There are currently four general approaches to modeling the water balance at a mine and the regional impacts of mining. These are listed below in order of least to most complexity:

1. Analytical-solution models and analytic-element models (e.g. Water balances incorporating Dupuit or similar assumptions, WHAEM, etc.)
2. Continuum numerical-solution models (e.g. MODFLOW, FEFLOW )
3. Continuum numerical-solution models using discrete fracture network (DFN) information (e.g. MODFLOW or FEFLOW using DFN data upscaled via an interface such as MAFIC which maps hydraulic properties from a fracture model onto finite difference or finite element grids)
4. Discrete fracture network (DFN) models (e.g. FRACMAN).

Other options that can be added to any of these approaches are the use of:

* parameter estimation to speed calibration, automate sensitivity testing, and analyze uncertainty; and
* geologic modeling and visualization.

In general, the most cost-effective approach is the least complex approach that matches the level of data available and the goals of the project. For example, if both geotechnical analyses and groundwater management are required, structural data on orientation, intensity and length scale of fractures are available, and flow from individual structures is important, then a DFN model is warranted. If groundwater data are sparse and conservative simplifying assumptions do not lead to expensive mitigation measures, then analytical solutions are warranted. Most projects fall between these categories, leaving the options of MODFLOW, FEFLOW, and MODFLOW-USG (not yet released by the USGS but will be an option by June 2013). Differentiators between these last options are summarized in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Model 🡺**  **Model Feature**  **🡻** | **MODFLOW** | **MODFLOW-USG\*** | **FEFLOW** |
| Groundwater-surface water interaction | yes | yes\* | yes |
| Lake package | yes | yes\* | somewhat\* |
| Vadose zone | no | not in first release | yes |
| Engineering optimization of dewatering | yes | yes | no |
| Complex layering and discontinuities | no | yes | yes |
| Localized fine discretization and large aspect ratios | no | yes | yes |
| Inflow rates from discrete features | yes | yes | yes |
| Associated transport code | yes | no | yes |
| Lake package | yes | no | somewhat\* |
| Familiar to regulators | yes | no | somewhat |
| Public domain or widely available | yes | yes\* | yes |

\*under development