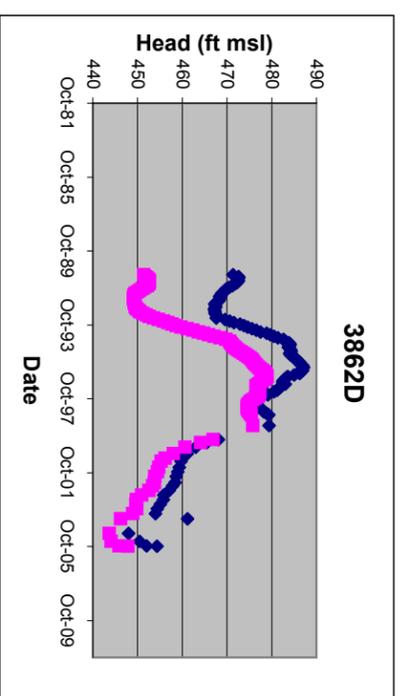
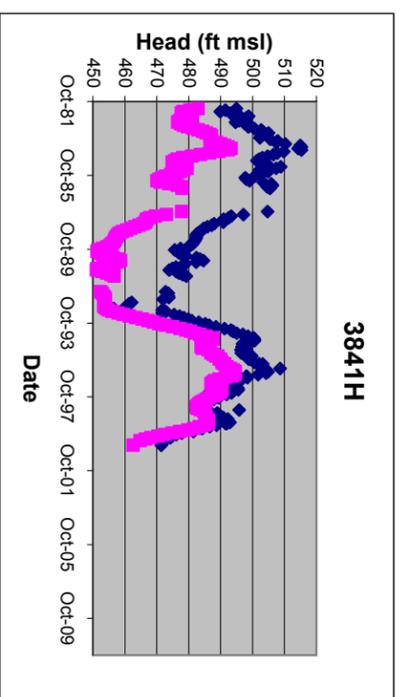
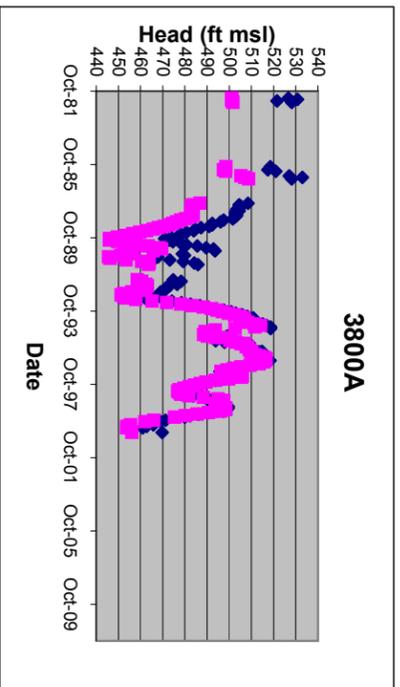


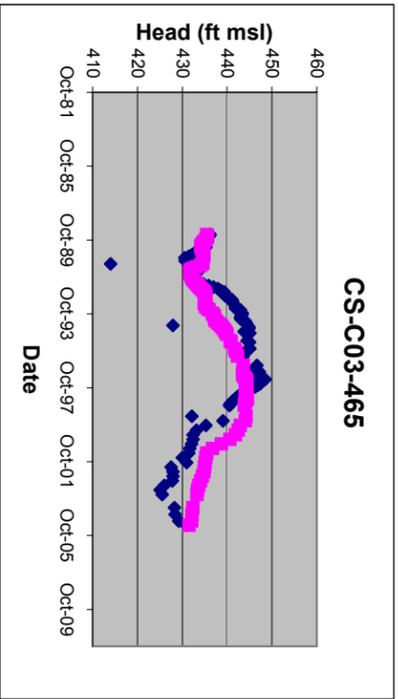
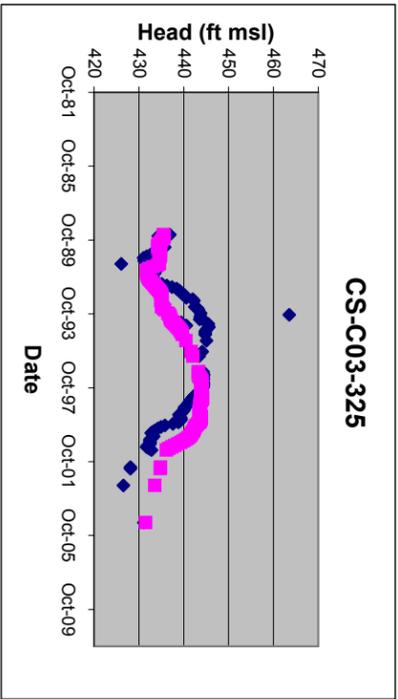
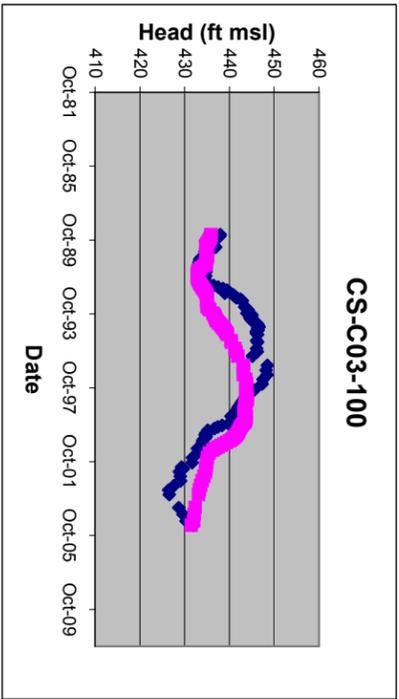
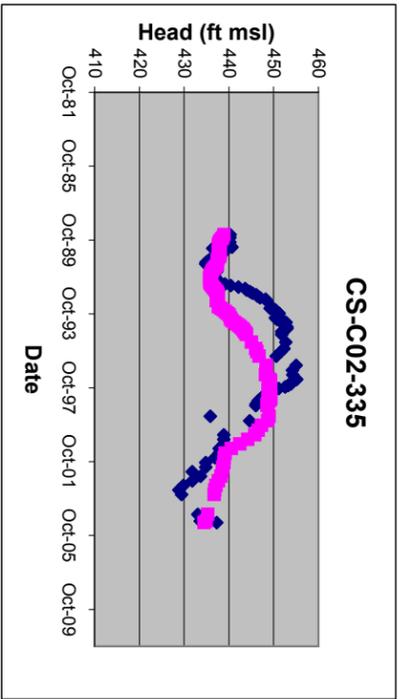
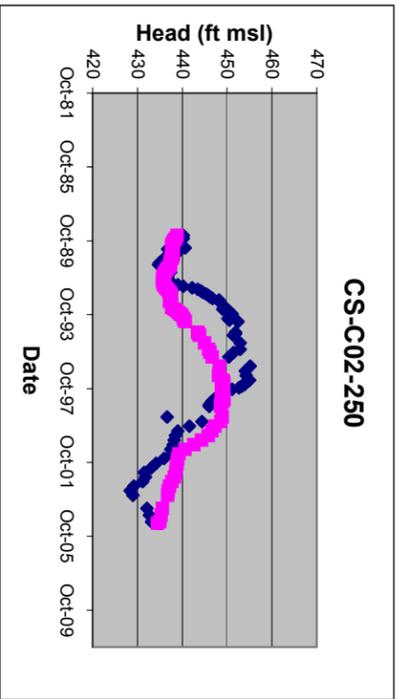
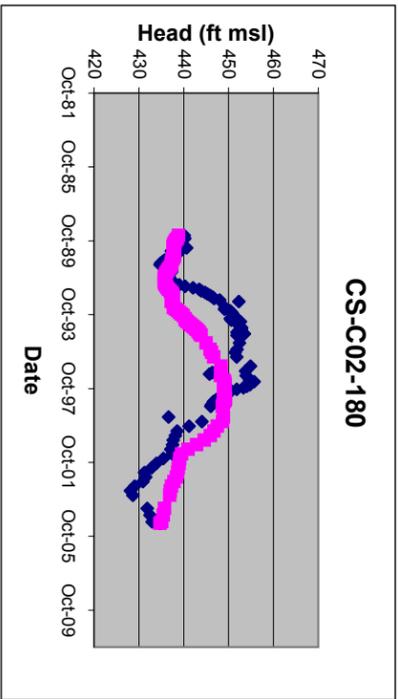
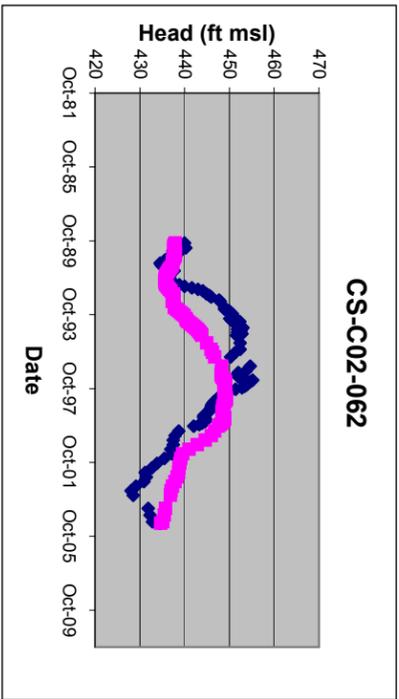
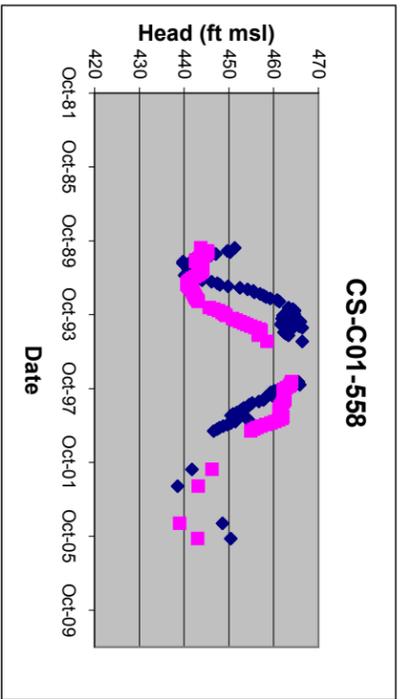
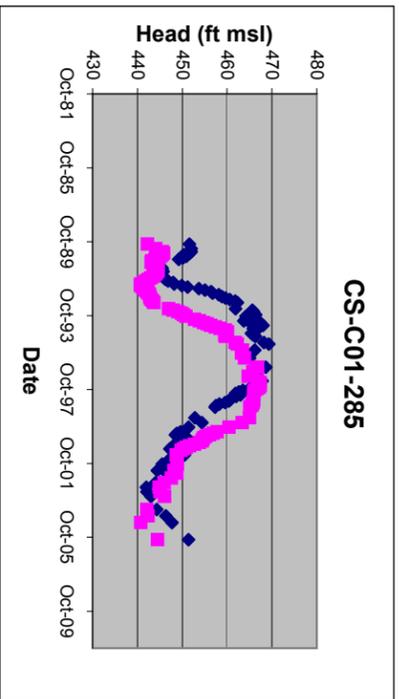
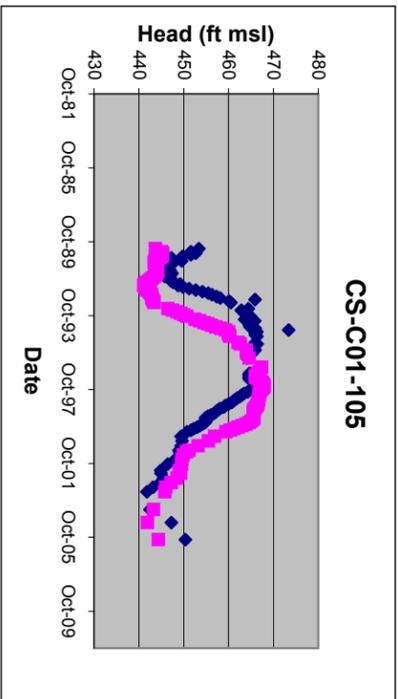
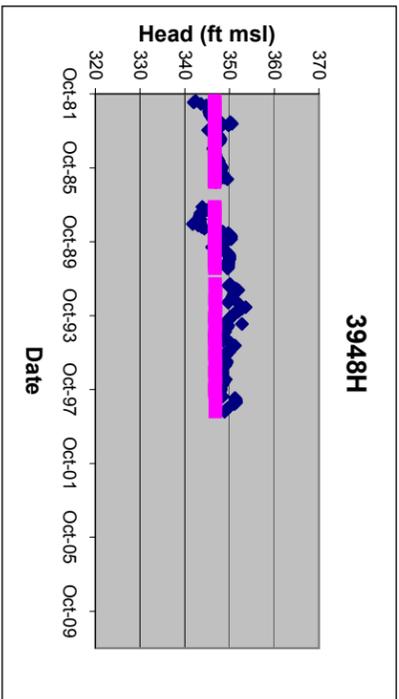
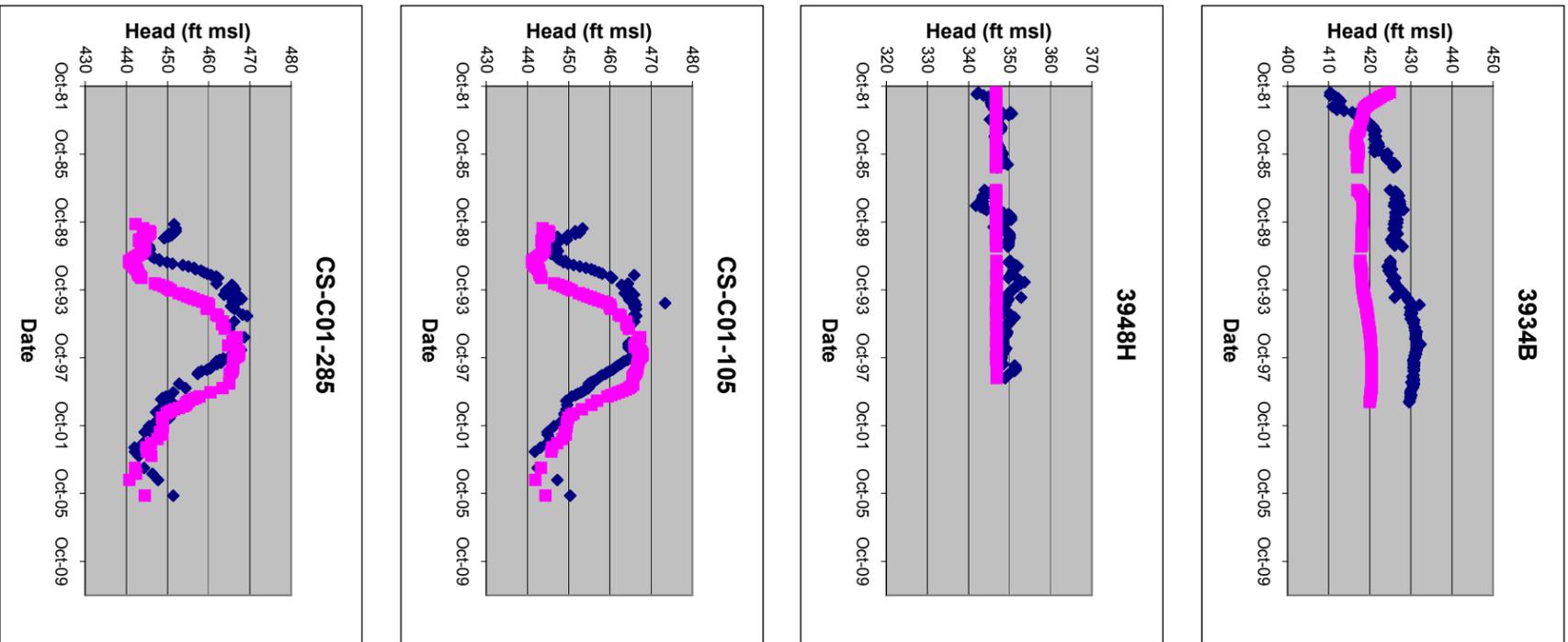
**FIGURE 4**  
**REVISED HYDRAULIC CONDUCTIVITY**  
**DISTRIBUTION FOR MODEL LAYER 2**  
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 SAN FERNANDO VALLEY, CALIFORNIA



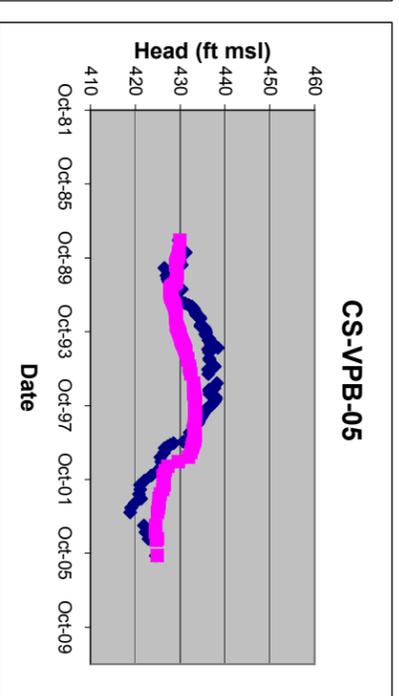
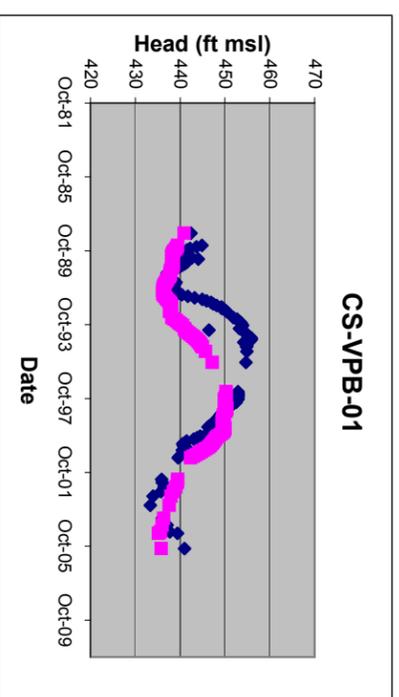
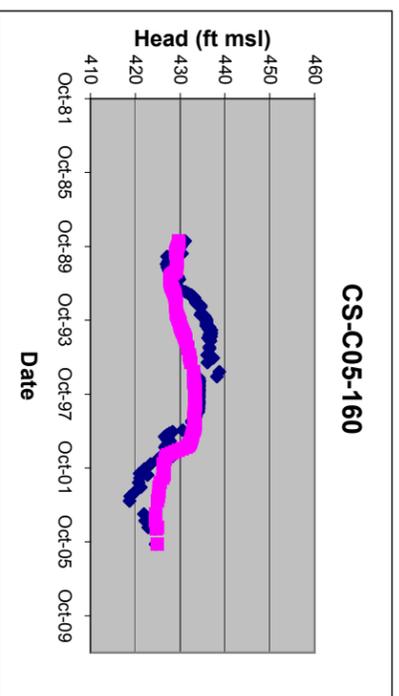
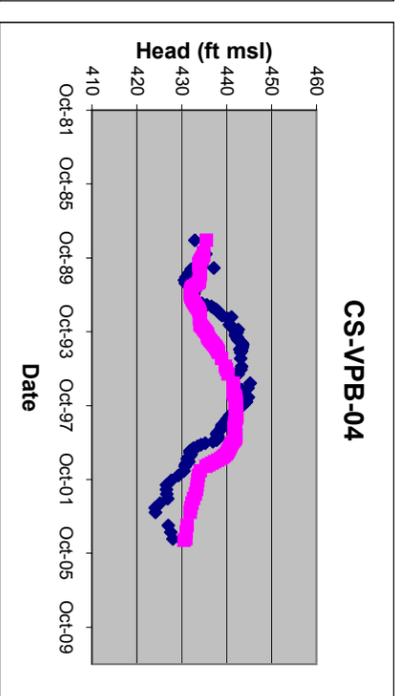
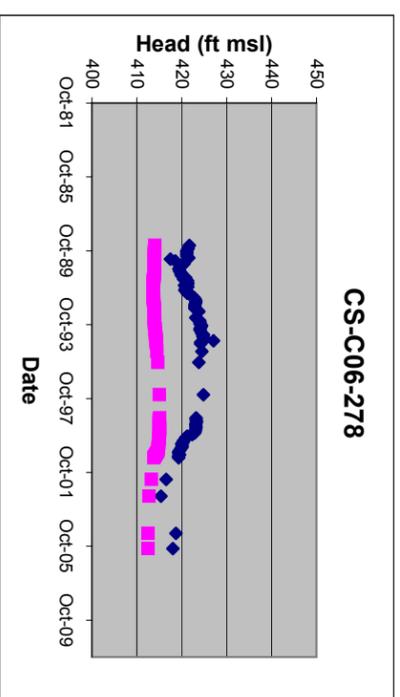
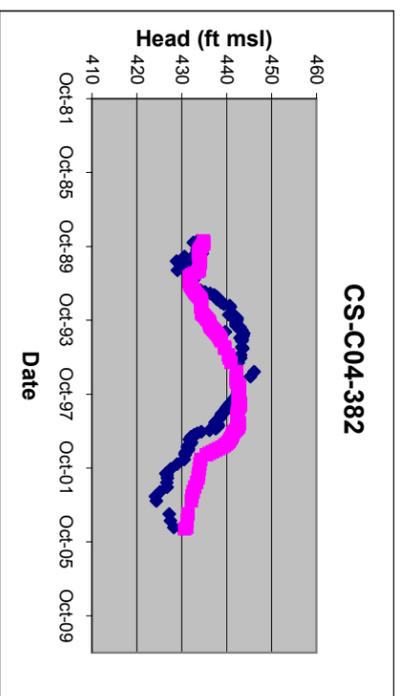
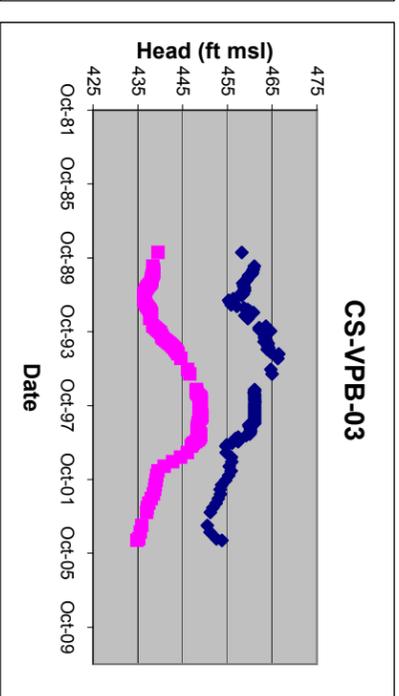
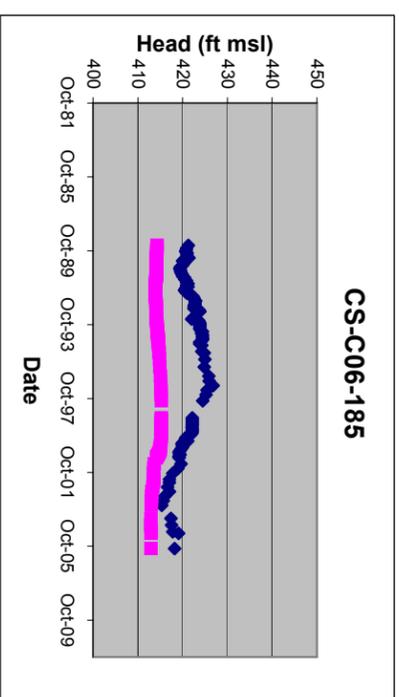
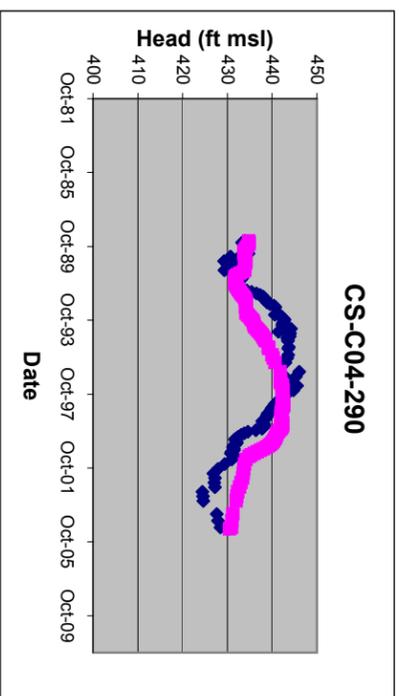
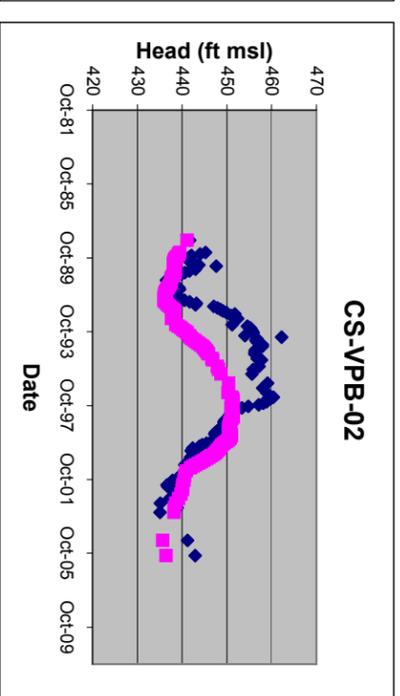
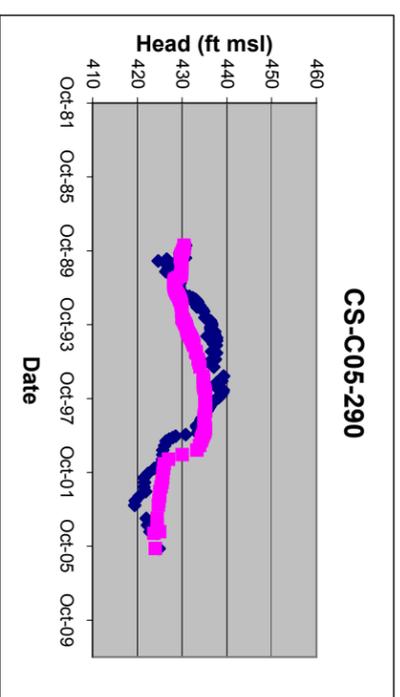
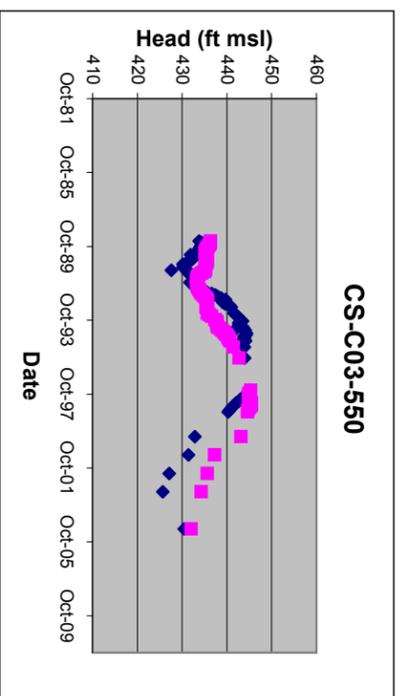
**FIGURE 5**  
**REVISED HYDRAULIC CONDUCTIVITY**  
**DISTRIBUTION FOR MODEL LAYER 3**  
 2007 SAN FERNANDO VALLEY GROUNDWATER MODEL UPDATE  
 SAN FERNANDO VALLEY, CALIFORNIA



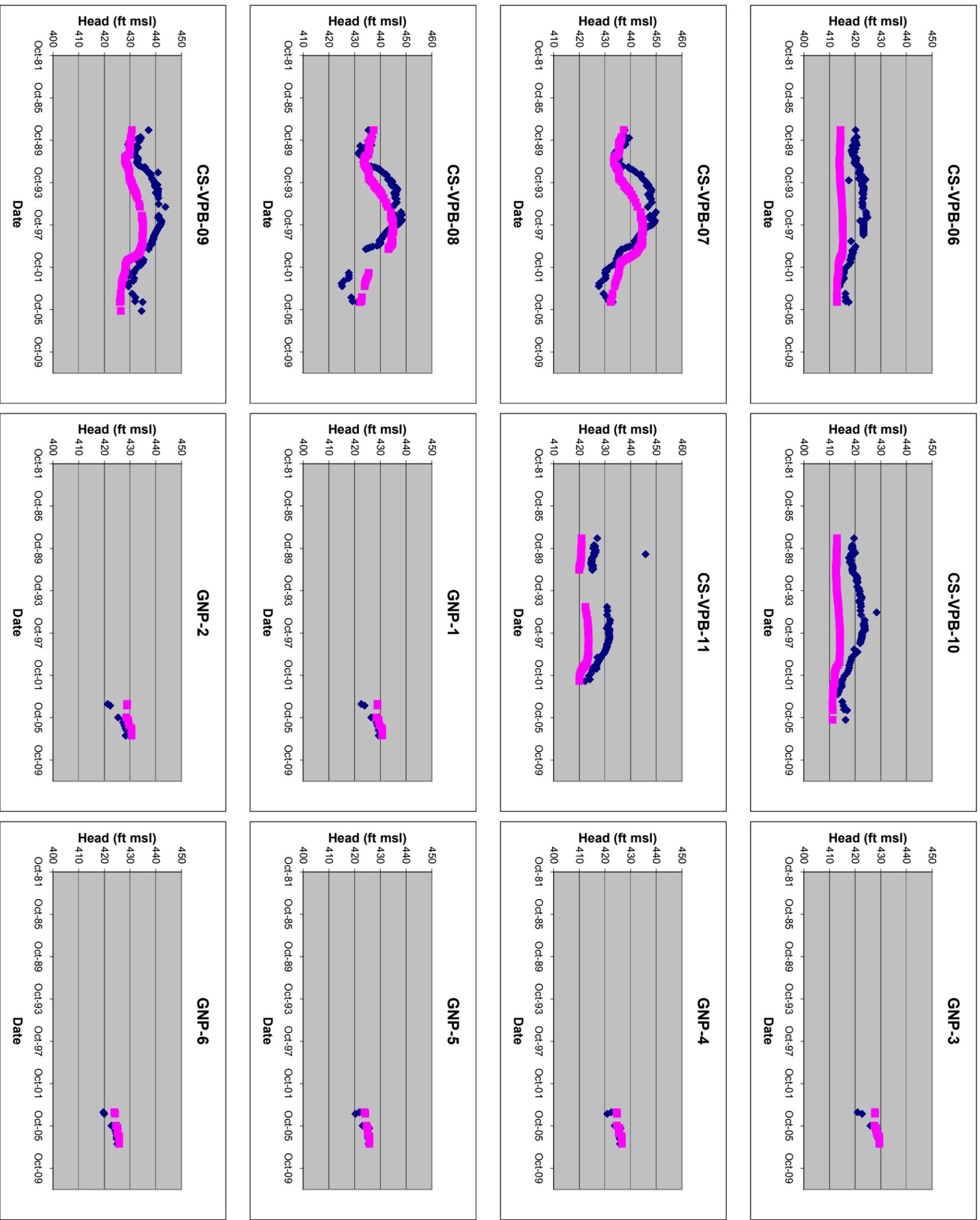


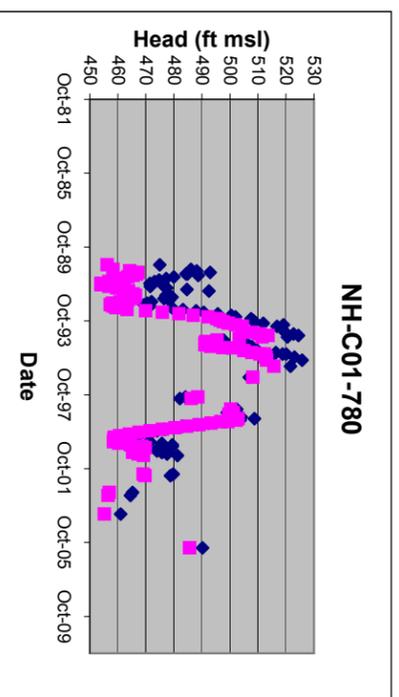
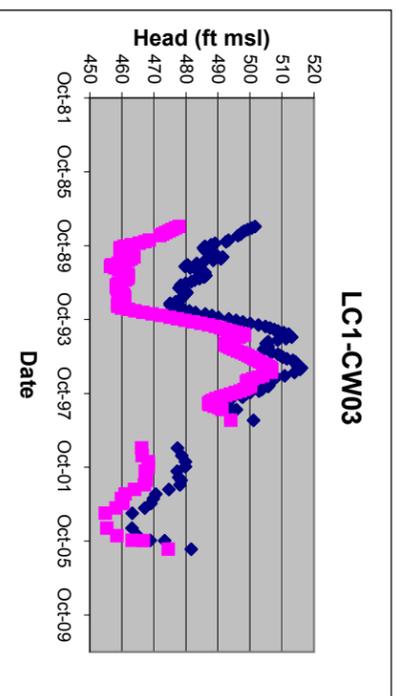
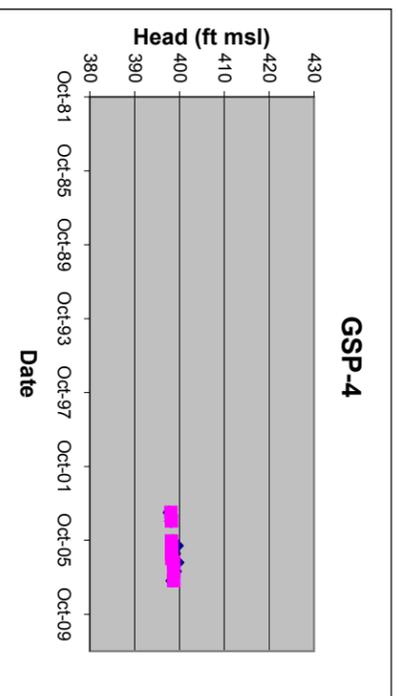
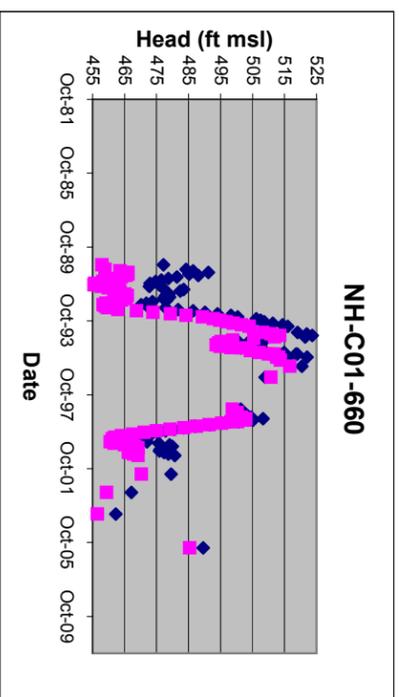
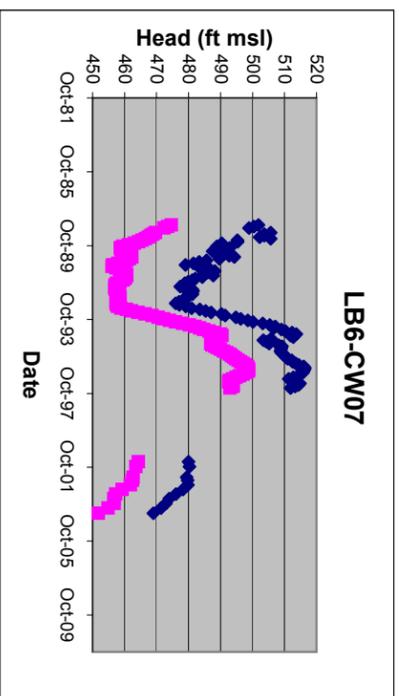
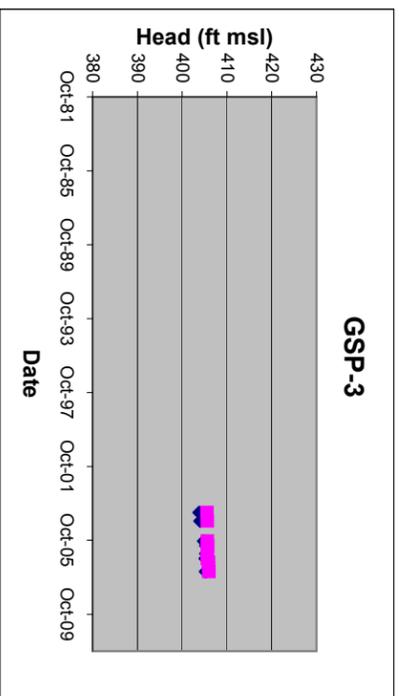
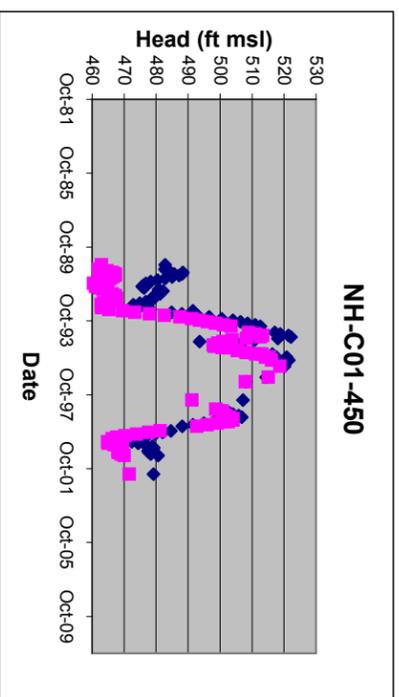
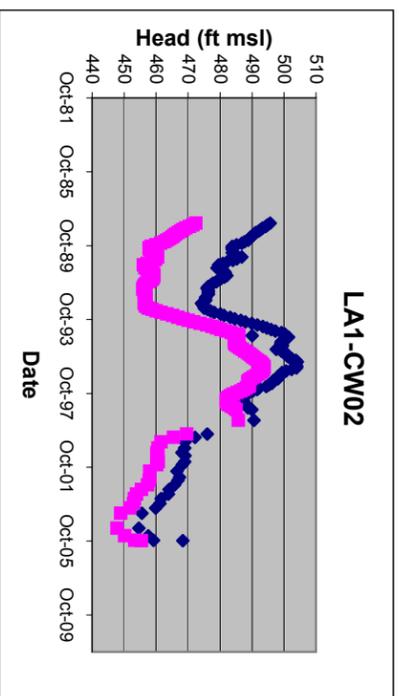
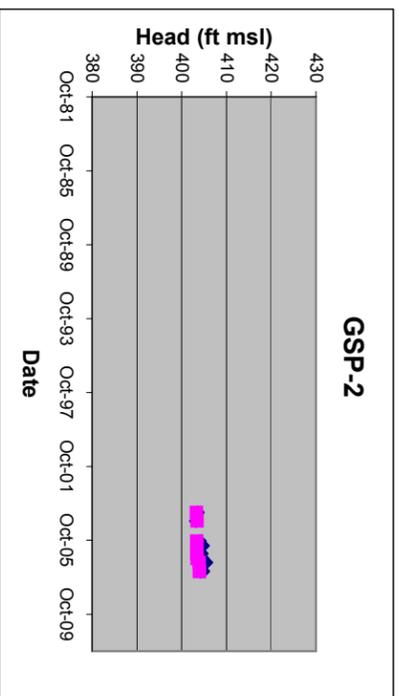
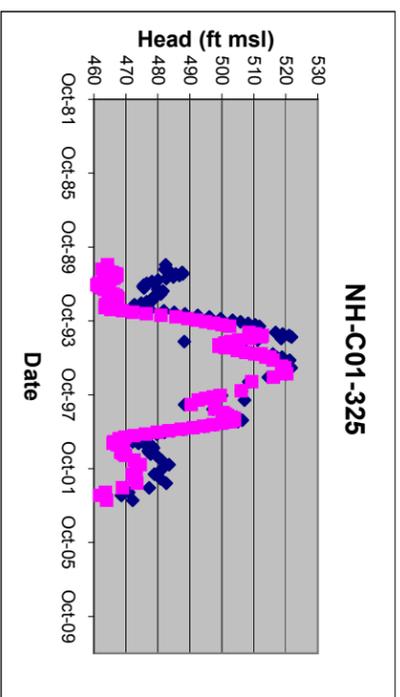
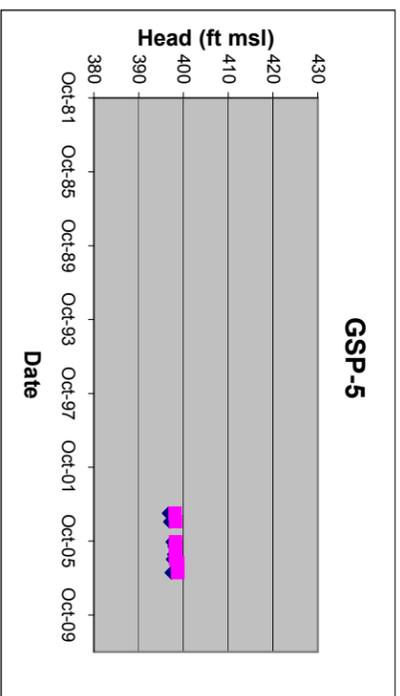
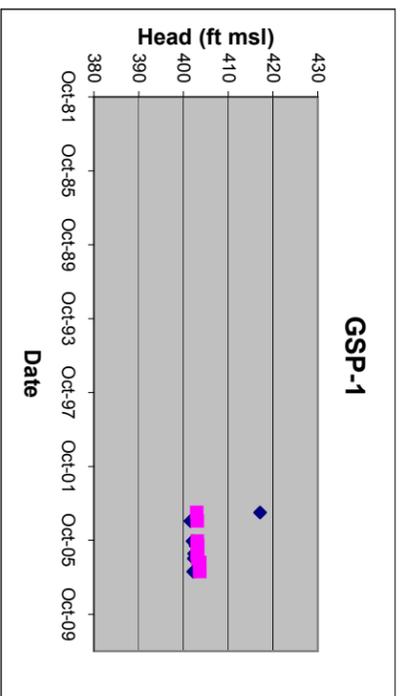


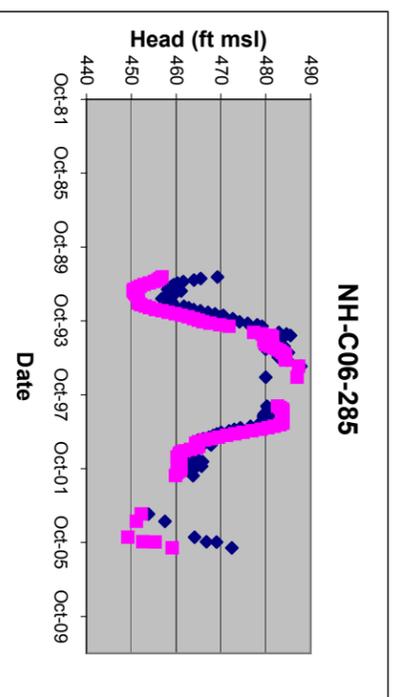
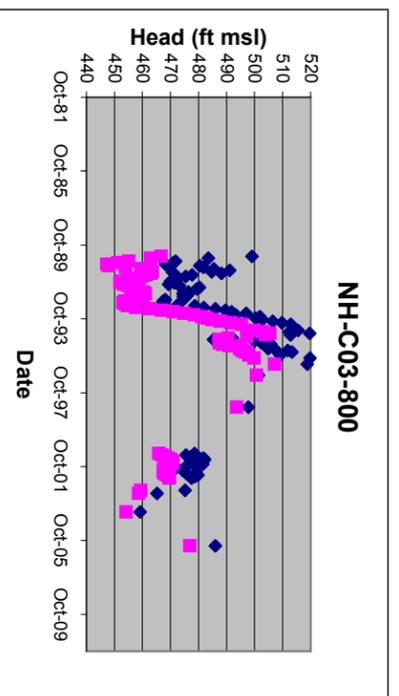
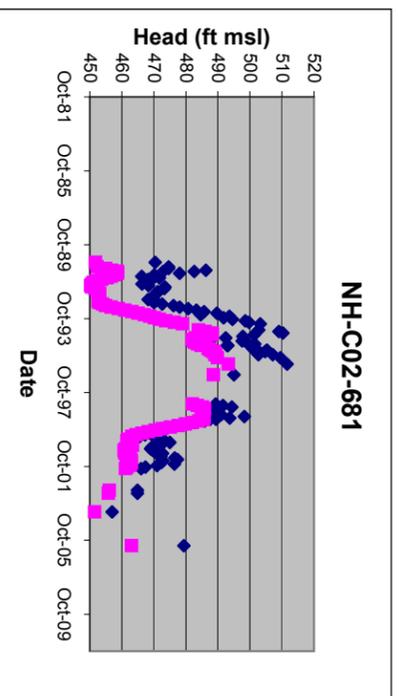
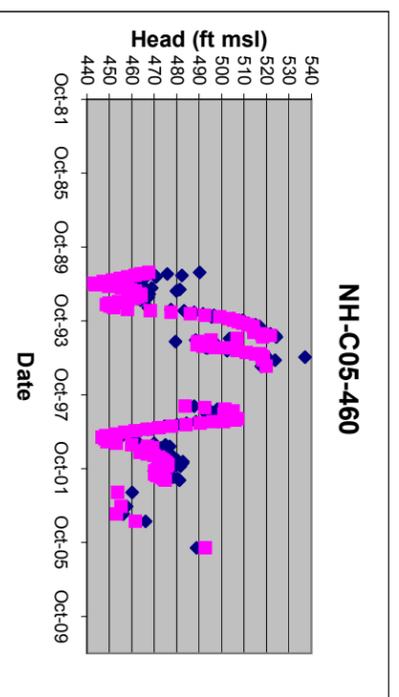
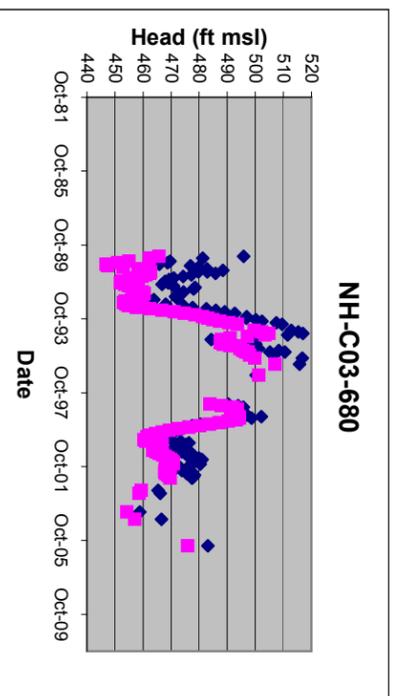
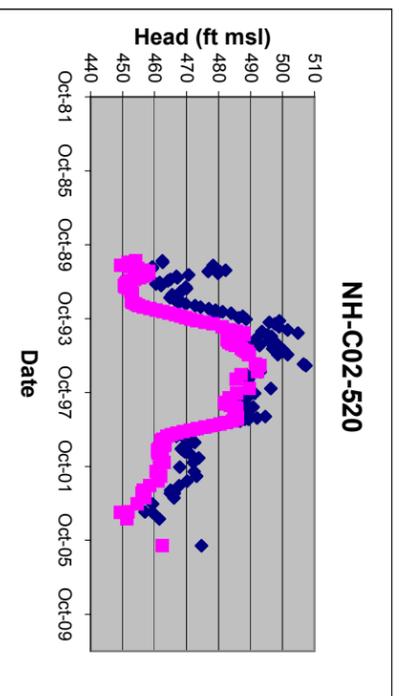
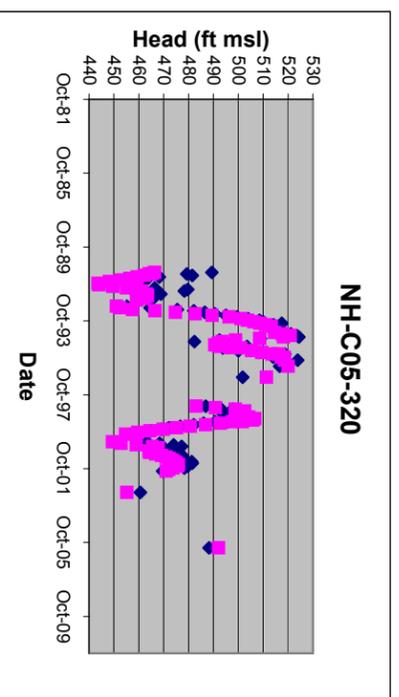
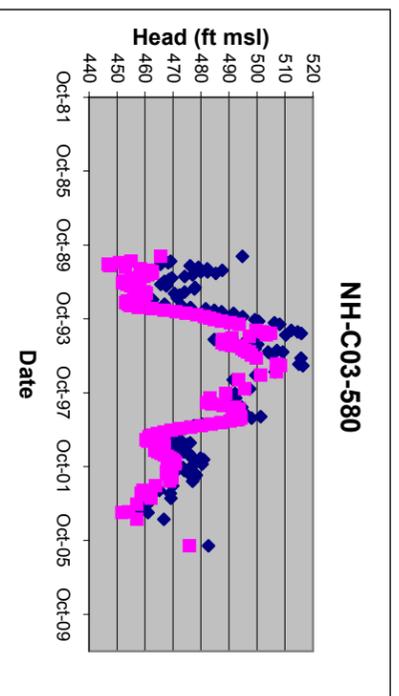
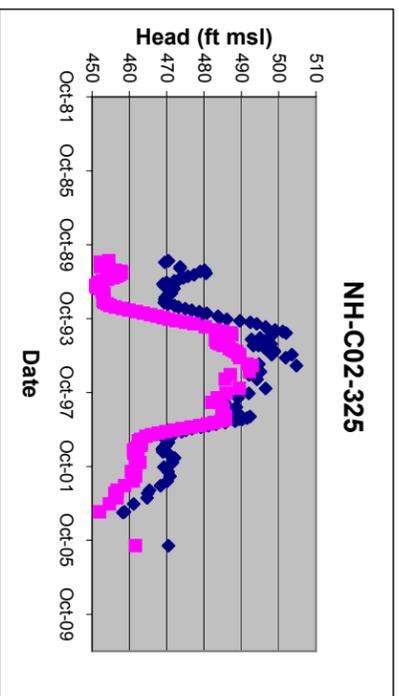
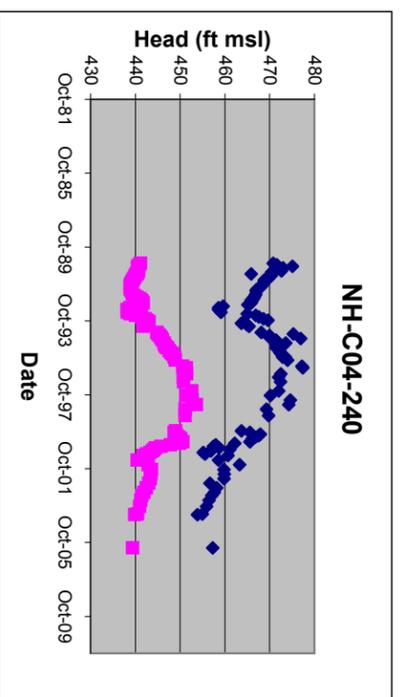
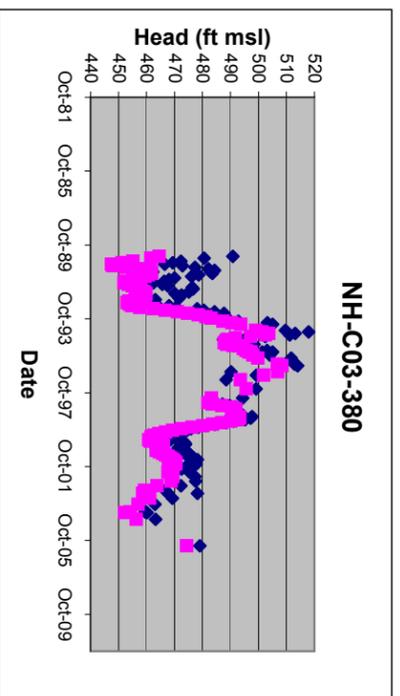
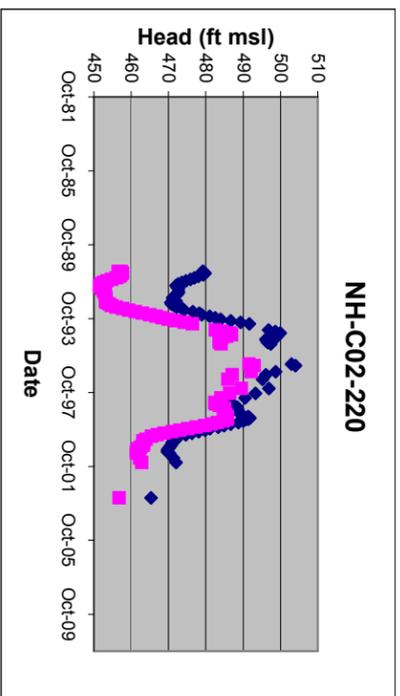
**FIGURE 7 (2 OF 8)**  
**SIMULATED AND MEASURED GROUNDWATER**  
**ELEVATIONS IN CALIBRATION WELLS**  
 2007 SAN FERNANDO VALLEY GROUNDWATER MODEL UPDATE  
 SAN FERNANDO VALLEY, CALIFORNIA

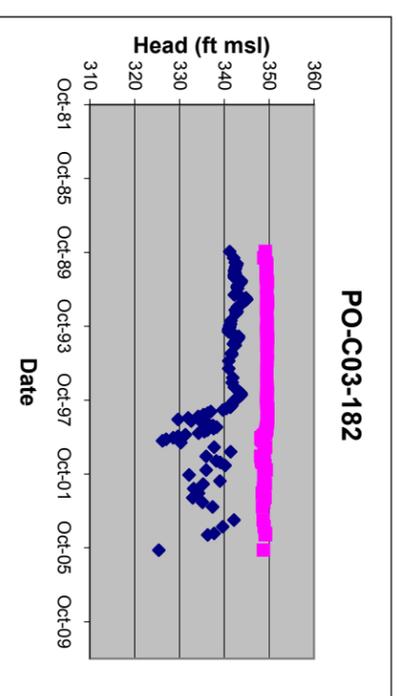
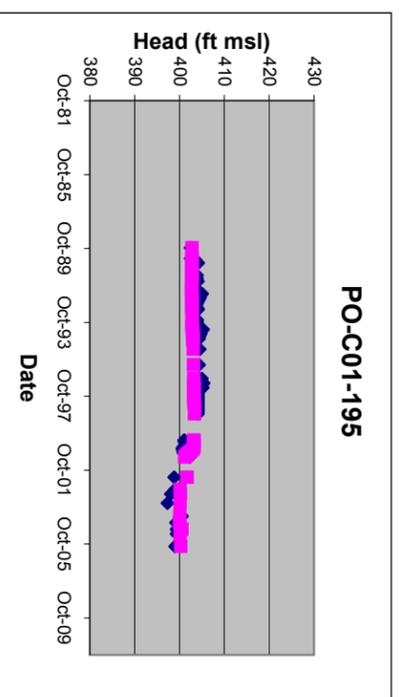
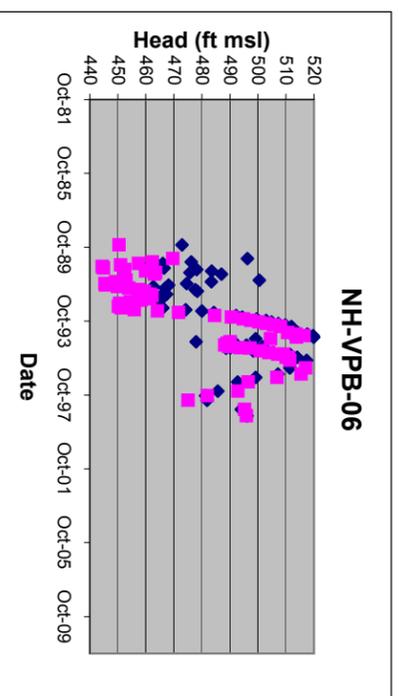
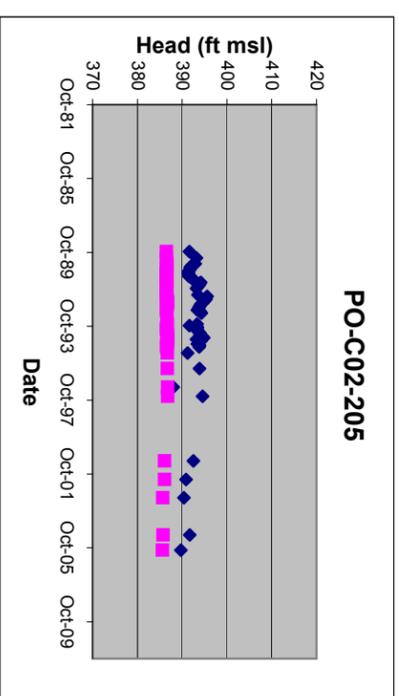
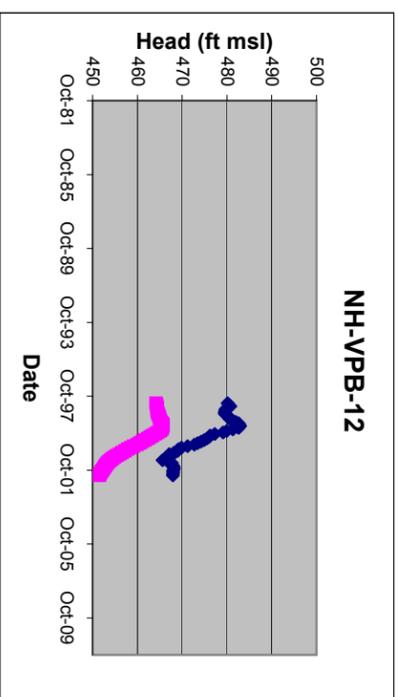
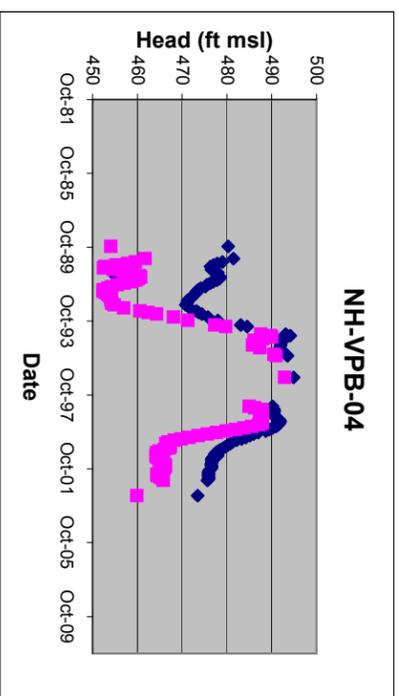
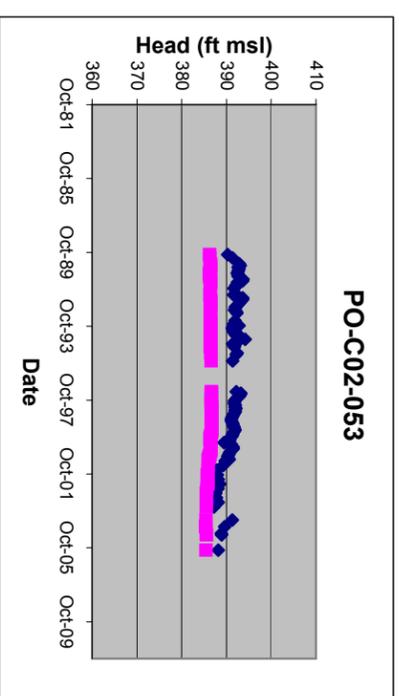
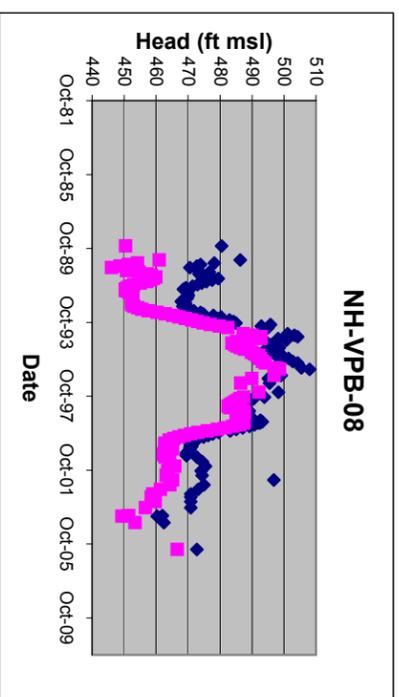
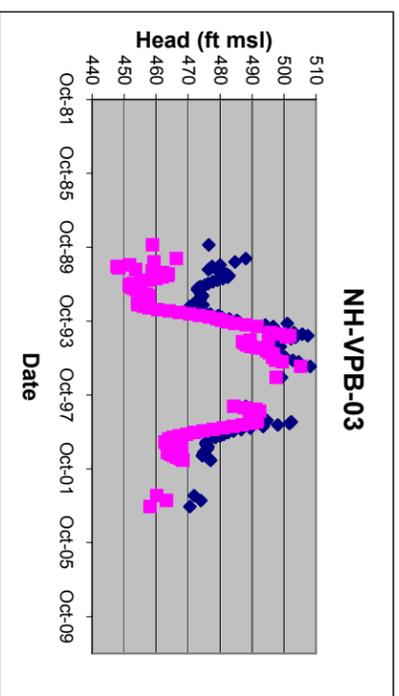
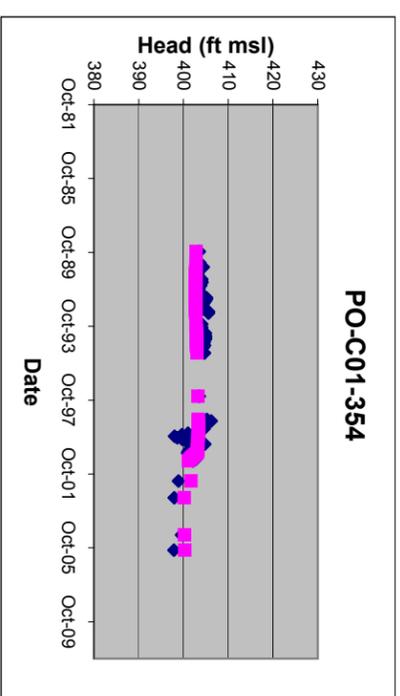
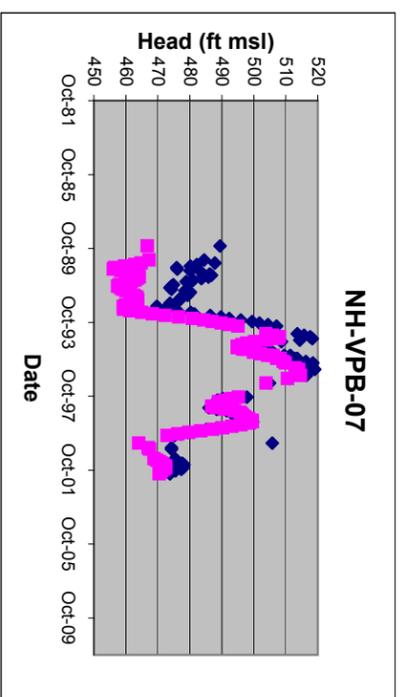
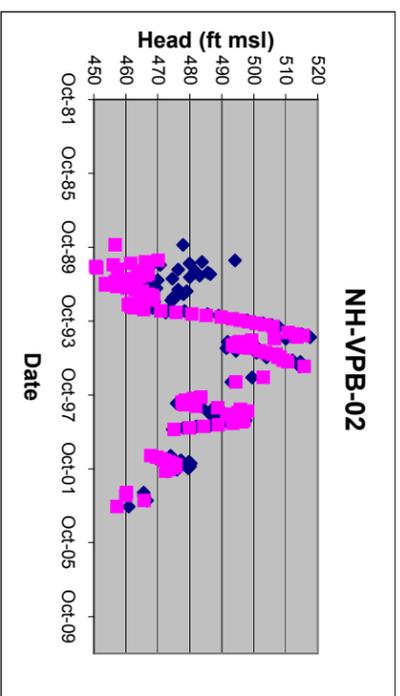


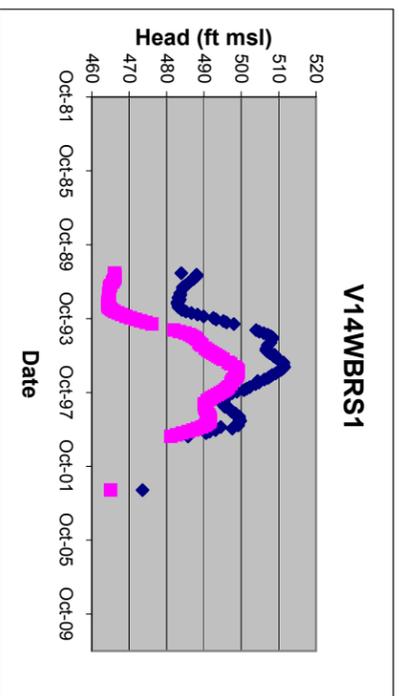
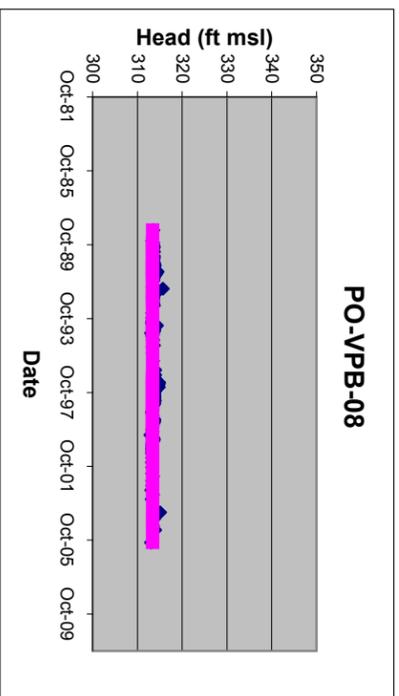
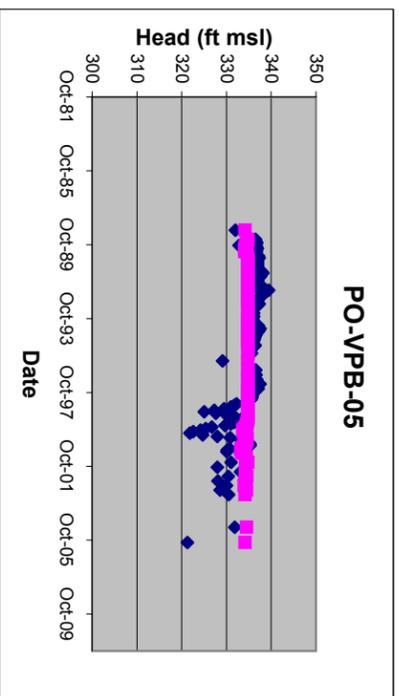
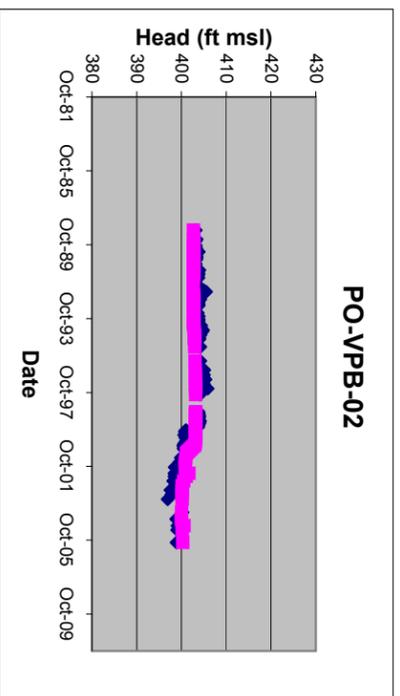
**FIGURE 7 (3 OF 8)  
SIMULATED AND MEASURED GROUNDWATER  
ELEVATIONS IN CALIBRATION WELLS  
2007 SAN FERNANDO VALLEY GROUNDWATER MODEL UPDATE  
SAN FERNANDO VALLEY, CALIFORNIA**











**FIGURE 7 (8 OF 8)  
SIMULATED AND MEASURED GROUNDWATER  
ELEVATIONS IN CALIBRATION WELLS  
2007 SAN FERNANDO VALLEY GROUNDWATER MODEL UPDATE  
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