BRISTLECONE
...NMENTAL TECHNOLOGY CORP

April 19, 1993

Dr. Joel S. O'Connor
Ocean Policy Coordinator
U.S. Environmental Protection Agency
Region II
Jacob K. Javits Federal Building
New York, New York 10278

Dear Joel:

Enclosed is a proposal entitled, "Project to Define an Indicator of Responsible Stewardship: Toxicant Loss from Manufactured Products in the Lake Ontario Basin." I proposed the sixteen-week project to begin on June 1, 1993 and end on September 17, 1993 in order to make maximum use of the intern who will be working on the indicator this summer. I would be the Principal Investigator, and would work on the project half-time (320 hours between June 1 and September 17). The intern would be expected to work full time during the period he or she is available to the project. The total project cost is proposed to be $20,000.

Please write or call me if you have any questions, would like additional information, or would like to modify the proposal in any way. Thank you for your consideration. I am looking forward to speaking to you again soon.

Sincerely,

Samuel R. Rod

Samuel R. Rod, Ph.D.
President

enclosure

cc: AKR, BETC
file

PROPOSAL

PROJECT TO DEFINE AN INDICATOR OF RESPONSIBLE STEWARDSHIP:

TOXICANT LOSS FROM MANUFACTURED PRODUCTS

IN THE LAKE ONTARIO BASIN

April 19, 1993

Submitted to the
United States Environmental Protection Agency
Region II
Jacob K. Javits Federal Building
New York, New York

Prepared by
Bristlecone Environmental Technology Corporation
11673 Newbridge Court
Reston, Virginia

PROJECT TO DEFINE AN INDICATOR OF RESPONSIBLE STEWARDSHIP: TOXICANT LOSS FROM MANUFACTURED PRODUCTS IN THE LAKE ONTARIO BASIN

Background

Under the Great Lakes Water Quality Agreement of 1978 between the United States and Canada, as amended in 1987, an ecosystem objective with associated indicators for Lake Superior was adopted and a commitment was made to develop ecosystem objectives and indicators for each of the other Great Lakes. Building upon a history of activities within the International Joint Commission related to the development of ecosystem indicators, a binational Ecosystem Objectives Work Group (EOWG) was established by the U.S. and Canada and charged with developing ecosystem objectives for the Great Lakes, beginning with Lake Ontario. The approach of the EOWG was to identify broad ecosystem goals, a suite of objectives whose attainment would ensure achievement of the goals, and one or more measurable indicators of progress toward meeting each objective [1].

In 1992, the EOWG Stewardship Indicator Subcommittee issued guidance for documenting indicators of responsible environmental stewardship to be applied to the selection and refinement of indicators of environmental conditions in the Lake Ontario Basin. In the guidance document [2], the Subcommittee listed seven criteria for ranking proposed indicators:

1. Usefulness of information provided to environmental managers/policymakers and the public,
2. Sensitivity to anthropogenic change in the environment,
3. Scientific defensibility,
4. Cost effectiveness,
5. Ability to be expressed quantitatively and, if possible, in probabilistic terms,
6. Ability to reflect as much as possible of the overall "ecosystem health," and
7. Ability to evoke action toward more responsible stewardship.

At the end of 1992, an indicator entitled "Toxicant Loss from Manufactured Products" was one of the stewardship indicators under consideration. The status of this indicator at that time was summarized by the Stewardship Subcommittee as follows [3]:

> Toxicant Loss from Manufactured Products
>
> Measurement: Mass of individual and of total toxicants incorporated in manufactured products, and rates of toxicant loss from products to the L. Ontario Basin. This measure permits the only apparent estimate of toxicants lost to the environment from use, disposal and breakdown of manufactured products (often largest fraction of toxicant release, but estimated only qualitatively as non-point sources).
>
> Effect on Decisionmaking: For at least some chemicals, these estimates may improve reliability of existing mass balances (which do not quantify toxicant loss from products). For many chemicals seldom measured in the environment, mass balances can not be estimated. But these estimates may provide the missing components needed for mass balances for these additional chemicals. Also, new knowledge of large loadings of particular toxicants, and the products from which large loadings derive, would be important in decisions to impose or encourage pollution prevention, recycling and modifying consumer behavior (public, corporate and governmental).
>
> Anticipated Products: Report every 3-5 years, estimating individual and total toxicant loss to environment from products manufactured within the Basin, and within watersheds.
>
> Schedule and Cost: Requires consultation with experts having experience with the estimates required.

Proposal

Bristlecone Environmental Technology Corporation (BETC) herein proposes to the United States Environmental Protection Agency (EPA) to conduct a pilot project to define a practical and cost-effective indicator of responsible stewardship in the Lake Ontario Basin. The specific indicator to be defined is "Toxicant Loss from Manufactured Products," derived from mass balance principles applied to the release and transport of anthropogenic pollutants in the environment.

Objectives of the Pilot Project

The objectives of the proposed pilot project are to (1) define the indicator, "Toxicant Loss from Manufactured Products," both in terms of quantitative measures and procedures, (2) demonstrate the application of the indicator on a selected priority pollutant in the Lake Ontario basin, and (3) evaluate the indicator on the basis of the seven criteria listed above (from EOWG guidance materials).

Approach

The first objective involves developing an analytical framework for interpreting and integrating a set of diverse indirect pollution data into a quantitative description of pollutant loadings in the Lake Ontario Basin. The proposed method is intended to reduce the uncertainty associated with estimating pollution loadings into environmental media. The second objective involves tailoring the analytical approach to the needs and limitations of national, state, province, and county environmental agencies, which are considered to be the principle users. To achieve this goal, the entire analysis will be performed on personal computers, using commercially available software and analytical tools as the building blocks of the methodology. The third objective is self-explanatory.

The condition, or "health" of a large-scale environmental system such as Lake Ontario is determined, in part, by the amounts of toxic substances entering the system and accumulating in it. Therefore, pollutant loadings, measured in mass per unit time (e.g., tons/year), are likely to be valuable indicators environmental health. Changes in the levels anthropogenic releases of environmental contaminants over time can be interpreted in terms of "stewardship." Anthropogenic toxicant releases and loadings into environmental media (i.e., toxicant losses from manufactured products) can be estimated using existing documentary evidence, completely independently of environmental measurements in the receiving media (and consequently at considerably lower cost for large regions).

The definition and demonstration of the toxicant loss indicator is based on mass balance principles applied both to human activities that release pollutants onto the land and into the air and water of the Lake Ontario Basin, and to natural mechanisms which transport the pollutants throughout the environment. The mass balance methodology models a river or lake basin as a source-receptor matrix. The basin is divided both geographically and by environmental medium. The apportionment of primary emissions among sources of pollutants is accomplished by applying mass balance constraints to industrial activities, end-use consumption of products, agricultural activities and natural processes. Information to complete material cycles and quantitative mass balances is taken from existing economic, industrial, agricultural, demographic, and related data or derived from existing transport models. The method can identify major pollutant source categories, key pathways and concentration points within the basin, and contaminant accumulations over long time periods.

The mass balance approach has been used in several recent studies of pollutant release and transport in the Great Lakes and nearby regions, for example, Green Bay/Fox River Mass Balance Study, (Lake Michigan) [4], Contribution of Technology to Prevent the Generation of Persistent Toxic Substances - Mercury, (Great Lakes Basin) [5], and Reconstruction of Historical Loadings of Heavy Metals and Chlorinated Hydrocarbon Pesticides in the Hudson-Raritan Basin, 1880-1980 [6].

Mercury provides an illustrative example of the mass balance approach to estimating losses from manufactured products in river and lake basins. Figures 1 and 2 (from the Great Lakes study [5] and the Hudson-Raritan Basin study [6], respectively) included at the end of this proposal show similar basic models of mercury sources and transport, including releases from manufacturing processes in the basins, combustion releases, releases from consumer end uses of products (both during use and after disposal), and multimedia transport to final environmental fates. Table 1 (from [6]) lists typical source categories for mercury emissions and the economic and/or demographic factors used to apportion mercury usage among geographic subdivisions of a basin.

In the Hudson-Raritan Basin study [6], the historical loadings of mercury (and lead, cadmium, copper, chlordane and DDT) onto land and into surface waters of the Hudson and Raritan River Basins were reconstructed to demonstrate an application of mass balance principles to multimedia pollution transport modeling. Trends of mercury emissions and river loadings were presented from 1880 to 1980. Figures 3 (from [6]) shows the results of the analysis from the perspective of mercury sources (metallurgical plants, fuel combustion, automotive uses, general industry uses, consumer end uses, airborne advection into the basin, and soil erosion). Figure 4 from [6]) shows the study results from the receptor perspective (surface waters, permanent immobilization or advection out of the basin, and retention on rural land).

The lower limits of spatial resolution achievable by the mass balance approach were also been explored. Quantitative contaminant flows were estimated for the 47 counties, sized from 20 to 1000 square miles (50 to 2600 square kilometers) in area, and for the fifteen river sub-basins, sized from 150 to 2,500 square miles (400 to 6,500 square kilometers), that comprise the Hudson-Raritan Basin. The county and sub-basin results were aggregated into estimates for the basin as a whole, a region of about 16,300 square miles (42,200 square kilometers). Figure 5 (from [6]) shows the basin's fifteen sub-basins, which are similar in structure and scale to the twelve sub-basins of the Lake Ontario Basin, shown in Figure 6 (from [7]). In fact, Lake Ontario sub-basins 07 and 08 (Seneca/Oneida/Oswego Rivers and Black River) adjoin Hudson sub-basin 02020004. Rome, New York, straddles the border between the Lake Ontario and Hudson River basins.

To verify the ability of the mass balance methodology to track trends in mercury emissions accurately, the Hudson-Raritan Basin study included comparisons of estimated mercury emissions and river loadings to actual measurements of mercury in river sediments. Figure 7 (from [6]) compares the estimates of historical mercury emissions and river loadings to the mercury deposition rate in a sediment core taken in Tivoli marsh (river mile 100 (km 259) on the Hudson River) and dated back to the early 1800's [8]. For the comparisons, the three scales in the figure were adjusted so that the variables' values in the chosen early reference year (1880 in this case) coincide. This effectively normalizes the trend lines.

The historical profiles of mercury emissions and loadings into the river match the deposition trend well from 1880 through 1980, substantiating, at least qualitatively, the correctness of the mass balance method. Comparing the emissions profile to the observed deposition rate, the value of the R^2 parameter (the fraction of the variation in the observed variable accounted for by the regression variable) was found to be $R^2_{emissions} = 0.77$. Comparing river loading to the core deposition rate, $R^2_{river\ loadings} = 0.82$. River loadings appear to be slightly better predictors of deposition rates for mercury.

Statement of Work

BETC will develop the environmental stewardship indicator, "toxicant losses from manufactured products," using indirect measures related to chemical production, distribution, use and disposal to reconstruct both the spatial and temporal patterns of pollutant releases. The tasks that make up the four-month project include:

1. Recommend for the client's selection a priority toxicant for the pilot study. Polychlorinated biphenyls (PCBs), mercury, chlordane, or dieldrin are suggested, based on (1) their high rankings on numerous priority pollutant lists (including their appearance on a list of toxic substances exceeding fish tissue standards, criteria, or guidelines in Lake Ontario [8]) and, (2) the relative abundance of available information related to the production and uses of these materials.

2. Define the physical boundaries and subdivisions of the system (the Lake Ontario Basin, tributary basins, the accompanying political divisions of land, etc.).

3. Construct a qualitative material cycle for the selected toxicant to show all links among system inputs, intermediate stages and "final" environmental fates.

4. Collect economic, industrial, demographic, meteorological, environmental, and other data to develop quantitative material balances throughout the cycle.

5. Where documentary evidence is inadequate to establish quantitative material flows, use environmental transport models with state, province or national data to complete the quantitative mass balances.

6. Formulate a vector of primary emission sources.

7. Formulate an environmental transport matrix from the material cycle and quantitative mass balance within the system.

8. Calculate environmental loadings. **The values yielded by the matrix calculation of loadings of the selected toxicant into surface water, land, air, and other environmental media are the Toxic Loss Indicators for those media.**

9. Check the material cycle model, source vector, transport matrix, and toxicant loss indicators with actual environmental measurements, to the extent possible (depending on the availability of relevant environmental measurements).

10. Submit a final report on all findings.

Steps 1, 2, and 3 are problem formulation steps. Steps 4 and 5 are data collection steps that provide the quantitative input to the analytical scheme in steps 6, 7, and 8.

Deliverables

1. Informal progress reports due at one month intervals throughout the project

2. A final report, due at the end of the project (September 17, 1993), presenting all findings and conclusions concerning the utility of Toxicant Loss from Manufactured Products as a responsible stewardship indicator for the Lake Ontario Basin.

3. All notes and materials collected as part of the project, due at the end of the project

Personnel

Principal Investigator: Dr. Samuel R. Rod

Duties include principal responsibility for the performance of technical work on the project - tasks 1 through 9 listed above, budgeting and scheduling, and communication with the client agency's representatives and the on-site intern (see below).

Dr. Rod is the principal author of the Hudson-Raritan Basin report [6] and has extensive experience in modeling and analysis of large-scale industrial and environmental systems. His previous work includes analyses and simulations of the handling and transport of radioactive materials, "mixed" radioactive and hazardous waste, PCB's, metals, pesticides, military nerve agents, and chemical munitions. (Resume included as attachment)

Intern: Under an agreement between EPA, Region II and the Atlantic States Legal Foundation (ASFL), the ASFL will hire a summer intern to assist the EPA on-site in developing the stewardship indicator, Toxic Loss from Manufactured Products. The intern will be a graduate student in a field such as environmental sciences or the law.

The intern's duties under the direction of the principal investigator will include gathering and reducing data (a major part of the work effort on the project), assisting in the analysis of various industrial and environmental parameters, and providing on-site support in New York to both the principle investigator and the client agency's coordinator on this project.

Schedule

BETC proposes the project to begin on June 1, 1993, continue for sixteen weeks, and conclude on September 17, 1993. The following is an outline of the project schedule:

WEEK	DATE(S)	PROJECT EVENT
1	6/1	"Kick-off" meeting - travel to New York by the principal investigator and the project intern for the initial project meeting with EPA's project coordinator.
2	6/11	Select toxicant for study.
1 - 4	6/1-6/27	Establish mass balance framework for the overall analysis. Conduct literature searches and collect quantitative data. Provide informal written progress report to EPA coordinator.
5-9	6/28-8/1	Compile data and formulate specific methodology for the Indicator. Provide informal written progress report to EPA coordinator.
10-13	8/2-8-29	Complete numerical analyses. Compare Indicator predictions of spatially distributed environmental loadings to actual environmental measurements. Summary meeting - EPA/principal investigator/intern.
14-16	8/30-9/17	Write final report.
16	9/17	Submit final report and project notes.

Cost

Personnel Costs:			
Principal Investigator:	320 hours @ $59.00/hour*	$18,880.00	
Intern:	640 hours (paid for by ASFL)	0.00	
			$18,880.00
Travel Costs:			
Principal Investigator:	Two one-day trips from Reston, VA to New York City @ $215.00 per trip - RT train fare = $180.00; per diem (meals) = 25.00; local transport = 10.00	430.00	
	One two-day (overnight) trip from New York City to Syracuse to meet with intern on location - RT train fare = $150.00; per diem total (lodging/meals) = $150.00; local transport = 20.00	320.00	
Intern:	Two one-day trips from Syracuse to New York City @ $185.00 per trip - RT train fare = $150.00; per diem (meals) = 25.00; local transport = 10.00	370.00	
			1,120.00
Miscellaneous Expenses:	(included in burdened rate for Principle Investigator)		0.00
TOTAL PROJECT COST:			$20,000.00

Notes * Essentially all work by the principal investigator will be performed using Bristlecone Corporation's facilities, equipment, and supplies (including all postage, copying, telephone, facsimile and overnight delivery expenses for communications originating at Bristlecone). The rate of $59.00/hour for the principal investigator is BETC's total burdened rate. It includes a base hourly rate of $56.00/hour for Dr. Rod and $3.00/hour (5.36 percent) overhead.

Billing

Invoices will be submitted at the end of each month during the project. Payment is due within 30 days of invoice (net 30 days).

References

[1] Paul E. Bertram and Trefor B. Reynoldson, "Developing Ecosystem Objectives for the Great Lakes: Policy, Progress and Public Participation," Journal of Aquatic Ecosystem Health, 1:89-95, 1992.

[2] Joel S. O'Connor, Guidance for Documenting Indicators of Responsible Stewardship, U.S. EPA, Region II, New York, April 27, 1992.

[3] EOWG Stewardship Subcommittee, "Lake Ontario Stewardship Indicators Under Development," (working document), November, 1992.

[4] Science Applications International Corporation, Green Bay/Fox River Mass Balance Study, (EPA-905/8-89/002), U.S. Environmental Protection Agency, Great Lakes National Program Office, Chicago, Illinois, August, 1989.

[5] J. A. McCorquodale, J. K. Bewtra, N. Biswas, M. Siddique, A. McCorquodale, and A. Spicer, The Contribution of Technology to Prevent the Generation of Persistent Toxic Substances - Mercury, International Joint Commission, Windsor, Ontario, October 30, 1992.

[6] Samuel R. Rod, Robert U. Ayres, and Mitchell Small, Reconstruction of Historical Loadings of Heavy Metals and Chlorinated Hydrocarbon Pesticides in the Hudson-Raritan Basin, 1880-1980, (final report to the Hudson River Foundation under grant number 001-86A-3) Carnegie Mellon University, Pittsburgh, Pennsylvania, May, 1989.

[7] Joel S. O'Connor, An Indicator of Responsible Stewardship: Toxicant Usage in Manufacturing within the Lake Ontario Basin, (draft, prepared for the Lake Ontario Stewardship Indicator Subcommittee of the EOWG) U.S. EPA, Region II, New York, New York, October, 1992.

[8] K. A. Stevenson, R. Armstrong, and W. R. Schell, "Chronological Determination of Mercury, Lead, and Cadmium in Two Hudson River Freshwater Tidal Marshes," Polgar Fellowship Report to the Hudson River National Estuarine Sanctuary Program, 1985, J. C. Cooper, Ed., Hudson River Foundation, New York, New York, 1986.

[9] U.S. Environmental Protection Agency, Niagara Update, US EPA, Region II, 1:1, June, 1991.

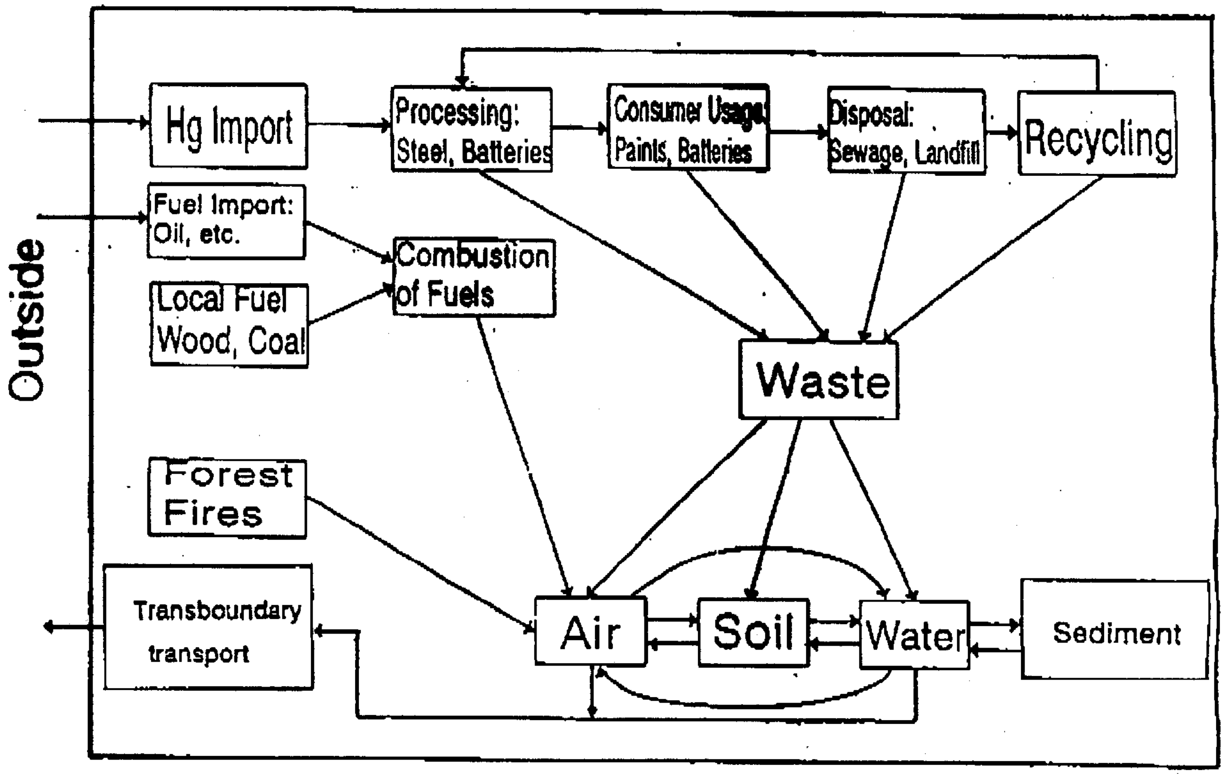


Figure 1 Proposed Model for Mercury Transport In The Environment.

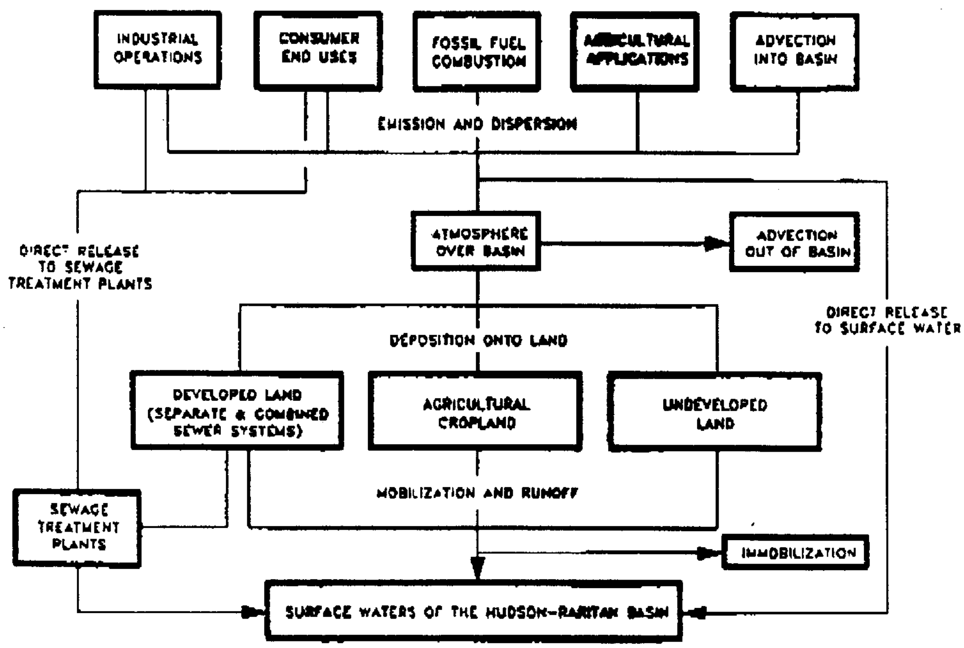


FIGURE 2

EMISSION AND TRANSPORT OF POLLUTANTS IN THE HUDSON-RARITAN BASIN

TABLE 1
ENVIRONMENTAL TRANSPORT MODEL: GEOGRAPHIC APPORTIONMENT OF MATERIAL USES

SOURCE CATEGORY:	SOURCE SUB-CATEGORIES:	COUNTY or HYDROLOGICAL UNIT (HU) PRODUCTION & CONSUMPTION COMPUTATION:
1) METALLURGICAL OPERATIONS:	SIC 3312: IRON & STEEL WORKS: \ SIC 3331: PRIMARY COPPER: > SIC 3332: PRIMARY LEAD: /	[US or STATE PRODUCTION] * [CO. or HU SIC PRODUCTION WORKERS] / [US or STATE SIC PRODUCTION WORKERS]
2) FUEL: Stationary sources; Utilities (high stack)	COAL (bituminous):	[STATE UTILITY FUEL USE] * [COUNTY or HU TOTAL POPULATION] / [STATE TOTAL POPULATION]
3) FUEL: Stationary sources; Industry (mid stack)	COAL (anthracite & bituminous) \ OIL (residual) > OIL (distillate) /	[STATE INDUSTRY FUEL USE] * [CO. or HU ALL PRODUCTION WORKERS] / [STATE ALL PRODUCTION WORKERS]
4) FUEL: Stationary sources; Residential, Commercial & Miscellaneous (low stack)	COAL (bituminous) \ OIL (residual) / OIL (distillate) /	[STATE RES., COM. & MISC. FUEL USE] * [COUNTY or HU TOTAL POPULATION] / [STATE TOTAL POPULATION]
5) FUEL: Transportation	(..) used in LEAD calculations only:	[US TEL CONSUMPTION (lead content)] * [STATE GAS. USE] / (US GAS. USE) * [COUNTY or HU TOTAL POPULATION] / [STATE TOTAL POPULATION]
6) INDUSTRY: Point Sources	SIC 2812: ALKALIES & CHLORINE (mercury) \ SIC 2816: INORGANIC PIGMENTS (lead) > SIC 2851: PAINTS & ALLIED PRODUCTS (lead) /	[US or STATE PRODUCTION] * [CO. or HU SIC PRODUCTION WORKERS] / [US or STATE SIC PRODUCTION WORKERS]
7) INDUSTRY: Non-Point Sources	CHEMICAL: Non-Embodied Industrial Chem. Use:	[US CONSUMPTION (pollutant content)] * [CO. or HU TOTAL PRODUCTION WORKERS] / [US TOTAL PRODUCTION WORKERS]
8) END USES: All Categories	METALLIC USES (Except Coating & Elec.) \ PROTECTIVE COVER: Plating & Coating \ PROTECTIVE COVER: Paints & Pigments \ ELECTRICAL: Batteries & Equipment \ ELECTRICAL: Other Uses, Instruments, etc. / BIOCIDAL: Non-Agricul. (except medical) / MEDICAL, DENTAL & PHARMACEUTICAL / NOT ELSEWHERE CLASSIFIED: /	[US CONSUMPTION (pollutant content)] * [COUNTY or HU TOTAL POPULATION] / [US TOTAL POPULATION]
9) AGRICULTURE:	RELEVANT CROPS	[US BIOCIDE USE (pollutant content)] * [COUNTY or HU ACRES OF CROP] / [US ACRES OF CROP]
10) SOIL LOSS:	NATURAL SOIL CONCENTRATION: \ ANTHROPOGENIC ACCUMULATION: /	LOCAL SOIL CONCENTRATION (from reference or calculation)
11) ADVECTION INTO AIRSHED:	(1) METALLURGICAL OPERATIONS: \ +(2) FUEL: Stat; Utilities (high stack) \ +(3) FUEL: Stat; Industry (mid stack) > +(4) FUEL: Stat; Other (low stack) / +(5) FUEL: Transportation /	STATE-LEVEL MATERIAL USE COMPUTATIONS FOR: IL, MI, MD, DC, OH, PA, VA, WV, Ontario & Quebec (Canada); also, parts of CT, MA, NJ, NY & VT not in H-R basin

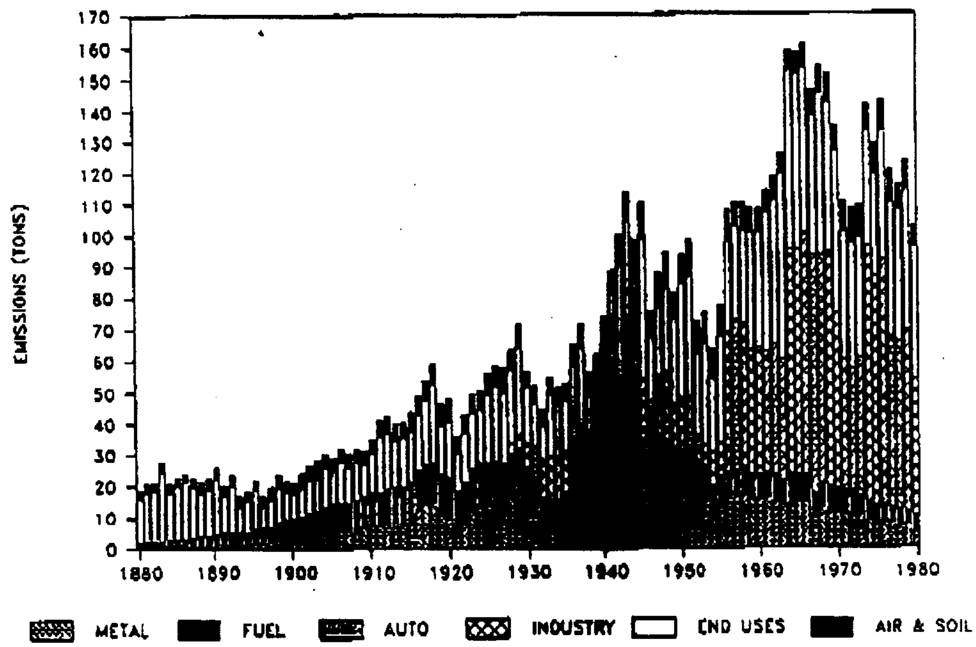


FIGURE 3

ESTIMATED MERCURY EMISSIONS IN THE HUDSON-RARITAN BASIN

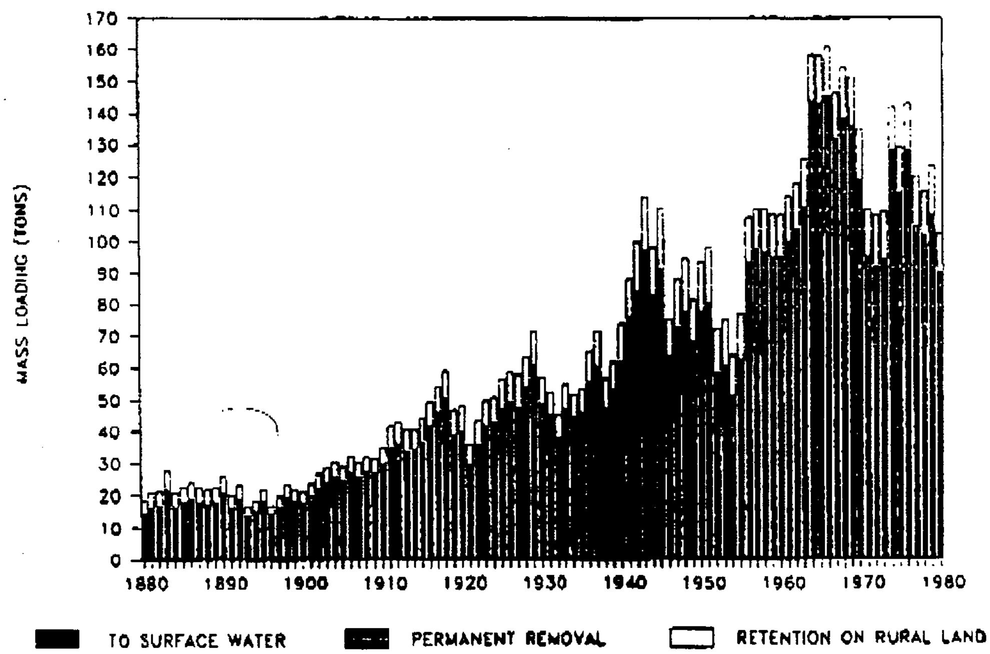


FIGURE 4

ESTIMATED MERCURY LOADING TO ENVIRONMENTAL RECEPTORS
IN THE HUDSON-RARITAN BASIN

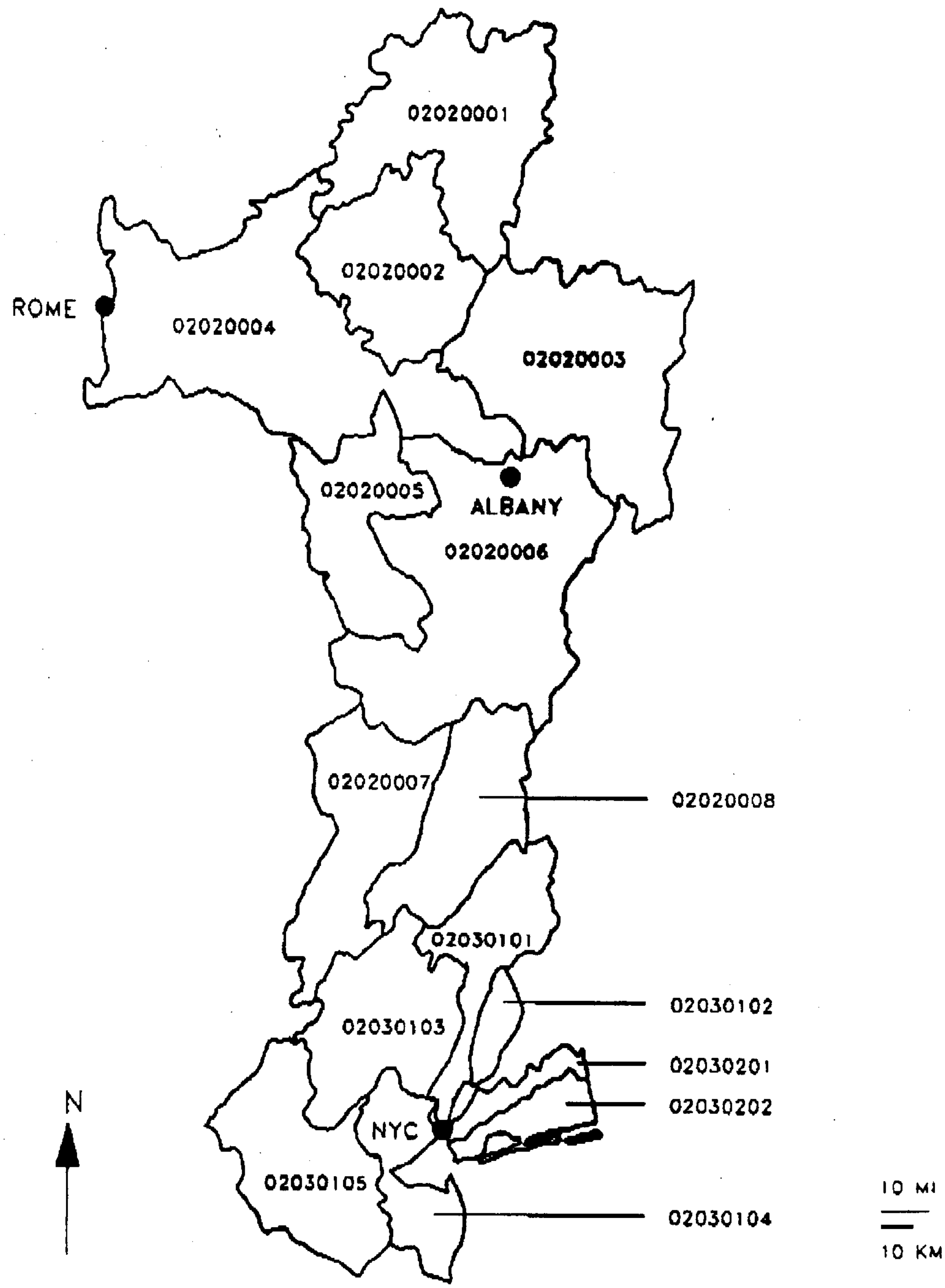
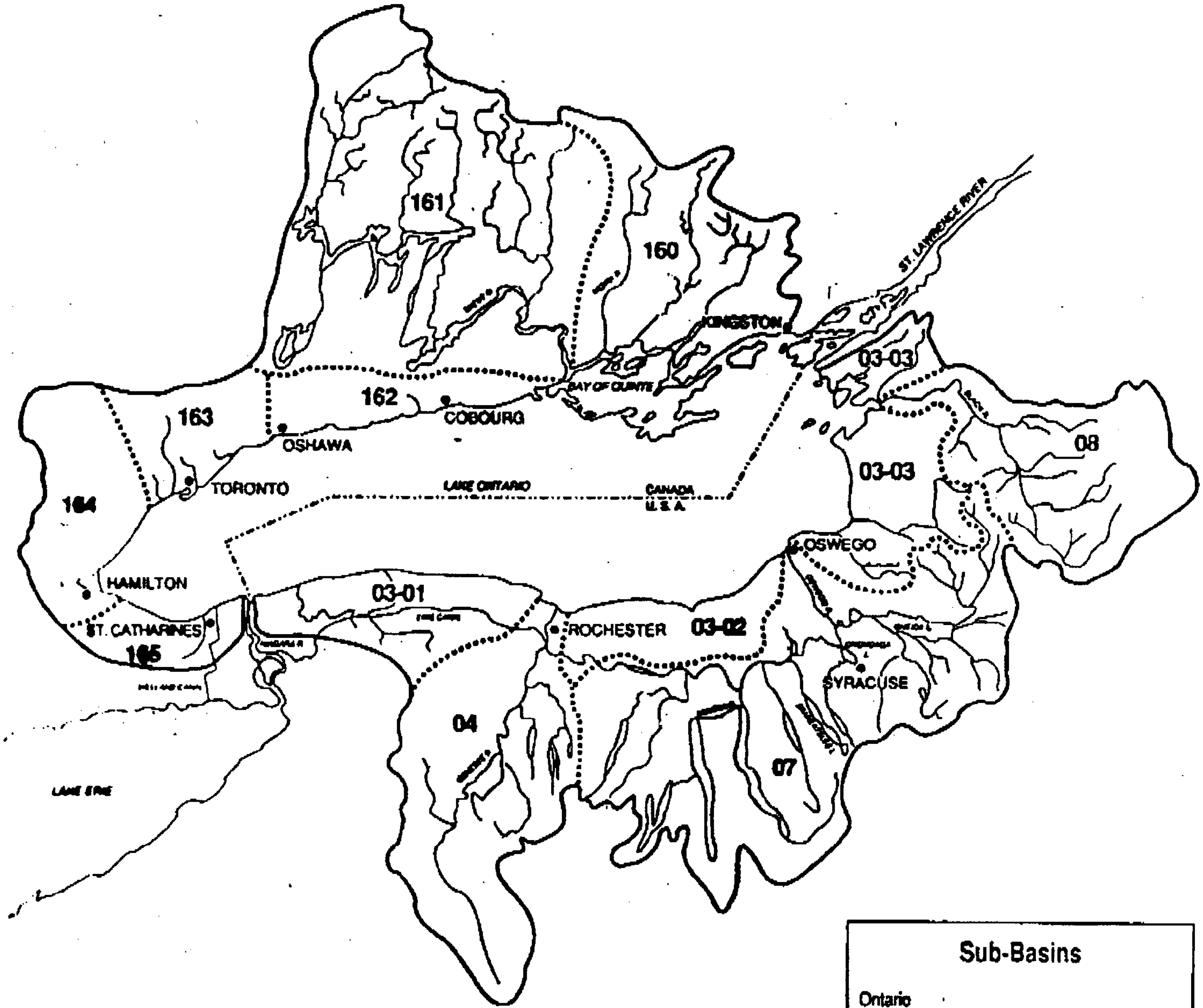


FIGURE 5

CATALOGING UNITS IN THE HUDSON-RARITAN BASIN



Sub-Basins

Ontario

- 160 - Belleville - Napanee Area Rivers
- 161 - Trent River
- 162 - Oshawa - Colborne Area Rivers
- 163 - Toronto Area Rivers
- 164 - Hamilton Area Rivers
- 165 - Niagara Peninsula Rivers

New York

- 03 - Lake Ontario
  - 01 Western Section
  - 02 Central Section
  - 03 Eastern Section
- 04 - Genesee River
- 07 - Seneca - Oneida - Oswego Rivers
- 08 - Black River

Figure 6 Lake Ontario Basin and Major Sub-Basins

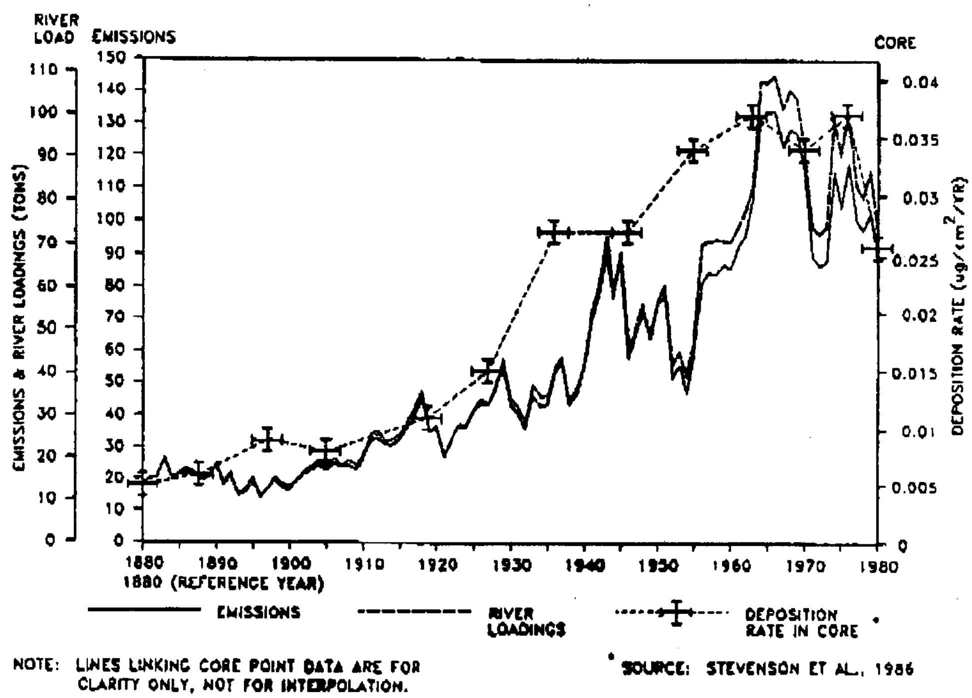

RIVER LOAD
EMISSIONS
CORE
EMISSIONS & RIVER LOADINGS (TONS)
DEPOSITION RATE (ug/cm²/YR)
1880 (REFERENCE YEAR)
EMISSIONS
RIVER LOADINGS
DEPOSITION RATE IN CORE
NOTE: LINES LINKING CORE POINT DATA ARE FOR CLARITY ONLY, NOT FOR INTERPOLATION.
SOURCE: STEVENSON ET AL., 1986

FIGURE 7