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PROPOSED MODIFICATION OF THE GREAT LAKES ATMOSPHERIC DEPOSITION (GLAD) NETWORK TO INCLUDE TOXIC ORGANICS

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1. INTRODUCTION

The Great Lakes National Program Office (GLNPO) is responsible for coordinating activities undertaken by the U.S. Environmental Protection Agency (EPA) to restore and maintain the water quality of the Great Lakes. In order to effectively address its coordination responsibilities and set priorities for Great Lakes remedial activities, GLNPO initiates and oversees numerous research and monitoring programs directed at identifying and quantifying pollutant inputs to the Great Lakes Basin. This paper summarizes GLNPO's past efforts in determining the nature and extent of atmospheric inputs to the Great Lakes ecosystem and briefly discusses proposed modifications to the existing Great Lakes Atmospheric Deposition (GLAD) monitoring program.

The second chapter of this document provides background information concerning atmospheric deposition and the existing monitoring network. The third chapter describes the proposed revised monitoring network. The fourth chapter discusses the joint coordination of network activities by GLNPO and Environment Canada. The fifth chapter discusses ancillary functions of the new atmospheric deposition monitoring network, and the final chapter describes the proposed implementation schedule and estimated costs for the modified network.

2. BACKGROUND

2.1 GOALS OF GLNPO

The Great Lakes National Program Office (GLNPO) was chartered to coordinate EPA's commitments under the Great Lakes Water Quality Agreement to restore and maintain the physical, chemical, and biological integrity of the Great Lakes and their tributaries. Consequently, the fundamental goals of GLNPO are to identify environmental problems in the Great Lakes Basin, to recommend the development of remedial programs to solve these problems, and to determine the effectiveness of past remedial programs in correcting environmental problems.

The Great Lakes receive conventional and toxic pollution from both point and nonpoint sources, threatening the ecological integrity of the lakes and potentially posing hazards to human health. Fish consumption advisories have been issued and recreational activities have been restricted in several of the more heavily polluted areas of the Great Lakes. Recently, GLNPO adopted a five year program strategy for the years 1986 to 1990. An important component of this strategy is the recognition that the water quality of the Great Lakes is intrinsically connected to the rest of the ecosystem. As stated in the five year plan, "While the program strategy is most concerned with cleanup and prevention of pollution of waters of the Great Lakes themselves, an ecosystem perspective requires attention to the tributaries, to land and to the atmosphere as sources of contamination to the lakes."
The goals of this strategy are to:

1. Apply an ecosystem approach to environmental management by considering effects of lake usage on biota and human health
2. Obtain sufficient information about sources, fates and effects of toxic contaminants to support a mass balance approach in remedial programs
3. Develop and implement remedial programs in all areas of concern
4. Evaluate results of remedial programs for conventional pollutants, including phosphorus controls, and determine whether more stringent controls are needed

5. Develop a stronger partnership with the Great Lake States, other EPA programs and other federal agencies for implementation of the Great Lakes Water Quality Agreement with Canada.

Existing programs directed at improving Great Lakes water quality have principally emphasized the control of industrial and municipal point source discharges. Emphasis has also been placed on urban and agricultural runoff control programs aimed at reducing phosphorus and nitrogen loadings to the Great Lakes. Comparatively less emphasis has been placed on determining the relative contributions of toxic substances to the Great Lakes Basin from more nontraditional, nonpoint sources such as landfill leachate, resuspension of contaminated sediments, and atmospheric deposition.

Studies conducted by GLNPO and others conclude that atmospheric deposition is a source of toxic pollutants to the Great Lakes. The quantitative significance of this source in relation to other nonpoint sources, however, has not been reliably established.

As a first step in determining the relative significance of atmospheric deposition, GLNPO established the Great Lakes Atmospheric Deposition (GLAD) network in 1981. The GLAD network will be discussed in Section 2.3 of this report. Currently, GLNPO proposes to extend overall GLAD network concepts into a revised, upgraded network. The proposed GLAD network will be discussed in Chapter 3 of this report.

In the following section, the nature of atmospheric deposition is briefly discussed and the mechanisms of atmospheric deposition are delineated.

2.2 ATMOSPHERIC DEPOSITION MECHANISMS

Pollutants are deposited from the atmosphere via three routes: precipitation, dry deposition, and vapor exchange. The existing atmospheric deposition network (GLAD), as well as the proposed network use sampling and/or modeling efforts to determine pollutant loadings to the Great Lakes through the three aforementioned routes. The three mechanisms are briefly described below.

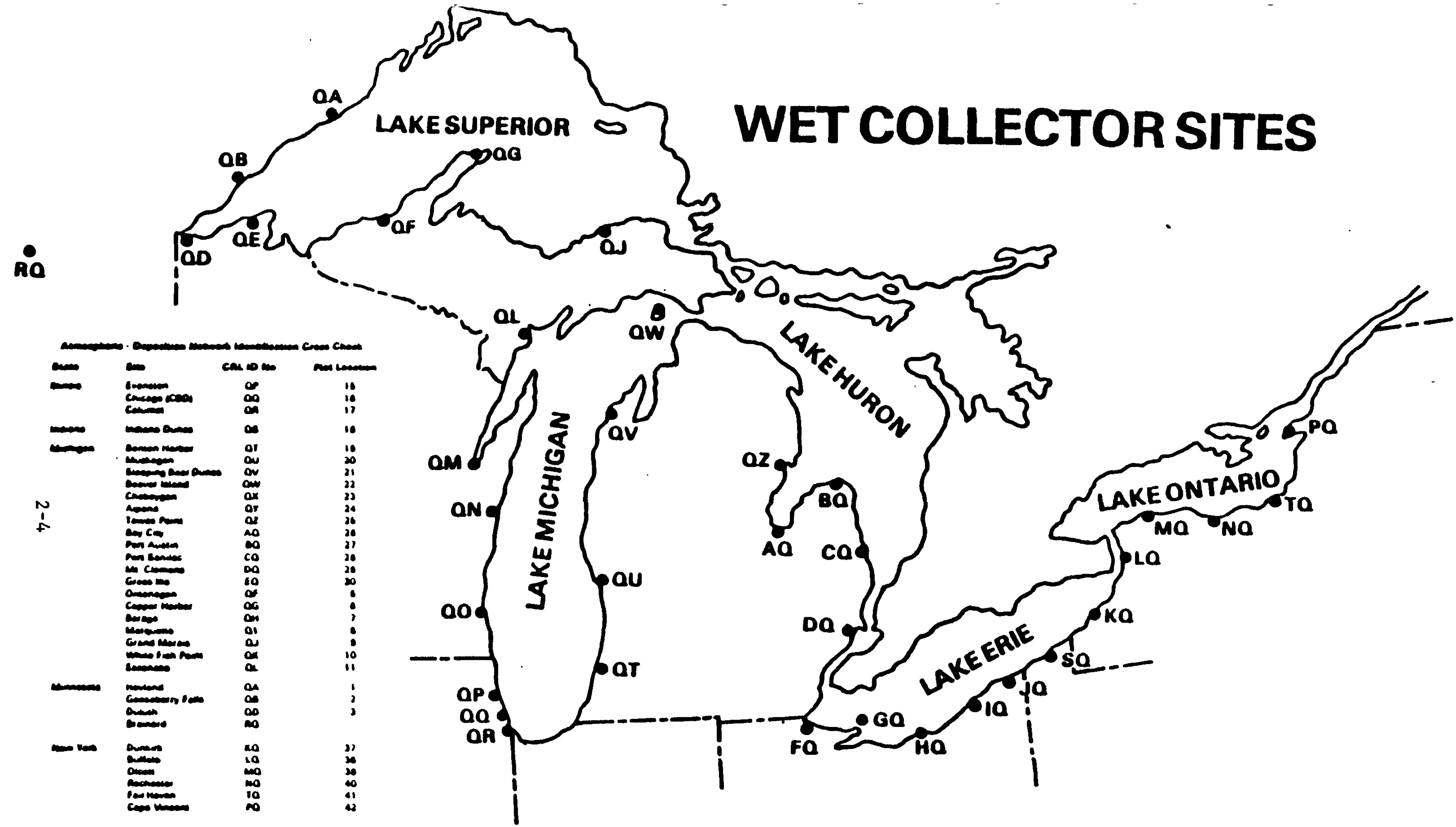
Precipitation sampling and analysis can be used to determine pollutant loadings to the Great Lakes during rainfall/snowfall events. Pollutant loadings deposited by rainfall/snowfall are functions of precipitation intensity (precipitation depth/time) and pollutant concentration within the precipitation.

Dry deposition is another atmospheric deposition mechanism. Falling airborne particulate matter bearing sorbed pollutants continually enter the Great Lakes. Pollutant loadings from the dry deposition of particulate matter are functions of pollutant concentration within the particulate matter, particulate deposition velocity (which in turn is a function of particle size), and particulate concentration in the atmosphere.

The third deposition mechanism is vapor exchange. Vapor exchange deposition to, or losses from, the Great Lakes are at least partially a function of the thermodynamic equilibrium relationships between vapor and water concentrations of each pollutant. Vapor exchange deposition loadings to the Great Lakes are not readily calculated and appropriate modeling efforts to estimate these loadings are needed.

2.3 THE GREAT LAKES ATMOSPHERIC DEPOSITION (GLAD) NETWORK

Recognition of atmospheric deposition as a source of pollution in the Great Lakes has evolved slowly over the past decade. Early studies indicated that air transport was a significant pathway for phosphorus loadings to the lakes, giving rise in 1976 to the Atmospheric Deposition Network, the purpose of which was to collect data on airborne phosphorus loadings to Lake Erie. In 1981, this effort was expanded to monitor the deposition of a variety of pollutants into all of the Great Lakes. This expanded effort was called the Great Lakes Atmospheric Deposition (GLAD) Network. The GLAD network included 36 U.S. monitoring sites bordering the Great Lakes, representing industrial, agricultural, and urban sources (see Figure 2-1). Thirty-eight physical and chemical parameters were monitored including heavy metals, nutrients, conductivity, acidity, and alkalinity. A complete list of parameters appears in Table 2-1.



Atmospheric - Deposition Network Identification Cross Check

State	Site	CRL ID No.	Plot Location
Illinois	Evanston	QP	15
	Chicago (CBD)	QQ	16
	Calumet	QR	17
Indiana	Indiana Dunes	QS	18
Michigan	Benton Harbor	QT	19
	Muskegon	QU	20
	Sleeping Bear Dunes	QV	21
	Beaver Island	QW	22
	Cheboygan	QX	23
	Alpena	QY	24
	Tawas Point	QZ	25
	Bay City	AQ	26
	Port Austin	BQ	27
	Port Sanilac	CQ	28
	Mt. Clemens	DQ	29
	Grosse Ile	EQ	30
	Ontonagon	QF	5
	Copper Harbor	QG	6
	Baraga	QH	7
	Marquette	QI	8
	Grand Marais	QJ	9
	White Fish Point	QK	10
	Escanaba	QL	11
Minnesota	Hovland	QA	1
	Gooseberry Falls	QB	2
	Duluth	QD	3
	Brainerd	RQ	
New York	Dunkirk	KQ	37
	Buffalo	LQ	38
	Olcott	MQ	39
	Rochester	NQ	40
	Fair Haven	TQ	41
	Cape Vincent	PQ	42
Ohio	Toledo	FQ	31
	Put-in-Bay	GQ	32
	Lorain	HQ	33
	Fairport Harbor	IQ	34
	Conneaut	JQ	35
Pennsylvania	Erie	SQ	36
Wisconsin	Cornucopia	QE	4
	Green Bay	QM	12
	Manitowoc	QN	13
	Milwaukee	QO	14

FIGURE 2-1. GLAD NETWORK WET COLLECTOR SITES

TABLE 2-1. GLAD NETWORK POLLUTANTS

Sample Size (ml)
pH (field)
pH (lab)
Specific Conductance (field)
Specific Conductance (lab)
Acidity
Alkalinity
Aluminum (Al)
Arsenic (As)
Barium (Ba)
Beryllium (Be)
Boron (B)
Cadmium (Cd)
Calcium (Ca)
Chromium (Cr)
Cobalt (Co)
Copper (Cu)
Iron (Fe)
Lead (Pb)
Lithium (Li)
Magnesium (Mg)
Manganese (Mn)
Total Mercury (Hg)
Nickel (Ni)
Potassium (K)
Sodium (Na)
Strontium (Sr)
Titanium (Ti)
Vanadium (V)
Zinc (Zn)
Ammonia Nitrogen (NH_3) - N
Chloride (Cl)
Total Kjeldahl - N (TKN)
Nitrogen-Nitrate and Nitrite (NO_2 + NO_3) - N
Silicate (SiO_2)
Sulfate (SO_4)
Total Organic Carbon (TOC)
Total Phosphorus (TP)

GLAD was established to fulfill the following purposes:

1. To determine atmospheric loadings of metals and nutrients
2. To evaluate annual trends in the deposition of these substances
3. To assess results of various program strategies.

GLAD Network data has been submitted annually to the Acid Deposition System (ADS) operated by Battelle Pacific Northwest Laboratory in Richland, Washington. The 36 GLAD sites were equipped with wet/dry automatic precipitation samplers that monitor for nutrients and heavy metals on a weekly basis. An analysis performed on the data collected for the years 1982 to 1984 yielded the following results:

- Total phosphorus (P) loadings declined in four of the five lakes over the three year period. Lake Superior showed a decline in 1983, but an increase in 1984 to a level greater than that in 1982. Table 2-2 presents the estimated 1982 phosphorus loadings to each of the Great lakes from atmospheric (wet deposition), industrial, municipal, tributary, and unmonitored areas as well as the percent contributions of atmospheric (wet deposition) to the total loadings of each lake. Fifty to seventy percent of the phosphorus loads to Lakes Erie and Ontario emanates from tributary sources; less than 5 percent of the total loadings result from atmospheric loadings (wet deposition). For Lakes Superior, Michigan, and Huron atmospheric loadings represent from 14 to 19 percent of total loadings. Dry deposition atmospheric loadings of phosphorus to the Great Lakes have not been estimated.

- Annual sulfate (SO_4) loadings increased in Lakes Michigan, Huron and Erie from 1982 to 1984 but remained relatively constant in Lakes Superior and Ontario. As part of the grant for the "Great Lakes Atmospheric Deposition (GLAD) Network Data Analysis and Interpretation" the Illinois State Water Survey compared the effect the addition of GLAD sites to NADP data sets would have on the respective concentration patterns for SO_4. The addition of GLAD data provides additional resolution of localized SO_4 concentration gradients, particularly within Lakes Erie and Ontario.

- Nitrite/nitrate (NO_2/NO_3) loadings increased in Lakes Michigan, Huron and Erie, and remained constant in Lake Ontario. Loadings to Lake Superior were highest in 1983 and almost identical in 1982 and 1984. The addition of GLAD NO_x data to the NADP data sets provides additional resolution of localized NO_x concentration gradients, particularly in and adjacent to urban areas. The incorporation of GLAD data, especially GLAD data from urban monitoring sites, expands the area across the Great Lakes Basin over which NO_x concentration gradients can be predicted. Urban areas constitute major sources of NO_x to the

TABLE 2-2. 1982 ESTIMATED ATMOSPHERIC, INDUSTRIAL, MUNICIPAL, AND TRIBUTARY PHOSPHORUS LOADINGS TO THE GREAT LAKES (METRIC TONNES/YEAR)[1]

SOURCE	GREAT LAKE: LAKE SUPERIOR	LAKE MICHIGAN	LAKE HURON	LAKE ERIE	LAKE ONTARIO
Atmospheric (Wet Deposition)	604	604	642	321	194
Industrial Discharge	33	53	5	67	54
Municipal Discharge	128	246	113	1,388	1,589
Tributary	1,338	2,808	1,921	7,483	2,581
Unmonitored Area	1,008	671	819	1,671	737
Total Loading	3,111	4,382	3,500	10,930	5,155
% Atmospheric (Wet Deposition)	19%	14%	18%	3%	4%

[1]Sources: Atmospheric data is based upon precipitation samples taken by GLNPO and the Canadian Center for Inland Waters (CCIW). The loadings from industrial, municipal, tributary, and unmonitored areas were obtained from the 1983 Report to the International Joint Commission on Great Lakes Water Quality.

Great Lakes atmosphere. Exhaust from automobiles, the principal contributor of NO_x to the atmosphere, is highest in urban areas.

- Lead measurements showed a significant decrease in all lakes after 1982. However, this decrease may be due in part to the use of more sensitive analytical instrumentation, with lower detection limits, beginning in 1983. Between 1983 and 1984, lead loadings decreased in all lakes except Lake Erie.

- Cadmium measurements also showed a significant decrease in all lakes after 1982. Again, this decrease may be related to the shift in analytical instrumentation beginning in 1983. Little or no change occurred in the magnitude of cadmium loadings in any of the lakes between 1983 and 1984.

2.4 RATIONALE FOR ESTABLISHING A SUBSTITUTE NETWORK

In 1985, GLNPO began evaluating the ability of the GLAD network to meet the evolving goals of the atmospheric deposition program. This evaluation, conducted by GLNPO in conjunction with committees of recognized technical experts in the field of atmospheric deposition, brought to light several deficiencies in the network. The most significant deficiency was the conclusion that the system is not adequate to provide data on airborne loadings of trace pollutants to the Great Lakes. One study indicated that many of the sites are poorly located on the basis of EPA-established siting criteria. Another study found inconsistencies between GLAD data and National Atmospheric Deposition Program (NADP) data, indicating potential inadequacies in GLAD laboratory quality assurance and control programs. An additional deficiency in the GLAD network is the lack of coordination between the efforts of Canada and the U.S., making data comparisons impossible.

In light of these deficiencies, GLNPO, in conjunction with recognized experts in the field of atmospheric deposition, began studying ways of modifying the GLAD network. Working in association with Environment Canada, it was decided that the two agencies should jointly develop a program to monitor atmospheric deposition of trace pollutants. This second generation program has three objectives:

1. To determine the portion of total loadings of critical toxic pollutants contributed by atmospheric deposition

2. To recommend the extent to which additional remedial programs and international activities are needed to control atmospheric sources
3. To provide source information for immediate regulatory action.

The proposed network is discussed in the following chapter.

3. DESCRIPTION OF PROPOSED GLAD NETWORK

The proposed Great Lakes Atmospheric Deposition (GLAD) network will consist of atmospheric deposition monitoring and computer modeling activities designed to identify and quantify atmospheric inputs of toxic and/or bioaccumulative pollutants to the Great Lakes. The need to establish a coordinated atmospheric deposition monitoring network such as GLAD is firmly tied to GLNPO's mission to restore and maintain the water quality of the Great Lakes. Recent GLNPO observations indicate that Great Lakes fish tissues continue to show high concentrations of certain bioaccumulative pollutants despite the success of control programs directed at point source dischargers. Concentrations of certain pollutants in fish tissues have recently stabilized, reversing an earlier trend of decreased pollutant concentrations over time. Nonpoint source inputs of pollutants to the Great Lakes, including atmospheric deposition, are now thought to be at least partially responsible for the still elevated pollutant levels currently observed in Great Lakes fish.

In this chapter, the proposed GLAD network will be described. Identification of pollutants of concern, the proposed siting of GLAD sampling equipment, sample handling and analytical procedures, and requisite staffing to conduct GLAD monitoring activities will be described in the following sections.

3.1 IDENTIFICATION OF POLLUTANTS OF CONCERN

As noted above, the GLAD network will be designed initially to monitor atmospheric deposition of those pollutants identified as bioaccumulating to sufficient levels in Great Lakes fish to warrant concern regarding fish consumption. Personnel attending the November 1985 Atmospheric Deposition Workshop on Organic Contaminant Deposition to the Great Lakes Basin have tentatively identified the following bioaccumulative pollutants as warranting consideration for atmospheric deposition monitoring:

- Metals: Arsenic, Cadmium, Mercury
- Pesticides: Chlordane, DDT and metabolites, Dieldrin, Mirex, Toxaphene

- Polynuclear Aromatic Hydrocarbons
- Polychlorinated Biphenyls.

In addition, special studies will be conducted in the future to investigate the atmospheric deposition of polychlorinated dibenzodioxins and dibenzofurans. The high costs associated with analysis of dibenzodioxins and dibenzofurans are expected to prohibit routine GLAD monitoring for these pollutants.

The pollutant list cited above will be modified as necessary in response to shifts in future priorities.

3.2 PROPOSED SITING OF GLAD SAMPLING EQUIPMENT

The proposed GLAD network will consist of two distinct types of atmospheric deposition sampling sites: master sites and routine sites. The functions of each of these types of sites are described below, and considerations in their siting are discussed.

3.2.1 Master Sites

The proposed GLAD network is to include five master sites. In addition to routine monitoring activities, master sites are to conduct nontraditional, research-oriented atmospheric deposition monitoring activities, as well as to provide quality assurance support for the GLAD program. The research activities shall be supplemented on a year to year basis. Master sites will address the deficiencies identified in the earlier evaluation of the GLAD network, including:

- Identification of trace organics in precipitation samples
- Calibration/verification checks on the proper operation of GLAD network sampling systems
- Field verification of new atmospheric deposition sampling equipment and sample collection procedures
- Quality assurance studies on GLAD network sample collection activities.

In addition, master site activities will include the following research components:

- Investigating vapor exchange of organic contaminants at the air-water interface
- Analyzing the importance of deposition from urban sources versus rural sources
- Assisting in the development and implementation of dry particle deposition models
- Assisting in the development and implementation of both wet and dry particle deposition models to measure differences between over-land versus over-water deposition
- Identifying nonroutine chemical substances in atmospheric deposition causing potentially adverse impacts on ecosystem health
- Implementing research to ascertain "dry" particle deposition to artificial surfaces.

These monitoring activities will accelerate research identifying the specific mechanisms of deposition and the interaction between these mechanisms and the environmental media. Proposed research studies include the following:

<u>Precipitation Types and Loading Estimates</u>

Planned instrumentation and sampling equipment at master sites will provide for collection and analysis of contaminants in rain, snow, particulates, and air. For those research parameters being analyzed, a detailed annual analysis and interpretation of the data will be required. The analysis and interpretation of data involves calculations of annual loadings for each parameter via each precipitation type, including different particle sizes; evaluation of the relative importance of each type in terms of contaminant loadings to the Great Lakes; evaluation of the efficacy of the various sampling equipment utilized, including recommendations for improvements; and determination of the relative importance of total atmospheric loadings of toxics to the area of the master site as compared to other known sources of contaminants (e.g., tributary, point sources, ground water, and runoff).

Vapor Exchange

Measurement of atmospheric loadings of toxics to the Great Lakes requires knowledge of both the total and net atmospheric inputs of organic and inorganic contaminants. Vapor exchange at the air/water interface may result in absorption of contaminants from the atmosphere and/or volatilization of contaminants into the atmosphere.

Research is needed to determine the importance of this exchange for the various inorganic and organic chemicals planned for measurement at the master site. Potential studies to address this subject area encompass the following topics:

- Henry's Law Constants for organic and inorganic chemicals including the temperature dependence of those constants
- Differentiation of vapor and particulate chemical species in the atmosphere
- Differentiation of dissolved and nondissolved or gaseous chemical species in the water
- Development of time-dependent model for describing air-water interactions
- Development of methodology to estimate environment-dependent mass transfer coefficients.

Over-Land Versus Over-Water Precipitation and Loading Amounts

Existing or planned atmospheric deposition sites for the Great Lakes are currently located over land on either the shore of the lakes or on islands. Research is needed to determine what, if any, difference exists in the amount of precipitation, the type of precipitation, and the composition of precipitation at land based sites as compared to over-water locations. Such research should take into account the availability of surface ships that will be involved in intensive research from 1987 to 1989 on Green Bay as part of pilot studies on the application of the mass-balance approach to toxics. Potential studies to address the subject area include the following topics:

- Differences in the amounts of precipitation over land and over water. These studies should consider not only changes in the total amounts but also changes in the relative amounts of rain, snow, and particulates. Also of interest is the differentiation of wind-driven snow versus new-fallen snow as well as the significance of contaminant transport in surface fogs

- Differences in the contamination content of precipitation over land and over water.

Identification of New or Previously Undetected Contaminants in Precipitation

Atmospheric deposition may represent a significant loading for several contaminants to the Great Lakes. Research studies are needed for the development and application of methodology for detection and quantification of potential contaminants in precipitation at ultratrace level utilizing samples to be collected, or that could be collected at a master site. Such studies shall specify the class or classes of compounds to be analyzed and justify why the specified class of compounds are important and likely to be found in precipitation.

3.2.1.1 Proposed Equipment for Each Master Site

Proposed equipment to be situated at each master site includes:

- Three wet precipitation collectors with XAD-2 and/or Tenax resin columns for collection of precipitation samples to be analyzed for trace organics
- Three directionally operated high volume dry deposition collectors with backup adsorbent columns, to identify/quantify the dry deposition of trace organics
- A Nipher Snow gauge to measure the snowfall in millimeters (mm) of water
- One wet/dry automatic precipitation collector for the collection of weekly precipitation samples to be analyzed for nutrients
- One high volume sampler dedicated to total suspended particulate/ organic carbon measurements
- Two cascade impactors; one for organics and one for metals and nutrients
- Meteorological tower capable of providing hourly average data pertaining to:
  - Wind speed
  - Wind direction

- Humidity
- Temperature
- Precipitation intensity
- Solar radiation.

Master sites are to be located in the proximity of a university or research laboratory to ensure ease of site operation and sample collection. The master sites will be staffed with technical, research-oriented personnel. Universities (in particular, those with chemistry and/or environmental programs) located in rural areas would constitute ideal sites for master sites. The master sites could thus be operated by qualified university faculty and students, and university laboratory facilities could be effectively utilized for sample analysis.

Master sites would be logical locations for conducting joint United States-Canada atmospheric deposition research studies. If appropriate locations could be identified, one or more master sites might be situated near the United States-Canada border, providing convenient access for research personnel from both countries.

3.2.2 Routine Sites

The proposed GLAD network will also include 12 routine monitoring stations. Routine sites are to conduct weekly/biweekly atmospheric deposition monitoring activities in support of deposition model calibration efforts and/or Great Lakes pollutant mass balance inventory development.

3.2.2.1 Proposed Equipment for Each Routine Site

Proposed equipment to be situated at each routine monitoring site includes:

- One wet precipitation collector, for collection of precipitation samples to be analyzed for organics present in greater than trace amounts.
- A Nipher snow gauge to measure the snowfall in millimeters (mm) of water.

- One wet/dry automatic precipitation collector for the collection of weekly precipitation samples to be analyzed for nutrients.
- One wet/dry precipitation collector for the collection of weekly precipitation samples in polyethylene or teflon-lined containers. Nitric acid will be added to the collector to minimize sorption losses.
- Two high volume dry deposition collectors with backup adsorbent columns to identify and quantify the dry deposition of trace organics.
- One cascade impactor.
- One high volume dry deposition collector dedicated to total suspended particulate/organic carbon dry deposition measurements.
- Meteorological tower capable of providing hourly/hourly average data pertaining to:
  - Wind speed
  - Wind direction
  - Humidity
  - Temperature
  - Precipitation intensity
  - Solar radiation.

In general, routine sites will be located in urban areas, on islands in the lakes, and in relatively remote areas free from pollutant interferences from urban areas. Routine sites will not be so remote, however, as to be inaccessible to site operators during inclement weather. Remote routine sites will also be located within practical driving distance of the analytical laboratory (or post office, if samples are to be shipped). Data collected at urban sites would be used to define atmospheric deposition gradients surrounding urban areas, and to identify the contribution of urban emission sources to Great Lakes atmospheric deposition.

3.3 SAMPLE HANDLING AND ANALYTICAL PROCEDURES

Detailed GLAD network standard operating procedures for collection and analysis of atmospheric deposition samples will be developed to ensure accuracy and reproducibility of analytical results. Considerations in establishing these procedures include:

- Organics--Samples must be collected in glass or teflon-lined equipment. Samplers with large interception areas are required for collection of sufficiently large samples. Appropriate GC/MS analytical methodologies must be identified and followed.

- Metals--Samples must be collected in polyethylene or teflon-lined equipment. Nitric acid should be added to the collector to minimize sorption losses. Appropriate atomic absorption analytical methodologies must be identified and followed.

- Mercury--An appropriate oxidant must be added to precipitation samples to prevent reduction and subsequent solubilization of particulate mercury.

Laboratory quality assurance/quality control programs, involving analysis of blank, duplicate, and spike samples, will also be developed to adequately quantify data accuracy and precision.

3.4 REQUISITE STAFFING

Requisite staffing for the proposed GLAD network can be outlined as follows:

- Each master and routine site requires at least one operator. The operator's responsibilities include maintenance of the sampling equipment as well as sample acquisition and delivery to the laboratory. The operator should be a trained technician, knowledgeable of the operation of the samplers and the GLAD network's sample collection and preservation protocols.

- Each GLAD network laboratory will be staffed with at least one expert in the analysis of organic and inorganic (metal) pollutants. This individual shall possess PhD qualifications in the field of chemistry. In addition, each laboratory will be staffed with a sufficient number of trained laboratory technicians to assist in analytical duties.

- One or more of the master sites will be staffed with a GLAD network coordinator. The GLAD coordinator is to direct all research activities conducted at the GLAD master sites, as well as coordinate all activities with appropriate GLNPO personnel. The GLAD coordinator must be knowledgeable in the science of atmospheric deposition. In addition, the GLAD coordinator must be familiar with the mission of GLNPO and other Great Lakes environmental agencies, and must be able to effectively communicate with these organizations.

3.5 COMMON LABORATORY

GLNPO is considering two options for providing laboratory analytical services to the GLAD program. One option is to rely on the analytical capabilities of the various private and academic laboratories located in the vicinity of the GLAD sampling sites. The principal advantages and disadvantages of this option are as follows:

<u>Advantages</u>	<u>Disadvantages</u>
• Sample dropoff is a simple procedure; packing samples into parcels for shipment is not required.	• Quality assurance oversight cannot be provided by GLAD personnel on a daily basis.
• Local laboratories can often ensure that analytical results will be provided expeditiously.	• Analytical results from the various laboratories may not be statistically comparable. Determinations of relative precision and accuracy will have to be made.

A second option is to establish a common laboratory to which all GLAD network samples will be sent for analysis. The principal advantages and disadvantages of this option are as follows:

<u>Advantages</u>	<u>Disadvantages</u>
• GLAD personnel can provide continual quality assurance oversight.	• All samples must be packed and shipped subsequent to collection. Appropriate sample preservation will be required to ensure that samples are not chemically altered during the shipment period.
• Comparability of results between laboratories is not an issue.	• Samples cannot be analyzed until actually received at the common laboratory. Shipment periods ensure at least some delay in sample analysis.

Both of these options will be carefully considered before a decision is made as to whether a GLAD network common laboratory should be established.

4. CANADIAN PARTICIPATION

Participation by Environment Canada in the GLAD network will greatly enhance the validity and utility of network data. Canadian atmospheric deposition monitoring data would be used to fill in GLAD network data gaps concerning deposition to the Great Lakes across the United States-Canada border. The resulting joint United States-Canada atmospheric deposition monitoring data bases will enable the derivation of more accurate estimates of lakewide pollutant loadings to each Great Lake.

Canadian participation in the GLAD network will also contribute to the resolution of existing issues concerning the direction and extent of atmospheric pollutant transfer across the United States-Canada border. Resolution of these issues is critical to assessing emission control strategies on both sides of the border.

Before a joint United States-Canada GLAD network can be established, several practical issues concerning Canadian participation in the GLAD network will require resolution. Major issues include:

- Coordination--All GLAD monitoring activities should be coordinated by both American (GLNPO) and Canadian (Environment Canada) representatives.
- Choice of laboratory--If a common laboratory is to provide analytical services for the entire GLAD network, should the laboratory be an American or Canadian laboratory? If multiple laboratories are used, common analytical procedures, test methods, and quality assurance programs should be established.
- Location of monitoring sites--the number and location of both American and Canadian monitoring sites must be jointly agreed upon.

5. ANCILLARY GLAD NETWORK FUNCTIONS

In addition to atmospheric deposition monitoring and data acquisition activities, GLAD personnel will also be responsible for ensuring effective data utilization. In this regard, ancillary GLAD network activities will include the communication and distribution of GLAD network monitoring data to appropriate regulatory programs, and the development of Great Lakes atmospheric deposition models.

5.1 COORDINATION WITH REGULATORY PROGRAMS

Results of GLAD monitoring activities will be distributed to those officials responsible for relevant State (Provincial) and Federal regulatory programs in both the United States and Canada. Those regulatory programs which might be expected to benefit from the results of a GLAD monitoring network might include:

- Air emissions point source permitting programs--The GLAD network can provide deposition monitoring data which identify and quantify toxic organic pollutants typically emitted to the atmosphere by industrial point sources (e.g., PAHs emitted by coking plants, etc.)

- Pesticide programs--The GLAD network can provide pesticide deposition monitoring data. Such data would be useful to various pesticide programs in their role of tracking the environmental fates of applied pesticides.

- Toxic substance control programs--Similarly, the GLAD network can provide toxic substance deposition monitoring data, which would be useful to toxic substance control programs in their role of tracking the environmental fates of toxic substances.

5.2 DEVELOPMENT OF ATMOSPHERIC DEPOSITION MODELS

The development and calibration of atmospheric deposition models will be critical to the validity and effective use of GLAD network monitoring data. Atmospheric deposition models are necessary to effectively characterize pollutant loadings to the Great Lakes. In particular, GLAD network atmospheric deposition models must be developed to accomplish the following:

- Provide accurate estimates of lakewide pollutant loadings--Monitoring data from scattered GLAD monitoring stations must provide the basis for estimating lakewide pollutant loadings. However, the linear extrapolation of limited single station loading data across the entire Great Lakes will be highly inaccurate. Models must be developed which quantitatively establish pollutant loading gradients across the Great Lakes.

- Quantify the influence of environmental conditions on atmospheric deposition--Statistical correlations between pollutant loadings to the Great Lakes and environmental conditions such as rainfall, pollutant volatility, temperature, and atmospheric turbulence must be established before accurate predictive estimates of pollutant loadings to the Great Lakes can be made.

- Estimate pollutant transport distances and link pollutant sources to sinks--Atmospheric deposition pollutant loading gradients could potentially be correlated to meteorological data to provide estimates of pollutant transport distances and direction. Such estimates could be effectively used to identify point and nonpoint sources of atmospheric emissions.

- Estimate pollutant loadings to the Great Lakes via vapor exchange--Vapor exchange pollutant loadings to the Great Lakes can only be estimated by mathematical modeling efforts (see Section 2.2).

- Quantitatively establish the relative importance of the three atmospheric deposition mechanisms (see Section 2.2)--Quantitative relationships between the three atmospheric deposition mechanisms (precipitation, dry deposition, vapor exchange) can be established from GLAD monitoring data. These relationships will serve to focus future GLAD monitoring activities.

6. RESOURCES AND TIME SCHEDULE

This section summarizes the resources and time schedule necessary to design and implement the GLAD network. The summary is provided in three separate tables.

Table 6-1 is a time schedule for the set-up and operation of the proposed network. It provides, by fiscal year, the resource costs for network operation from 1987 to 1991. Cost breakdowns are provided by type of analysis for both master (I) and routine (II) sites. (Costs for the operation for a single site for each type of analysis appear in the lefthand column of Table 6-1.) Costs are projected at $406K, $562K, $772K, $813K, and $752K for FY 1987-FY 1991 respectively. Table 6-2 presents the total operating cost for 1991 as $752,000. The cost is broken down by lake. The cost per lake is directly related to the number and type of stations on each lake.

Setting up master sites, a one time expenditure, will cost approximately $56,000 per site. Annual operational costs for organics sampling equipment, and analyses of those samples, will cost $100,000 per site not including the cost of separately funded research studies. Metals and nutrient analyses from precipitation samples will cost far less--an estimated $10,000. Thus, after the first year set-up costs, master stations should cost $110,000 to maintain per year. Routine sites will be comparatively less expensive. The set-up cost for a routine site is estimated at $42,000. Annual operation of organic sampling equipment and analyses of those samples at routine sites is estimated at $26,000 per site. Annual operational costs associated with analysis of metals and nutrients from precipitation samples is estimated to cost $10,000 per site. Thus, annual operation of routine sites is expected to cost $36,000 annually.

Finally, Table 6-3 provides a schedule for implementing the program on a lake-by-lake basis. Implementation begins in FY 1987 with the set-up and operation of master and routine sites on Lake Michigan. Monitoring on Lake Huron is proposed to begin in FY 1988 on both sides of the U.S./Canadian border. In FY 1989, sites will be added on Lake Erie and Superior. In FY 1990, sites will begin operation on Lake Ontario.

TABLE 6-1. **ESTIMATED U.S. COSTS FOR SET-UP AND OPERATION OF THE PROPOSED GREAT LAKES ATMOSPHERIC DEPOSITION (GLAD) NETWORK**

		COST/SITE $K/YEAR	1987	1988	1989	1990	1991
I.	MASTER SITES						
	A) Set-up: 1 in '87; 1 by Canada in '88, 2 in '89 1 by U.S. & 1 by Canada; 1 in '90, 50% U.S. & 50% Canada funds	56 K	56 K		56K	28 K	
	B) Organic analyses (bi-weekly) (wet & air) 26 x 2 x $200 + 60 x 3 x $200	48 K	24 K	48 K	72 K	108 K	120 K
	C) Organic analyses (event) 60 x $200	12 K	6 K	12 K	18 K	27 K	30 K
	D) Cascade impactors 2 x 60 x $200	24 K	12 K	24 K	36 K	54 K	60 K
	E) Operation	16 K	8 K	16 K	24 K	36 K	40 K
II.	Routine Sites A) Set-up: 2 in '87; 4 in '88; 4 in '89; 2 in '90	42 K	84 K	168 K	168 K	84 K	
	B) Organic Analyses 26 x $200	6 K	6 K	24 K	48 K	66 K	72 K
	C) Cascade Impactor 60 x $200	12 K	12 K	48 K	96 K	132 K	144 K
	D) Operation	8 K	8 K	32 K	64 K	88 K	96 K
III.	19 Nutrient and Metal Samples	10 K	190 K	190 K	190 K	190 K	190 K
	Total Costs by Year		406 K	562 K	772 K	813 K	752 K

TABLE 6-2. 1991 OPERATING COSTS BY LAKE

LAKE			TOTAL COST
Superior:	1 Master Site	100 K	182 K
	2 Routine Sites	52 K	
	3 Metals and Nutrient Sites	30 K	
Michigan:	1 Master Site	100 K	274 K
	4 Routine Sites	104 K	
	5 ~~7~~ Metals and Nutrient Sites	70 K	
Huron:	2 Routine Sites	52 K	82 K
	3 Metals and Nutrient Sites	30 K	
Erie:	2 Routine Sites	52 K	82 K
	3 Metals and Nutrient Sites	30 K	
Ontario:	1/2 Master Site	50 K	132 K
	2 Routine Sites	52 K	
	3 Metals and Nutrient Sites	30 K	
			= 752 K

TABLE 6-3. PROPOSED SCHEDULING BY LAKE AND SITE TYPE

	YEAR 1987	1988	1989	1990	1991
I. MASTER SITES					
A. U.S.					
Lake Michigan	●------	------	------	------	------●
Lake Superior			●------	------	------●
Lake Ontario		~~●~~------	●------	------	------●
B. CANADA					
Lake Huron		●------	------	------	------●
Lake Erie			●------	------	------●
Lake Ontario			●------	------	------●
II. ROUTINE SITES (U.S.)					
Lake Michigan	●------	------	------	------	------●
Lake Huron		●------	------	------	------●
Lake Erie		●------	------	------	------●
Lake Ontario				●------	------●