Visual MODFLOW Pro V 4.3

The Proven Standard for Professional Groundwater Flow and Contaminant Transport Modeling

Visual MODFLOW Pro’s three-dimensional groundwater flow and contaminant transport modeling capabilities are trusted and used by more groundwater professionals than any other modeling software in the world thanks to several seamlessly integrated numeric engines with an easy-to-use graphical interface.

With the ability to simulate groundwater and surface water interactions, and the added capability of calculating changes to groundwater chemistry, groundwater professionals now have a complete set of tools necessary for addressing water quality, groundwater supply, and source water protection initiatives.

MODFLOW-2000 - World standard for groundwater flow simulations
MODFLOW-2005 - three-dimensional finite-difference groundwater-model, 2005 version
MODPATH - standard package for forward and reverse particle tracking
Zone Budget - for sub-regional water budget calculations
MT3DMS - for multi-species contaminant transport simulations
MT3D99 - an enhanced version of MT3DMS, that includes support for implicit solver, TVD Solution scheme, dual-porosity advection-diffusion, Non-equilibrium Sorption and Monod Kinetics, and Multispecies Reactions, including First-Order Parent-Daughter chain reactions, and Instantaneous Reactions among species.
MNW (Multi-Node Well) - designed to help simulate wells with well screens that span multiple layers.
RT3D - for reactive transport simulations
PHT3D – a multi-component transport model for three-dimensional reactive transport in saturated porous media. It couples the two existing and widely used computer programs, the solute transport model
MT3DMS and the USGS geochemical code PHREEQC-2. **SEAWAT-2000** - the latest USGS modeling code designed to address three-dimensional, variable-density, transient groundwater flow conditions. **MGO** - for determining the optimal well pumping and/or injection rates at one or more wells, in order to achieve a specific objective while maintaining reasonable system responses.

**VMOD 3D-Explorer** - 3D visualization and animation. **WinPEST** - automated calibration and sensitivity analysis. **GMG (Geometric Multi-Grid) Solver Integration** - latest USGS solver designed to optimize memory usage and reduce model run times. **Stream Routing Package** - suited for simulating the effects of surface water/groundwater interactions. **MIKE11** - The basic river network/channel modeling component of MIKE 11 is now integrated, providing the tools for integrated surface water - groundwater flow.

Add-on software:

**Visual MODFLOW 3D-Builder** - Visual MODFLOW 3D-Builder prepares a wide-range of output data for Visual MODFLOW within a single modeling environment for simulating your groundwater and surface water interactions. **MODFLOW-SURFACT** - Three-dimensional finite-difference variably-saturated flow or soil vapor flow simulations (supports flow only).

**With Visual MODFLOW Pro, you have all the tools necessary to:**

Graphically assign model grids, properties and boundaries
Visualize model input parameters (2D or 3D views)
Run the flow, pathline, and transport simulations
Automatically (WinPEST) or manually calibrate the model
Display and interpret the modeling results in full 3D
Produce professional reports

**Visual MODFLOW Pro Product Details Overview**

<table>
<thead>
<tr>
<th>About The Interface</th>
<th>Specifically designed to increase modeling productivity and decrease complexities typically associated with building three-dimensional groundwater flow and contaminant transport models. The interface is divided into three separate modules; Input, Run and Output.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building The Model</td>
<td>Logical structure and layout eliminates the difficulties of building the input data file for a groundwater flow and/or transport model by guiding the user through the sequence of steps necessary to build a model.</td>
</tr>
<tr>
<td>Running The Simulation</td>
<td>Allows the user to select and modify the various flow and transport run-time options and start the model</td>
</tr>
</tbody>
</table>
calculations using the Win32 MODFLOW Suite directly from within the modeling environment.

**Power Features**
Visual MODFLOW Pro has multiple power features including:

- USGS SEAWAT-2000
- MGO - Modular Groundwater optimizer
- GMG Solver Implementation
- MNW – Multi-Node Well

**Displaying And Interpreting Results**
Visual MODFLOW Pro automatically reads the results created from each successful simulation and provides a comprehensive selection of graphical formats for displaying full-color results in plan view and cross-sectional views.

**Calibrating The Model**
An extensive selection of built-in model calibration plots and statistical summaries give you with all the interpretation capabilities you need to properly and thoroughly analyze the model calibration data.

## Compare the different versions of Visual MODFLOW

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>MODFLOW 96/2000/2005</td>
<td>🟢</td>
<td>🟢</td>
<td>🟢</td>
</tr>
<tr>
<td>MODPATH</td>
<td>🟢</td>
<td>🟢</td>
<td>🟢</td>
</tr>
<tr>
<td>ZoneBudget</td>
<td>🟢</td>
<td>🟢</td>
<td>🟢</td>
</tr>
<tr>
<td>MT3DMS</td>
<td>🟢</td>
<td>🟢</td>
<td>🟢</td>
</tr>
<tr>
<td>RT3D 1.0/2.5</td>
<td>🟢</td>
<td>🟢</td>
<td>🟢</td>
</tr>
<tr>
<td>StreamRouting MNW</td>
<td>🟢</td>
<td>🟢</td>
<td>🟢</td>
</tr>
<tr>
<td>MGO</td>
<td></td>
<td></td>
<td>🟢</td>
</tr>
<tr>
<td>WinPEST</td>
<td></td>
<td></td>
<td>🟢</td>
</tr>
<tr>
<td>VMOD 3D-Explorer</td>
<td></td>
<td></td>
<td>🟢</td>
</tr>
<tr>
<td>SEAWAT</td>
<td></td>
<td></td>
<td>🟢</td>
</tr>
<tr>
<td>GMG</td>
<td></td>
<td></td>
<td>🟢</td>
</tr>
<tr>
<td>PHT3D</td>
<td></td>
<td></td>
<td>🟢</td>
</tr>
<tr>
<td>MODFLOW 2005</td>
<td></td>
<td></td>
<td>🟢</td>
</tr>
<tr>
<td>SAMG</td>
<td></td>
<td></td>
<td>🟢</td>
</tr>
<tr>
<td>MT3D99</td>
<td>add-on</td>
<td>add-on</td>
<td>🟢</td>
</tr>
<tr>
<td>Visual MODFLOW</td>
<td>add-on</td>
<td>add-on</td>
<td>add-on</td>
</tr>
</tbody>
</table>
Multi-Node Well package (MNW)

The Multi-Node Well package allows for true representation of wells screened over multiple layers. The simulation of pumpage by wells is a fundamental and widely used feature of ground-water models such as MODFLOW. Visual MODFLOW’s new addition, the Multi-Node Well Package (MNW), is designed to help simulate wells with well screens that span multiple layers. Now you can:

- Accurately simulate pumping wells screened in multiple aquifers
- Analyze the intra-borehole flow in pumping or injection and evaluate the dynamic changes in the distribution of wellbore inflow
- Simulate three types of well losses: linear, non-linear, and skin-effects
- Simulate development of well skin over time - charging transmissivity and radius
- Simulate Well Impact Assessments, Well Impairment and Well Underperformance

Wells Manager

To accommodate data input for the MNW package, the wells manager was dramatically improved to allow for easier definition and modification of properties for pumping and observation wells

MODFLOW-SURFACT v3

Enjoy more options for decomposition of the matrix with the added PCG5 solver

- The Recharge Package (RSF4) has been enhanced to include input of recharge with zonal recharge values via a separate recharge time-series (RTS) file
- The ET packages EVT and ETS1 have been modified to include zonal input of ETmax values provided via a separate ET time-series (ETS) file

Multi-Processor Support

Simulate wells over multiple layers with the powerful USGS Multi-Node Well package

Reduce run times with the new MODFLOW-SURFACT PCG-5 solver

Leverage the power of the MT3DMS multi-processor for simulating multiple species

<table>
<thead>
<tr>
<th>3D-Builder</th>
<th>MODFLOW-SURFACT</th>
<th>MIKE 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>add-on</td>
<td>add-on</td>
<td>add-on</td>
</tr>
<tr>
<td>add-on</td>
<td>add-on</td>
<td></td>
</tr>
</tbody>
</table>
Leverage the power of multiple processors on your machine with MT3DMS multi-processor support for transport variants that involve multiple species

Numeric Engines

MODFLOW 2000 1.18.00
MODFLOW 1.4.00

At Schlumberger Water Services, our goal is to develop powerful, yet easy-to-use software that meets the needs of groundwater and environmental professionals around the world. Visual MODFLOW Pro is an excellent example of how we have accomplished this goal by making groundwater modeling accessible for any hydrogeologist or engineer who is familiar with the basic concepts and limitations of groundwater modeling.

Professional Applications of Visual MODFLOW Pro:

- Predict impacts from saltwater intrusion from over pumping in coastal regions
- Delineate well capture zones for municipal drinking water supplies
- Design and optimize pumping well locations for dewatering projects
- Evaluate groundwater remediation systems (pump & treat, funnel & gate, etc.)
- Simulate natural attenuation of contaminated groundwater
- Estimate the reductive dechlorination of TCE, PCE and DCE in groundwater
- Determine contaminant fate and exposure pathways for risk assessment

A regional-scale groundwater flow model for the Leon-Chinandega aquifer, Nicaragua
Heyddy Calderón Palma and Laurence R. Bentley

Hydrogeology Journal - June 6 2007

Abstract

Groundwater flow in the Leon-Chinandega aquifer was simulated using transient and steady-state numerical models. This unconfined aquifer is located in an agricultural plain in northwest Nicaragua. Previous studies were restricted to MORE...

Vertical migration of municipal wastewater in deep injection well systems, South Florida, USA
Robert G. Maliva, Weixing Guo and Thomas Missimer

Hydrogeology Journal - 24 April 2007

Abstract

Deep well injection is widely used in South Florida, USA for wastewater disposal largely because of the presence of an injection zone ("boulder zone" of Floridan Aquifer System) that is capable of accepting very large quantities of fluids, in some wells over 75,000 m3/day. MORE...

Visual MODFLOW Pro Case Studies:

Water Resource Management for Mining
Tailings Pond Evaluation and Impact Assessment

About The Interface
Building The Model
Running The Simulation
Add-On Packages

Power Features
Displaying & Interpreting Results
Calibrating The Model
System Requirements

ABOUT THE INTERFACE

When you open or create a file, you will be able to seamlessly switch between these modules to build or modify the model input parameters, run the simulations, and display results.

The Display Control Buttons
The ability to quickly and easily switch between plan view and cross-section display of the model is a powerful feature that allows the user to gain a better perspective on the three-dimensional aspects of the model input parameters and simulation results.

The Navigator Cube
The Navigator Cube provides a three-dimensional schematic representation of the model grid and layers. This navigator cube provides a quick visual reference of your active position within the model domain. Also, the active mouse location (X,Y,Z model co-ordinates and I, J, K grid coordinates) are interactively displayed below the navigator cube as you move the mouse around the screen.

Cell Inspector
The Cell Inspector is used to inspect selected model parameter values on a cell-by-cell basis. Model parameters that may be viewed in the Cell Inspector include:
Grid Position
Model Position
World Position
Properties (Kx, Ky, Kz, Specific Yield, Specific Storage, Effective Porosity, Initial Head, and Initial Concentration values)
Boundary Conditions
Output

BUILDING THE MODEL

Project Wizard

Improved project creation wizard helps you to choose the optimal numeric engines to meet your project objectives. You can also import MODFLOW-2000, MODFLOW-96, and MODFLOW-88 data sets.

Site Map Layers

Load site maps and overlay on your model. Supported formats included AutoCAD (.DXF), Shapefiles (.SHP), and Raster images (.BMP, .JPG, .GIF).

Grid Design

Visual MODFLOW Pro allows you to rotate the model domain over the site map (.DXF or .BMP format) to align the model grid with the site characteristics and groundwater flow direction. The finite difference grid can be modified by adding, deleting, moving and automatically refining rows, columns and layers.

Automatic Grid Smoothing

It is important to design the model grid with proper grid spacing to give you the level of detail you needed, while maintaining the numerical stability required for the solution to converge. Automatic grid smoothing is used to identify and fix regions of the grid which are poorly designed and optimize the transition from small grid spacing to large grid spacing.

Importing Layer Elevations

Since most aquifers are not 'flat' layers, Visual MODFLOW Pro allows you to import layer surface data from ASCII (X,Y,Z), Surfer (GRD), USGS DEM (.DEM), ESRI (.GRD), Mapinfo (.GRD). Import and interpolate layer elevations and
elevation data from XYZ ASCII files (TXT), MS Access Database (MDB), MS Excel (XLS), and ESRI Point Shape files (SHP).

There is an option to specify control points, manipulating the interpolation results.

**Grid Cell Elevation Editor**

This tool allows you to modify the individual elevations of each cell using an array editor to modify the elevation value. The cell elevations can also be modified in cross-section using 'drag-and-drop' methods to stretch or compress a cell thickness.

**Pumping Wells**

Pumping wells or injection wells can be added, deleted, copied or moved using the intuitive well edit tools that allow you to graphically delineate the well screen interval and enter or import real-time pumping schedules from an ASCII text file. For sites with many pumping wells, Visual MODFLOW Pro can also import all relevant pumping well data.

Import wells from .txt, .vc, .shp, .xls, .mdb files.

Multiple well screens for a single well are easily accommodated while the pumping rate distribution between layers is automatically calculated based on the transmissivity of the layers through which it is screened.

**Observation Wells**

Visual MODFLOW Pro is the only MODFLOW modeling environment that allows you to assign multi-level observation wells, just like ones you have in the field. In addition, Visual MODFLOW is the only modeling software package that allows you to group the observation points into one or more observation groups. This grouping feature is used for interpreting the calibration data for an isolated section(s) of your model domain.

**Properties**

Visual MODFLOW Pro separates the model properties into two distinct categories:

**Flow Properties**

Those physical model properties affecting the groundwater flow simulation. Flow properties include; hydraulic conductivity (Kx, Ky, and Kz), specific storage (Ss), specific yield (Sy), porosity and initial heads.

**Transport Properties**

Those physical and chemical model properties affecting the fate, migration and degradation of a contaminant plume in groundwater, or
adsorbed to the soil. Transport properties include; dispersion (Dx, Dy and Dz), bulk density, distribution coefficient (Kd), decay constants, initial concentrations.

Import property zones from ESR1 polygon (.SHP) files.

Properties can be interpolated from XYZ ASCII files (TXT), MS Access Database (MDB), MS Excel (XLS), and ESRI Point Shape files (SHP). Interpolation options include Natural Neighbor, Kriging, and Inverse Distance.

**Boundary Conditions**

MODFLOW boundary conditions supported by Visual MODFLOW Pro include both steady-state and transient Constant Heads, Rivers, General Heads, Drains, Recharge and Evapotranspiration. The Horizontal Flow Barrier package is also supported.

Visual MODFLOW Pro also supports all contaminant transport boundary conditions available for the latest versions of MT3D including MT3DMS for multi-species transport, and RT3D for reactive transport and natural attenuation simulation. These include constant, recharge, or evapotranspiration concentration, and point source.

For transient simulations, real-time schedules of boundary condition values can be entered directly or imported into the time schedule from an ASCII text file. Recharge and evapotranspiration boundary conditions can be imported from ESRI polygon shapefiles.

**Particles**

Forward or backward tracking particles can be easily assigned for determining advective transport, preferred flow pathways and delineating well capture zones. Visual MODFLOW Pro's intuitive graphical tools allow you to easily assign single particles, lines of particles and a circle of particles anywhere in your model domain.

**Zone Budget**

The Zone Budget package allows you to produce zone-to-zone flow summaries for regions of interest in your model domain. Define zone budget flow observations, such as baseflow to a stream, or flux across a boundary, which can be used for calibrating the groundwater flow model against data other than just head measurements. Zone budget observations can be included in WinPEST.

**Enviro-Base Pro**

Visual MODFLOW Pro now integrates Enviro-Base Pro - an all-in-one database designed to house a variety of referenced property information used when developing groundwater models. Enviro-Base Pro enables
you to consolidate your technical references into one package that can be easily launched, searched and updated.

---

**RUNNING THE SIMULATION**

**The Run Settings**

Using Visual MODFLOW Pro, you can easily set up a batch file to run several models in successions. This powerful feature allows you to create multiple versions of the same model and run them while you are doing other tasks.

- Initial head estimates (import from ASCII or Surfer, or previous run). Option to calculate VCONT from ground elevation or initial heads
- Number of time-steps and time-step multiplier
- Solver selection and convergence settings
- Recharge layer settings
- Layer-types (e.g. confined, unconfined)
- Rewetting options, including option to maintain a minimum saturated thickness for dry cells and to specify a head value in these cells equivalent to the cell bottom elevation.
- Anisotropy option

**MT3D run settings include:**

- Initial concentrations (import from ASCII or Surfer)
- Solver and advection package settings (UFD, TVD, MOC, MMOC, HMOC)
- Simulation output times

**Advanced Settings**

For the advanced users of MODFLOW, you can substitute your own manually created input data files for any MODFLOW by using the Advanced Settings. The Advanced Settings allows you to specify which files you will use from Visual MODFLOW Pro, and which files you will substitute.

**Batch Runs**

Visual MODFLOW Pro also now allows you to easily set up a batch file to run several models in succession. This is a very powerful feature that allows you to create several versions of the same model and then run the models while you are doing other tasks.

**The Win32 MODFLOW Suite**
Visual MODFLOW Pro includes the Win32 MODFLOW Suite with MODFLOW-2000, MODPATH, Zone Budget, MT3DMS and RT3D compiled to run as true Windows, 32-Bit applications. This unique and powerful modeling utility actually provides you with the ability to control the numerical solution process by manipulating the solver parameters and convergence criteria while the solution is in progress. In addition, it provides a real-time graphical display of the solution convergence data and a detailed graphical summary of the Zone Budget results.

After each successful run has completed, the Win32 MODFLOW Suite automatically produces all of the necessary files required for you to analyze and interpret the results, and produce full-color, report-quality graphical presentations using Visual MODFLOW Pro’s post-processing graphical features.

POWER FEATURES

USGS SEAWAT-2000

The USGS SEAWAT 2000 engine has now been included in Visual MODFLOW Pro, allowing modeling of variable density flow such as seawater intrusion modeling problems. SEAWAT combines a flow code (MODFLOW) with a solute-transport code (MT3DMS) to form a single program that solves the coupled flow and solute-transport equations. It formulates flow equations using mass conservation instead of volume conservation (MODFLOW-2000).

The SEAWAT Engine has also been integrated with the WinPEST parameter optimization component of Visual MODFLOW Pro.

MGO - Modular Groundwater Optimizer

Modular Groundwater Optimizer is a simulation optimization software system, that can be used to reduce the costs associated with installing and operating a pump-and-treat remediation system. MGO code can be applied with no or minor modification to a variety of groundwater resource management issues and other types of remediation systems such as bioremediation, optimization of groundwater pump-and-treat systems.

View MGO Summary Paper

GMG Solver Implementation

The new Geometric Multigrid Solver (GMG) solver from USGS has been integrated with the MODFLOW-2000 and SEAWAT-2000 Engines. GMG is based on the geometric multigrid solver method. The GMG solver has been demonstrated to greatly reduce model run times relative to other
solvers using a comparable amount of memory.

**MNW - Multi-Node Well**

The simulation of pumpage by wells is a fundamental and widely used feature of ground-water models such as MODFLOW. Visual MODFLOW’s new addition, the Multi-Node Well Package, is designed to help simulate wells with well screens that span multiple layers. Now you can accurately simulate pumping wells screened in multiple aquifers.

**ADD-ON PACKAGES**

**MIKE 11**

MIKE 11, developed by DHI, is a world-recognized surface water modeling package designed for simulating the hydrodynamic conditions found in rivers, lakes, reservoirs, and irrigation canals. Visual MODFLOW Pro and MIKE 11 are now available as a fully coupled, groundwater and surface water simulation environment. This impressive combination represents the only truly conjunctive groundwater/surface water model combining USGS MODFLOW 2000 and DHI’s MIKE 11. Ideally suited for:

- Analyzing the hydraulic connection between rivers, streams, and aquifer systems
- Determining groundwater base-flow and potential impacts to ecologically sensitive areas
- Calculating infiltration rates from surface water to groundwater during rainfall events
- Developing comprehensive watershed management plans

**MODFLOW-SURFACT**

MODFLOW-SURFACT is a three-dimensional finite-difference flow and transport program containing many advancements and improvements over the standard public-domain versions of MODFLOW.

With more robust solution methods and enhanced simulation capabilities for handling complex saturated/unsaturated subsurface flow and transport processes, MODFLOW-SURFACT is specifically designed to address the many limitations and short-comings of the standard MODFLOW codes.

**Use MODFLOW-SURFACT when simulating:**

- Multiple water tables, or perched water table systems
- Steep water table gradients crossing multiple model layers
- Over-pumped wells screened across multiple model layers
- Surface water infiltration through the vadose zone to the water
Large water table fluctuations causing desaturation/resaturation of grid cells
Soil vapor flow through the unsaturated zone

DISPLAYING AND INTERPRETING RESULTS

In order to get the most out of the model that you build, it is critical that you have the tools necessary to properly analyze the results.

Contouring and Color Maps

Visual MODFLOW Pro creates detailed contour maps of modeling results including:

- Heads, drawdown and multi-species concentrations
- Water table elevations/depth and net recharge
- Head difference between layers and flux between layers

High-quality color shaded contouring is also available for creating presentation quality color maps of all contoured results.

Flow Velocity Vectors and Pathlines

Visual MODFLOW Pro displays flow velocity vectors and flow pathlines. Flow velocity vectors can be used to effectively illustrate the direction and magnitude of groundwater flow velocity throughout the model domain.

Export Options

Export model display to Raster image format (.BMP, .JPG, .TIF, .PNG, .TIF), or AutoCAD (.DXF) in model or world co-ordinates

Export contour lines, velocity vector maps, and pathline locations to ESRI Shapefile (.SHP) in model or world co-ordinates

Export a wide variety of gridded data to ASCII .TXT, Surfer .GRD, or TecPlot (.DAT) Visualization using VMOD 3D-Explorer

To achieve an in-depth understanding of your model, and to effectively present the model results to clients or the general public, we’ve incorporated powerful two and three dimensional visualization and animation tools through the VMOD 3D-Explorer.

Create contour/color maps of model properties and simulation
results

Present graphical summaries of global and local mass budgets
Create model calibration plots and statistical summaries including
mean error, absolute mean error, standard deviation, and many more!
Full control of map overlays - save your overlay configurations
and view only the overlays you require!
Display 3D pumping wells and observation wells
Represent soil property zones and boundary conditions in 3D
Render high resolution 3D volumetric contaminant plumes
Create irregular shaped cross-sections
3D pathlines with time markers
Define 3D cut-away regions
Animate sequential degradation of contaminant plumes and save
into AVI file format for use in Microsoft PowerPoint presentations!

Mass Budgets for Flow and Transport

Visual MODFLOW Pro produces detailed tabular and graphical reports of
the mass balances for both the flow and mass transport simulations.
These reports provide global and local summaries of the mass inflows
and outflow from the system, or from a localized region of the model.

Printing

Visual MODFLOW Pro prints full-color, high-resolution graphics to any
printer or plotter supported by Windows. The graphical display of the
simulation results and/or input files can be printed in portrait or landscape
format as a full-page image or with a title block that describes the details
of the model and the results being displayed. Color-shaded contours can
be printed with or without a color legend.

Visual MODFLOW Pro also prints the on-screen display to several
graphics file formats and exports results to ASCII files in two or three
dimensional format.

CALIBRATING THE MODEL

WinPEST

WinPEST has been seamlessly integrated into Visual MODFLOW Pro to
allow you to conveniently select the model parameters you want to
optimize, and then easily launch the built-in WinPEST application directly.

WinPEST not only modifies the MODFLOW input data files, it also
modifies and updates the Visual MODFLOW Project data files. This
makes it much more practical and convenient to re-load your model files.
once the automated calibration procedure is completed.

Supported parameters for a PEST simulation include flow properties and recharge. You can include head and/or concentration observations, and zone budget observations in the objective function.

During PEST execution, you can view a number of useful pieces of information for displaying and interpreting the PEST simulation results, many of them in real-time graphical form. You can also see how PEST adjusted the values of the parameters during the optimization process.

In all of these plots, Right-Clicking on the graphs and selecting Properties will allow you to alter the appearance of the plots. These plots include:

<table>
<thead>
<tr>
<th>Objective Function (Phi)</th>
<th>Covariance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composite Sensitivity</td>
<td>Eigenvectors and Eigenvalues</td>
</tr>
<tr>
<td>Parameters History</td>
<td>Uncertainties</td>
</tr>
<tr>
<td>Marquardt Lambda</td>
<td>Residuals</td>
</tr>
<tr>
<td>Calculated vs. Observed</td>
<td>Residual Histogram</td>
</tr>
<tr>
<td>Jacobian</td>
<td>Prediction</td>
</tr>
<tr>
<td>Correlation</td>
<td>Regularization Weight Factor</td>
</tr>
</tbody>
</table>

**Tools for Manual Calibration**

An extensive set of built-in model calibration plotting utilities and statistical calculations help you properly evaluate the modeling results and interpret the calibration data. Comprehensive calibration plotting utilities and statistical summaries provide you with all the graphical interpretation tools you need to properly and thoroughly analyze the model calibration data.

Visual MODFLOW allows you to assign multi-level observation wells and group the observation points for isolated analysis of local model regions.

For each simulation Visual MODFLOW calculates the following calibration statistics:

- Mean Error
- Mean Absolute Error
- Standard Error of the Estimate
- Root Mean Error
- Normalized Root Mean Error

These statistics can be calculated for all observations, or just for selected
groups of observation points (as defined by the user).

The calibration plotting options provided include:

- Scatter plot of calculated vs. observed data
- Histogram of calibration residuals
- Time-series plot of calculated and observed data
- Time-series plot of calibration statistics
- Bubble plot of calibration residuals

All plots can be exported to common image format (.BMP, .JPG, .TIF, .PNG), and the plot data can be exported to .ASCII for further analysis.

**SYSTEM REQUIREMENTS**

Supported on Windows 2000 SP4, Windows XP Pro SP2, and Windows Vista (Business, Enterprise and Ultimate)

- RAM: 512MB and 1GB (or more) would be recommended
- Hard drive space: 200MB
- A minimum screen resolution of 1024 X 768
- A Microsoft compatible mouse
- Microsoft Framework 2.0 installed