6.0 Transient Model Development

The transient Black Rock model includes all of the base-case model features in addition to a head-dependent boundary condition representing the reservoir. The head-dependent reservoir condition is represented either as a MODFLOW Lake Package (LP) boundary condition or as a MODFLOW General Head Package (GHP) boundary condition. The former is imposed using a reservoir water availability hydrograph.

All of the head-dependent boundary conditions for rivers, creeks, drains, and springs are present in both the steady-state base-case model and in the transient reservoir model (as steady-state conditions). The only new (transient) boundary condition introduced in the transient Black Rock model is the head-dependent LP or GHP boundary used to represent the Black Rock reservoir.

6.1 Early-Time and Late-Time Versions of the Transient Model

In order to answer as efficiently as possible, questions involving both the early-time and late-time hydrologic impacts of the reservoir, it was deemed expedient to develop two versions of the transient Black Rock model. One uses the MODFLOW LP boundary condition to represent the initial filling of the reservoir. The other uses the MODFLOW GHP boundary condition to represent the long term effects of a full reservoir. The two model versions are otherwise identical, and are based on the same (steady-state) base-case conceptual models.

The LP model is used to simulate early-time interactions between the reservoir and the aquifer. Changes in the reservoir head (stage) are calculated based on user input of a hydrograph that describes reservoir inflow and outflow rates over time. The LP model represents the reservoir as a head-dependent boundary condition; however, in each stress-period the reservoir head condition (the stage) is adjusted (using a Newton-Raphson iterative procedure) to account for the seepage that is expected to occur during that stress period. As a result, the LP model provides a more accurate estimate of reservoir interaction with the aquifer when the reservoir stage is changing very rapidly, as is the case during the initial filling of the reservoir (USGS, 2000a). The transient LP model is run for nine years, and the duration of each LP model stress period (and time step) is ten days.

The GHP model is used to make late-time estimates of reservoir seepage; to assess reservoir impacts on aquifer heads; to estimate discharge to creeks, drains, and springs; and to estimate groundwater flux conditions. The GHP model applies a reservoir head condition (stage) that is representative of a full reservoir (a 1,775-foot elevation head). The GHP model does not impose any constraints

on availability of water to fill the reservoir, and the full reservoir head condition is established instantaneously in the first transient model stress period. As a consequence, the GHP model does not provide as accurate a measure of initial reservoir seepage as the LP model. As time progresses, however, the GHP boundary condition is characteristic of actual reservoir-aquifer interactions. The GHP model is run for 300 years, and the duration of stress periods (and time steps) varies from 10 days to 10 years.

The computational ease with which the GHP boundary condition can be applied in the model, and the robustness of the GHP Package compared to the LP Package within MODFLOW, make it a more desirable alternative for representing the reservoir, when it is appropriate.