



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY  
NATIONAL HEALTH AND ENVIRONMENTAL EFFECTS  
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RESEARCH AND DEVELOPMENT

**MEMORANDUM**

SUBJECT: Lower Fox River/Green Bay Mass Balance Study - Modeling Overview

FROM: Russell G. Kreis, Chief  
Large Lakes & Rivers Forecasting Research Branch

THRU: Steven P. Bradbury, Director 

TO: William E. Muno, Director  
Region V, Superfund Division

The objectives of the lower Fox River/Green Bay Mass Balance Study were to: 1) assess the technical and economic feasibility of the mass balance approach for use in the management of pollutant loadings and impacts on Great Lakes ecosystems, 2) calibrate the mass balance models for sources, transport routes, and fates of pollutants in the Great Lakes ecosystem, 3) identify the major sources of selected pollutants entering the Green Bay ecosystem and rank their relative significance, and 4) demonstrate methods and priorities for further studies of toxic pollutants in the Great Lakes.

The lower Fox River/Green Bay Mass Balance Study was initiated by the USEPA Great Lakes National Program Office and included a sizeable number of USEPA, federal, state, academic, and private partners. The project spanned a period of ten years, from 1986 to 1996. The field and laboratory activities were conducted during 1989 and 1990, with laboratory analyses progressing until about 1993. Database development and finalization occurred after analyses of approximately two years. Model development continued throughout the project. Application of models to answer management questions was conducted at several different points and continued to be used as different questions were raised and iterations were required.

One of the primary goals was to develop a forecasting capability through mathematical mass balance modeling to predict various options to aid management in environmental restorative decisions. The USEPA ORD group was charged with facilitation and implementation of the mathematical modeling goals for predictive forecasts. The modeling group interacted in the planning, field design, field sampling and analysis phases to satisfy the needs of the modeling construct. A sampling and analysis program was designed to meet the needs of calibrating the models where samples were collected in a coordinated, synoptic fashion. Unique, datasets of PCBs and other chemicals were produced for water, sediment, and biota. Quality assurance ✓

(QA) was a primary force during the project and methods and data were approved and thoroughly checked. Project data were archived in a data system that served as a means of data quality assurance and data distribution during and after the course of the project. Infrastructure for the project included several phases: planning, field design, field sampling, laboratory analyses, laboratory quality assurance, database design and population, database quality assurance, mathematical modeling framework design, and modeling quality assurance.

Models used in the lower Fox River/Green Bay effort were generally modified from the EPA-supported WASP family of models (Ambrose et al., 1983;1988) and many modifications made during the effort were incorporated into the supported WASP models (Ambrose et al 1993). Many aspects of this project, including modeling methods and results were discussed, presented and reviewed in several types of forums. As a summary these included all-investigator and modeling planning meetings, meetings with all-investigators and modeling presentations, federal and state only meetings, public presentations, technical conference presentations including special Green Bay and Green Bay modeling sessions, project reports, and peer-reviewed journal publications. This series of forums included discussions and review by federal, state, academic, and private groups, both internally and externally. During the project, modeling quality assurance narratives were, for the first time, required in cooperative agreement documentation. During this time period, and in part as a consequence from the lower Fox/Green Bay project efforts, the first quality assurance guidance documents were developed for modeling projects (USEPA 1991; 1993; 1994; 1995).

#### References

Ambrose, R.B., Jr., S.I. Hill, and L.A. Mulkey. 1983. User's Manual for the Chemical Transport and Fate Model (TOXIWASP), Version I. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Athens, Georgia. EPA-600/3-83-005, 178 pp.

Ambrose, R.B., T.A. Wool, J.P. Connolly, and R.W. Schanz. 1988. WASP4, A Hydrodynamic and Water Quality Model - Model Theory, User's Manual and Programmer's Guide. U.S. Environmental Protection Agency, Office of Research and Development, ERL-Athens, Georgia. EPA-600/3-87-039, 297 pp.

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U.S. EPA. 1991. **Quality Assurance Guidelines for Modeling Development and Application Projects: A Policy Statement.** USEPA, ORD, ERL-Duth.

U.S. EPA. 1993. **Reducing Uncertainty in Mass Balance Models of Toxics in the Great Lakes – Lake Ontario Case Study.** Great Lakes Program, State University of New York at Buffalo.

U.S. EPA. 1995. **Agency Guidance for Conducting External Peer Reviews of Environmental Regulatory Modeling.** USEPA Agency Task Force on Environmental Regulatory Modeling.

#### **Selected Partners/Cooperators in Model Development**

U.S. Environmental Protection Agency, **Great Lakes National Program Office**

U.S. Environmental Protection Agency, **ORD, ERL-Duluth and Grosse Ile**

U.S. Environmental Protection Agency, **ORD, ERL-Athens**

U.S. Environmental Protection Agency, **ORD, ERL- Narragansett**

U.S. Fish and Wildlife Service, **Ann Arbor and Green Bay**

National Oceanic and Atmospheric Administration, **Ann Arbor**

Argonne National Laboratory

Wisconsin Department of Natural Resources, **Madison, Marinette, and Green Bay**

Michigan Department of Natural Resources, **Menominee and Lansing**

Clarkson University

Manhattan College

State University of New York at Buffalo

University of California at Santa Barbara

University of Minnesota

University of Notre Dame

#### **Selected Planning, Review, and Public Meetings**

Initial Planning Meeting, 1986

Green Bay Ad-hoc Biological Meeting, **Milwaukee, WI** December 16, 1986

Green Bay Ad-hoc Biological Meeting, **Madison, WI** January 27, 1987

Green Bay Biological Committee Meeting, **Green Bay, WI** February 24, 1987

Management Committee Meeting **Milwaukee, WI** March 24, 1987

Green Bay Committee Chairs Meeting **October 16, 1987**

Green Bay Biota Modeling Meeting **June 23-24, 1988**

Green Bay All Investigators Meeting, **Grosse Ile, MI** August 14-15, 1989

Balancing the Bay **December 3-4, 1992** - All investigators and public

Green Bay Workshop **May 24-25, 1993**

Public Meeting for the lower Fox/Green Bay Remedial Action Plan - **Green Bay, WI**

Model Briefing and Review for U.S. Dept of Justice, USEPA Superfund, and US Fish & Wildlife Service, **Grosse Ile, MI** May 20, 1999

National Academy of Sciences, **Green Bay, WI** Sept 27-28, 1999

Fox River Forum, **Green Bay, WI** June 13, 2001 in conjunction with the International Association for Great Lakes Research

### **Peer-Reviewed Journal Publications**

DePinto., J.V. 1994. Role of Mass Balance Modeling in Research and Management of Toxic Chemicals in the Great Lakes: The Green Bay Mass Balance Study. *Great Lakes Res. Rev.*, 1(1)1-8.

Endicott, D. D., 1997. Great Lakes mass balance modeling: the Green Bay mass balance study. In: Q. R. Dokken, G. Meier, and H. Kumpf (Eds.), *Report workshop: models and mass balance calculations for the Gulf of Mexico*, pp. 64-66. Gulf of Mexico Foundation, Corpus Christi, Texas.

Lesht, B.M. 1988. Nonparametric Evaluation of the Size of Limnological Sampling Networks - Application to the design of a Survey of Green Bay. *J. Great Lakes Res.*, 14(3): 325-337.

Martin, J.L., W.L. Richardson, and S.C. McCutcheon. 1991. Modeling Studies for Planning: The Green Bay Project. *Water Res. Bull.*, 27(3):429-436.

Martin, S.C., S.C. Hinz, P.W. Rodgers, V.J. Bierman, Jr., J.V. DePinto, and T.C. Young. 1995. Calibration of a Hydraulic Transport Model for Green Bay, Lake Michigan. *J. Great Lakes Res.*, 21(4):599-609.

Velleux, M.L. and D. Endicott. 1994. Development of a Mass Balance Model for Estimating PCB Export from the Lower Fox River to Green Bay. *J. Great Lakes Res.*, 20(2):416-434.

Velleux, M., D. Endicott, J. Steur, S. Jaegar, and D. Patterson, 1995. Long-Term Simulation of PCB Export from the Fox River to Green Bay. *J. Great Lakes Res.*, 21(3):359-372.

Velleux, M., J. Gailani, and D. Endicott. 1996. Screening-level approach for estimating contaminant export from tributaries. *J. Environ. Engin.*, 122(6):503-514.

### **Selected Project Reports**

Bierman, V.J., Jr., J.V. DePinto, T.C. Young, P.W. Rodgers, S.C. Martin, and R. Raghunathan. 1992. Development and Validation of an Integrated Exposure Model for Toxic Chemicals in Green Bay, Lake Michigan. Final Report. U.S. Environmental Protection Agency, Office of Research and Development, ERL-Duluth, Large Lakes Research Station, Grosse Ile, Michigan. 381 pp.

Connolly, J.P., T.F. Parkerton, J.D. Quadrini, S.T. Taylor, and A.J. Thumann. 1992. Development and Application of a Model of PCBs in the Green Bay, Lake Michigan Walleye and Brown Trout and their Food Webs. Report to the USEPA, Office of Research and Development, ERL-D, Grosse Ile, MI, 300 pp.

Di Toro, D.M. and T.F. Parkerton. 1993. Uncertainty Analysis of Methodology for Green Bay Models. Report to the USEPA, Office of Research and Development, ERL-D, Grosse Ile, MI. 40 pp.

DePinto, J.V., R. Rahunathan, P. Sierenga, X. Zhang, V.J. Bierman, Jr., P.W. Rodgers, and T.C. Young. 1993. Recalibration of GBTOX: An Integrated Exposure Model for Toxic Chemicals in Green Bay, Lake Michigan. Report to the USEPA, Office of Research and Development, ERL-D, Grosse Ile, MI. 132 pp.

Fontaine, T.D. February 1990. Modeling the Transport and Fate of Toxic Substances in Green Bay, Lake Michigan. Report to the U.S. Environmental Protection Agency, Office of Research and Development, ERL-Duluth, Large Lakes Research Station, Grosse Ile, Michigan. 76 pp.

Gailani, J.Z., C.K. Ziegler, and W. Lick. 1990. The Transport of Suspended Solids in the Fox River. Report to the U.S. Environmental Protection Agency, Office of Research and Development, ERL-Duluth, Large Lakes Research Station, Grosse Ile, Michigan. 36 pp.

HydroQual, Inc. 1995. Addendum to Green Bay Final Report, Food Chain Model Projections. Report to the USEPA, Office of Research and Development, ERL-Duluth, LLRS, Grosse Ile, MI. 33 pp.

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Richardson, W.L., D.D. Endicott, and R.G. Kreis, Jr. 1999. Managing Toxic Substances in the Great Lakes: The Lower Fox River/Green Bay Mass Balance Study. USEPA Report, ERL-Duluth, LLRS, Grosse Ile. In Internal Review.

U.S. Environmental Protection Agency, Great Lakes National Program Office. 1993. Lake Michigan Mass Budget/Mass Balance Work Plan. Chicago, IL.

USEPA, 1995. *Lake Michigan Mass Balance Project: Modeling Work Plan*. Office of Research and Development, National Health and Environmental Effects Research Laboratory, Mid-Continent Ecology Division, Community-Based Science Support Staff, Large Lakes Research Station, Grosse Ile, Michigan, 37 pp.

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U.S. Environmental Protection Agency. March 1988. Project Planning for the Green Bay Physical-Chemical Mass Balance and Food Chain Models. Internal Report. U.S. Environmental Protection Agency, Office of Research and Development, ERL-Duluth, Large Lakes Research Station, Grosse Ile, Michigan. 339 pp.

### **Selected Conference Presentations - Abstracts/Proceedings**

Abdelrhman, M.A. and J.F. Paul. June 1989. Numerical Modeling of Contaminant Loading From Fox River to Lower Green Bay. Presented at the 32nd Conference on Great Lakes Research, International Association for Great Lakes Research, University of Wisconsin, Madison, Wisconsin. May 30-June 2, 1989.

Bird, S.L. and S.C. McCutcheon. June 1989. Hydrodynamic and Sediment Transport Modeling of Green Bay, Lake Michigan. Presented at the 32nd Conference on Great Lakes Research, International Association for Great Lakes Research, University of Wisconsin, Madison, Wisconsin. May 30-June 2, 1989.

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Connolly, J.P., T.F. Parkerton, and R. Kreis. June 1993. A Model-Based Evaluation of PCB Bioaccumulation in Green Bay Walleye and Brown Trout. Presented at the 36th Conference on Great Lakes Research, International Association for Great Lakes Research, St. Norbert College, DePere, Wisconsin. June 4-10, 1993.

DePinto, J.V., R. Raghunathan, T.C. Young, V.J. Bierman, Jr., and P.W. Rodgers. June 1989. Sensitivity of PCB Fate in Green Bay to Differentiation of Particle Properties. Presented at the 32nd Conference on Great Lakes Research, International Association for Great Lakes Research, University of Wisconsin, Madison, Wisconsin. May 30-June 2, 1989.

DePinto, J.V., R.K. Raghunathan, V.J. Bierman, Jr., P.W. Rodgers, S.C. Hinz, and T.C. Young. June 1991. Development and Calibration of an Organic Carbon-Based Sorbent Model for Toxic Chemicals in Green Bay. Presented at the 34th Conference on Great Lakes Research, International Association for Great Lakes Research, State University of New York at Buffalo, Buffalo, New York. June 3-6, 1991.

DePinto, J.V., R. Raghunathan, V.J. Bierman, Jr., P.W. Rodgers, S. Hinz, and T.C. Young. June 1993. Development and Calibration of an Organic Carbon Based Sorbent Dynamics Model (GBOCS) for the Green Bay Mass Balance Study. Presented at the 36th Conference on Great Lakes Research, International Association for Great Lakes Research, St. Norbert College, DePere, Wisconsin. June 4-10, 1993.

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Devault, D., D. Anderson, and J. Filkins. June 1993. PCBs in the Green Bay Water Column, 1989-1990. Presented at the 36th Conference on Great Lakes Research, International Association for Great Lakes Research, St. Norbert College, DePere, Wisconsin. June 4-10, 1993.

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Mullin, M.D., J.C. Filkins, C.A. Koshko, and J.L. Utz. May 1988. A Reconnaissance Survey of Green Bay for Congeneric PCBs. Presented at the 31st Conference on Great Lakes Research, International Association for Great Lakes Research, McMaster University, Hamilton, Ontario, Canada. May 16-20, 1988.

Raghunathan, R., J.V. DePinto, S.C. Martin, V.J. Bierman, Jr., P.W. Rodgers, and T.C. Young. June 1993. Development and Calibration of a Toxic Chemical Dynamics Model (GBTOX) for the Green Bay Mass Balance Study. Presented at the 36th Conference on Great Lakes Research,

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Young, T.C., V.J. Bierman, Jr., J.V. DePinto, and P.W. Rodgers. June 1993. Assessing the Accuracy of Fox River Load Estimates at the DePere Dam During the Green Bay Mass Balance Study. Presented at the 36th Conference on Great Lakes Research, International Association for Great Lakes Research, St. Norbert College, DePere, Wisconsin. June 4-10, 1993.

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