

## **Delaware River Basin Daily Flow Model**

In 1981, recognizing the need for a more accurate and effective means of quantitatively comparing alternative operating plans for major reservoirs in the Delaware River Basin, the Philadelphia District U. S. Army Corps of Engineers engaged Camp Dresser and McKee (Ref. 1) to develop a daily flow model for the reservoirs. The Fortran based model allowed reservoir operating rules to be evaluated using an incremental inflow file representative of historic unregulated hydrology. The incremental inflows were calculated using flow records of adjacent stream gages and record correlation where necessary to eliminate regulation effects and to fill in gaps in gaging records. The model allowed incremental inflows, representative of unregulated hydrology, to be combined with alternative operating plans for the basin's major reservoirs. The original incremental inflow file was developed for the 50-year period from October 1927 to September 1977.

The original daily flow model code was modified by the City of New York during the 1980s to reflect City reservoir operating rule curves. Later, the Merrill Creek Owners Group included rules for the operation of Merrill Creek Reservoir (Ref. 2). The Delaware River Basin Commission (DRBC) also modified the code to represent lower basin reservoir operations and to perform analysis of adjustments to the reservoir releases program under the direction of the parties to the 1954 Amended U. S. Supreme Court Decree (Decree Parties).

In 1990, the incremental inflow file was extended through water year 1987 by Columbia University under contract with the DRBC (Ref.3). This added 10 years of unregulated inflows to the data set used to drive the model. The period from October 1927 to September 1987 includes droughts of the 1930s, 1950s, 1960s and early 1980s as well as the wet hydrologic period of the 1970s.

The Massachusetts Institute of Technology (MIT) Transient Salinity Intrusion Model (MIT-TSIM), previously applied to the Delaware Estuary by Thatcher and Harleman in 1978 (Ref. 4), was used by DRBC in conjunction with the daily flow model to determine the effect of alternative reservoir operations on chloride movement in the Delaware Estuary.

In 2002, as part of a flow management study for the DRBC (Ref. 5), HydroLogics, Inc. developed a new version of the daily flow model under the trade name OASIS (Ref. 6). The advantages of the OASIS model were a new Windows-based PC user interface and more compact operations control language (OCL). HydroLogics, Inc. developed the OASIS version of the flow model to closely match the operation of the original daily flow model. The OASIS model was programmed to use the same incremental inflow file that was used to drive the original daily flow model.

In 2002, PPL Generation, LLC, added features to the OASIS version of the daily flow model, which provided for modeling of Lake Wallenpaupack operations. With the permission of PPL Generation, LLC, these features were incorporated into the official DRBC version of the model. In 2004, the DRBC, through a contract with Jan C. Phillips, P.E., (Ref. 7) added features to improve representation of New York City reservoir operations and to evaluate several alternative reservoir releases programs under consideration by the Decree Parties to better support fisheries in the tailwaters of the three City reservoirs in the upper Delaware River Basin. Funding for this work was provided by the New York City Department of Environmental Protection and the New York State Department of Environmental Conservation. The current version of the OASIS model includes most of the features of the interim reservoir releases program agreed to by the Decree Parties and adopted by the DRBC in April 2004, and included in DRBC Docket D-77-20 CP (Revision 7) (Ref.8).

A cost-shared project to extend the incremental inflow file through the year 2000 was conducted by the Philadelphia District Corps of Engineers, with DRBC serving as the local sponsor. The method used to extend the incremental inflow file is the same as the method used previously by Columbia University as documented in Reference 3. This work was completed in early 2006.

In developing the OASIS model, HydroLogics, Inc. added a non-linear regression function, based on MIT-TSIM results (Ref. 9), as a means of estimating chloride movement in response to estuary inflow. The DRBC staff plans to directly link a hydrodynamic chloride model (such as the MIT-TSIM or similar) with OASIS to provide for interactive operation of the two models.

In summary, the original daily flow model, and now the OASIS version of the model, have been developed for use as planning tools for comparing the quantitative performance of reservoir release programs over a long term period. The incremental inflows that drive the models have been developed to eliminate the effects of regulation and allow the models to be independent of historic reservoir operations. Consequently, either model can be used for comparing a range of potential operating rules and reservoir releases programs. However, the OASIS version better reflects the most current basin operations. Accordingly, the Decree Parties and the DRBC consider the current version of the OASIS model the primary tool for comparing alternative reservoir operating rules and releases programs.

References

- 1) Camp Dresser, and McKee, Inc., Daily Flow Model of the Delaware River Basin, Main Report, prepared for the U.S. Army Corps of Engineers, September 1981.
- 2) Merrill Creek Owners Group, Users Manual for the Delaware River Daily Flow Model, prepared with assistance of Charles T. Main, Inc. and Public Service Electric and Gas Company, October 1987.
- 3) Thatcher, L. M., and Mendoza, C., Extension and Testing of the Daily Flow Model, Columbia University, Department of Civil Engineering and Engineering Mechanics, July, 1990.
- 4) Thatcher, L. M., and Harleman, R. F., Development and Application of a Deterministic Time-Varying Salinity Intrusion Model for the Delaware Estuary (MIT-TSIM) – Final Report, Volume I – Main Report, November 1978.
- 5) HydroLogics, Inc., Strategy for Resolution of Interstate Flow Management Issues In the Delaware River Basin, Prepared for the Delaware River Basin Commission, August 2004.
- 6) HydroLogics, Inc., Modeling the Delaware River Basin with OASIS, Prepared for the Delaware River Basin Commission, January 2002.
- 7) Phillips, J. C., Upgrade of the Delaware River Basin OASIS Model, Simulation of Operations of Cannonsville, Pepacton, and Neversink Reservoirs for Downstream Fisheries Management, Prepared for the Delaware River Basin Commission, June 2004.
- 8) Delaware River Basin Commission, Resolution No. 2004-3, Docket No. D-77-20 CP (Revision 7), Approved April 21, 2004.
- 9) Gianella, T., The Impact of Freshwater Discharge on Salinity Intrusion on the Delaware Estuary, Cornell University, December, 1987.