SECTION 3
WATER RESOURCES MODELS

A series of water resources models will be developed and calibrated using available data during the pre-operational phase of the Cadiz Project. The models will be refined and recalibrated as additional data are collected during the operational phase of the project. Water resources models, including a rainfall-runoff model, unsaturated and saturated zone flow models, solute-transport models, and a density dependent groundwater flow and solute-transport model will be considered in consultation with the BLM Authorized Officer and the TRP. Metropolitan will prepare and refine the selected models during the pre-operational and operational phases. The BLM Authorized Officer will provide input and guidance throughout the development and refinement of the selected models. The BLM Authorized Officer will receive comments and recommendations from the TRP regarding the development and refinement of the selected models. The BLM Authorized Officer will approve the initial water resources models in accordance with Section 10. Refinements to models will be made in accordance with the decision-making process described in Sections 7, 9 and 10.

Models are only approximations and simplifications of real systems. However, they can be useful management tools, when used in conjunction with measured data, for testing alternative monitoring designs and management options. Accordingly, these models will be used to help guide decisions on further evaluating and refining the monitoring network, and evaluating and refining action criteria.
The models discussed below are examples of models that may be implemented to assist Metropolitan with its periodic review and analyses of project operations. Although there are a number of models discussed below, Metropolitan will utilize those necessary and appropriate for the Management Plan. Ongoing data collected during the term of the project, combined with the modeling tools, will assist Metropolitan in its compliance with the Management Plan.

As the responsible party, Metropolitan will prepare the water resources models.

3.1 DESCRIPTION OF WATER RESOURCES MODELS

3.1.1 RAINFALL-RUNOFF MODEL

Rainfall-runoff models simulate the surface water balance and include parameters specific to the watershed, mean areal rainfall, interception, depression storage, infiltration, soil moisture storage, evapotranspiration, surface runoff, snowmelt runoff, interflow, groundwater baseflow, and channel routing. The rainfall-runoff models would be integrated with other models (e.g. groundwater flow and solute transport models).

Data input would include precipitation and evaporation data distributed as interception loss, rainfall on impervious areas (which contributes directly to runoff), and infiltration. Infiltration is either interflow, which moves through the upper soil zone to channel flow, or deep percolation, which is flow into the lower soil zone, which contributes to active or inactive groundwater storage. The rainfall-runoff model would be initially calibrated using the streamflow data collected during the pre-operational phase of the project.

3.1.2 UNSATURATED ZONE FLOW AND TRANSPORT MODEL

An unsaturated zone flow and transport model would be employed to simulate the movement of infiltrated water under the ephemeral stream channels as well as the project spreading basins. For the purposes of simulation, infiltration under an ephemeral stream would be treated as a line source and would initially be simulated as a two-dimensional process coincident with the stream. Lateral redistribution away from the stream would be simulated as a two-dimensional process perpendicular to the stream. This model (along with other models) would be utilized in analysis and refinement of both the monitoring network and action criteria.

The model input requires volumetric moisture content, moisture potential, porosity, unsaturated and saturated hydraulic conductivity data, and subsurface layering. These data would be estimated from soil cores collected during the pre-operational phase of the project. Unsaturated zone instrumentation would be installed, if necessary, to measure soil suction, pressure head, and water chemistry as the water percolates downward through the unsaturated zone to the water table. Neutron and electromagnetic logs may be used to collect data at selected well sites to monitor the movement of the recharge “wetting” front if warranted following further evaluation. Data collected from the instrumentation would be used to help recalibrate the model when Colorado River water is delivered into the project spreading basins.

3.1.3 SATURATED ZONE FLOW AND TRANSPORT MODEL

A numerical groundwater flow and solute transport model would be developed and calibrated to better understand the dynamics of groundwater flow and solute transport in the project area. The domain of the groundwater flow and transport model would include the Bristol, Cadiz, Fenner and Orange Blossom Wash watersheds. This model along with other models would be utilized in analysis and refinement of both the monitoring network and action criteria.

A conceptual model would first be developed incorporating the area of interest, aquifer systems to be modeled and boundary conditions. It is understood that the conceptual model would be predicated upon a thorough analysis of the available geohydrologic data for the area. Only after a conceptual model is developed can the numerical models be developed. Development of the numerical models requires information on: (1) the aquifer geometry; (2) rate and quality of groundwater inflow and outflow; and (3) aquifer characteristics (hydraulic conductivity, saturated thickness, effective porosity, specific storativity, dispersivity, retardation and leakance). The groundwater flow model would integrate quantities and distribution of recharge estimated from the rainfall-runoff and unsaturated zone models.

3.1.4 DENSITY DEPENDENT GROUNDWATER FLOW AND TRANSPORT MODEL

Density dependent flow and transport models would be developed near both Cadiz and Bristol dry lakes. The models would simulate the transport of solute mass through numerical solution of a mass balance equation involving fluid density. The single solute species could be transported conservatively, or it could undergo sorption. Sources and boundary conditions of fluid and solute would be specified at the upgradient boundary of the model.

The model domain would extend outward from the project spreading basins to Bristol and Cadiz dry lakes. The area of interest for the model grid would be determined by further evaluation but would probably extend several miles. The height, and horizontal and vertical grid spacing would be selected based on available data and the intended use of the models. These models include hydraulic conductivity, specific storativity, effective porosity, and dispersion coefficients for each model element. Specified flux and chloride mass fraction would be provided by the regional groundwater flow and solute transport model described previously.

3.2 EVALUATION OF POTENTIAL ADVERSE IMPACTS USING NUMERICAL MODELS

The water resources models developed during the pre-operational phase of the project will be used to simulate the impacts of planned project operations. Water resources models, including a rainfall-runoff model, unsaturated zone flow and transport model, saturated zone flow and transport model and density dependent groundwater flow and transport model will be considered in consultation with the BLM Authorized Officer and the TRP. Metropolitan will select the models that are necessary and appropriate to be used in evaluating the potential impacts. The BLM Authorized Officer will provide input and guidance regarding the selection and development of the models. The BLM Authorized Officer will receive comments and recommendations from the TRP regarding the selection and development of the models. The BLM Authorized Officer will approve the initial water resources models in accordance with Section 10. The results of the simulations will be used to evaluate and refine action criteria and the locations of certain monitoring features. Models will also be used to simulate potential impacts for feasible project operations (including Cadiz agricultural operations) within the estimated ranges of natural recharge (low and high estimates). Evaluation of the model results could result in refinements to action criteria as well as identifying areas where collection of additional data may be needed to improve the monitoring network.

3.2.1 EVALUATION OF VARIABLE RECHARGE ESTIMATES AND LONG-TERM IMPACTS

Models, in conjunction with measured data, will be used to refine the estimates of natural recharge as well as groundwater travel times from areas of recharge to areas of discharge. The models will be run for various operational scenarios using a range of natural recharge estimates. The put (artificial recharge) and take (extraction) cycles will be tested for the range of natural recharge estimates to evaluate the sensitivity of the aquifer system, the action criteria, and the monitoring network to low and high estimates of natural recharge. Impacts from the project could have delayed effects which could persist after the termination of the project. Therefore, the project operation (put and take cycles) will be simulated with different natural recharge characteristics into the future until simulated water-level and water-quality changes approach a steady state condition. These models will enable evaluation of the potential for adverse impacts during the operational and post-operational phases and well into the future.

3.2.2 MODEL REFINEMENT AND MULTI-YEAR PREDICTIONS

During the term of the project, new data and analysis as well as any new project operational considerations will be used to refine the calibration of the various water resources models. This model refinement will take place approximately every two years, or as otherwise determined to be necessary. The refined models will be used to provide five-year predictions based on the current stage of the project. For example, a five-year prediction should be simulated before the first “put” cycle. Two years into the “put” cycle the model should be refined based on the new data and analysis to produce another five-year prediction.

The models will be a necessary part of the Management Plan and provide input to the decision-making process. These model results will assist Metropolitan with its periodic analyses of monitoring data and action criteria, and for example, show how the system might respond under the varying natural recharge conditions. Ongoing data collected during the operational phase combined with the predictive modeling tools will help to resolve project-related issues. If, for example, the “take” cycle caused a one-foot decline in an S-Series well (an observation-well cluster located upgradient of the project wellfield), and the decision was made to modify project operations, this management decision could then be simulated with the model to predict how long it may take for the system to recover assuming different natural recharge rates. Modifications of project operations could include one or more of the following: (a) reduction in pumping from project wells, (b) revision of pumping locations within the project wellfield, (c) stoppage of groundwater extraction for a duration necessary to correct the predicted impact, or (d) delivery of Colorado River water, if available, to the project spreading basins.