



## APPENDIX B

### GROUNDWATER MODEL USER'S MANUAL

#### B.1 DESCRIPTION OF NUMERICAL MODEL

The design, construction, and calibration of the groundwater model is documented in Section 6 and Appendix A of this report. This section briefly discusses the manner in which key model input data was manipulated and entered into model input data files for model execution. The reader should be familiar with standard MODFLOW input file format or refer to the references in Appendix A for background on model input and output files. MODFLOW96, in particular, has a concise summary of model input file construction.

Much of the data for the SSA groundwater flow model was maintained in a Geographic Information System (GIS) Database to automate the construction of the large arrays required for the MODFLOW input files. These input files were then modified using a visual MODFLOW preprocessor (Groundwater Vistas, 1999) during model calibration and prediction simulations.

##### B.1.1 Layer Elevation Data

Layer elevation data are contained in the \*.BCF MODFLOW input file. These data were derived from the stratigraphic model discussed in Sections 3 and 6, and are shown in the topographic layer contours in Appendix G. Modifications to these arrays can be made by creating an array using contouring or interpolation software with 186 rows and 103 columns that covers the entire model area (minus ¼ mile on each model side to account for the block centered grid block formulation in MODFLOW). The array data must then be formatted in the desired MODFLOW format and edited into the appropriate location in the \*.BCF file.

##### B.1.2 Hydraulic Conductivity Data

Hydraulic conductivity data are contained in the \*.BCF MODFLOW input file. These data are shown in the hydraulic conductivity contours in Section 6, which were initially derived from both the Imperial County Groundwater Model (Montgomery Watson, 1995) and the USBR Model (Bureau of Reclamation,

1988) and later modified during model calibration as discussed in Section 6. Modifications to these arrays can be made as summarized in Section B.1.1.

### **B.1.3 Boundary Condition Data**

Data describing boundary conditions are input in several MODFLOW files depending on the type of boundary conditions. Inactive cells that create model no-flow boundaries depicted by the inactive area in the figures in Section 6 are entered in the IBOUND array in the MODFLOW \*.BAS file. Initial model heads were estimated using the 1960/65 composite water level contour map in Figure 3-1, and are contained in the MODFLOW \*.BAS file. Time varying boundary constant heads were derived by interpolation from Figures 3-1 and 3-2 and the figures in Appendix F and are contained in the MODFLOW \*.CHD file.

Drain input data for the New and Alamo Rivers was derived from river topographic data and are contained in the \*.DRN file. Stream input data used for the AAC, CB, and East Highline canals were derived from canal topographic data and are contained in the \*.RIV file. Lake input data for the Salton Sea were derived from bathymetry data and are contained in the \*.LAK file (see also Section A.4). General head boundary data were estimated from known fluxes between the Cargo Muchacho mountains and Pilot Knob, and the Cargo Muchacho and Chocolate mountains; the general head boundary data are contained in the \*.GHB file.

### **B.1.4 Other Model Data**

Groundwater extraction data for the Mesquite and American Girl Mines were derived from the Imperial County Groundwater Model (Montgomery Watson, 1995), and are contained in the \*.WEL file. Evapotranspiration data were derived from previous analyses of the wetlands (see Sections 4 and 5) and are contained in the \*.EVT file. Recharge due to precipitation was estimated at 0.02 inches per year, and the data are contained in the \*.RCH file. Fault data were derived from geologic maps and by model calibration, and are contained in the \*.HFB file.

Other model data which relates to the model water balance such as canal leakage rates were not hard-wired as recharge rates in the model and they are entered using the River package (\*.RIV). In order to

modify canal recharge rates, the river stage, bed, or conductance data in the \*.RIV files must be modified.

### **B.1.5 Key Model Assumptions**

This section presents a brief discussion of the assumptions used in the mathematical model, including features of the model, assumptions about lateral anisotropy, boundary conditions, mesh size, time steps, which items change during time steps and which are constant, and other assumptions and generalizations.

The New and Alamo Rivers were treated as drain features using the MODFLOW model, which assumes that groundwater inflow into these rivers can be simulated using the methodology employed in MODFLOW for drains. All canals were treated as river features using the MODFLOW model, which assumes that groundwater inflow or outflow into these canals can be simulated using the methodology employed in MODFLOW for rivers. The aquifer was modeled to be laterally isotropic given that neither the data nor the geologic environment suggests the aquifer is laterally anisotropic. Boundary conditions are discussed in detail within the report, with the La Mesa Drain treated as a time-varying head boundary, the Pilot Knob area as a general head boundary, and the IID area as a constant head boundary, which assumes that groundwater inflow or outflow at these locations can be simulated using the methodology employed in MODFLOW for these boundary types.

The mesh size was set to one-half mile in order to resolve the local seepage and canal features. Time steps are set to one-year time periods, except immediately following stress changes in 1979 and 2006 when time steps are ramped up from monthly to yearly values. During transient runs, the only model input parameters which change are the time-varying boundary heads and boundary flux from Coachella Valley into the Salton Sea. Canal seepage factors change twice, once in 1979 at the transition from the steady-state calibration to the transient calibration, and once in 2006 at the AAC and CB lining, but they do not vary within a transient run segment. All other model input parameters are not time variable.

## B.2 GROUNDWATER FLOW MODEL

This section provides brief instructions for running the groundwater flow model using MODFLOW96. Additional notes are included to utilize Groundwater Vistas for pre- and post-processing. The majority of MODFLOW files provided with this report were created using Groundwater Vistas. Note the model must be run using MODFLOW96 with the Lake Package to reproduce the model results given in this report.

### B.2.1 Provided CD Directory Structure

The files included with this report are subdivided into several directories based on the simulation (steady-state or transient), and the model software (Groundwater Vistas or MODFLOW96). Files created in Groundwater Vistas were transferred from that directory to the MODFLOW96 (MF96) directory to run the simulations.

C:\SSA\_CD\Steady-State\MF96

C:\SSA\_CD\Transient\MF96

### B.2.2 Model Input Files

The following Groundwater Vistas model input files were distributed with this report:

RUNIN.GWV	Steady-state simulation (represents 1979 conditions)
RUN1NT.GWV	Transient simulation (represents 1979 to 2006 conditions)
RUN1PT.GWV	Transient simulation (represents 2006 to 2026 conditions with canal linings)
RUN1QT.GWV	Transient simulation (represents 2006 to 2026 conditions without canal linings)
RUNTOSS.GWV	Transient simulation (represents long term SS conditions with canal linings)

The following MODFLOW96 model input files for each simulation was distributed with this report:

RUN*.BAS	basic model input data
RUN*.BCF	model construction and hydraulic data

RUN*.CHD	time varying constant head cells (transient simulations only)
RUN*.DRN	drain elevation and conductance data
RUN*.EVT	evapotranspiration data (transient simulations only)
RUN*.GHB	general head boundary data
RUN*.HFB	horizontal flow barrier data
RUN*.LAK	lake data
RUN*.OC	model output control
RUN*.PCG	PCG solver options
RUN*.RCH	recharge data
RUN*.RIV	river elevation and conductance data
RUN*.WEL	well location and pumping schedules

The data contained in each is briefly documented in Section B.1. All files are needed to run the model. The CHD file created by Groundwater Vistas for simulation RUN1PT was not used in running MODFLOW96 and should not be used in place of the CHD file provided.

### B.2.3 Model Batch Files

Within the MF96 directory a batch file is included that automatically runs MODFLOW96. The batch file calls all relevant MODFLOW96 input files and creates all relevant MODFLOW96 output files. Additionally, the batch file will change the MODFLOW96 format head save (\*.HED) and cell-by-cell flow (\*.CBC) output files to Groundwater Vistas format (\*.HDS and \*.CBB, respectively). Although this step is not necessary for use in MODFLOW96 it is included for Groundwater Vistas users.

The following model batch files for each simulation were distributed with this report:

RUNLAK1N.BAT	model simulation RUN1N batch file
RUNLAK1NT.BAT	model simulation RUN1NT batch file
RUNLAK1PT.BAT	model simulation RUN1PT batch file
RUNLAK1QT.BAT	model simulation RUN1QT batch file
RUNLAKSS.BAT	model simulation RUNTOSS batch file

#### **B.2.4 Model Output Files**

The following model output files were distributed with this report:

RUN*.OUT	text model output summary
RUN*.HED	unformatted model head save data (MODFLOW96)
RUN*.HDS	binary model head save data (GW VISTAS)
RUN*.CBC	unformatted model water budget data (MODFLOW96)
RUN*.CBB	binary water budget data (GW VISTAS)
RUN*.STG	lake package stage file (transient simulations only)

Only the text \*.OUT file can be viewed directly, and a post-processor is required to view the binary file data. However, the \*.OUT file also contains limited model head and drawdown output arrays, as well as an echo of the model input data; model execution and error messages; mass balance summaries; and lake stage data for the steady-state simulation. Head save and cell-by-cell data was output for the beginning and ending time step of each stress period. Additional data was output based on period length, which varied by simulation. Review of the Output Control file (\*.OC) will reveal which additional time steps were output. Note that the transient cell-by-cell output files are zipped up in file "CBB\_CBC.zip" due to the large size of these files (>70MB each). Lake stage data for each time step are located in the \*.STG files. Drawdown files (\*.DDN) were not included, but can be created by modifying the .OC file and re-running the desired simulation.

#### **B.2.5 Model Execution**

The model must be executed with the MODFLOW96 version with the Lake Package (MODFL96.EXE) that was distributed with this report using the batch job file RUN\*.BAT (Section B.2.3). To execute the model, copy all input files, the batch file RUN\*.BAT, and the executable MODFL96.EXE into a single directory. Then, type "RUN\*.BAT" at the DOS prompt in the same directory. The model execution time will vary based on the simulation run and individual computer processing speed. The output files listed above will be created. Note that output files will automatically be overwritten when simulations are re-run if they are located in the same directory, so a backup copy should be maintained elsewhere.

### **B.2.6 Model Pre- and Post-Processing Using Groundwater Vistas**

Changes to file paths are required to run the simulations in Groundwater Vistas properly on individual computers. Specifically, the paths to model executables (including the working directory), paths to Groundwater Vistas base maps, and the starting heads files need to be modified based on the user's directory structure.

It is recommended that MODFLOW96 files be kept in a directory separate from the directory (working directory) in which Groundwater Vistas files are created (similar to the structure on the CD provided) to prevent overwriting files modified specifically for MODFLOW96. After new files are created, transfer the desired files to the MODFLOW96 directory (MF96 on CD) to run the simulation.

When accessing output files for display and analysis in Groundwater Vistas it is necessary to "browse" for the appropriate files as Vistas defaults to its "working directory", which should be different than the MODFLOW96 directory in which the simulations were run.

The Basic Package (\*.BAS) created by Groundwater Vistas must be modified for MODFLOW96 to call the Lake Package (\*.LAK). The unit number for the Lake Package (39, for the simulations provided) must be added in IUNIT location 15.

As stated in Section B.2.2, the CHD file created by Groundwater Vistas for simulation RUN1PT is not used, and should be modified outside of Groundwater Vistas.

### **B.3 REFERENCES**

Bureau of Reclamation

1988 *Colorado River Water Underground Storage and Recovery Study, Imperial County, California.*

Groundwater Vistas

1999 Environmental Simulations, Inc., Oak Hill, VA 20171, Version 2.1, Internet address [www.groundwatermodels.com](http://www.groundwatermodels.com)

Montgomery Watson

1995 *Imperial County Groundwater Study, Final Report.*



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