

**PROGRESS ENERGY
YADKIN-PEE DEE RIVER PROJECT
WATER RESOURCES WORKING GROUP
ISSUES EVALUATION TEMPLATE
January 2004**

Issue No. 12: Project Operations Modeling.

1. Description of Issue

Several stakeholders have indicated that there is a need for Progress Energy to develop a computer-based operations model to evaluate existing Project operations, evaluate alternative reservoir level management scenarios, downstream effects of various future operating scenarios, and current and future uses of the surface waters of the Yadkin-Pee Dee River. Several stakeholders have indicated that a single model covering both Progress Energy's facilities and the four upstream APGI facilities is preferred, and further, that the model should be a "basin-wide" model encompassing the entire Yadkin-Pee Dee watershed from headwaters to Winyah Bay. This "basin-wide" model, it has been suggested, should not only include the hydropower facilities, but should also include the effects of long-term water supply and use by municipalities, irrigators, and others throughout the basin.

2. Project Effects

Progress Energy, through its ownership and operation of the Tillery and Blewett hydro facilities, is responsible for the safe and effective use of the surface waters of the Yadkin-Pee Dee River at its Project. The effective use must consider both power and non-power values and recognize, understand, and address the various effects the Project may have on other resources. The existing operation of the Project, at river flows below about 9,000 cfs, affects lake levels at Tillery and Blewett reservoirs, flows in the river reach between Tillery Dam and the headwaters of Blewett Falls Lake, and flows for some distance below Blewett Falls dam, certainly extending into South Carolina.

Progress Energy's operation of the Project does not significantly influence, nor exert any control over, events that occur upstream of its Project (although it can certainly be affected by such activities) or in tributaries downstream of the Project. Progress Energy does not exert any control over activities downstream of its Project, including future withdrawals of waters for municipal or industrial use that are outside the Project boundary and which are regulated by duly authorized regulatory bodies.

3. Applicable Existing Information

There is an extensive amount of existing information available to aid in understanding the current operations of the Tillery and Blewett developments, including Progress Energy operations records, APGI discharges from its Falls facilities, and records of streamflow at several gages downstream of Blewett Falls in North and South Carolina.

4. Study Needs

Progress Energy agrees that there is a need for a computer-based model to simulate existing Project operations and evaluate various reasonably achievable scenarios of future operations. Progress Energy believes that there is alternative merit to having a consistent modeling platform

for evaluating the inter-related operations of the APGI and Progress Energy facilities. Finally, Progress Energy agrees that there is a need to understand and model the downstream effects of Project operations especially below Blewett Falls dam and into South Carolina.

Progress Energy will, therefore, agree to develop a single model, based on CHEOPS technology, extending from the inflow to High Rock Reservoir to at least the USGS gage at Pee Dee, South Carolina. This model will include three fixed nodes below Blewett Falls dam (Rockingham gage area, Bennetsville gage area, and Pee Dee gage area) and up to two “floating nodes” to be jointly selected by SCDNR and Progress Energy. The exact limit to the Project’s influence in South Carolina is not yet known (and indeed, is likely to vary with Project flow, and flow from the intervening drainage area). Further study is needed to “fix” the best/proper location for the “floating” nodes.

The model will fully comply with all the “objective and output requirements” specified by the NCDENR, Division of Water Resources (see attached memo provided by Tom Fransen) except for:

- Input data to the model will not include modeling or projections of current or future groundwater use, water purchases, interbasin transfers, or municipal/industrial water use or wastewater discharge. However, if North Carolina or South Carolina agencies with relevant responsibility for these issues request that these inputs be included as point additions or withdrawals (including seasonal shaping) and provide this data to Progress Energy, then Progress Energy may include such data in the model for evaluation of alternative scenarios, as long as these are limited to a reasonable number of points (~ half-dozen) and are of a size that is mathematically meaningful to the analysis of Project flow regimes.
- Forecasting or real-time operations. The model will be a simulation tool designed to respond to “what-if” scenarios. For example, drought contingency planning can be evaluated by asking the relevant “what-if” questions and developing the resulting flow regime.
- No “bunching” of withdrawals, uses, or other stakeholder-supplied inputs will include or assume dam removal scenarios.
- The model is not public domain software, however, agreements can be entered into to accommodate stakeholder use of the model under certain covenants.

Resource Working Group Overlap (check if applicable)

___ Water Resources Issue # ___
___ Land Use and Recreation Issue # ___
___ Terrestrial Resources Issue # ___



North Carolina Department of Environment and Natural Resources
Division of Water Resources

Michael F. Easley, Governor

William G. Ross Jr., Secretary
John N. Morris, Director

**Yadkin-Pee Dee Reservoir Management/Hydrologic Model
Modeling Criteria**

Currently there is no model available to assess basinwide impacts of existing and future water withdrawals on the project reservoirs and the impacts of reservoir operations on water resources. There needs to be a **single** basinwide hydrologic model that covers the basin from Georgetown, SC upstream to the headwaters. The model needs to include all withdrawals and discharges of 100,000 gpd or greater and all water supply and hydroelectric reservoirs. In addition to the basic hydrology and reservoir management, additional issues such as the following need to be studied: salinity, water quality, and instream flow. Depending upon the model selected to study these other issues the reservoir management/hydrology model may need to function as a pre- or post-processor. For example, a salinity response model of the tidally influenced areas of the Pee Dee River is needed to understand the effects of salinity on surface water intakes and aquatic biota in coastal SC. The reservoir management/hydrology model will simulate the flows and then that flow data set can be used in the salinity response model to determine if there are changes in the salinity profiles. The model goals, requirements, and examples of output that follow are for the reservoir management/hydrology model and do not include the requirements for the salinity, water quality, and instream flow models.

Examples of typical impact analysis and performance criteria such a model would be used for include:

- Impacts to lake recreation. A summary by reservoir of how many boat ramps and swimming beaches are closed or unusable: total days, days per year, and how many years a ramp is closed at least 1 or more days during the recreation season.
- Impacts on lake waterfowl hunting. A summary by reservoir of how often lake levels will impact hunting: how many days, days per year, and how many years.
- Impacts on fish spawning in the lakes. A summary of daily lake level changes and how often spawning is impacted for identified critical spawning periods.
- Impacts to water supply withdrawals, for both run-of-river intakes and reservoir withdrawals. Demand satisfaction for the current conditions and 50-year projected demands.
- Impacts to low-flow/minimum release targets. How often is the target not satisfied?
- Changes in stream flow at any node. This includes changes in the duration curve and parameters such as the 7Q10.
- Characterize hourly and 15 minute changes in flow and stage at sites chosen for instream-flow studies.
- Impacts to hydroelectric generation.

Goals & Objectives of the Reservoirs Management/Hydrologic Model

The goal is the development of a single basin model that will meet the needs for both relicensing and for long-term management decision-making. This effort must result in a surface water quantity and reservoir management tool, which can be accepted as the primary tool for evaluating current and future uses of the surface waters of the Yadkin-Pee Dee River Basin. Since this model will be used for significant decision-making tool, the model must be developed in an open, cooperative manner and be subject to scrutiny by all interested parties. The resulting model must be a generally accepted analytical tool that can be widely used to develop consensus among the numerous stakeholders in the basin. Users must be able to evaluate a variety of "what-if" scenarios that will provide insight into impacts relating to power generation, downstream flows for wastewater assimilation, water supply availability, instream uses, and recreational lake levels, for example. While this model need not include water quality or habitat analysis directly, the steamflow output data from this model must be capable of being used as input or flow calibration data to the water quality models currently approved by the States of NC and SC. Water quality effects will be important in evaluating the impacts of proposed operational changes.

Model Requirements

The model will geographically cover the entire Yadkin-Pee Dee River Basin from the headwaters down to the most downstream water supply intake in Georgetown, SC. The model needs to have a user-friendly interface and incorporate seasonally varying withdrawal and discharge information of 100,000 gpd or larger. It needs to incorporate annually varying water consumption from agricultural use based on climatic conditions during growing season. The model needs have the capability to allow for stream flow analysis, drought management planning and forecasting. In addition the model will have the capability to incorporate alternative drought management policies. Basic model documentation and training needs to be provided to users of the finished model.

The data needed for the modeling will include, but not be limited to, the following:

Inflows: Wherever possible, the model must use actual historical streamflow, precipitation, and evaporation records corresponding to the same historical time step. A hydrologic period of record of at least 75 years or longer must be used where data are available. The period of record used in the model must include the drought of the early 1930's and 2002. This will require the adjustment of gage flow data in order to generate unimpaired flows. Synthetic generation of inflows will be necessary at some locations where historic records are shorter than the period of record used in for the model. At a minimum, the adjustment of gage flow data must include historical adjustments for regulation, consumptive uses, net evaporation, and transfers in order to generate unimpaired flows.

Data on consumptive water use, discharges, transfers, evaporation and precipitation must be prepared for the same period of record as that used for streamflows.

Reservoir data and operation: The model must incorporate the current operating policies for APCI's and Progress Energy's reservoirs and other significant impoundments, such as W. Kerr Scott Reservoir. Data needed will include, but not be limited to, flow ratings of hydraulic outlets, turbine rating curves, seasonal low flow targets downstream, seasonal water withdrawals and return flows, stage-storage-surface area information, discharge-stage relationships of flood control points downstream and interactions between the impoundments being modeled.

Required instream flows: Information regarding instream flows for river segments must be included. These flow requirements may vary monthly or seasonally.

The basic objectives and output requirements of the model are as follows:

- (1) The model must be a mass-balance simulation model that will emulate the operation of the reservoirs of interest and flow conditions for major stream segments for the Yadkin-Pee Dee River Basin for the full range of flows in the hydrologic record.
- (2) The model must be capable of displaying a schematic basin map showing locations of all model nodes. ArcView is a preferred method for displaying geographic information.
- (3) Default model conditions must correspond to existing withdrawal and discharge conditions, and these withdrawal and discharge levels must be allowed to vary for each individual time step of simulation period. Withdrawals and discharges for each user must be simulated as a system with the capability to have multiple withdrawals and discharges for a single user. The system demand needs to be able to include ground water, water purchases, and interbasin transfers. The model needs to be able to account for multiple withdrawals and discharges at the same node and/or reservoir from different users. Model must also be flexible enough and sufficiently documented to allow simulation of user-defined withdrawal and/or discharge levels at any point on the river (probably defined by river mile) or lakes, which differ from existing conditions.
- (4) The model must be able to simulate the existing and future operating policies for the reservoirs. Default model conditions must correspond to existing reservoir operating policies. The model must also be flexible enough and sufficiently documented to allow simulation and display of user-defined reservoir operating policies, that differ from existing conditions (e.g., reservoir storage allocation, reservoir releases, new or revised low-flow targets, etc.)
- (5) The model shall track low flow targets downstream that can vary seasonally. The model must be capable to begin simulation with user-defined reservoir storage volumes, which may be less than 100 percent.
- (6) The model must be able to run on a daily time step and be able to run for periods of one year up to the total number of years in the record. Users must be able to specify these parameters from simple menu screens. From these screens, users must also be able to specify additional withdrawals and discharges for specific model nodes.
- (7) Model runs must generate time-series outputs. The time series outputs should be available in table format for ready export into water quality models, spreadsheets, or other tools used by NC and SC.
- (8) The model must be capable of displaying system variables in an input/output layer to facilitate inspection of key model parameters and performance of sensitivity analyses.
- (9) The model must be capable of displaying a history of river flow conditions at all selected model nodes during the simulation period for all the major stream/river segments.
- (10) The model must be capable of displaying a history of water elevation, surface area, storage volume, power generation, and water balance information in any modeled reservoir over the simulation period. This also includes annual summary tables of maximum and minimum lake levels, etc.
- (11) The model must be capable of producing streamflow output data for use as input data or as flow calibration data to water quality models currently approved by both States. It must be capable of producing such stream flow profiles for a variety of flow scenarios including 7Q10/drought conditions.

- (12) The model must be capable of producing flow output data suitable to establish boundary conditions for hydrodynamic, water quality and water quantity models of the tidally influenced portion of the river, in the event that such models are developed.
- (13) The model must be capable of supporting drought management planning and forecasting. Specific drought evaluation techniques which the model must be capable of performing include: safe yield estimation for river withdrawals; tracking user-defined minimum instream flow targets at individual model nodes, flow targets must be allowed to vary by time step; and evaluating water supply benefits from conservation scenarios. The ability to input conservation measures by water users need only have the form of thresholds (flow or pool volume, for example) and associated percentage reductions in water use.
- (14) The model needs to have nodes at all withdrawals and discharges of 100,000 gpd or greater, all water supply and hydroelectric reservoirs, all instream flow study sites, and additional nodes for water quality purposes as needed. The model must be flexible enough and sufficiently documented to allow addition of new model nodes for new withdrawals, discharges, or stream/flow evaluation points. Nodes must not be hard-coded such that program modification is required to add or delete nodes. The model must have the ability to have nodes added and different operating policies be used without having to modify and recompile the model for each change.
- (15) The model should incorporate annually varying water consumption for agricultural uses based on climatic conditions during growing season.
- (16) To promote accessibility and usability, the model must be user friendly and written for the PC environment, and be available on CD-ROM or downloadable from Internet. An application needs to be built for the Windows_{tm} (2000/XP) environment. This model will be available as public domain software. This requires that appropriate licensing arrangements be made with any owner of proprietary software shipped with the model. For practicality, the run-time for a daily time step run for the entire period-of-record must not exceed 15 minutes for the full period of record base case simulation.
- (17) A detailed document describing the data set preparation and model formulation and a detailed user's manual, adequate for use by less technical staff, and training needs to be provided.