

**LOCAL GROUNDWATER ASSISTANCE GRANT PROGRAM
APPLICATION**

ATTACHMENT 5

WORK PLAN



UPPER DISTRICT GROUNDWATER REPLENISHMENT MODEL

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Attachment 5 Work Plan

The Upper District will develop a GSFlow¹ or MODFLOW-2005² model to support the design, regulatory permitting, and management of an Indirect Reuse Replenishment Project (IRRP) along the San Gabriel River and near the Santa Fe Dam in the San Gabriel Valley. The groundwater replenishment model will focus on the recharge areas and encompass approximately 50 square miles of the Main San Gabriel Groundwater Basin (Basin). This Work Plan presents a step-wise process for developing a comprehensive three-dimensional groundwater flow model for the IRRP in the Basin. The purpose of the model is to provide a tool that will be used to address regulatory concerns and constraints; and to assess project design and management alternatives.

Specific tasks of the Work Plan include: (1) Data and Document Review; (2) Definition of Geologic Structure and Aquifer Properties; (3) Surface Water Analysis; (4) Conceptual Model Development; (5) Steady-State Calibration; (6) Transient Model Calibration; (7) IRRP Management Model Runs; (8) Project Meetings and Presentations, Quarterly Progress Reports, Model Documentation, and Final Report. The purpose of each task and its specific requirement is described throughout this Work Plan.

5-1. DATA REVIEW AND PREPRATION

All known and available datasets, including existing / previous models developed by the Watermaster (Stetson, 1997), the United States Environmental Protection Agency (U.S. EPA), and Responsible Parties (RPs) within the basin will be relied upon to populate and calibrate all model parameters. This Work Plan builds upon the large body of knowledge that has been developed since the Basin was adjudicated in 1973. Previously developed datasets and published work will be incorporated into the

¹ U.S. Geological Survey, 2008; Coupled Ground-Water and Surface-Water Flow Model based on the integration of the precipitation-runoff modeling system (PRMS) and MODFLOW-2005.

² U.S. Geological Survey, 2005. Modular three-dimensional finite difference groundwater flow model.

groundwater replenishment model to provide a management tool for induced groundwater recharge in the Basin.

The Data Review and Preparation step includes gathering all available data in order to prepare hydrologic, hydrogeologic, and land use analyses required to develop model datasets. Existing models operated by Stetson Engineers, the U.S. EPA, and RPs will be reviewed in order to obtain the most recent and up-to-date data. All of the available hydrologic data and information will be compiled and inventoried in preparation for populating the proposed groundwater model.

The data and information include, but are not limited to: geology, hydrology, hydrogeology, land use, well locations, surface spreading areas, historic groundwater production, and historic water level data. Results from aquifer performance tests (APTs) conducted by the Watermaster will be relied upon to provide site-specific aquifer characteristics such as storage coefficients, as well as vertical and horizontal hydraulic conductivities. Data from monitoring wells such as the Baldwin Park Key Well (Key Well), Garfield Well of the City of Alhambra, Well 2947F of the Los Angeles County Department of Public Work (LACDPW), and Well No. 1 of the City of Covina will be relied upon for model construction.

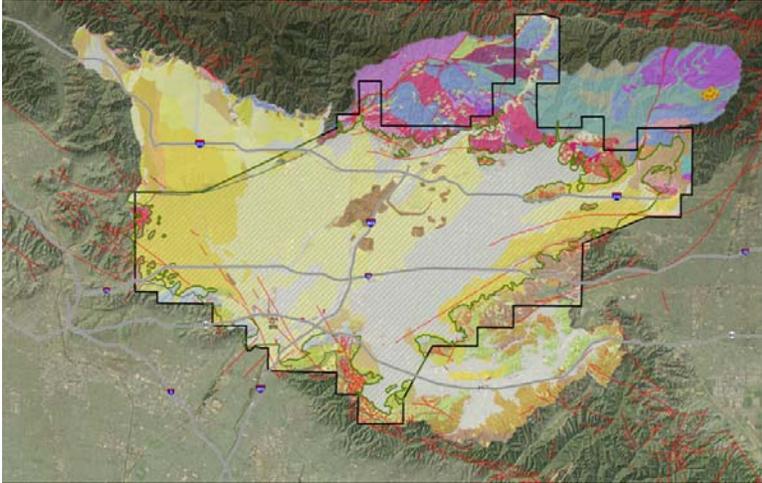
DELIVERABLES:

Annotated bibliography of Reports and Data

Description of other models developed for the Basin

5-2. GEOLOGIC STRUCTURE AND AQUIFER PROPERTIES

The accuracy of the proposed Groundwater Replenishment Model will rely on the physical properties that describe the occurrence and movement of groundwater throughout the study area. Geologic mapping and lithologic well data will be incorporated into a GIS database to develop the stratigraphy, bedrock contours, isopach maps, faults, and other geologic structures. Available data from aquifer performance



testing well logs will be used to develop aquifer properties for the model. These datasets will be used in developing both the conceptual and numerical models that will be used to map the movement of groundwater through the Basin.

San Gabriel Valley Surficial Geology

DELIVERABLES:

Geology, Fault, and Structure Map

Aquifer Isopach Map

Geometry of the model domain and boundary conditions for each layer

Cross sections of the model grid (model boundaries and model layers and thicknesses)

Analysis of areal and vertical distribution of aquifer properties based on aquifer testing

Maps of aquifer properties

5-3. SURFACE WATER ANALYSIS

Surface water is typically the largest single source of recharge and discharge from a groundwater basin. The surface water analysis will rely on existing gaged data to reconstruct flow at the model boundaries. Hydrologic analysis will be applied where no

gaged data exists. Areal recharge will also be estimated based on precipitation and land use throughout the study area. All facilities that store or recharge surface water throughout the study area will be accounted for and quantified in the surface water analysis. Commonly, a reservoir operation model is often necessary to account for precipitation, evaporation, inflow, and discharge from these facilities.

DELIVERABLES:

Reconstructed Streamflow at Model Boundary

Calculation of Boundary Conditions and Subsurface Flow

Calculation of Areal Recharge

Determination of River Reaches and Initial Streambed Conductance

Determination of Surface Spreading Grounds and Recharge Rates

Development of Reservoir Operation Model for Replenishment Basins

Development of Balanced Hydrologic Period for Baseline Analysis

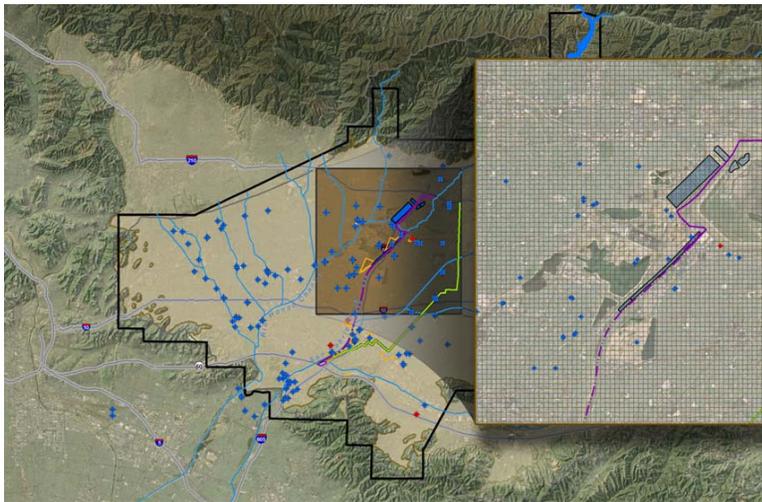
5-4. DEVELOPMENT OF THE CONCEPTUAL MODEL

The conceptual model is often the most important component in developing a comprehensive numerical model. All stresses that affect the occurrence and movement of water through the study area are identified and quantified before numerical modeling may begin. The conceptual model is also the basis for choosing the grid and cell size, and the number of model layers that will be used to simulate the flow through the numerical model. Development of the conceptual model will consider existing datasets and the availability of data, as well as the proposed application of the model in regulatory compliance and management decisions.

The hydrologic data with the largest impact to the IRRP include precipitation, groundwater extraction, imported water, and surface water spreading. Based on available records for critical model parameters, it is likely the period from Water Year

(WY) 1974 to WY 2011 will be selected for the hydrologic conditions for the simulation period of the groundwater replenishment model.

This Work Plan focuses on building upon the existing two-dimensional groundwater model (MSGBWM³ Model) currently used for basin management by the Watermaster⁴. The MSGBWM Model has been in use for over 15 years and has developed comprehensive files that include: groundwater levels, pumping records, well locations, aquifer properties, groundwater replenishment facility records, and other related water resource management attributes important to basin management. Building upon



previously developed datasets from the MSGBWM Model will assure a strong foundation in the historical and institutional understanding of managed recharge projects and groundwater production within the project site.

Proposed Groundwater Replenishment Model Extent

The choice of model code will be based on the processes that control the movement of water through the basin and the extent of available datasets. The USGS GSFLOW is a coupled Groundwater and Surface-water FLOW model based on the integration of the USGS Precipitation-Runoff Modeling System (PRMS) and the USGS Modular Groundwater Flow Model (MODFLOW-2005). MODFLOW was selected because it is well-documented and widely used by researchers, consultants, and government agencies.

³ Main San Gabriel Basin Watermaster Model (MSGBWM Model)

⁴ *San Gabriel Basin Ground-Water Flow Model, Documentation and User's Manual*; prepared by Stetson Engineers, March 28, 1997

DELIVERABLES:

Graphical Model showing all Water Sources and Sinks
Conceptual Annual Groundwater Budget
Conceptual Annual Surface Water Budget
Calculation of Subflow In and Out
Estimates of Evapotranspiration Rates and Locations
Identification of Key Wells and Water Level Target Locations
Description of Conceptual Model

5-5. STEADY-STATE SIMULATION

Following completion of the conceptual model, construction of the three-dimensional numerical model will commence with a goal of simulating historical conditions. Referred to as a steady-state model run, average annual historical conditions will be simulated to ensure that the model accurately accounts for all sources and sinks of water. The steady-state solution will be checked against the groundwater contour map for WY 1975 and the steady-state solution generated by the existing model under the same conditions. In addition, the steady-state drawdown at each pumping node will also be checked with the measured drawdown available from the aquifer performance test data conducted at the well(s) that node represents to ensure the reasonability of the model solution.

A steady-state model run does not simulate changes over time, rather it is intended to show that the model inputs and outputs are stable and convergence of numerical solutions is reached.

DELIVERABLES:

Map Historical Groundwater Levels
Annual Steady State Hydrologic Budget
Description of Steady-State Calibration Approach and Methods

5-6. TRANSIENT CALIBRATION AND SIMULATION

Following completion of the steady-state model run, the transient run simulates changes in groundwater flow conditions during a balanced hydrologic period. The transient simulation is used to verify the model as well as determine its use and limitations based on comparison of model simulated results to observed data.

The transient flow model will simulate changes in groundwater conditions throughout the calibration period to verify that the set of calibrated parameters reproduce measured field data. A sensitivity analysis will be conducted to quantify the uncertainty in the calibrated model. The differences in simulated and measured groundwater levels and streamflow from the calibrated solution will be used for determining the sensitivity of the groundwater replenishment model.

DELIVERABLES:

Map Initial Groundwater Levels

Annual and Average Monthly Hydrologic Budgets

Observed versus Simulated Groundwater Level Residual Maps

Observed versus Simulated Surface Water Hydrographs

Observed versus Simulated Hydrographs of Key Wells

Description of Transient Calibration Approach and Methods

5-7. GROUNDWATER REPLENISHMENT MANGEMENT MODEL RUNS

As previously stated, the purpose of the groundwater replenishment model will be to provide a tool that may be used to assess the impacts from the proposed IRRP and other recharge projects. The three-dimensional numerical groundwater model will be used to evaluate the potential to deliver tertiary-treated wastewater or advanced-treated wastewater for groundwater recharge. The model will simulate baseline and

management scenarios that account for the project's beneficial use of recycled water, as well as ensure that the necessary subsurface retention time along pathways to the closest existing potable production wells to maintain a safety factor for public health.

The results of these management runs will provide knowledge and understanding of not only the impact of the IRRP, but will provide a basis for developing a monitoring plan using existing or new wells to measure the aquifer response to the IRRP.

DELIVERABLES:

Annual and Average Monthly Groundwater and Surface Water Budgets

Hydrographs of Key Wells and Groundwater Level Contour Maps

Description of Each Management Run Impact

Development of a Groundwater Monitoring Plan for the IRRP.

5-8. QUARTERLY PROGRESS REPORTS, MODEL DOCUMENTATION, AND FINAL REPORT; PROGRESS MEETINGS AND PRESENTATIONS

Quarterly progress reports will be provided to ensure that the project progresses through the appropriate milestones in a timely manner. The quarterly reports will summarize the actual work performed, meetings, emerging issues and solutions, and status of each task's schedule and budget. Meetings and presentations will be scheduled throughout the timeline to discuss progress and make decisions regarding model assumptions and required deliverables.

Model development will be documented to provide a clear and complete understanding of the construction, calibration, and validation of the groundwater replenishment model. The documentation will provide access for future modifications and development of input files for new simulations. The report outline will include, but is not limited to, the following sections.