Lake St. Clair Monitoring Gap Analysis and Strategic Plan

Prepared by

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Executive Summary

The Lake St. Clair Watershed Monitoring Inventory and Strategic Plan were developed to meet the ever increasing need for coordination, collaboration, and prioritization among monitoring agencies. A large number of organizations currently perform some type of monitoring within the Lake St. Clair watershed. As the number of monitoring organizations in the region expands and the environmental issues become more complex, the need for communication and coordination among monitoring agencies increases. The overall objective of this project was to compile a monitoring inventory, gap analysis and strategic plan to provide information needed for effective coordination of current monitoring programs as well as provide direction for future monitoring in the watershed.

The U.S. Army Corps of Engineers, Detroit District (USACE), in partnership with Macomb County, St. Clair County, Macomb County Public Works Commissioner's Office, Office of Oakland County Drain Commissioner, and Southeast Michigan Council of Governments, initiated this project. The USACE contracted with the Great Lakes Commission to conduct project activities. Products include the Lake St. Clair monitoring needs assessment, monitoring inventory, monitoring gap assessment, and monitoring strategic plan. The monitoring inventory is a web-based, searchable database that contains a variety of descriptive characteristics, including but not limited to contact information, program description, parameters, geographic characteristics, program funding, and data collection procedures. The gap analysis is a comparison between a previously identified list of monitoring needs (see Table 1 in project results section) and results of the monitoring inventory. The Lake St. Clair Monitoring Strategic Plan incorporates the results of the gap analysis and examines opportunities to better coordinate monitoring programs to meet previously identified monitoring needs. Links to the monitoring inventory and strategic plan are available at http://glc.org/monitoring/stclair/

Monitoring Inventory

The Great Lakes Commission worked with federal, state/provincial, and local organizations to develop an inventory of current monitoring programs in the Lake St. Clair watershed. While some program information regarding Canadian monitoring programs was included, efforts were primarily directed at creating a comprehensive inventory of U.S. monitoring programs.

The monitoring inventory contains a variety of descriptive characteristics. Descriptive information for more than ninety Lake St. Clair watershed monitoring programs is captured in the monitoring inventory. These programs range from long-term, basinwide programs run by federal agencies to local-scale programs run by non-governmental organizations. A detailed analysis providing a comparison between previously identified Lake St. Clair watershed monitoring needs and the monitoring inventory is available in the Gap Analysis.

Gap Analysis

Knowing the extent of current monitoring programs and understanding where gaps in monitoring lie will become important as coordination and collaboration among monitoring organizations increases. Understanding the scope of monitoring performed and how it relates to the watershed's monitoring needs is also a key component to the development of a sound monitoring strategic plan. A gap analysis based on a comparison of previously identified

monitoring needs and the inventory of current monitoring programs was performed to address these issues.

Monitoring programs were broken into twenty categories ranging from water quality monitoring to identifying illicit discharges. For each of these categories, a number of recommendations were made to address gaps in monitoring. A few of the more important categories and associated key recommendations are presented below.

Macroinvertebrate Sampling

- Develop guidelines for integrating macroinvertebrate data collected by volunteer groups into the larger monitoring regime.

Assessing Quality of Habitat and Natural Communities

- Develop a coordinated monitoring strategy for natural communities in the basin.

Monitoring Fish and Wildlife Community Health

- Consider expanding focus to include more non-game fish species monitoring.
- Consider expanding the monitoring of wildlife populations throughout the basin.

Monitoring Drinking Water

- Public drinking water utilities should periodically test for levels of bacteria, viruses, parasites, chemicals, endocrine disruptors, and other emerging pollutants that are not currently among standard parameters.

Monitoring Impacts of Land Use on Water Quality

- Identify measurable land use criteria that can be used to track impacts of land use and prioritize data collection.

Identifying Pollutant Sources

- Standardize NPDES monitoring requirements.
- Consider repeating the Upper Great Lakes Connecting Channels Study performed on the St. Marys, St. Clair, and Detroit rivers in 1985 and 1986 to establish a comprehensive set of trend data.

Monitoring Combined Sewer Overflow (CSO)/Sanitary Sewer Overflow (SSO) Events

- Identify SSO problem areas and map their locations and begin detection monitoring.
- Create a centralized database for CSO/SSO location and monitoring information.

Identifying Contaminant Sources

- Examine the timeliness of reporting on toxic and hazardous substance releases to determine if it fits the time scale of management decisions.

Assessing Water Quality

- Form a watershed-wide water quality monitoring committee to coordinate and organize monitoring in the watershed and develop opportunities for collaboration and communication among monitoring organizations.
- Conduct in-depth evaluations of parameter-based monitoring coverage, as needed. This should include an examination of objectives and methodologies and evaluation of current monitoring programs in relation to defined monitoring needs.

Assessing Sediment Quality

- A more in-depth examination of sampling parameters and sampling frequency across programs would more clearly determine if sampling coverage is adequate.
- Evaluate utility of sediment quality data submitted for U.S. Army Corps of Engineers dredging permits.

Weather Monitoring

- Consider expanding monitoring in Lake St. Clair to enable researchers to more accurately predict surface flow and water turnover volumes, as well as better forecast local lake conditions.

Monitoring Water Flow and Conditions

- Monitor flow regimes throughout the watershed to determine current flow patterns. Use data to establish target flow rates and develop long-term database of flow patterns.

Quantifying Atmospheric Deposition

- Establish a baseline air deposition monitoring program specific to the Lake St. Clair watershed.

Tracking Total Maximum Daily Load (TMDL)

- MDEQ should communicate in advance their plans for monitoring the impaired stream segments with other monitoring organizations to facilitate efficient broad-scale monitoring coordination; address most environmentally degraded and/or at-risk TMDL areas first.

Delisting Areas of Concern

- Identify measurable delisting targets addressing beneficial use impairments in the Areas of Concern and the monitoring data needed to support these targets.

Monitoring Permit Compliance

- Consider developing monitoring guidelines for permit compliance requirements where currently none exist.
- Evaluate the effectiveness of current permit compliance requirements, by comparing permit compliance records with in-stream water quality monitoring data.

Strategic Plan

One of the fundamental components of a successful watershed management plan is a well–orchestrated regional environmental monitoring strategy that provides policymakers useful information in a timely manner. Data collected through a well-planned, long-term monitoring strategy not only provides the objective means necessary to determine the environmental integrity of an ecosystem, it also provides the means necessary to measure the success of corrective actions. As a means for increasing the organization and effectiveness as well as collaboration and coordination among monitoring organizations, the Lake St. Clair Monitoring Strategic Plan seeks to provide the framework necessary to accomplish these goals. The goals and objectives of this strategic plan are primarily to create a monitoring framework that will enhance the ability of organizations in the watershed to work with one another, while collecting monitoring data in the most efficient method for all parties involved.

The foundation upon which the strategic plan rests is the need for a broad-based monitoring coordination committee. The function of this group would be to establish monitoring needs in the watershed, maintain the inventory of current monitoring programs, coordinate U.S. monitoring organizations and direct future regional monitoring in a manner that best meets the needs of the Lake St. Clair watershed. Its focus should be on broad watershed-wide monitoring goals, rather than more geographically- or media-focused goals that drive most monitoring programs.

To be effective, this monitoring committee should be comprised of representatives from all levels of monitoring organizations in the region. It will be essential for the committee to communicate and coordinate beyond immediate members into the larger monitoring community.

A number of potential frameworks for this coordination committee have been proposed. These include:

- An informal monitoring coordination committee comprised of a network of representatives from various monitoring organizations in the watershed;
- A "super-watershed" monitoring coordination committee that would build upon watershed and subwatershed plans to ensure that Lake St. Clair watershed monitoring goals are met; and
- An independently funded and driven organization established through congressional or state mandate or bilateral agreement to conduct essential monitoring and synthesize data being collected by other organizations.

The most effective method for monitoring coordination would likely come from an independent monitoring body with a congressional, state or regional mandate to oversee monitoring in the watershed. Although this approach may ultimately be the most effective, it will also be the most financially and politically challenging. The most immediate feasible approach is to allow for the evolution of such a monitoring body by first developing a committee based on representation from monitoring agencies in the region. Using a phased approach to create a monitoring coordination body would allow the group to develop products and support upon which to base a proposal for independent funding.

The strategic plan includes a number of other recommendations for establishing a coordinated monitoring network. Some of the key recommendations are listed below.

Spatial Monitoring Network Design

- Determine the statistically valid number of sampling sites and maintain at least that many sampling locations for each area under consideration.

Temporal Monitoring Network Design

- Coordinate sampling frequency among monitoring programs that need to merge their data or results for a watershed-wide analysis.

Parameters to be Sampled

- When considering parameter selection, consider the location and frequency to increase the effectiveness of coordination across programs.

Methods Comparability

- The monitoring committee should establish priority needs and have relevant organizations meet to conduct methodological comparability analyses.

Quality Assurance (QA) and Quality Control (QC)

- Establish QA/QC standard(s) for data to be used in watershed analyses.

Metadata Requirements

- All participating monitoring programs in the Lake St. Clair watershed should develop comprehensive metadata to accompany their monitoring data sets.

Reporting Needs

- The monitoring committee should develop a strategy to generate regular reports on monitoring results for the Lake St. Clair watershed.

Funding

- The monitoring committee should establish a financial plan for supporting staff and addressing monitoring gaps, among other priorities.

Lake St. Clair Monitoring Gap Analysis and Strategic Plan

Lake St. Clair, fondly referred to as the heart of the Great Lakes by its patrons, provides a wide array of benefits to nearly six million U.S. and Canadian residents living within its watershed boundaries. Lying between Lake Huron and Lake Erie, Lake St. Clair is an invaluable resource in the Great Lakes network. Although not politically considered one of the Great Lakes, Lake St. Clair and its watershed are integral parts of the Great Lakes system and include a significant area of the Great Lakes basin, covering in total 4,890 sq. miles/12,616 sq. km., or about 2.5% of the Great Lakes drainage area.

Within the Lake St. Clair watershed lies one of the most densely populated areas of the Great Lakes basin. Due to extensive use, the environmental integrity of the Lake St. Clair watershed has suffered. Human impacts to the watershed include impairment of water and sediment quality, alteration of natural processes due to degradation of wetlands and creation of hardened shorelines, loss of fish and wildlife habitat, and fish contamination.

In recent years, efforts to correct the long-standing negative human impacts have been considerable. A wide array of laws, regulations and pollution prevention activities has dramatically reduced the impact of human activities on the watershed – but much work remains.

In addition to enforcing regulations, developing sound environmental monitoring programs is a critical component to restoring ecosystem health. Data collected through a well-planned, long-term monitoring program not only provides the objective means necessary to determine the environmental integrity of an ecosystem, it also provides the means necessary to measure the success of corrective actions.

A multitude of organizations currently perform some type of monitoring within the Lake St. Clair watershed. Each has its own inherent mission and monitoring focus. As the number of monitoring organizations in the region expands and environmental issues become more complex, the need for coordination, collaboration, and prioritization among monitoring agencies increases.

The objective of this project was to compile a monitoring inventory and strategic plan that will provide the information needed for effective coordination and collaboration among monitoring organizations as well as regulatory agencies.

Project Overview

The U.S. Army Corps of Engineers, Detroit District (USACE), in partnership with Macomb County, St. Clair County, Macomb County Public Works Commissioner's Office, Office of Oakland County Drain Commissioner, and Southeast Michigan Council of Governments, initiated this project to inventory the environmental monitoring programs in the Lake St. Clair watershed. The USACE contracted with the Great Lakes Commission to conduct project activities. Working with federal, state/provincial, and local organizations, the Great Lakes Commission developed a comprehensive list of current monitoring programs in the Lake St. Clair watershed. This inventory is housed in a web-based, searchable database broadly distributed for use throughout the basin. Based on gaps identified in the monitoring inventory,

a monitoring strategic plan has been developed and recommendations are being presented to federal, state/provincial, and local stakeholders throughout the Lake St. Clair watershed.

Products include the monitoring needs assessment, monitoring inventory, monitoring gap assessment, and monitoring strategic plan. The monitoring inventory is a web-based, searchable database that contains a variety of descriptive characteristics, including but not limited to contact information, program description, parameters, geographic characteristics, program funding, and data collection procedures. The gap analysis is a comparison between a previously identified list of monitoring needs (see Table 1 in project results section) and results of the monitoring inventory. The strategic plan incorporates the results of the gap analysis and examines opportunities to better coordinate monitoring programs to meet previously identified monitoring needs.

Project Results

Needs Assessment

Completion of a monitoring needs assessment to identify key environmental issues for which monitoring is needed was the first step of the project. The Lake St. Clair monitoring needs assessment lists the primary monitoring needs in the Lake St. Clair watershed as defined by the project's technical advisory committee (TAC). Members of the TAC included representatives from local, state, federal, and non-governmental organizations. These representatives were chosen based on their proven knowledge of the Lake St. Clair watershed and active involvement in monitoring programs in the watershed. When asked to identify the primary monitoring needs of the Lake St. Clair watershed, the TAC created the list of needs in Table 1.

The needs identified in the Lake St. Clair region include assessing water quality, establishing fish advisories, determining beach safety, and identifying illicit connections to storm sewers. In addition to listing each monitoring need, the needs assessment includes the purpose, parameters, and sampling locations associated with each of these needs. By comparing monitoring needs and the monitoring inventory, gaps in current monitoring were identified.

Table 1. Lake St. Clair Watershed Monitoring Needs Assessment.

Monitoring Need	Purpose	Parameters	Locations
Aquatic Organisms/Habitat			
Contaminant concentrations and effects in fish	Establishing fish advisories	PCB, mercury, metals, site specific organics	
Assessing habitat quality for macro invertebrates, aquatic organisms, algae, plants, water quality	Assessing quality of habitat	Aquatic organism types and quantities, assessing water quality parameters	To be determined based on stream morphology and study design
Terrestrial			
Planned community growth and development	Supporting sustainable zoning/ master planning	Water quality parameters; habitat quality parameters;	Upstream and downstream of study areas
Water, Sediment, Soil and Air			
Sustainable stormwater management	Supporting stormwater management	Water quality parameters; habitat quality parameters; illicit connections parameters	Upstream and downstream of study areas
Measure of atmospheric deposition	Quantifying atmospheric deposition	PCB, mercury, metals, particulate, rain intensity, total inches, site specific	Rain gauge collection locations; storm sewer outfalls; upstream and downstream locations; non-point source locations

Tracking total maximum daily loads (TMDLs)	Tracking total maximum daily loads (TMDLs)	Water quality parameters; habitat quality parameters; TMDLs	To be determined based on specific study
Contaminant and nutrient concentrations and distribution in offshore, near shore, and coastal waters	Determining beach safety; Assessing water quality; Delisting areas of concern	BOD, TSS, Temp., Turbidity (Secchi Disk), Metals, Phosphorus, Ammonia, Conductivity, Flow, Nitrate, Nitrite, TKN, site specific organics, E. Coli, Weather, color, odor, surface film, pH, oil, grease, hormones, drugs, pesticides, wind, develop specific parameter list based on RAP and/or watershed plan defined causes of impairments	Upstream and downstream of study areas; head and mouth of stream segment
Contaminant and nutrient concentrations and distribution in offshore, near shore, and coastal sediments	Assessing sediment quality	nutrients, metals, odor, color, oil, grease, site specific organics, E. coli, physical characteristics	Depositional areas upstream and downstream
Contaminant and nutrient concentrations and distribution in offshore, near shore, and coastal sediments and waters	Identify pollutant sources Permit compliance	Water quality parameters; Water quality parameters;	At suspected source outfall to receiving waters or pipe connection
Contamination and nutrient concentrations at sewage overflow events	Assessing impacts of sewage overflow events	E. Coli, surfactants, ammonia, pH, color, odor, raw sewage materials, phosphorus, flow, volume of overflow, precipitation, dye testing as appropriate, physical evaluation of drain field area for standing water or enriched nutrient conditions and evaluation, also as determined by permit	outfall to receiving waters and below outfall
Contamination and nutrient concentrations at failing septic systems	Identifying failing septic systems	E. Coli, surfactants, ammonia, pH, color, odor, raw sewage materials, phosphorus, flow, volume of overflow, precipitation, dye testing as appropriate, physical evaluation of drain field area for standing water or enriched nutrient conditions and evaluation of septic tank	At signs of failure, in tile/seepage field area and septic tank
Identifying illicit connections	Identifying illicit connections	Surfactants, ammonia, pH, conductivity, temperature, E. Coli, dye testing, visual inspection for unusual conditions	At storm sewer outfall to receiving waters

Monitoring Inventory

The Great Lakes Commission worked with federal, state/provincial, and local organizations to develop an inventory of current monitoring programs in the Lake St. Clair watershed. Some information regarding Canadian monitoring programs was captured, but efforts were primarily directed toward creating a comprehensive inventory of U.S. monitoring programs.

In total, information describing 95 monitoring programs is contained in the monitoring inventory. These programs range from long-term, basinwide programs run by federal agencies to local-scale programs run by non-governmental organizations. The monitoring inventory contains a variety of descriptive characteristics -- which include, but are not limited to – contact information, program description, parameters measured, geographic characteristics, program funding, and data collection procedures. See Appendix A for a condensed list of monitoring programs.

A web-based version of the monitoring inventory has been developed and is freely available at http://www.glin.net/gis/lkstclair/. Interested individuals can search the monitoring inventory based on area of interest. Search criteria include organization, project title, description, monitoring medium, monitoring category, frequency, and parameters. Results of the search produce a list of monitoring programs matching the search criteria. Selection of one of the programs matching the search criteria will yield information on organization, program manager, program descriptions and, when possible, a map of sampling stations. See Figures 1-4 for screenshots of the web site interface.

In addition to being made freely available through the Internet, the information in the monitoring inventory has been used to determine potential gaps in monitoring for the Lake St. Clair watershed. By comparing the monitoring inventory to the needs assessment, such gaps were identified.

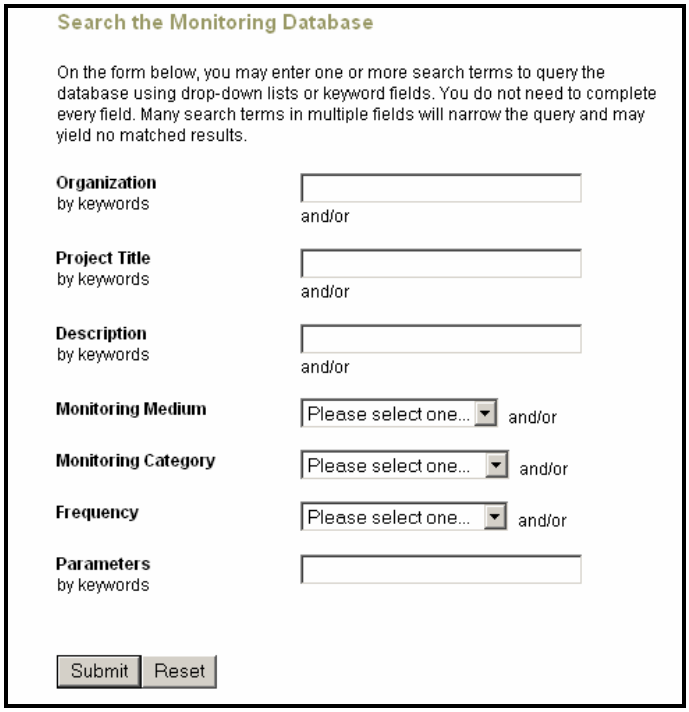

Figure 1. Interface to search the Lake St. Clair Monitoring Inventory website.

At this interface the user can choose one or more search criteria. To make a selection the user will input relevant search criteria and submit the response to the monitoring inventory. See Figure 2 for results.

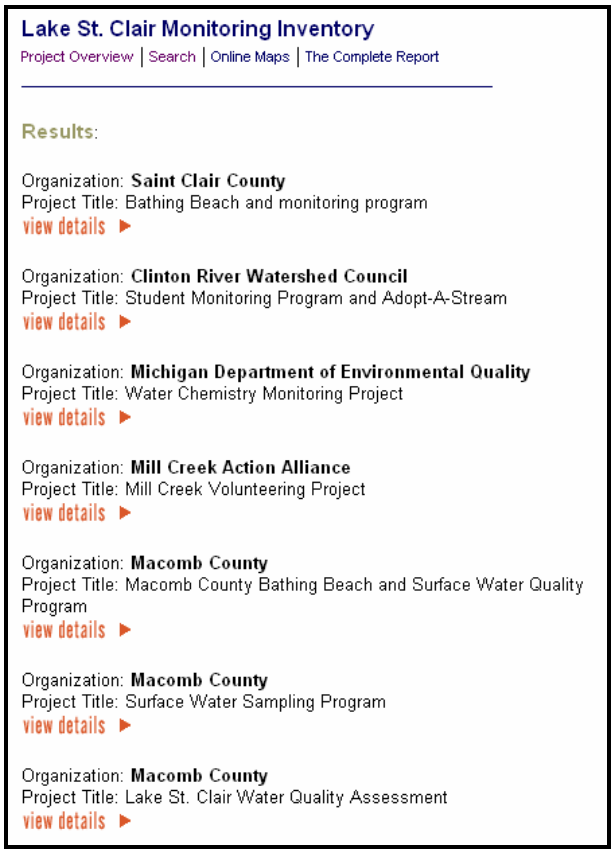

Figure 2. Results from search.

After entering search terms, a list of programs that match the search criteria is created. Selecting a program in this list will yield the information found in Figure 3.

Figure 3. Metadata for program found through search.

The end result is metadata from the program that was selected. In many cases there is also the option of viewing a map of sampling locations. Not all fields are shown.

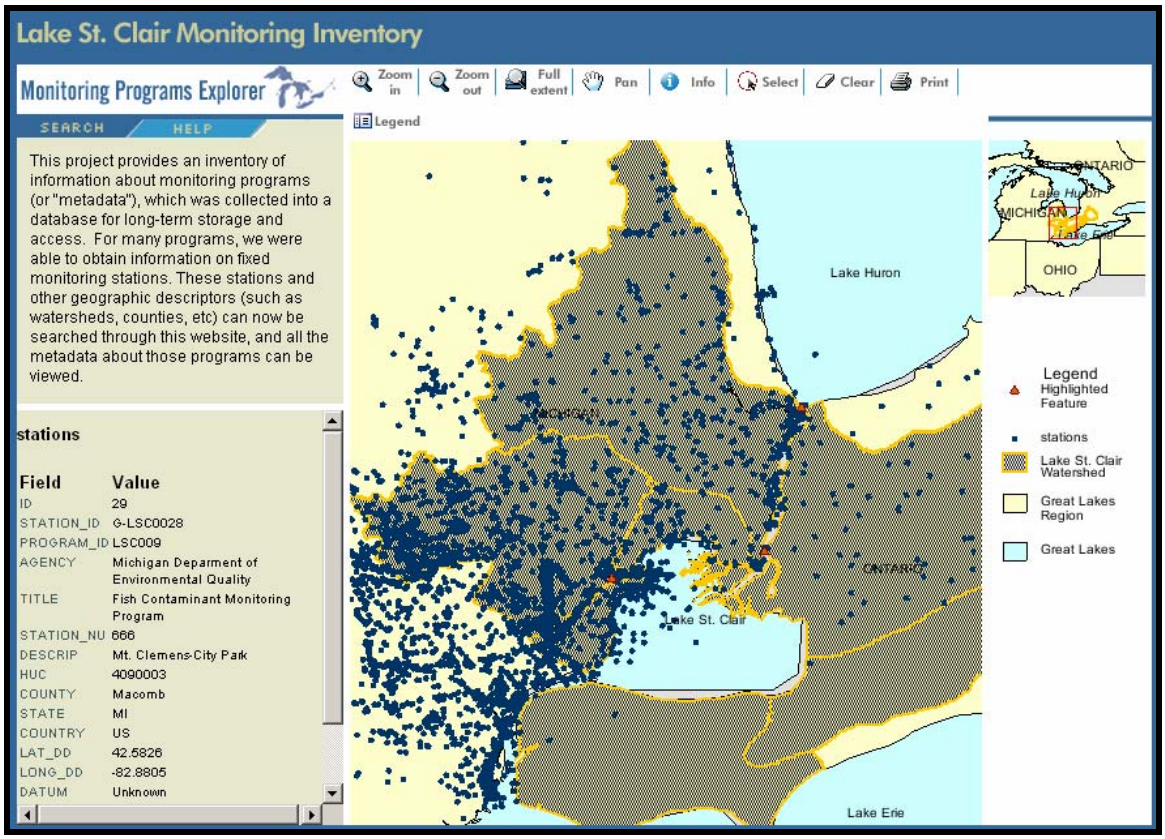

Figure 4. Map of sampling locations.

Dots represent all the sampling locations in the basin and the immediate surroundings; triangles show sampling locations for the specific program selected.

Maintenance Needs

In order for it to be a truly effective tool, the monitoring inventory must be maintained. As new programs are initiated, descriptive information will need to be added to the inventory. It will also be important to periodically update the information associated with the monitoring programs. Currently this is done by Great Lakes Commission staff. In order to increase efficiency in the future, it would be useful to develop an automated update option directly on the inventory website.

A new initiative is underway to create a monitoring inventory for the entire Great Lakes basin similar to the inventory developed for the Lake St. Clair watershed. Once the comprehensive Great Lakes inventory and its associated web site has been developed, the Lake St. Clair monitoring inventory will be integrated into the larger system.

Gap Analysis

As one of the final products, an analysis of gaps in current Lake St. Clair watershed monitoring programs was performed. This gap analysis was based on a comparison of previously identified monitoring needs and the inventory of current monitoring programs. Knowing the extent of current monitoring programs and understanding where gaps in monitoring lie will become important as coordination and collaboration among monitoring organizations increases. Understanding the scope of monitoring performed and how it relates to the watershed's monitoring needs is also a key component toward the development of a sound monitoring strategic plan.

Methods

The monitoring inventory and the monitoring needs assessment were compared to identify gaps in overall monitoring and to determine where additional monitoring efforts should be directed. The Lake St. Clair / St. Clair River Management Plan has identified a number of key management issues each with a different set of management concerns and consequently a different set of monitoring needs. The following areas were identified as the key management issues: habitat and biodiversity; human health; land use; and general monitoring. Within each of these key management issues lie a number of monitoring needs. For each of the monitoring needs there will be a discussion of current monitoring programs as well as recommendations to address monitoring gaps and increase efficiency of monitoring programs in the basin.

Results

Current monitoring programs for previously identified monitoring needs are discussed in greater detail below. Topics are grouped based on key management issues and the monitoring needs associated with each of the key issues.

Habitat and Biodiversity

Macroinvertebrate Sampling

Macroinvertebrate communities serve as important indicators of ecosystem health. In environmentally stressed ecosystems, local plant, animal, and invertebrate populations may suffer adverse effects. Many macroinvertebrate species are sensitive to changes in their aquatic habitat. By monitoring macroinvertebrate communities, managers can gain a better sense of aquatic health and trends in a region. Although monitoring of macroinvertebrate communities was not identified specifically as a need, this analysis will describe what is known about macroinvertebrate monitoring in the Lake St. Clair region.

Based on monitoring inventory results, 13 monitoring programs focus some amount of effort on macroinvertebrate sampling. Programs range in scope from region-wide monitoring to local monitoring and species-specific sampling.

Region-wide monitoring
Michigan Department of Environmental Quality (MDEQ) runs a Stream Bioassessment Program that samples every major watershed in the state on a rotating five-year cycle. This program includes macroinvertebrate, habitat quality, and fish population monitoring. MDEQ has developed a qualitative biological and habitat survey protocol for sampling these elements in wadable rivers. Sampling procedures for non-wadable rivers are currently being developed.

The Michigan Natural Features Inventory (MNFI) is a state-wide program that maintains a database on Michigan's endangered, threatened, and special concern plant and animal species, natural communities, and other natural features. MNFI has responsibility for inventorying and tracking the state's rarest species and exceptional examples of natural communities. Terrestrial and aquatic macroinvertebrate inventories are included in their database.

In 1991, the U. S. Geological Survey (USGS) implemented the National Water Quality Assessment (NAWQA) Program to support national, regional, and local water quality information needs. Sampling includes general water chemistry, pesticides, contaminants in bed sediments, and contaminants in fish and benthic invertebrates. There are several sampling locations in Macomb, Oakland, and Sanilac counties.

Local monitoring
The Habitat Stewardship Program, which has been run by the St. Clair Conservation Authority since 1999, is an annual benthic macroinvertebrate sampling program that currently includes 68 sampling locations throughout the St. Clair Conservation Authority region. Sarnia-Lambton Environmental Association has been running a program on the St. Clair River to assess impacts on the local environment since 1952. One of the many components of this program includes aquatic macroinvertebrate sampling.

Local macroinvertebrate sampling also includes a number of student- and volunteer-run programs. Clinton River Watershed Council's Stream Leaders Program and their Adopt-A-Stream Program sample water quality and macroinvertebrates in the Clinton River watershed. The Clinton River Coldwater Conservation Project, a joint program between Clinton River Watershed Council, Michigan Department of Natural Resources (MDNR), and Trout Unlimited, assesses fish habitat including macroinvertebrate communities. In 1999, Mill Creek Action Alliance's Mill Creek Volunteering Project began sampling benthic macroinvertebrates and other water quality data semi-annually from nine sites along the creek in St. Clair County. St. Clair County MSU Extension's Adopt-A-Stream Program has organized volunteers since 1998 to monitor aquatic macroinvertebrates semi-annually at 10 locations throughout St. Clair County. Other volunteer macroinvertebrate sampling programs include Oakland University's Interim Monitoring Program and Lake Shore Public School's 6th grade Great Lakes Education Program.

Species specific monitoring
Two programs in the Lake St. Clair watershed focus on species-specific monitoring. The Nature Conservancy currently heads an effort to study the interactions between freshwater mussels and zebra mussels in the Upper Clinton River. A study by the National Oceanic and Atmospheric Administration's (NOAA) Great Lakes Environmental Research Laboratory focuses on the temporal and spatial variation in lipid content of the mayfly Hexagenia. Many other species- specific research projects are likely conducted by university investigators. Since this project focuses on ongoing monitoring, it was beyond its scope to collect information on short-term research projects.

Recommendations

- Analyze data from MDEQ's Stream Bioassessment Program, MNFI, and the NAWQA Program to determine how comprehensive these databases are in regard to macroinvertebrates.

- Expand macroinvertebrate sampling to include sampling locations along the Lake St. Clair shoreline as well as in Lake St. Clair.
- Develop a standard scoring procedure to rank macroinvertebrate community health in the open water of Lake St. Clair.
- Develop guidelines for integrating macroinvertebrate data collected by volunteer groups into the larger monitoring regime.

Assessing Quality of Habitat and Natural Communities

Developing and maintaining an inventory of natural habitat or communities is essential to effectively achieving biodiversity goals for a region. Two of the recommendations in the Lake St. Clair/St. Clair River Management Plan point to this need for an inventory and map of both habitat and species. Without such an inventory, it is difficult to determine the extent, status and diversity of habitat that exists in the Lake St. Clair watershed. The ecological integrity of existing natural communities also needs to be monitored to ensure a complete habitat status assessment.

The monitoring inventory identifies two programs that determine the status and quality of natural communities in the Lake St. Clair watershed. MNFI inventories and tracks the state's endangered, threatened, and special concern species along with exceptional examples of natural communities. Records are kept of species and community occurrences, expected range and population size. Coverage includes the entire Lake St. Clair watershed, including its coastal margins. Data collection is ongoing. In addition to sampling macroinvetebrates, the Michigan Department of Environmental Quality's (MDEQ) Stream Bioassessment Program monitors habitat quality and fish populations. This program uses a scoring system to rate habitat and natural community health for every major watershed in the state on a rotating five-year cycle.

Oakland County Planning and Economic Development Services maintains an extensive Geographic Information System (GIS) which includes coverage of natural areas and other land cover features. Map sets are updated at least biennially, sometimes on a yearly basis.

The Clinton River Watershed Council takes part in three programs that study habitat conditions. The Stream Leaders program and Adopt-A-Stream are volunteer monitoring programs that include analysis of in-stream and riparian habitat conditions throughout the Clinton River. The Clinton River Coldwater Conservation Project, a joint project between CRWC, Michigan Department of Natural Resources, and Trout Unlimited, assesses fish habitat and identifies enhancement opportunities in the Clinton River.

Three other programs monitor fish habitat in conjunction with fish population studies. These programs are described in detail in the "Fish Population Health" section. They include Fish Species at Risk (SAR) in the Sydenham River Watershed, Lake Sturgeon Assessment in Lake St. Clair and St. Clair River and Assessment of the Fish Community of Lake St. Clair. In general, these programs target a limited number of species or a specific watershed. Other programs track macroinvertebrate and bird populations, which are described in separate sections of this report.

Environment Canada reports only one program engaged in habitat monitoring. This is the Sydenham River Habitat Stewardship sampling program, managed by the St. Clair

Conservation Authority. No details were provided about the program. Several other programs monitor species populations, covered in other sections of this report.

Further, a new effort to inventory and classify fish habitat is underway by the Michigan Department of Natural Resources with funding from the Great Lakes Fishery Commission. This project covers the Lake Erie basin as well as the Lake St. Clair watershed and follows a model established for the Lake Huron basin. Finally, the Great Lakes Coastal Wetlands Consortium is developing a monitoring strategy for all Great Lakes coastal wetlands. The strategy should be developed and implemented in the not-too-distant future.

Recommendations

- Develop a consolidated and classified habitat inventory for the Lake St. Clair watershed.
- Develop a coordinated monitoring strategy for natural communities in the basin.
- Standardize a scoring procedure for rating the health of natural communities and habitats.

Monitoring Fish and Wildlife Community Health

Any program designed to manage ecosystem health or quality should include monitoring of a broad range of native aquatic and terrestrial faunal species. Such monitoring should consider population trends in species across different trophic levels and address potential stresses and causes of the trends. Understanding the interactions and interdependencies between populations is important for determining the stability or resiliency of an ecosystem.

Fish Populations
The monitoring inventory yielded ten programs that address fish populations in the Lake St. Clair watershed. Most of the fish programs focus on Lake St. Clair and the St. Clair River. These include programs that focus on individual species or aspects of populations as well as programs that track multiple species.

One of these broader programs is the fish community assessment administered by the Michigan Department of Natural Resources (MDNR). This program has multiple objectives that include measuring the abundance of juvenile and adult sport fish, documenting the abundance of aquatic plants, and monitoring trends in sportfish catch rates in Lake St. Clair. The program is administered sporadically during the summer months. The Ontario Ministry of Natural Resources also assesses the status of fish stocks in Lake St. Clair and administers angler creel surveys. The Ontario Ministry of the Environment runs a young-of-year monitoring program as well.

The MDNR and U.S. Fish and Wildlife Service (FWS) both administer programs to assess the health and long-term dynamics of the Lake Sturgeon population in the Lake St. Clair watershed. Both programs track various population parameters, spawning locations and movements. The FWS program coordinates a tagging program and critical habitat assessment. The MDNR cites fish movement monitoring and feeding habitat assessment, as well. The MDNR program is administered sporadically in the summer months. It is likely that these programs are coordinated, but if not, efforts should be made to do so.

There are a few programs that track fish populations upstream of Lake St. Clair and the St. Clair River. The MDNR conducts broad surveys of fish populations at random sites in lakes and streams throughout the Lake St. Clair watershed. The surveys focus on species diversity and population abundance. They are conducted annually during the summer months. The Canadian Department of Fisheries and Oceans assesses the status of fish species at risk in the Sydenham River watershed. The assessment uses 50 sampling stations throughout the watershed and collects information annually during the summer months. Michigan Department of Environmental Quality's Stream Bioassessment Program monitors habitat quality and fish populations. This program monitors fish and wildlife community health in every major watershed in the state on a rotating five-year cycle.

Wildlife Populations

Only five programs address wildlife populations in the Lake St. Clair watershed. The Michigan Natural Features Inventory maintains records and tracks the populations of endangered, threatened and special concern species. This includes fish as well as other aquatic and terrestrial wildlife species. While this program maintains extensive records about these stressed species, information was not obtained which describes the level of effort applied to monitoring species within the Lake St. Clair watershed. The Wildlife Habitat Council administers a volunteer nest monitoring program that measures reproductive success of a variety of bird species. Level of effort information was not obtained for this program.

Bird Studies Canada runs an extensive Marsh Monitoring Program along a wide number of routes throughout the Great Lakes basin, including the Lake St. Clair watershed. This program utilizes volunteers to monitor the presence and relative abundance of vocal amphibian and bird species that utilize marsh habitat. Surveys are conducted three times during the spring and summer months. The number of routes in the Lake St. Clair watershed was not obtained.

The Canadian Wildlife Service also administers programs that monitor bald eagles and herring gull eggs. No details were obtained about these programs.

Recommendations

- Ensure that there is communication and coordination of effort among Lake Sturgeon monitoring programs in the Lake St. Clair basin.
- Evaluate current criteria used to determine fish and wildlife community health.
- Consider expanding focus to include more non-game fish species monitoring.
- Examine the extent of fish sampling in watersheds to determine if it is sufficient.
- Consider expanding the monitoring of wildlife populations throughout the basin.

Human Health

Establishing Fish Advisories

Contaminants in fish have been linked to detrimental health effects in individuals consuming these fish. Bioaccumulation – the build-up of chemicals from the environment in the aquatic food chain – is the primary reason for the high contaminant concentration in many predator fish species. Through environmental deposition or direct environmental pollution, chemical contaminants are fed into an ecosystem and in turn absorbed into tissues of the organisms in

that ecosystem. Contaminants can accumulate in previously consumable fish either directly from the water or indirectly through the food chain.

Gathering the data needed for establishing fish consumption advisories was identified as a monitoring need in the Lake St. Clair watershed. Fish contaminant data are used to determine whether fish from waters of the state are safe for human and wildlife consumption. Fish consumption advisories are based on these data as well as known safe consumption levels.

Four programs collect fish contamination or consumption advisory data. Three programs are run by governmental agencies in the U.S.; information was available for one monitoring program in Ontario.

Fish Consumption Advisories (U.S. Environmental Protection Agency) – The National Listing of Fish and Wildlife Advisories (NLFWA) database includes all available information describing state, tribal, and federally-issued fish consumption advisories in the United States for the 50 States, the District of Columbia, and four U.S. territories, and in Canada for the 12 provinces and territories. The database contains information provided to the U.S. Environmental Protection Agency by the states, tribes, territories and Canada. There are advisories for 39 chemical contaminants, but the vast majority of the advisories involve mercury, PCBs, chlordane, dioxins, and DDT.

Fish Contaminant Monitoring Program (Michigan Department of Environmental Quality) – The principal objectives of Michigan's Fish Contaminant Monitoring Program are to evaluate the need for sportfish consumption advisories and commercial fishing regulations; identify spatial and temporal trends; and evaluate whether existing programs are effectively eliminating or reducing chemical contamination. This program has tested fish tissue levels approximately every other year since 1980 for PCBs, mercury, and organochlorine pesticides; and yearly for dioxins/furans. Thirty-one sampling locations are spread throughout the Lake St. Clair watershed. These sampling locations are located primarily along the St. Clair and Clinton rivers and in Lake St. Clair.

National Water Quality Assessment (NAWQA) Program (U.S. Geological Survey) – The U.S. Geological Survey implemented the NAWQA program in 1991 to support national, regional, and local information needs and decisions related to surface and ground water quality management and policy. By combining information on water chemistry, physical characteristics, stream habitat, and aquatic life, the NAWQA program aims to provide science-based insights for current and emerging water issues and priorities. Sampling includes general water chemistry, pesticides, contaminants in bed sediments, and contaminants in fish and benthic invertebrates. There are eight sampling locations in the Lake St. Clair watershed.

The other known program in the Lake St. Clair watershed is the Ontario Sport Fish Contaminant Monitoring Program run by the Ontario Ministry of the Environment and the Ontario Ministry of Natural Resources. No additional information is available for this program at this time.

Recommendations

- Consider expanding fish contamination monitoring to include additional fish habitat and sportfishing locations.
- Consider the benefits of expanding the number of fish species sampled.
- Consider the benefits of expanding the number of sampling locations.

- Identify sources of fish contamination.

Monitoring Drinking Water

The effort to protect drinking water quality has emerged as a key environmental issue driving Lake St. Clair watershed planning. A plentiful supply of clean water is essential to every member of the Lake St. Clair community. Drinking water sources vary depending on the type of community. Urban populations generally rely on surface water sources while rural communities generally maintain well water systems. The four community intakes on Lake St. Clair include Ira Township, New Baltimore, Mt. Clemens, and Grosse Pointe Farms/Highland Park.

The U.S. Environmental Protection Agency (EPA) and the Michigan Department of Environmental Quality (MDEQ) set and enforce drinking water standards, while each water supplier is responsible for the quality of drinking water produced at that facility. EPA regulations establish maximum contaminant levels, treatment techniques, and provide that monitoring and reporting requirements for safe water is provided to customers.

EPA maintains the Safe Drinking Water Information System (SDWIS). SDWIS contains information about public water systems and EPA drinking water regulation violations at each facility. This database has been in operation since 1993. This site provides a listing of all community and non-community water systems required to submit water quality data. The public water utilities are responsible for monitoring the quality of drinking water provided. There is no requirement for local communities to monitor the water at system intakes. Owners of private wells are not required to monitor drinking water quality and are therefore excluded from this list.

The U. S. Geological Survey's (USGS) National Water Quality Assessment (NAWQA) program assesses water quality trends in a portion of the Lake St. Clair watershed. NAWQA has been collecting data since 1991. This program monitors surface and ground water quality (or source water) rather than treated water quality. Data is collected from streams, ground water, and aquatic ecosystems.

The MDEQ maintains primary enforcement authority for the Federal Safe Drinking Water Act as well as the Michigan Safe Drinking Water Act. MDEQ has regulatory oversight for all public water supplies as well as private drinking water wells. MDEQ is also completing a Source Water Assessment Program (SWAP) that identifies public drinking water sources; inventories contaminants and water's susceptibility to contamination; and informs the public of the results. MDEQ also runs the Drinking Water Contamination Investigation Program that conducts drinking water testing in areas with known or suspected environmental contamination.

Issuance of drinking water facility/well construction permits are primarily the responsibility of local government. The Oakland County Health Division manages the Drinking Water Supply Program, Well Protection and Education Code. The purpose of this program is to allow for the issuance of permits for new well construction and inspection of private wells, as well as to educate the citizens of Oakland County who utilize ground water for drinking. This program has been testing bacteriological and nitrate levels since 1998. Wayne County administers a Cross Connection Control program that monitors contamination of potable water through connections with non-potable sources.

Recommendations

- Public drinking water utilities should periodically test for levels of bacteria, viruses, parasites, chemicals, endocrine disruptors, and other emerging pollutants that are not currently among standard parameters.
- Coordinate monitoring around dredging projects with drinking water intake monitoring.
- Develop a notification system to inform the public when drinking water concerns arise.
- Consider the value of pre-treatment source water monitoring at each water intake to track the variability in source water quality.

Determining Beach Safety

Determining if bathing beaches are safe for recreation is an important shared goal across the Great Lakes basin. This goal is heightened in the Lake St. Clair watershed due to the large population and vast number of recreational access points. The primary reason for beach safety warnings or closures is bacterial contamination. The wide use of outdated combined sewer systems and the extensive urbanized landscape can contribute large amounts of nutrients to surface waters in the region, which encourages bacterial growth.

Michigan Department of Environmental Quality (MDEQ) provides federal and Clean Michigan Initiative grants to selected county health departments for beach monitoring. Counties perform the monitoring through the funds provided by MDEQ. All monitoring data is housed in the MDEQ maintained beach monitoring database which is accessible to the public at http://www.deq.state.mi.us/beach/.

Six programs were identified that specifically target monitoring beaches to determine human health conditions. Five of these six programs are administered by county agencies. These programs covered beaches in Macomb, St. Clair, Oakland and Wayne County. No programs reported monitoring beach conditions in Sanilac or Lapeer counties. Environment Canada reports that beach sampling programs are conducted by Health Units in Ontario, but no specific information was obtained about these programs.

Macomb County – The Macomb County Bathing Beach and Surface Water Quality Program has been in operation since 1948. The county administers six locations – four at Lake St. Clair shore beaches and two at Stony Creek beaches. Monitoring at these locations is conducted on a twice-weekly schedule from April through September. Water is analyzed for *Escherichia Coli (E. coli)* content at the stations. The county also administers another 122 stations distributed throughout the county that monitor water chemistry as part of the Lake St. Clair Water Quality Assessment (described further under the water quality section).

Oakland County – Oakland County administers a program that tests water at all county beaches for *E. coli* from June through August. The program has been in existence since 1970 and tests 286 locations at beaches throughout the county including those in the Clinton River watershed. The county uses summer interns to collect the water samples.

St. Clair County – St. Clair County administers two programs that address human health concerns at county beaches. The Bathing Beach and Monitoring Program includes 17

monitoring locations at coastal beach sites and another 14 at non-beach sites. Exact locations could not be determined from available information. Microbiological measures are taken from water samples, but specific parameters were not listed. The county also runs a separate program that monitors non-beach sites to gather data for background information and to help determine possible causes of beach closings. *E. coli* measures are taken from 40 locations May through August. Some locations are monitored on a weekly basis while others are monitored monthly. Both programs utilize students to collect the samples.

Wayne County – The Wayne County Environmental Health Division monitors for *E. coli* levels at Grosse Pointe Farms and Grosse Pointe Park beaches from June through September. Specific program details were unavailable.

Several other programs administered by St. Clair, Oakland, Macomb and Wayne counties or local municipalities engage in monitoring for *E. coli*, however, it is done either as part of a general surface water quality sampling program or to examine illicit discharges. These programs, therefore, are described in other sections of this report.

A past non-county program administered by the University of Michigan was designed to model how weather and environmental conditions in Lake St. Clair impact shoreline beaches. This was the only program which monitored open lake conditions to forecast beach closure events. However, it was terminated in July of 2002 when the buoy was damaged.

In addition to ongoing monitoring efforts, the U.S. Army Tank Command is developing hand-held, self-powered instrumentation to analyze effluent water samples from water treatment systems for the presence of biological and chemical warfare agents. The system will provide real time (5-15 minutes) results while minimizing error. This system is targeted for the commercial market, so it may be useful for regular beach contaminant monitoring.

Recommendations

- Improve the coverage of monitoring at inland beach locations.
- Improve the standard procedures for beach monitoring to include sample collection methods, number of samples, lab analysis procedures, and acceptable turn-around times.
- Consider the utility of monitoring other biological parameters in addition to *E. coli*.
- Beach monitoring coordinators should follow the development of the Army Tank Command project and other rapid detection technologies to improve the result times on beach testing.

Land Use

Monitoring Impacts of Land Use on Water Quality

In an area developing as quickly as the Lake St. Clair watershed, understanding the relationship between increased development and environmental health is important to the long-term preservation of the environmental integrity of the watershed. Industrial development and population increases create environmental pressures that can have detrimental effects on water quality, air quality, and the overall integrity of an ecosystem.

When looking at the impact of land use on water quality, it is important to first define those land use criteria that can be used as factors by which to measure changes in land use. By identifying and tracking measurable land use criteria, trends and patterns can be analyzed to determine various land use impacts on water quality. Table 2 provides a list of some of the land use criteria identified for the Lake St. Clair watershed as well as possible data sources.

Table 2. Using land use criteria to help identify land use trends and patterns. (Table provided by Southeast Michigan Council of Governments (SEMCOG))

Land Use Criterion	Possible Data Source	Comments
Forecast build-out densities	Local zoning/master plans	To predict where development will occur and at what density
Areas served/to be served by sewers	Local zoning/master plans	Availability of sewers effects density levels and types of development that can take place
Areas served/to be served by on-site sewer systems	Local zoning/master plans	
Land use – current and future	Local zoning/master plans	Identify trends in land use
Land not to be developed	Local zoning/master plans	Conservation easements, parkland, floodplains, etc.
Building permits issued	Municipalities / SEMCOG	SEMCOG collects building permit (only residential) information from all Southeast Michigan municipalities and maintains a searchable, online database
Agricultural lands enrolled in PA 116	State / Municipalities	In return for agreeing to keep farmland in agricultural production, farmers enrolled in PA 116 receive certain income tax benefits and exception from certain special assessments
Changes in impervious surfaces	Municipalities	This data is not directly collected or maintained by municipalities, but GIS can make reasonable estimates, based on land use maps, etc.
Soil erosion permits issued and compliance records	Counties and authorized municipalities	
Stormwater BMPs installed	Counties / municipalities	Site plan approvals will identify BMPs
Stormwater BMP operation & maintenance	Counties / municipalities	Privately owned BMPs (subdivisions, industrial parks, etc.) should have an O&M plan as part of the site plan approval
Natural features inventory	Counties / municipalities / state / conservation groups	Information on and mapping of natural features (wetlands, woodlands, etc.) varies greatly between jurisdictions
Open space / wetlands / woodlands ordinances	Counties / municipalities	Local ordinances, if they exist, vary greatly in scope
Conservation easements	Counties / municipalities / nonprofit conservation groups	These lands are not subject to development pressure and may serve a water quality benefit (stream corridor protection, etc.)

Monitoring impacts of land use on water quality was identified as an important monitoring need for the Lake St. Clair watershed. With increased availability of monitoring data, a more objective and sustainable land use strategy can be incorporated into the regional planning effort. Four monitoring programs currently address this need.

Oakland County – Oakland County addresses sustainable zoning and master planning with two programs. The Geographic Information System (GIS) Data Inventory monitors a variety of land-based information. Data collected includes land use, impervious surface, community master plans, significant potential natural areas, and wetlands and water features. This program has been mapping out land-based information throughout Oakland County since 1999. Maps are updated every one to two years.

The second program is Oakland County's Environmental Stewardship Community Inventory whose purpose is to inventory local community master plans and ordinances relative to standards for water resources and natural area protection. This program evaluates local plans and ordinances, provides local communities with a list of areas for improvement, and creates a network between communities. This program began in 2003 and will survey 61 local units of government in Oakland County.

Southeast Michigan Council of Governments (SEMCOG) – The Southeast Michigan Council of Governments (SEMCOG) runs two programs that span across Southeast Michigan. SEMCOG's, Aerial Photography program includes a 36-year collection of aerial photos from seven surveys. The first survey took place in 1966 and has been repeated every five years since 1970, totaling over 16,300 frames. Aerial photos are collected in April of each survey season. Each survey covers the Southeast Michigan region consisting of Livingston, Macomb, Monroe, Oakland, St. Clair, Wayne and Washtenaw counties.

SEMCOG's Demographic Data program collects and develops a wide range of demographic data across Livingston, Macomb, Monroe, Oakland, St. Clair, Wayne and Washtenaw counties. Included in this database are regional development forecasts (RDF), community profiles, annual and monthly estimates of population and households, and residential building permits. Most demographic data is presented in reports and databases that are available online and can be mapped using GIS. Data has been collected monthly and annually, depending on parameter, since before 1970.

Recommendations

- Review Oakland County's sustainable zoning and master planning programs to determine if they might serve as models for similar programs in other counties.
- Expand monitoring data collection on sustainable zoning and master planning into each county that currently does not have such a program.
- Identify measurable land use criterion that can be used to track impacts of land use and prioritize data collection.

Identifying Pollutant Sources

The first step in effectively controlling pollution is the identification of pollutant sources. Only after the source of pollution has been found can measures be taken to correct a problem.

Sources of pollution include waste and emissions from private industry, community treatment facilities, transportation emissions, accidental spills and contamination, illicit discharges, as well as any number of disparate nonpoint sources.

Many of these pollution sources can be identified through current permit compliance requirements and the resulting databases of pollutant levels. Monitoring of potential polluters offers another avenue to determining pollution sources. Another method is analysis of nonpoint source pollution and possible sources of contamination in the surrounding environment.

There are currently a number of programs collecting data and monitoring pollutant levels throughout the Lake St. Clair watershed. Ten programs perform some type of pollutant monitoring in the watershed. Eight of these programs include long-term databases maintained by the U.S. Environmental Protection Agency (EPA); one program, the National Pollutant Release Inventory (NPRI), is maintained by Environment Canada; and a final program, the Integrated Atmospheric Deposition Network, is a joint program between U.S. EPA and Environment Canada. Programs focusing on illicit discharge elimination are numerous in the Lake St. Clair watershed and will be discussed in detail in another section.

U.S. Environmental Protection Agency
EPA manages nine of the eleven data sets which identify pollutant sources. The focus of these EPA databases ranges from air emissions at known and potential source locations to monitoring Superfund sites. These programs are discussed in more detail below.

Air – The AirData database has provided yearly summaries of U.S. air pollution data since 1970. AirData has information about where air pollution comes from and how much pollution is in the air outside our homes and work places. Air quality is measured at monitoring sites, primarily in cities and towns along with some other point, area, and mobile sources. In the Lake St. Clair watershed, there are 56 AirData monitoring stations. Since 1970, the Aerometric Information Retrieval System (AIRS/AFS) has provided data on air releases in the U.S. Air pollutants released by various stationary sources of air pollution, such as electric power plants, steel mills, factories, and universities are housed in this database. This air pollutant information specifically relates to industrial plants and their components (stacks, points, and segments) and the chemicals they introduce into the air. In total AIRS/AFS collects air quality data from 251 locations in the Lake St. Clair watershed.

Water – The Permit Compliance System (PCS) has been providing information for more than 30 years on companies in the U.S. that have been issued permits to discharge waste water into rivers. This program primarily provides monitoring data for the National Pollutant Discharge Elimination System (NPDES) program. The PCS database provides information on when a permit was issued and expires, how much the facility is permitted to discharge, and the actual monitoring data from the facility showing what was discharged. Ninety-nine monitoring locations are spread throughout the U.S. Lake St. Clair watershed. The STORET (storage and retrieval) database contains raw biological, chemical, and physical surface and ground water data collected by self-selected federal, state and local agencies, Indian tribes, volunteer groups, universities, and others. Among other information, STORET contains data on why the data were gathered, sampling location, and sampling and analytical methods used. The current number of sampling stations is 311; sampling began in 1999.

Waste/Toxic – The Toxics Release Inventory (TRI) contains information on more than 650 toxic chemicals that are being used, manufactured, treated, transported, or released into the environment. Manufacturers of these chemicals are required to report the locations and

quantities of chemicals stored on-site to state and local governments. The TRI reports on 244 locations in the Lake St. Clair watershed annually and has been collecting data since 1987. Hazardous waste information is contained in the Resource Conservation and Recovery Act Information (RCRAInfo) program, a national program management and inventory system about hazardous waste handlers. All generators, transporters, treaters, storers, and disposers of hazardous waste are required to provide information about their activities to state environmental agencies. Information on hazardous waste is collected at locations throughout the Lake St. Clair watershed. EPA's Comprehensive Environmental Response, Compensation and Liability Act Information System (CERCLIS) has tracked information on all Superfund sites since 1986.

Multipurpose – Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) is a multipurpose environmental analysis system used by regional, state, and local agencies in performing watershed and water quality based studies. It integrates a geographic information system (GIS), historical watershed and meteorological data, and state-of-the-art environmental assessment and modeling tools into one package. Among other information included in the database are industrial facility discharge sites from a total of 134 data collection sites.

Atmospheric – Established in 1991 by the United States and Canada, the *Integrated Atmospheric Deposition Network (IADN)* conducts air and precipitation monitoring in the Great Lakes basin. The goals of *IADN* are to determine the atmospheric loadings and trends in toxic chemical deposition from the airshed to the Great Lakes basin; acquire air and precipitation concentration measurements; and help determine the sources of the continued input of those chemicals. In total, *IADN* operates two monitoring stations in the Lake St. Clair watershed that are sampled biennially at a minimum. One station is in on Lake St. Clair's Canadian border and the other is at Canada's Point Pelee.

Environment Canada
In addition to IADN, Environment Canada also maintains the National Pollutant Release Inventory (NPRI) which is a database of pollutants released to the environment or transferred off-site as waste or for recycling from major industrial point sources in Canada. Facilities which meet certain reporting criteria must file annual reports on 273 substances to Environment Canada. The NPRI is the only legislated, publicly-accessible database of its kind in Canada.

Recommendations

- Consider the benefits of additional atmospheric deposition monitoring stations in the Lake St. Clair watershed to determine if deposition rates to the watershed could be more accurately estimated.
- Standardize NPDES monitoring requirements.
- Ambient monitoring may be needed to identify new sources of pollution and pollution sources that are out of compliance with discharge or monitoring requirements.
- Increase monitoring efforts directed at locating additional point and nonpoint sources of pollution.
- Consider repeating the Upper Great Lakes Connecting Channels Study performed on the St. Mary's, St. Clair, and Detroit rivers during 1985-86 to establish a comprehensive set of trend data.

Monitoring Combined Sewer Overflow (CSO)/Sanitary Sewer Overflow (SSO) Events

The project's Technical Advisory Committee (TAC) identified a need to examine two issues related to stormwater management in the Lake St. Clair watershed. One need is to monitor impacts from sewage overflow during storm events. The TAC also wanted to examine other monitoring programs that may support stormwater management activities.

The basin is struggling with problems related to the legacy of sewer systems that combine sewage flows with stormwater flows. During large rain events, a storm surge can overwhelm sewage collection, transport, or treatment systems and result in the release of raw sewage into surface waters. This occurrence is termed a Combined Sewer Overflow (CSO)/Sanitary Sewer Overflow (SSO) event. CSOs are overflows from older sewer systems designed to carry sanitary sewage and stormwater. SSOs are discharges of raw or inadequately treated sewage from municipal sewer systems, which are designed to carry domestic sanitary sewage but not stormwater.

CSOs fall under the NPDES permitting system and therefore have specific monitoring requirements. Generally CSO locations are known. SSOs, on the other hand, are illegal and often constitute a serious environmental and public health threat. The number of communities with SSO problems is unknown, as are the specific locations of the SSOs. Michigan law requires that all sewer overflows (both combined and sanitary) be reported to Michigan Department of Environmental Quality within 24 hours of the beginning of the discharge. MDEQ has CSO/SSO reports available on their website (http://www.deq.state.mi.us/csosso/) and also a SSO reporting form for individuals who recognize SSO problems in their communities.

Four programs directly monitor the effects of CSOs/SSOs. These programs cover Oakland and Macomb counties and the City of Center Line. The Center Line and Oakland County programs monitor storm sewers for *E. coli* levels during wet weather events. One sewer is monitored in Center Line, while the Oakland County Drain Commissioner's office tracks eight drains, including seven separated storm sewers. Oakland County has also mapped all the major drains within the county. A more general program in Macomb County monitors for *E. coli* and other contaminants near drains during wet weather events as part of the Lake St. Clair Water Quality Assessment. Also, the Bear Creek Clean Water Initiative systematically samples *E. coli* in the creekshed to track sources. Sampling is executed in wet and dry weather and occurs at 58 stations throughout the creekshed. Monitoring for all these programs occurs during late spring to early fall, with the Oakland County and Bear Creek programs also monitoring during January and February.

There appear to be no programs to monitor CSOs/SSOs in Wayne, St. Clair, Lapeer or Sanilac counties; however, it was beyond the scope of this project to investigate the extent of combined sewers present in those areas.

In addition to direct sewer monitoring, there are numerous programs that monitor for surface water impacts resulting from CSO/SSO events. These programs include general water quality monitoring programs, which track nutrients and bacteria, and beach monitoring programs. These programs are discussed in other sections. The data from these programs should be used in conjunction with sewer monitoring data to gain a complete understanding of impacts.

Recommendations

- Identify SSO problem areas, map their locations and begin detection monitoring.
- Continue to inventory and map CSOs throughout the basin.

- Strategically monitor existing CSOs to gain a better assessment of functional success.
- Include other parameters in sewer monitoring that may be beneficial for improving storm sewer management.
- Create a centralized database for CSO/SSO location and monitoring information.

Identifying Illicit Discharges

Contamination of waterways due to illegal dumping into storm sewers is a critical issue in the Lake St. Clair watershed. Identification of illicit connections and discharge locations remains a high level concern in the region. Identifying these point source locations of contamination requires periodically testing *E. coli* and surfactant levels as well as odor and appearance changes along creek and drain lines. This task requires that individuals manually walk creek and drain segments looking for potential contaminant sources.

The task of identifying illicit connections and discharges is a high priority in the Lake St. Clair watershed and was identified as a monitoring need. In total, eight programs address identification of illicit connections and discharges. Most of these programs take place at the county level in response to the federal Phase II stormwater regulations Illicit Discharge Elimination Program (IDEP). MDEQ provides grants to counties to run IDEPs. Every community with a Phase II stormwater permit is required by law to administer an IDEP. Due to time and resource limitations not all communities were surveyed; therefore, there are likely a number of communities whose IDEP programs were missed in this inventory. Below is an overview of the most comprehensive illicit discharge elimination programs.

Macomb County – Macomb County manages five programs that address illicit discharges. The Macomb County IDEP, managed by the Macomb County Health Department, focuses on the elimination of improper connections to the storm sewer system as well as the elimination of illegal dumping into storm sewers. In addition, the project focuses on minimizing the amount of seepage into the stormwater system from sanitary sewers and septic systems. Investigators walk creek and drain areas looking for discharges. Discharges are sampled for *E. coli*, surfactants, and unusual odor. The program is currently focusing on the North branch of the Clinton River and Anchor Bay and will move to other areas in the county as funding and time permits. This monitoring program was created is in response to IDEP.

Macomb County Public Works administers another IDEP similar to that of the Health Department. This program currently measures ammonia, *E. coli*, surfactants, and water temperature in Anchor Bay and Lake St. Clair including St. Clair Shores, Chesterfield, and New Baltimore and is part of the Phase II permitting process. Macomb County Public Works also manages the Bear Creek Clean Water Initiative, whose goal is identifying and eliminating sources of *E. coli* contamination in Bear Creek. This program began in 2000 measuring depth of flow, odor, color, conductivity, temperature, ammonia, surfactants, *E. coli*, sediment depth, and sediment *E. coli* during both wet and dry weather events.

The Macomb County Department of Planning and Economic Development manages the Mapping Database of Macomb County Outfall Locations. GIS data layers are being created to help communities with Phase II permit requirements. Data layers include U.S. Census urban boundaries, MDEQ approved subwatershed and drainage basins, and outfall locations and ownership.

The Centerline IDEP is operated by the City of Centerline. Sixty-one samples along 19 miles of sewer tributary have been sampled for *E. coli.* This program has been active since 2000 and collects data in response to IDEP.

St. Clair County – St. Clair County Health Department's IDEP focuses on the elimination of improper connections to the storm sewer system as well as the elimination of illegal dumping into storm sewers in the Anchor Bay and Pine River watersheds, by testing drainage areas along natural waterways and roadside ditches. It also targets testing of failing septic systems. This program has been active since 2002 sampling *E. coli* and surfactants in the Anchor Bay and Pine River watersheds. The St. Clair County Drain Office manages another IDEP that also focuses on the elimination of improper connections to the storm sewer system in the Anchor Bay and Pine River watersheds by testing all county drains for *E. coli* and surfactants. This project will move to other watersheds as funding permits.

Oakland County – Oakland County's Drain Commissioner's Office manages the Oakland County IDEP that focuses on the elimination of improper connections to the county's storm sewer system. Wet and dry weather sampling includes monitoring bacteria, conductivity, temperature, surfactants and ammonia levels.

Recommendations

- Inventory Phase II stormwater permits to determine exactly which communities administer IDEPs and determine if the extent of coverage in each county is adequate.
- Determine if the extent of illicit discharge monitoring programs in Sanilac, Lapeer, and the Lake St. Clair watershed portion of Wayne County is sufficient.
- Develop ideas for funding alternatives to increase sampling possibilities. Because of the high level of effort involved, it has been difficult to identify how to pay for this type of investigation on a basinwide scale.

Supporting Flood Forecasting

Although not identified as a specific monitoring need, flood forecasting is an issue of concern in many areas within the Lake St. Clair watershed. Despite the fact that the Great Lakes basin possesses a number of natural reservoirs, some areas of the basin are still subject to occasional flooding. Flood prone locations include river basins and areas with a high percentage of impervious surfaces.

The St. Clair and Detroit Rivers, which feed into and out of Lake St. Clair respectively, are potential flood zones. There are a host of other river basin areas within the watershed that also pose a flooding risk. In addition to flood prone river basins, concentrated urban areas have created large expanses of impervious surfaces throughout the watershed. In these areas, the natural porous surfaces of the watershed have been altered through development which consequently leaves no place for water drainage. During wet weather events these areas repeatedly face flooding problems.

There are two programs within the watershed that specifically generate flood forecasting data. These include the Hydraulic Discharge Measurements managed by the U. S. Army Corps of Engineers Detroit District and the Flood Forecasting program managed by the Lower Thames Valley Conservation Authority. A number of other programs discussed in the weather

monitoring section also collect precipitation data which could be used for flood forecasting. For more detailed information, see the weather monitoring section of this report.

Hydraulic Discharge Measurements (U. S. Army Corps of Engineers, Detroit District) – The U.S. Army Corps of Engineers Detroit District has collected river velocity, magnitude and direction at about 20 sites in the St. Clair and Detroit Rivers on a recurring basis since 1970. This information is used to verify the inflow and outflow for Lake St. Clair, to provide information for net basin supplies and water level forecasting, and for monitoring of flood and ice conditions. Sampling parameters include bathymetry, water depth, discharge/flow, stage height, and water depth.

Flood Forecasting (Lower Thames Valley Conservation Authority) – This program provides information on flood forecasting for the Lower Thames Conservation Authority region. In total, three sampling stations collect precipitation data daily throughout the year.

Recommendations

- Consider the importance of flood forecasting as related to key Lake St. Clair watershed monitoring needs.
- If need is established, determine appropriate monitoring parameters, frequency and spatial extent and compare to current monitoring programs.
- Consider natural flow regimes and how alterations to these natural flow patterns affect water levels during storm events.

Identifying Contaminant Sources

Although not specifically defined as one of the established Lake St. Clair monitoring needs, monitoring contaminant occurrence and management is a necessary component to an effective environmental monitoring plan. The creation, recovery, transportation, and disposal of contaminants produce a host of possible environmental problems including ground water contamination and human health threats through direct contact with toxic chemicals or radioactivity.

With the careful monitoring of potential sources of contaminants and the activities associated with such waste, these types of problems may be avoided. The Lake St. Clair monitoring inventory identifies four programs in the watershed that monitor contaminants in some way. Three of these programs are managed by the United States Environmental Protection Agency (EPA) and Environment Canada manages a comprehensive program that monitors pollutants released in Canada.

U.S. Environmental Protection Agency – The Toxics Release Inventory (TRI) contains information on more than 650 toxic chemicals that are being used, manufactured, treated, transported, or released into the environment. Manufacturers of these chemicals are required to report the locations and quantities of chemicals stored on-site to state and local governments. TRI reports on 244 locations in the Lake St. Clair watershed annually and has been collecting data since 1987.

Contaminant information is contained in the Resource Conservation and Recovery Act Information (RCRAInfo) system, a national program management and inventory system about

hazardous waste handling. All generators, transporters, treaters, storers, and disposers of contaminants are required to provide information about their activities to state environmental agencies. These agencies, in turn, pass on the information to regional and national EPA offices. Information on hazardous waste is collected at various locations throughout the Lake St. Clair watershed.

EPA's Comprehensive Environmental Response, Compensation and Liability Act Information System (CERCLIS) has tracked information on all Superfund sites since 1986. Both the most hazardous sites and those where cleanup is easier or less urgent are included in this database.

Environment Canada – Environment Canada maintains the National Pollutant Release Inventory (NPRI), which is a database of pollutants released to the environment or transferred off-site as waste or for recycling from major industrial point sources in Canada. Facilities which meet certain reporting criteria must file annual reports on 273 substances to Environment Canada. The NPRI is the only legislated, publicly-accessible database of its kind in Canada.

Recommendations

- Consider the importance of contaminants monitoring as related to key Lake St. Clair watershed monitoring needs.
- If need is established, determine appropriate monitoring parameters, frequency and spatial extent and compare to current monitoring systems.
- Examine the timeliness of reporting on toxic and hazardous substance releases to determine if it fits the time scale of management decisions.

General Monitoring

Assessing Water Quality

Introduction

The Lake St. Clair watershed is home to nearly five million people, all of whom rely in some way on this unique natural resource. The Lake St. Clair watershed provides its inhabitants with drinking water, recreational resources, aesthetic beauty and numerous economic advantages. Because of the close association between the human population and the watershed, the water quality in the Lake St. Clair watershed is tied directly to the quality of life of its residents. In an area as tied to human activities as the Lake St. Clair watershed, maintaining water quality remains an ever-present challenge.

Water quality monitoring is necessary to improve natural resource management, maintain sustainable ecosystems, and protect public health. Assessment of the environmental impacts of point and nonpoint source discharges is critical. As is careful monitoring of contaminant levels in beach bathing water, drinking water, and water used for other purposes such as fish and wildlife habitat. Because of the constantly changing threat to water quality, monitoring must be able to effectively address changing environmental conditions and issues. At the same time, water quality monitoring managers must prioritize the use of limited resources and therefore, effectively target monitoring.

Assessing water quality was identified as a key monitoring need in the Lake St. Clair watershed. Water contamination factors in the watershed include illicit discharge, point and nonpoint source pollution, combined and sanitary sewer overflow events, and stormwater runoff. There are a number of programs throughout the watershed that address these environmental concerns. The following will provide a more detailed discussion of water quality monitoring in the basin.

Monitoring Programs

A combined 31U.S. and Canadian water quality monitoring programs were identified in the Lake St. Clair watershed. Programs range from extremely comprehensive monitoring programs with hundreds of stations scattered evenly throughout the entire watershed to programs sampling for one parameter at a single sampling location. Table 3 presents a summary of these programs grouped by agency, including organization, program title, and description. Each of the programs in Table 3 will be more thoroughly discussed in the analysis following the table. In an effort to remain concise, a number of data fields in the Lake St. Clair Watershed Monitoring Inventory are not discussed in this analysis. Please see the complete inventory for more detailed information on each program. The inventory can be accessed at http://mapserver.glc.org/website/lkstclair/search.htm.

Table 3. Water quality monitoring programs in the Lake St. Clair watershed.

Organization	Department	Title	Description
U.S. Federal			
U.S. Environmental Protection Agency		STORET (Storage and Retrieval)	STORET (storage and retrieval) contains raw biological, chemical, and physical surface and ground water data collected by federal, state and local agencies, Indian Tribes, volunteer groups, universities, and others. STORET contains information on why the data were gathered; sampling location; sampling and analytical methods used; the laboratory used to analyze the samples; the quality control checks used when sampling, handling the samples, and analyzing the data; and the personnel responsible for the data.
U.S. Environmental Protection Agency		Permit Compliance System (PCS)	The Permit Compliance System (PCS) database tracks permit, compliance and enforcement status to meet the informational needs of the NPDES program under the Clean Water Act. It is a dynamic system that supports the NPDES program at the state, regional and national levels.
U.S. Environmental Protection Agency		Better Assessment Science Integrating Point and Nonpoint Sources (BASINS)	BASINS (Better Assessment Science Integrating Point and Nonpoint Sources) is a multi-purpose environmental analysis system for use by regional, state, and local agencies in performing watershed and water quality based studies. It integrates a geographic information system (GIS), national watershed and meteorological data, and state-of-the-art environmental assessment and modeling tools into one convenient package. Included in the database are water quality monitoring, bacteria monitoring, weather stations, USGS gaging stations, fish consumption advisories, national sediment inventory, shellfish classifications, GIS data, and point source data.
U.S. Geological Survey	National Water Quality Assessment Program	National Water Quality Assessment (NAWQA) Program	The U. S. Geological Survey implemented the National Water Quality Assessment (NAWQA) Program to support national, regional, and local information needs and decisions related to surface and ground water

			quality management and policy. By combining information on water chemistry, physical characteristics, stream habitat, and aquatic life, the NAWQA Program aims to provide science-based insights for current and emerging water issues and priorities. Sampling includes general water chemistry, pesticides, contaminants in bed sediments, and contaminants in fish and benthic invertebrates.
U.S. Geological Survey	Network Operations Section	Water Quality Sampling in Cooperation with State of Michigan (2001 - present)	This program collects water quality information at 30 stream locations and 200 lakes around the state. Data has been collected since 2001. A web site is being developed to make the data publicly accessible.
U.S. Geological Survey		Real-time Surface-Water (Streamflow) Monitoring	This program collects instantaneous data on stage and streamflow.
U.S. Geological Survey		Real-time Water Quality Data	Under this program, real-time water quality data are returned directly from field instruments. Instantaneous data are recorded at five-minute to one-hour intervals and uploaded to the data base every four hours.
U.S. Geological Survey		Water Quality Sample Database	This program collects water quality data from field and/or performs laboratory analysis of water, biological tissue, stream sediments, and other environmental samples.
U.S. State			
Michigan Department of Environmental Quality	Water Division	Water Chemistry Monitoring Project	The purpose of the Water Chemistry Monitoring Project (WCMP) is to assess temporal and spatial trends in surface water contaminant levels; assess the current status and condition of individual waters of the state and determine whether Michigan Water Quality Standards are being met; provide data to support water quality protection programs and evaluate their effectiveness; and detect new and emerging water quality problems.
U.S. Local			
Macomb County	Health Department	Surface Water Sampling Program	This project focuses on monitoring of surface water quality through systematic sampling of county watersheds.
Macomb County	Health Department	Lake St. Clair Water Quality Assessment	The objectives of this project include establishment of a surface water and sediment quality database; evaluation of impact of climatological variables and sewer overflows on surface water quality; and collection of sediment chemistry data at previously identified locations of concern. The project includes five complementary monitoring activities: near shore, off shore, watershed, bathing beach, and wet weather.
Macomb County	Public Works	Bear Creek Clean Water Initiative	The goal of this project is to identify and eliminate sources of *E. coli* contamination in Bear Creek. The first step is to track down the sources of *E. coli* entering the watercourse through systematic sampling and testing of Bear Creek and tributaries draining to it. Sampling is done in both wet and dry weather, and includes sediment sampling.
Saint Clair County	Health Department	St. Clair County Monitoring Sites Other Than Beaches	This program gathers data for background information and to help determine possible causes of beach closings.
U.S. Non-governmental Organization			
Clinton River Watershed Council		Stream Leaders Program	Stream Leaders is CRWC's school-based water quality monitoring program. Currently there are two dozen schools in the program monitoring at approximately 40

			sites twice a year (May and October). Data is collected on the following parameters: chemical (pH, phosphates, nitrates, temperature, turbidity, DO, BOD, and fecal coliform), physical (in-stream and riparian habitat conditions), and biological (macroinvertebrates). The data are compiled into a Water Quality Index and CRWC publishes an annual "scorecard" on the overall water quality for each of the seven major subwatersheds of the Clinton River (Upper Clinton, Paint Creek, Stony Creek, Clinton Main, North branch, Red Run, and Clinton River East).
Clinton River Watershed Council		Adopt-A-Stream	Adopt-A-Stream is the umbrella program for CRWC's volunteer stewardship activities. Monitoring includes physical (in-stream and riparian habitat conditions) and biological (macroinvertebrates) parameters. Other activities include riparian landowner stewardship such as streambank stabilization, native landscaping, and river cleanups. CRWC has developed a plan to expand this program to include monitoring teams in each of the seven major subwatersheds of the Clinton River.
Clinton River Watershed Council; Michigan Department of Natural Resources; Trout Unlimited		Clinton River Coldwater Conservation Project	This is a joint effort between CRWC, MDNR, and four chapters of Trout Unlimited to assess fish habitat and identify enhancement opportunities in the Clinton River watershed. The project's first phase is focusing on Galloway Creek in Auburn Hills and the mainstem of the Clinton River from Galloway Creek to the Oakland-Macomb county line. Volunteer teams are collecting data on temperature, flow, in-stream and riparian habitat conditions, and macroinvertebrate communities, using methods approved by MDNR. This will be the most comprehensive inventory of this stretch of the river that has ever been undertaken.
Michigan State University Extension	St. Clair County	Adopt-A-Stream	This is a grassroots program focused on macro-invertebrate and chemical testing in the streams of St. Clair County. Activities include streambank cleanups, streambank surveys, monitoring of stream insects to gauge water quality, and streambank enhancement projects to help control erosion and stabilize streambanks.
U.S. University/Education			
Oakland University	Chemistry	Interim monitoring program	This program is primarily an educational tool that is also used to support environmental groups or specific targeted issues.
Canadian Federal			
Department of Fisheries and Oceans	Great Lakes Laboratory for Fisheries and Aquatic S	Fish Species at Risk (SAR) in the Sydenham River Watershed	Objectives: assess the current status of fish species at risk (SAR); identify limiting factors of fish SAR; develop a standardized protocol for sampling fish SAR (use Ontario Stream Assessment Protocol); establish index monitoring stations. Fish SAR collected: bigmouth buffalo, black buffalo? (new record), spotted sucker, blackstripe topminnow, eastern sand darter, and greenside darter.
Environment Canada		Corridor Water Quality Monitoring	
Environment Canada		St. Clair River Head and Mouth Water Quality Monitoring Program	

Environment Canada		National Pollutant Release Inventory (NPRI)	
Environment Canada & U.S. Environmental Protection		Integrated Atmospheric Deposition Network (IADN)	This binational network measures atmospheric deposition of toxic substances to the Great Lakes at various master and satellite stations around the basin.
Canadian Regional			
Essex Region Conservation Authority		Ontario Provincial Water Quality (Surface) Monitoring Network (PWQMN)	
Essex Region Conservation Authority		Essex Region Watershed	
Lower Thames Valley Conservation Authority		Ontario Provincial Water Quality (Surface) Monitoring Network (PWQMN)	
St Clair Region Conservation Authority	Planning/ Research	Provincial Water Quality Monitoring Network Program	This program conducts water chemistry sampling.
St. Clair Conservation Authority	Planning/ Research	Habitat Stewardship Program	This program conducts annual benthic macroinvertebrate sampling for watershed water quality monitoring.
Upper Thames River Conservation Authority		Ontario Provincial Water Quality (Surface) Monitoring Network (PWQMN)	
Canadian Provincial			
Ontario Ministry of the Environment		Clean Water Regulation (MISA) Monitoring Data Ontario Point Sources	
Canadian Non-governmental Organization			
Sarnia-Lambton Environmental Association		Assessing impacts on local environment	The goals of this project are to ensure that local industries understand impacts of stressors on their local environment; track long-term change in local environmental quality; provide information to assist regulators with development of appropriate regulations; and provide information on local environmental quality to local communities.

United States

In the Lake St. Clair watershed, there are eighteen U.S.-led programs performing water quality monitoring. Broad-scale monitoring in the region is largely organized by the U.S. Environmental Protection Agency (EPA) and the U.S. Geological Survey (USGS) but county-level monitoring also contributes a large percentage of the water quality information collected in the watershed. State, non-governmental, and university organizations also contribute valuable water quality monitoring information. A list of these programs can be seen in the first half of Table 3 (above). These programs are described in more detail from both an agency and geographic perspective in the analysis below.

Agency Level

Federal – Eight federal monitoring programs have been identified that focus on water quality issues in the Lake St. Clair watershed. Of these eight programs, three include long-term databases maintained by the U.S. Environmental Protection Agency (EPA) and the remaining five programs are administered by the U.S. Geological Survey (USGS).

EPA's STORET (storage and retrieval) database, though not a monitoring program itself, contains raw biological, chemical, and physical surface and ground water data collected by federal, state and local agencies, Indian tribes, volunteer groups, universities, and others. In addition to data, STORET contains information on why the data were gathered, sampling location, and sampling and analytical methods used. STORET has been in operation since 1999 and currently has information about 311 active sampling locations.

The Permit Compliance System (PCS) has been providing information for more than 30 years on companies in the U.S. that have been issued permits to discharge waste water into rivers. This system provides information on when a permit was issued and expires, how much the company is permitted to discharge, and the actual monitoring data showing what the company has discharged. The PCS database tracks permit, compliance and enforcement status to meet the informational needs of the National Pollutant Discharge Elimination System (NPDES). Ninety-nine PCS reporting locations are spread throughout the Lake St. Clair watershed.

BASINS (Better Assessment Science Integrating Point and Nonpoint Sources) is a multi-purpose environmental analysis system for use by regional, state, and local agencies in performing watershed and water quality based studies. Though it is not a monitoring program, it integrates a geographic information system (GIS), historical watershed and meteorological monitoring data, and state-of-the-art environmental assessment and modeling tools into one convenient package. Among other information included in the database are industrial facilities' discharge sites, water quality stations, bacteria stations, a national sediment inventory, and water quality observation stations.

As stated earlier, USGS manages five water quality monitoring programs in the Lake St. Clair watershed. In 1991, USGS implemented the National Water Quality Assessment (NAWQA) Program to support national, regional, and local water quality information needs. One of the NAWQA study sites is the Lake Erie/Lake St. Clair drainage area. Sampling focuses on evaluating data for trends and includes monitoring of general water chemistry, pesticides, contaminants in bed sediments, and contaminants in fish and benthic invertebrates. Eight sampling locations are spread throughout Macomb, Oakland and Sanilac counties.

The Real-time Surface Water (Streamflow) Monitoring program collects instantaneous data on stage and streamflow at 15 locations throughout the watershed. The Real-time Water Quality Program collects real-time data at three stations. Stream water quality data are also collected in cooperation with the State of Michigan (2001 – present). This program collects mercury, PCB, common constituents, anion, cation, and nutrient data daily.

State – Michigan Department of Environmental Quality manages the Water Chemistry Monitoring Project. This monitoring program supports the state's water quality protection programs by monitoring water quality in the Lake St. Clair watershed. Various physical and chemical parameters have been collected monthly at three locations since 1998.

Local – County-level water quality monitoring accounts for four programs in the Lake St. Clair watershed. The Macomb County Health Department's (MCHD)Surface Water Sampling Program has been monitoring *E. coli* levels weekly since 1990 at 63 sites throughout the county.

In addition, MCHD manages the Lake St. Clair Water Quality Assessment whose objectives include establishing a surface water and sediment quality database; evaluation of impact of climatological variables and sewer overflows on surface water quality; and collection of sediment chemistry data at previously identified locations of concern. This program has been collecting chemical and microbiological data weekly during spring and summer months at roughly 120 sampling locations in Macomb County since 1998. Macomb County Public Works Department manages the Bear Creek Clean Water Initiative. The goal of this program is to identify and eliminate sources of *E. coli* contamination in Bear Creek. This is done through monitoring depth of flow, odor, color, conductivity, temperature, ammonia, surfactants, *E. coli*, sediment depth and sediment *E. coli* in the Bear Creek watershed. The St. Clair County Health Department manages the water quality monitoring program titled St. Clair County Sites Other Than Beaches, which has been measuring *E. coli* levels weekly during summer months at 40 sites since 1998.

Non-governmental Organizations – Five programs fall within this category. Clinton River Watershed Council organizes the Stream Leaders Program and Adopt-A-Stream. These programs organize local volunteer groups to monitor aquatic invertebrates, chemical, physical and land use parameters throughout Oakland and Macomb Counties. A joint effort between Clinton River Watershed Council, Michigan Department of Natural Resources and Trout Unlimited, the Clinton River Coldwater Conservation Project, samples water quality parameters in the Clinton River. The Mill Creek Action Alliance also organizes a volunteer monitoring project. This program has conducted semi-annual sampling of benthic macroinvertebrates and has collected other water quality data from nine sites along Mill Creek since1999. The St. Clair County Michigan State University Extension office organizes an Adopt-A-Stream program that focuses on *E. coli*, macroinvertebrate and chemical sampling in the streams of St. Clair County. This program has sampled from ten locations semi-annually since 1998.

University/Education – The Great Lakes Education Program administered by Lake Shore Public Schools collects aquatic invertebrate, chemical, physical and wildlife monitoring information annually at Memorial Beach in St. Clair County. This program is primarily an educational tool. Oakland University's Interim Monitoring Program collects monitoring information on aquatic invertebrates, chemicals and fish in the Lake St. Clair watershed.

Geographic

When determining the relative importance of monitoring programs in the region, it is important to consider the scale and scope of each project as well as sampling parameters and temporal coverage. In the following analysis a brief description is presented on the number of monitoring locations as well as the geographic extent of each program.

Table 4. Number of stations and geographic extent of U.S. monitoring programs in the Lake St. Clair watershed.

Organization	Program Title	# of Stations	Geographic Extent
Federal			
U.S. Environmental Protection Agency	STORET (Storage and Retrieval)	311	Oakland and Macomb counties (primarily clustered at mouth of Clinton River); Black River; Belle River; St. Clair River; Detroit River
U.S. Environmental Protection Agency	Permit Compliance System (PCS)	99	Evenly distributed throughout the Lake St Clair watershed

U.S. Environmental Protection Agency	Better Assessment Science Integrating Point and Nonpoint Sources (BASINS)	Unknown	Unknown
U.S. Geological Survey	National Water-Quality Assessment (NAWQA) Program	8	Macomb and Oakland counties; Black River
U.S. Geological Survey	Water Quality Sampling in Cooperation with State of Michigan (2001 - present)	Unknown	Unknown
U.S. Geological Survey	Real-time Surface-Water (Streamflow) Monitoring	15	Clinton River basin; Pine River; Black River
U.S. Geological Survey	Real-time Water Quality Data	3	Clinton River basin
U.S. Geological Survey	Water Quality Sample Database	390	Distributed throughout the Lake St. Clair watershed
State			
Michigan Department of Environmental Quality	Water Chemistry Monitoring Project	3	Clinton River; St. Clair River (upstream); St. Clair River (downstream)
Local			
Macomb County	Surface Water Sampling Program	63	Clinton River Watershed; Red Run Drain/Bear Creek Watershed; and Salt River; Milk River; Crapeau Creek Watershed
Macomb County	Lake St. Clair Water Quality Assessment	120	Macomb County
Macomb County	Bear Creek Clean Water Initiative	58	Bear Creek (Southwestern Macomb County)
Saint Clair County	St. Clair County Monitoring Sites Other Than Beaches	40	St. Clair County
Non-governmental Organization			
Clinton River Watershed Council	Stream Leaders	40	Over 60 municipalities in Oakland, Macomb, Lapeer, and St. Clair counties
Clinton River Watershed Council	Adopt-A-Stream	Unknown	Clinton River
Clinton River Watershed Council; Michigan Department of Natural Resources; Trout Unlimited	Clinton River Coldwater Conservation	Unknown	Clinton River
Mill Creek Action Alliance	Mill Creek Volunteering Project	9	Mussey, Lynn, Brockway, Kenockee, Imaly and Emmett Townships and the city of Yale
Michigan State University Extension	Adopt-A-Stream	10	St. Clair County
University/Education			
Lake Shore Public Schools	Great Lakes Education Program	1	Memorial Beach (St. Clair County)
Oakland University	Interim monitoring program	Unknown	Unknown

Lake St. Clair Watershed Scale – With 311 monitoring stations, STORET (EPA) contains data from numerous sampling programs in the region. Sampling locations are distributed throughout the entire Lake St. Clair watershed with the heaviest sampling in Oakland and Macomb counties as well as the Black, Belle, and St. Clair rivers. The Water Quality Sample Database (USGS) includes 390 stations distributed throughout the watershed. Other programs sampling throughout the basin which have a high number of stations include PCS (EPA), BASINS (EPA), and Water Quality Sampling in Cooperation with the State of Michigan

(USGS). Other programs, covering to some extent the entire Lake St. Clair watershed but with fewer sampling locations, include the National Water-Quality Assessment (NAWQA) Program (USGS), Real-time Surface Water (Streamflow) Monitoring (USGS), Real-time Water Quality Data (USGS), and the Water Chemistry Monitoring Project (MDEQ). See Table 4 for more detailed information, including number of stations and geographic extent.

County Scale – Four programs operate within county boundaries. The Lake St. Clair Water Quality Assessment (Macomb County) samples at 120 locations scattered throughout Macomb County. The Surface Water Sampling Program (Macomb County) samples at 63 locations throughout the county. In St. Clair County, the Monitoring Sites Other Than Beaches program samples from 40 stations and the Adopt-A-Stream project administered by the St. Clair County MSU Extension office samples at 10 locations.

Localized Ecological Scale – The Bear Creek Clean Water Initiative (Macomb County) is a local monitoring program sampling 58 sites in the Bear Creek Watershed. Clinton River Watershed Council organizes the Stream Leaders Program and Adopt-A-Stream. These programs organize local volunteer groups to monitor aquatic invertebrates, chemical, physical and land use parameters throughout Oakland and Macomb Counties. A joint effort between Clinton River Watershed Council, Michigan Department of Natural Resources and Trout Unlimited, the Clinton River Coldwater Conservation Project, samples water quality parameters in the Clinton River. Nine sampling stations are part of the Mill Creek Volunteering Project (Mill Creek Action Alliance). Lastly, the Great Lakes Education Program (Lake Shore Public Schools) samples at one location, Memorial Beach, in St. Clair County.

Canada

Although the primary focus of the Lake St. Clair Watershed Monitoring Inventory was compilation of U.S. run programs, information on Canadian monitoring programs was also collected where possible. In total, 13 water quality monitoring programs managed by Canadian organizations were included in the Lake St. Clair Watershed Monitoring Inventory.

Agency Level

Federal – Five federal programs were identified that monitor water quality in the Lake St. Clair watershed. Established in 1991 by the United States and Canada, the Integrated Atmospheric Deposition Network (IADN) conducts air and precipitation monitoring in the Great Lakes watershed. The goals of *IADN* are to determine the atmospheric loadings and trends of toxic chemicals to the Great Lakes watershed; acquire air and precipitation concentration measurements; and help determine the sources of the continuing input of those chemicals. *IADN* operates two monitoring stations in the Lake St. Clair watershed that are sampled biennially at a minimum.

Environment Canada maintains the National Pollutant Release Inventory (NPRI) which is a database of pollutants released to the environment or transferred off-site as waste or for recycling from major industrial point sources in Canada. Facilities which meet certain reporting criteria must file annual reports on 273 substances to Environment Canada. The NPRI is the only legislated, publicly-accessible database of its kind in Canada. Environment Canada also manages a Corridor Water Quality Monitoring program. The Department of Fisheries and Oceans Great Lakes Laboratory for Fisheries and Aquatic Sciences manages the Fish Species at Risk (SAR) program in the Sydenham River watershed. Although this program focuses on fish species at risk populations, some physical and chemical water quality testing is performed.

Regional – Four Conservation Authorities -- Essex, Lower Thames Valley, Upper Thames Valley, and St. Clair -- manage the Ontario Provincial Water Quality (Surface) Monitoring Network (PWQMN). This program focuses on water chemistry sampling. The Habitat Stewardship Program managed by the St. Clair Region Conservation Authority monitors water quality by annual sampling of benthic macroinvertebrates. In addition to the PWQMN, the Essex Region Conservation Authority also administers the Essex Region Watershed Monitoring Program.

Provincial – Ontario Ministry of the Environment manages the Clean Water Regulation Monitoring Data - Ontario Point Sources database.

Non-governmental Organizations – Sarnia-Lambton Environmental Association manages the monitoring program titled Assessing Impacts on Local Environment. This long-term monitoring program has been collecting data since 1952. Its goals are to ensure that local industries understand the impact of stressors on the local environment, track long-term change in local environmental quality, provide information to assist regulators with development of appropriate regulations, and provide information on local environmental quality to local communities. Monitoring of aquatic invertebrates, fish, invasive species, and chemical and physical parameters is currently being conducted at 20 sites along the St. Clair River.

Summary

Maintaining a long-term comprehensive water quality monitoring system has been recognized as a critical monitoring need in the Lake St. Clair region. The data gathered through long-term monitoring makes it possible to develop a baseline data set to analyze water quality trends as well as predict and manage water quality concerns. A combined 31 U.S. and Canadian water quality monitoring programs were identified in the Lake St. Clair watershed. Programs range from comprehensive monitoring programs with hundreds of stations scattered evenly throughout the entire watershed to programs sampling for one parameter at a single sampling location.

In the Lake St. Clair watershed, there are 18 U.S.-led programs conducting water quality monitoring. Broad-scale monitoring in the region is largely organized by the U.S. Environmental Protection Agency (EPA) and the U.S. Geological Survey (USGS), but county-level monitoring also contributes to the water quality information collected in the watershed. The Water Quality Sample Database (USGS) stores data for 390 sampling stations distributed throughout the watershed. With 311 monitoring stations, STORET (EPA) stores data on a comparable number of sampling stations with the heaviest sampling in Oakland and Macomb counties as well as in the Black, Belle, and St. Clair rivers. Other federal programs sampling throughout the watershed which have sampling stations include PCS (EPA), BASINS (EPA), and Water Quality Sampling in Cooperation with the State of Michigan (USGS).

At the county level, the Lake St. Clair Water Quality Assessment (Macomb County) samples at 120 locations scattered throughout Macomb County. The Surface Water Sampling Program (Macomb County) samples at 63 locations throughout the county. The St. Clair County program, Monitoring Sites Other Than Beaches, monitors 40 stations in that county.

Because of their ability to focus intensely on a specific area, local monitoring programs also contribute valuable monitoring information. Some of the best organized monitoring programs in the region take place at the local level. For instance, the Bear Creek Clean Water Initiative

(Macomb County) is a local monitoring program sampling 58 sites in the Bear Creek Watershed. Clinton River Watershed Council organizes the Stream Leaders Program and Adopt-A-Stream. These programs organize local volunteer groups to monitor aquatic invertebrates, chemical, physical and land use parameters throughout Oakland and Macomb Counties. The Clinton River Coldwater Conservation Project, a joint effort between the Clinton River Watershed Council, Michigan Department of Natural Resources and Trout Unlimited, samples water quality parameters in the Clinton River. Another localized monitoring program includes the Mill Creek Volunteering Project (Mill Creek Action Alliance) with nine sampling locations.

Thirteen water quality monitoring programs managed by Canadian organizations are included in the Lake St. Clair Watershed Monitoring Inventory. Of these programs, five are federally-run programs; four are run by regional Conservation Authorities; one is run at the provincial level; and one is managed by a non-governmental organization. At this time, it is difficult to draw conclusions about Canadian water quality monitoring in the Lake St. Clair watershed. This is due to the Canadian portion of the monitoring inventory not yet being complete and little descriptive information being available for many of the Canadian-run programs included in the database. Because of these factors, it is also not possible to make geographic comparisons at this time. In the future, as more Canadian programs are included in the monitoring inventory's database, a more thorough analysis can be performed.

Water quality monitoring in the region appears to be fairly well-represented. Monitoring sites exist throughout the entire watershed. The most intense sampling appears to be taking place in Oakland and Macomb counties. While each monitoring program currently collects a wealth of useful information, a much more powerful monitoring approach can begin as communication and collaboration among monitoring organizations increases. It is difficult to determine if the water chemistry monitoring is sufficient without examining specific objectives, parameters and methods employed by all programs. This requires expert examination; the monitoring inventory provides a starting point for this analysis. In order to form an effective conservation strategy, it will also be important to identify specific water quality monitoring needs. A detailed analysis of critical water quality sampling parameters, as well as key sampling locations, is needed for the watershed.

Recommendations

- Form a watershed-wide water quality monitoring committee to coordinate and organize monitoring in the watershed and develop opportunities for collaboration and communication among monitoring organizations.
- Conduct in-depth evaluations of parameter-based monitoring coverage, as needed. This should include an examination of objectives and methodologies and evaluation of current monitoring programs in relation to defined monitoring needs.
- Consider increasing ambient water quality monitoring within the entire watershed including open waters of Lake St. Clair.

Assessing Sediment Quality

Monitoring sediment quality has been identified as an important monitoring need in the Lake St. Clair watershed. Cycling of materials through sediment and into biological organisms has a major impact on the overall environmental health of an ecosystem. The Lake St. Clair Needs

Assessment identified nutrients, metals, odor, color, oil, grease, site-specific organics, *E. coli* and physical characteristics as important sediment quality monitoring parameters.

Upon analysis of current monitoring projects in the Lake St. Clair watershed, 10 were identified that address sediment quality. Projects range in scope from volunteer programs with creek-level focus to nationwide trend monitoring programs. It is important to note that although the projects address sediment quality, nearly all of them, excluding EPA's National Sediment Inventory, have a larger scope and monitor parameters other than sediment quality.

The Lake St. Clair Watershed Monitoring Inventory shows that a number of sediment sampling programs in the area have a relatively large geographic scope. The Lake St. Clair Water Quality Assessment (Macomb County Health Department) collects sediment chemistry data from areas throughout Macomb County that have been previously identified as locations of concern. The Operation and Maintenance of Federal Navigation Channels program (U.S. Army Corps of Engineers) monitors sediment quality in navigation channels in the Lake St. Clair watershed. Nationwide sediment chemistry data is also collected through EPA's National Sediment Inventory. The NAWQA Program (U.S. Geological Survey) monitors contaminants in bed sediments at study sites throughout the U.S.

The Mill Creek Volunteering Project (Mill Creek Action Alliance) and Bear Creek Clean Water Initiative (Macomb County Public Works) are geographically-targeted projects both of which analyze creek sediment chemistry. Other projects in the area that monitor sediment quality include the Comprehensive Environmental Response, Compensation and Liability Act Information System (U.S. Environmental Protection Agency); Interim Monitoring Program (Oakland University); St. Clair River, Lake St. Clair and Detroit River Suspended Sediment Characterization (Environment Canada); and Lake St. Clair Bottom Sediment Contaminant Characterization (Environment Canada).

Recommendations

- A more in-depth examination of sampling parameters and sampling frequency across programs would more clearly determine if sampling coverage is adequate.
- Consider adding sediment quality monitoring locations in St. Clair, Lapeer, and Sanilac counties including the Belle, Pine and Black rivers.
- Evaluate utility of sediment quality data submitted with U.S. Army Corps of Engineers dredging permits.
- Implement sampling of sediment outside major storm drains every 10 years to characterize long-term change.

Monitoring Air Quality

When determining the environmental health of an ecosystem it is important to consider not only terrestrial and aquatic ecosystem health but also atmospheric conditions. Data on air quality is invaluable when trying to understand threats posed to the environment by atmospheric deposition, human health risks associated with poor air quality, and the overall health of an ecosystem. Although air quality monitoring was not identified as a specific Lake St. Clair monitoring need, enough data was found to warrant an analysis of findings.

Eight programs in the Lake St. Clair watershed either monitor air quality or act as a clearinghouse for regional air quality data. Air quality monitoring stations appear to be spread throughout the Lake St. Clair watershed. A number of air quality sampling stations are found in each county, with the highest density of sampling stations along the St. Clair River and in metro Detroit.

Based on compiled results, it appears that the most comprehensive monitoring and reporting programs in the region are performed by the U.S. Environmental Protection Agency (EPA). These programs include the Aerometric Information Retrieval System (AIRS)/AIRS Facility Subsystem (AFS), Toxic Release Inventory (TRI), and AirData.

Aerometric Information Retrieval System (AIRS)/AIRS Facility Subsystem (AFS)

AIRS/AFS provides data on air releases in the United States. Air pollutants released by various stationary sources of air pollution, such as electric power plants, steel mills, factories, and universities are housed in this database. This air pollutant information specifically relates to industrial plants and their components (stacks, points, and segments) and the chemicals they release into the air. AIRS/AFS collects air quality data from 251 locations in the Lake St. Clair watershed. This database has been active since 1970.

Toxic Release Inventory (TRI)

The Toxics Release Inventory (TRI) contains information about more than 650 toxic chemicals that are being used, manufactured, treated, transported, or released into the ground, water or air. Manufacturers of these chemicals are required to report the locations and quantities of chemicals stored on-site to state and local governments. EPA compiles this data in an on-line, publicly accessible national computerized database. TRI tracks 244 locations in the Lake St. Clair watershed annually and has been collecting data since 1987.

AirData

The AirData database has provided yearly summaries of U.S. air pollution data since 1970. AirData has information about where air pollution comes from and pollutant levels in local regions. Air quality is measured at monitoring sites, primarily in cities and towns along with other point, area, and mobile sources. In the Lake St. Clair watershed, there are 56 AirData monitoring stations.

Other data sources include the Integrated Atmospheric Deposition Network (IADN), established in 1991 by the U.S. and Canada, for conducting air and precipitation monitoring in the Great Lakes basin; and EPA's Comprehensive Environmental Response, Compensation and Liability Act Information System (CERCLIS) which has tracked information on all Superfund sites since 1986.

Air quality monitoring programs in Canada include Ontario Ministry of the Environment's Continuous Ambient Air Monitoring program which has been monitoring air quality since 1975. It includes two sampling locations in the Lake St. Clair watershed and collects data both hourly and daily depending on parameter. Another program, Assessing Impacts on Local Environments (Sarnia-Lambton Environmental Association), has monitored emissions in Ontario since 1952. It includes eight monitoring locations that range in monitoring frequency from five minutes to hourly to every twelve days. Environment Canada also houses the

National Pollutant Release Inventory (NPRI) that provides data on the amounts and types of pollutants industrial-type facilities release to the environment and transfer to other sites.

Recommendations

- Consider benefits of producing air quality summaries more frequently than once a year.
- Consider expanding air quality sampling to additional locations throughout the basin beyond Metro Detroit and St. Clair River regions.

Weather Monitoring

Knowledge of weather patterns and regional weather trends provides information that is valuable to regional environmental management on a number of levels. Information on past weather trends is needed when forecasting future weather events. In many cases, weather monitoring data is also used in the detection of unusual weather phenomena such as prolonged elevated temperatures or unusual precipitation levels. Climatological data is also used in watershed modeling.

Based on inventory results, the Lake St. Clair watershed has a total of six operational weather monitoring programs. There are two operational weather monitoring buoys and one recently disabled buoy in Lake St. Clair and a number of monitoring locations in the Detroit and St. Clair rivers. Forty-four known precipitation monitoring sites are spread evenly throughout Macomb, Oakland, and Wayne counties. An additional program in Ontario focuses on precipitation monitoring, but no specific geographic information is available.

Lake St. Clair Weather Buoy (University of Michigan) – A data buoy was deployed in 2000 to collect and report weather data in Lake St. Clair. The buoy supplied wind and water data to aid in the development of a system to predict beach closures and to guide county health officials in water sampling strategies. This program collected data on wind direction, wind speed, current direction, current speed, air temperature, water temperature, wave height, and wave period every ten minutes until fall of 2002 when the buoy was disabled.

Lake St. Clair Weather Buoy (Environment Canada) - Environment Canada's Lake St. Clair Weather Buoy collects information hourly on sea level pressure, wind speed, wind direction, air temperature, sea surface temperature, and significant wave height. This buoy collects information from March through November and then is removed for the winter. These data are used in the production of marine forecasts and as input into numerical weather prediction models for marine forecast guidance. The buoys also provide data for climatological records which are used in many research projects and applications such as design wave climates for offshore construction.

Great Lakes CoastWatch Node (National Oceanic and Atmospheric Administration) - CoastWatch is a nationwide National Oceanic and Atmospheric Administration (NOAA) program that delivers Great Lakes weather data to support environmental science, decision making, and research. CoastWatch has one monitoring station in the Lake St Clair basin that monitors wind direction, wind speed, wind gust, atmospheric pressure, pressure tendency, and air temperature hourly.

Precipitation Data (Southeast Michigan Council of Governments - SEMCOG) - Since 1960, a rain gauge network covering much of Southeast Michigan has been operated by SEMCOG. This

program includes 44 precipitation monitoring locations collecting data hourly in the Lake St. Clair watershed.

Flood Forecasting (Lower Thames Valley Conservation Authority) – The goal of this program is to collect precipitation data for flood forecasting. Data is collected at three sampling locations in Ontario.

Hydraulic Discharge Measurements (U.S. Army Corps of Engineers) – The U.S. Geological Survey Detroit District collects river velocity, magnitude and direction at about 20 sites in the St. Clair and Detroit rivers on a recurring basis. This information is used to verify the inflow and outflow for Lake St. Clair, provide information for net basin supplies and water level forecasting, and monitor flood and ice conditions. Sampling parameters include bathymetry, water depth, discharge/flow, stage height, and water depth.

Recommendations

- Consider expanding weather monitoring in all counties to include precipitation data as well as other weather parameters such as wind and atmospheric conditions.
- Consider expanding weather monitoring in Lake St. Clair to enable researchers to more accurately predict surface flow and water turnover volumes, as well as better forecast local lake conditions.

Monitoring Water Flow and Conditions

Understanding the physical characteristics of an aquatic ecosystem provides baseline knowledge of environmental conditions. This historical water flow and conditions trend data of a water system can be very useful in the early detection of emerging environmental issues. The benefit of this data is that once an unusual trend is detected, measures can be taken to correct the problem or at least gain an understanding of what is occurring.

Three monitoring programs focus on collecting data on physical characteristics of the waters of the Lake St. Clair watershed. These programs collect data on stream flow, velocity, conductance and depth. A number of other programs that focus on weather monitoring also collect data on physical parameters. Parameters included are wind direction, wind speed, current direction, current speed, air temperature, water temperature, wave height, and wave period. See the weather monitoring section for a more detailed analysis of these weather-related programs.

Surface Water Monitoring (U.S. Geological Survey) – This program includes surface water gauging station data used for water quality studies, waste load allocations, distribution studies, and advanced waste treatment assessments. Data is collected at 15 stations. These stations collect stage and streamflow data.

Ground Water Levels (U.S. Geological Survey) – Depth-to-water in wells records are available at 124 locations throughout the watershed. Many of these sites have only on data point. Available site descriptive information includes well location (latitude and longitude), well depth, site use, water use and aquifer. A few of these sites have water quality data.

Hydraulic Discharge Measurements (U. S. Army Corps of Engineers, Detroit District) – The U.S. Army Corps of Engineers Detroit District collects river velocity, magnitude and direction at

about 20 sites in the St. Clair and Detroit rivers on a recurring basis. This information is used to verify the inflow and outflow for Lake St. Clair, provide information for net basin supplies and water level forecasting, and monitor flood and ice conditions. Sampling parameters include bathymetry, water depth, discharge/flow, stage height, and water depth.

Recommendations

- Review the need for monitoring water flow and conditions.
- Monitor flow regimes throughout the watershed to determine current flow patterns. Use data to establish target flow rates and develop long-term database of flow patterns.
- If need is established:
    - Determine appropriate monitoring parameters and frequency.
    - Consider expanding monitoring to include more sites on Lake St. Clair as well as in St. Clair, Sanilac, Lapeer and Wayne counties.

Quantifying Atmospheric Deposition

Atmospheric deposition is the result of airborne chemical compounds settling onto the land or water surface. Along with toxic components, nitrogen and phosphorus containing compounds are some of the most environmentally destructive chemical contaminants. Nitrogen compounds are involved in acid rain. Both nitrogen and phosphorus compounds contribute to nutrient loadings. A greater understanding of both the sources of pollution and atmospheric deposition is necessary to gain the knowledge needed to combat this environmental problem. The Great Lakes Binational Toxics Strategy provides a framework for actions to reduce or eliminate a number of toxic substances from the environment.

Developing the data needed to quantify atmospheric deposition is an important monitoring need in the Lake St. Clair watershed. Only one program is dedicated exclusively to measuring atmospheric deposition in the Great Lakes region. An additional seven programs in the Lake St. Clair watershed monitor air quality. The data available from these air sampling programs is valuable when determining potential atmospheric deposition and sources of contamination.

Atmospheric Deposition Monitoring – Established in 1991 by the United States and Canada, the *Integrated Atmospheric Deposition Network (IADN)* conducts air and precipitation monitoring in the Great Lakes basin. The goals of *IADN* are to 1) determine the atmospheric loadings and trends of toxic chemicals to the Great Lakes basin; 2) acquire air and precipitation concentration measurements; and 3) help determine the sources of the continuing input of those chemicals. *IADN* operates two monitoring stations in the Lake St. Clair watershed that are sampled biennially at a minimum. One station is on Lake St. Clair's Canadian border and the other is at Canada's Point Pelee, which is the far southern tip of Ontario.

Air Quality Monitoring – Air quality monitoring appears to be fairly well-represented throughout the Lake St. Clair watershed. There are eight programs that address air quality monitoring in the U.S. and Canada. The U.S Environmental Protection Agency (EPA) leads the effort to provide air quality data to managers throughout the Lake St. Clair watershed. EPA's Aerometric Information Retrieval System (AIRS)/AIRS Facility Subsystem (AFS), Toxic Release Inventory, and AirData represent the region's most comprehensive air quality databases in the U.S. In addition, EPA's Comprehensive Environmental Response, Compensation and Liability Act Information System (CERCLIS) has tracked information on all Superfund sites

since 1986. The majority of the air quality monitoring appears to be focused in the more heavily populated and industrially intense Detroit metro and St. Clair River regions.

Among Canada's air quality monitoring programs is Ontario Ministry of the Environment's Continuous Ambient Air Monitoring program which has been monitoring air quality since 1975. It includes two sampling locations in the Lake St. Clair watershed and collects data both hourly and daily depending on parameter. Another program, Assessing Impacts on Local Environments (Sarnia-Lambton Environmental Association), has monitored emissions in Ontario since 1952. It includes eight monitoring locations that range in monitoring frequency from five minutes to hourly to every twelve days. Environment Canada also houses the National Pollutant Release Inventory (NPRI) that provides data on the amounts and types of pollutants industrial-type facilities release to the environment and transfer to other sites.

Recommendations

- Establish a baseline air deposition monitoring program specific to the Lake St. Clair watershed.
- Examine the Binational Toxic Strategy for direction on how to best address air deposition concerns.
- Determine if traditional air quality sampling information can be used to build on findings from IADN.
- Investigate available air deposition modeling approaches.

Tracking Total Maximum Daily Load (TMDL)

The establishment of Total Maximum Daily Loads or TMDLs is the newest approach at U.S. EPA to address impaired waters listed by each state as part of Clean Water Act compliance. The purpose is to develop a plan with numerical limits on the pollutant of concern such that the total load will result in water quality that meets water quality standards. This requires specific monitoring of the impaired water body, location of pollutant sources and determination of load allocations across point and nonpoint sources. Beyond monitoring for the development of the TMDL, monitoring is needed to determine the effectiveness of implementation.

The state of Michigan has developed one EPA-approved TMDL for a tributary to Lake St. Clair. The TMDL covers a section of Crapaud Creek running through New Baltimore and discharging into Anchor Bay. The reach, or stream section, was listed as impaired in the 1998 list of impaired waters (Clean Water Act requirement). The stream segment was impaired by consistently elevated levels of *E. coli.* The Michigan Department of Environmental Quality monitored for *E. coli* at five stations at different locations along the impaired reach in 2001 in preparation for TMDL development. The TMDL report (MDEQ, 2002) indicates that monitoring was conducted from May through August and dependant on minimum flow levels. Additional sampling took place in 2002 to determine if the water was meeting water quality standards (WQS). There are plans for future year monitoring from May through September to determine if the waterbody is meeting WQS, and if not, continue to identify and eliminate pollution sources.

Table 5 shows the current schedule for developing TMDLs for impaired waters in the Lake St. Clair watershed.

Table 5. Michigan TMDL schedule for impaired waters in the Lake St. Clair watershed.

Stream segment	Impairment	Year(s)
Bear Creek	Bacteria	2006
Clinton River	- Combined sewer overflows, pathogens, poor fish community - Fish consumption – PCBs – Mercury	2006 2010 2011
Deer Creek	Bacteria	2006
Lake St. Clair	Fish consumption – PCBs – Mercury	2010 2011
Lake St. Clair - Metro Beach	Bacteria	2006
Lake St. Clair - Memorial Beach	Bacteria	2006
Milk River	CSOs, pathogens, dissolved oxygen, nutrients, fish kills	2005
Red Run Drain	Bacteria, poor macroinvertebrates	2006
Salt River	Bacteria	2005
St. Clair River	- Bacteria - Fish consumption – PCBs – Mercury	2009 2010 2011

This compares with the schedule for developing TMDLs statewide:

2002: 11
2003: 15
2004: 22
2005: 21
2006: 30
2007: 24
2008: 24
2009: 39
2010: 57
2011: 158
2012: 9
Total = 410

Assuming the same type of schedule is carried out for monitoring pre- and post-TMDL development, this schedule represents a significant amount of data collection on these stream sections. TMDL monitoring should be considered when reviewing monitoring coverage or planning for basinwide monitoring coordination. However, monitoring for TMDL development is limited in time, space and parameters. Additionally, the TMDL program guidance is currently under national review for redevelopment, which could significantly alter the above schedule or monitoring approach.

Recommendations

- When appropriate, include TMDL monitoring when planning coordinated monitoring schemes.
- MDEQ should communicate in advance their plans for monitoring the impaired stream segments with other monitoring organizations to facilitate efficient broad-scale monitoring coordination.
- Address most environmentally-degraded and/or at-risk TMDL areas first.

Delisting Areas of Concern

Areas of Concern (AOC) are environmentally troubled areas in the Great Lakes basin, which because of historic and ongoing pollution, suffer from degraded environmental conditions. These areas were designated under the U.S.-Canada Great Lakes Water Quality Agreement

based on the presence of environmental problems such as restrictions on fish and wildlife consumption, beach closures, drinking water restrictions, and loss of fish and wildlife habitat. Remedial Action Plans (RAPs) have been developed for each AOC to provide a methodical approach to cleanup and delisting.

Two AOCs lie within the Lake St. Clair watershed. The St. Clair River AOC includes wetlands from St. Johns Marsh on the west (near Anchor Bay) to the north shore of Mitchell's Bay in Ontario. St. Clair River RAP priorities include contaminated sediment remediation on the Canadian side of the river; elimination of combined sewer overflows (CSOs) and sanitary sewer overflows (SSOs) on both sides of the river; elimination of spills to the river from "Chemical Valley" downstream of Sarnia, Ontario; and ensuring proper notification when spills do occur. The Clinton River AOC includes the entire watershed. Clinton River RAP priorities include elimination of CSOs and SSOs, nonpoint source pollution control, Superfund waste site remediation, spill notification, habitat restoration, and elimination of illicit connections and failing septic systems.

Although no programs in the Lake St. Clair Monitoring Inventory directly address delisting Areas of Concern, many programs do collect pertinent information. Programs monitoring sewage overflow events provide particularly useful information for the two AOCs. Other monitoring data that may provide critical information for delisting AOCs includes general water quality monitoring, identification of pollutant sources, fish advisories, and monitoring sediment quality. In order to determine if appropriate data is available to evaluate delisting the AOC, a careful comparison of the delisting criteria with monitoring programs is needed for both the St. Clair River Area of Concern and the Clinton River Area of Concern to determine what additional information, if any, is needed.

Recommendations

- Identify measurable delisting targets addressing beneficial use impairments in the Area of Concern and the monitoring data needed to support these targets.
- If not already in place, establish a specific monitoring strategy for each AOC.
- Compare delisting criteria and monitoring needs to current Lake St. Clair monitoring programs to determine gaps in data collection.

Monitoring Permit Compliance

Maintaining a healthy watershed requires observation and management of natural and man-made environmental influences. One such impact that requires careful management is environmental permitting. Permits are distributed throughout the Lake St. Clair watershed to regulate water outfall, air emissions, wetland mitigation, construction, toxic chemical storage, etc. Understanding the effects of implementing these permits is important when seeking to protect the environmental integrity of an ecosystem.

Assessing permit compliance was identified as an important monitoring need for the Lake St. Clair watershed. There are five programs in place in the Lake St. Clair watershed that provide this permit compliance data to the public. A permit often requires submission of permit compliance data. Permit compliance data is essential to determining the success of permit programs in reducing point source pollution of the local and regional environment. Analysis of

permit compliance data in comparison with in-stream water quality monitoring can generate programmatic success measures.

Permit Compliance System (U.S. Environmental Protection Agency) – The Permit Compliance System (PCS) has been providing information for more than 30 years on facilities in the U.S. which have been issued permits to discharge waste water into rivers. This resource provides information on when a permit was issued and expires, how much the facility is permitted to discharge, and the facility's monitoring data showing what has been discharged. The PCS database tracks permit compliance and enforcement status to meet the informational needs of the National Pollutant Discharge Elimination System (NPDES) program under the Clean Water Act. Ninety-nine permitted facilities are spread throughout the U.S. Lake St. Clair watershed.

Aerometric Information Retrieval System (U.S. Environmental Protection Agency) – AIRS/AFS provides data on air releases in the United States. Air pollutants released by various stationary sources of air pollution, such as electric power plants, steel mills, factories, and universities are reported to the EPA. This air pollutant information specifically relates to industrial plants and their components (stacks, points, and segments) and the chemicals they release into the air. AIRS/AFS collects air quality data from 251 locations in the Lake St. Clair watershed. This database has been active since 1970.

Toxic Release Inventory (U.S. Environmental Protection Agency) – The Toxics Release Inventory (TRI) contains information about more than 650 toxic chemicals that are being used, manufactured, treated, transported, or released into the environment. Manufacturers of these chemicals are required to report the locations and quantities of chemicals stored on-site to state and local governments. EPA compiles this data in an on-line, publicly accessible national computerized database. TRI tracks 244 locations in the Lake St. Clair watershed annually and has been collecting data since 1987.

Resource Conservation and Recovery Act Information (U.S. Environmental Protection Agency) – Hazardous waste information is contained in the Resource Conservation and Recovery Act Information (RCRAInfo) system, a national program management and inventory system about hazardous waste handlers. All generators, transporters, treaters, storers, and disposers of hazardous waste are required to provide information about their activities to state environmental agencies. These agencies, in turn, pass on the information to regional and national EPA offices. Information on hazardous waste is collected at locations throughout the Lake St. Clair watershed.

National Pollutant Release Inventory (Environment Canada) – The National Pollutant Release Inventory (NPRI) is a database of pollutants released to the environment or transferred off-site as waste or for recycling from major industrial point sources in Canada. Facilities which meet certain reporting criteria must file annual reports on 273 substances to Environment Canada. The NPRI is the only legislated, publicly-accessible database of its kind in Canada.

Recommendations

- Examine permitting programs at state and federal levels to determine if permits are being granted without monitoring for compliance requirements.
- Consider developing monitoring guidelines for permit compliance requirements where currently none exist.

- Evaluate the effectiveness of current permit compliance requirements, by comparing permit compliance records with in-stream water quality monitoring data.

Strategic Plan

Background

One of the fundamental components of a successful watershed management plan is a well–orchestrated regional environmental monitoring strategy that provides policymakers useful information in a timely manner. Data collected through a well-planned, long-term monitoring strategy not only provides the objective means necessary to determine the environmental integrity of an ecosystem, it also provides the means necessary to measure the success of corrective actions.

A multitude of organizations currently perform some type of monitoring within the Lake St. Clair watershed. Each has its own inherent mission and monitoring focus. As the number of monitoring organizations in the region expands and the environmental issues become more complex, the need for coordination, collaboration, and prioritization among monitoring agencies increases.

The U.S. Army Corps of Engineers, Detroit District (USACE), in partnership with the Macomb-St. Clair Intercounty Watershed Advisory Group, initiated a project to inventory the environmental monitoring programs in the Lake St. Clair watershed and develop a monitoring strategic plan to help with the coordination, collaboration, and prioritization of monitoring needs. The Great Lakes Commission was contracted to conduct project activities under the consultation of a Technical Advisory Committee made up of experts from federal, state, local, university, and non-governmental organizations.

This monitoring strategic plan responds to the gaps identified in the previous sections. Recommendations are presented below for federal, state/provincial, and local stakeholders throughout the Lake St. Clair watershed. The framework for this plan is somewhat based on designs recommended and being utilized by the Lake Michigan Monitoring Coordination Council (LMMCC) and the National Water Quality Monitoring Council (NWQMC). This framework was adapted in order to maintain a consistent approach to development of a monitoring strategic plan throughout the Great Lakes basin. Feedback from the project's Technical Advisory Committee was also incorporated to improve the monitoring strategic plan. The framework is directed at establishing a fully integrated monitoring network for the Lake St. Clair watershed.

Goals and Objectives of the Strategic Plan

In an area as large and complex as the Lake St. Clair watershed, a sound, coordinated plan is needed to bring order to the many monitoring projects being managed by a diverse group of monitoring organizations. A sound monitoring coordination plan can provide the framework necessary to help monitoring organizations work with one another and maximize utility of information being gathered by sharing and coordinating data collection procedures.

Although much effort has been directed at monitoring in the Lake St. Clair watershed, to date there has been a lack of a unified monitoring approach. As a means for increasing the organization and effectiveness, as well as collaboration and coordination among monitoring organizations, the Lake St. Clair Monitoring Strategic Plan seeks to provide the framework necessary to develop a coordinated monitoring effort.

The goals and objectives of this strategic plan are primarily to create a monitoring framework that will enhance the ability of organizations in the watershed to work with one another, while also collecting monitoring data in the most efficient method for all parties involved. Below is a more detailed list of the goals and objectives of the strategic plan.

- Create a monitoring framework that will enhance abilities to meet previously identified monitoring needs in the region
- Create a monitoring coordination committee to promote collaboration and coordination among monitoring agencies as well as guide monitoring efforts in the Lake St. Clair watershed
- Define additional goals and objectives not previously identified in the needs assessment
- Assess occurrence and distribution of monitoring in the region
- Maintain a database of current monitoring efforts for Lake St. Clair watershed communities as well as aid in organizational collaboration
- Ensure that all monitoring data collected meets standards defined within the strategic plan framework

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To set the stage for more detailed discussions about creating a coordinated monitoring framework for the Lake St. Clair watershed, the authors of this document asked Joe Rathbun, Environmental Quality Analyst with MDEQ, to discuss some important considerations for designing a complete monitoring program and establishing a successful sampling strategy. This introductory discussion appears below. The rest of the monitoring framework and strategic plan follows this discussion.

Guidelines to consider when designing a monitoring program

Monitoring Program Design

The specifics of designing and executing an environmental monitoring program have been described in many useful publications. These include Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska (U.S. EPA, 1991); Monitoring Guidance for Determining the Effectiveness of Nonpoint Source Controls (U.S. EPA, 1997); Planning Aquatic Ecosystem Restoration Monitoring Programs (U.S. Army Corps of Engineers, 1996); Statistical Methods for Environmental Pollution Monitoring (Gilbert, 1987); and Sampling Design and Statistical Methods for Environmental Biologists (Green, 1979). The following text will summarize some basic concepts applicable to monitoring water bodies like Lake St. Clair and its tributaries. The next section provides more details on sampling program designs, including the number of samples necessary to achieve specific statistical objectives.

Well prior to filling the first sample bottle or netting the first macroinvertebrate, it is essential to identify the goals, procedures and limitations of the monitoring program in as great of detail as possible. Steps in designing a monitoring program (modified from U.S. EPA, 1997) include:

- Identifying the objective, or purpose, of the monitoring program
- Assessing personnel, time and budget constraints
- Reviewing existing data
- Defining the specifics of the monitoring program
    - Monitored parameters
    - Sampling locations, frequency and duration
    - Sample analysis and data analysis procedures necessary to achieve the program objectives
- Establishing data reporting procedures and responsibilities

Defining Objectives

The most important step in designing a useful monitoring program is defining its objective(s). Typical general monitoring objectives include:

- Determining whether an impairment exists
- Determining the extent of an impairment
- Determining the cause(s) of an impairment
- Determining temporal trends of an impairment
- Determining the effectiveness of management practices intended to reduce or remove an impairment

Every monitoring program, regardless of objective, has certain common components (number and identity of parameters, sampling frequency and duration, etc.), the details of which must be decided during the program design phase. Descriptions of these monitoring components as related to the general objectives described above are listed in Table 6.

Table 6. General Characteristics of Monitoring Programs for Different Objectives.

Objective	Number of Measured Parameters	Frequency of Sampling	Duration of Sampling	Intensity of Data Analysis
Existence of impairment	Low to moderate, focused on desired use(s)	Moderate	Short	Low
Extent of impairment	Low	Low to moderate	Short to medium	Low to moderate
Cause(s) of impairment	Potentially high	Potentially high	Short to medium	High
Trend of impairment	Low	Moderate to high	Long	High
Management practice effectiveness	Low to moderate	Moderate to high	Medium to long	Moderate to high

Some general guidance on each of these program components are provided below.

Parameter Selection

The number of measured parameters can range from one to dozens, and they should be directly related to the project objectives. Additional factors influencing parameter selection, besides applicability to the project objectives, include the regulatory framework under which the monitoring is executed, existing historic data, and program resources.

In many cases some secondary variables, other than those directly related to the project objectives, may be measured, especially if they are relatively inexpensive and will perhaps be useful for purposes not yet described. In this case, it is necessary to (1) anticipate those undescribed purposes to the extent possible so that the extra variables provide useful data (e.g., are statistically valid), and (2) be sure the cost of the extra measurements does not preclude modifying the core monitoring program over time, as necessary.

Table 7 contains examples of sampling parameters for different monitoring objectives. Further discussion of variable selection is in U.S. EPA, 1991, and U.S Army Corps of Engineers, 1996.

Table 7. Example Sampling Parameters.

Monitoring Program Objective	Primary Parameters	Secondary Parameters
Evaluate effectiveness of BMPs to reduce stream bank erosion	Bank erosion rate, via erosion pins Hydrologic data, via USGS gage station	Streambed embeddedness Sediment grain size distribution Instream macroinvertebrate and/or fish community data
Assess lake trophic status	Water chemistry – phosphorus, nitrogen, chlorophyll *a* Secchi depth	Diurnal dissolved oxygen profile Algae and macrophyte biomass and community composition
Assess sediment quality	Sediment chemistry – organic contaminants (PCBs, PAHs, etc.), and metals	Total organic carbon Acid-volatile sulfides Sediment bioassays Macroinvertebrate community composition

Sampling Frequency

Sampling frequency – the number of stations (spatial frequency) and the number of samples collected at each station (temporal frequency) – can vary from one sample at one station to dozens of samples at multiple stations (or even thousands of readings, if using continuously-reading in-situ meters), depending on the monitoring objectives. Spatial frequency and temporal frequency are often independent; trend analysis can involve many samples at a single station, while the extent of an impairment can be assessed with only a small number of measurements at numerous stations.

An important aspect of temporal sampling frequency is the number of samples to collect at each station (minimum sample number) to characterize conditions at the station with known statistical confidence. This is further described in the following section. Perhaps the most common shortcoming of monitoring programs is collecting too few samples to satisfy the program objectives. There don't necessarily have to be *lots* of samples, just *enough* samples to meet program objectives.

Sampling Duration

Sampling duration – the time span over which samples are collected – can range from a single instantaneous reading with an in-situ meter to many years of measurements, depending on the monitoring objectives. Many monitoring objectives can be addressed in a single field season (typically spring through fall in a single year), although trend analysis or assessments of management practice effectiveness usually require several years of data. Studies lasting for decades, like the National Science Foundation's Long Term Ecological Research Network, are also extremely valuable, and should be considered for the Lake St. Clair ecosystem. It should be noted that long-term monitoring programs do not necessarily require collecting samples every year – it can be acceptable to sample regularly but intermittently. For instance, the Michigan Department of Environmental Quality's Stream Bioassessment Program samples every major watershed in the state on a rotating schedule of once every five years.

Data Analysis

Data analysis – the graphical, mathematical, and statistical techniques applied to data to assist with deriving conclusions – can vary from calculating and graphing simple parameter averages to sophisticated analyses like three-dimensional illustrations of principal component analysis results for contaminant "fingerprinting", or statistically rigorous temporal trend analyses, depending on the monitoring objectives. It is extremely important that the data analysis techniques to be used are identified in the very early stages of designing the monitoring program, because they strongly influence the type and quantity of data required. For example, a quantitative assessment of water quality status for a specific parameter at a single station in a single year requires collection of enough samples to calculate a mean concentration value that has a known precision. Based on recent work in the Rouge River watershed (Michigan, USA) this can range from 10 to 20 samples per station per field season to characterize dry weather conditions for a parameter like total phosphorus; or from 50 to a hundred or more samples per station per field season to characterize dry weather conditions for a more variable parameter like coliform bacteria, or almost any water quality parameter under wet weather conditions. U.S. EPA (1997) and Gilbert (1987) contain good discussions of data analysis techniques.

Two other aspects of designing a monitoring program are pertinent to current plans for monitoring the Lake St. Clair watershed – the technical issue of selecting reference stations, and the managerial issues of multi-agency monitoring programs.

Selecting Reference Sites

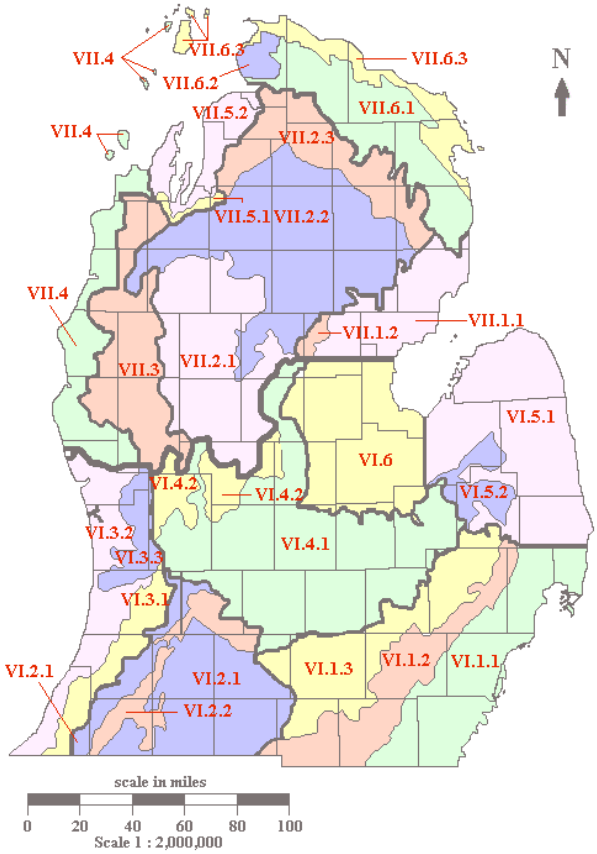
Reference sites are used to establish "background conditions" against which conditions at other sampled locations are evaluated. They are not necessary for all monitoring programs; they are most commonly used in monitoring programs supporting remedial activities. Where needed, their choice is extremely important as their data contributes to project goals, the choice of remediation actions, and final remediation costs.

A useful reference site must meet two general criteria: it must be minimally impacted by the impairment under study (if not all human influence), while at the same time be otherwise representative of the impacted sites. A hierarchy of preferred reference site locations suitable for most environmental investigations would be:

1. Same stream reach or lake as the impacted site(s), upstream or otherwise removed from the impact
2. Same watershed if a lake, or same watershed in the same stream order (1st order, 2nd order, etc.; Figure 5) if a river
3. Adjacent watershed or water body, in the same ecoregion (Figure 6)

Figure 5. Example of Stream Order Classification.

Figure 6. Michigan Natural Features Inventory ecoregions



Where possible, it is desirable to have multiple reference sites to account for spatial variability in background conditions.

Publications with recommendations for selecting reference sites include Bailey et al (1998), Hughes (1985; 1995), Hughes et al (1986; 1990), Hunt et al (2001), Mrazik (1999), Reynoldson et al (1997), U.S. Forest Service (1994), and Zampella and Bunnell (1998).

Multi-Agency Monitoring Studies

Optimally, the coordinated, holistic monitoring program envisioned for the Lake St. Clair watershed will be interdisciplinary, interagency, and trinational (U.S., Canada, and the First Nations). This objective raises several challenging issues, including:

- All of the involved agencies and stakeholders must be brought together to identify and prioritize short-term and long-term monitoring objectives, and decide which agencies are capable and willing to address each objective under their current monitoring programs;
- A limited number of agencies must be identified to act as monitoring coordinators, to track the status of the monitoring activities;
- Technical staffs will have to integrate new objectives and activities into their current monitoring programs – or vice versa – at a time of extremely limited financial and organizational support;
- One agency should act as a data repository, so that monitoring results from multiple agencies are available from a single source in a common format; and
- Agencies should coordinate sampling and analysis methods in order to ensure data comparability.

Sampling Strategy Creation

This section describes several of the numerous sampling strategies applicable to environmental monitoring, and also gives two examples of designing a sampling survey based on a well-defined objective. Much of this information is explained more fully in U.S. EPA (1997) and Gilbert (1987).

Sampling Strategies

To select among the many potential sampling strategies requires:

- Clear, quantitative program objectives
- An understanding of the behavior of the watershed or water body, optimally from historic data
- To the extent possible, some knowledge or assumptions about the source(s) of the impairment under study

Monitoring Program Types – Parameter Estimation vs. Hypothesis Testing

Virtually all monitoring programs fall into one of two general categories - parameter estimation or hypothesis testing.

Parameter estimation studies applicable to the Lake St. Clair watershed include:

- environmental status studies
    - water quality
    - sediment quality

    - biological integrity
- reconnaissance surveys

Monitoring studies taking a hypothesis testing approach include:

- trend studies
- assessing best management practice (BMP) performance
- effects studies (e.g. sediment bioassays)
- cause and effect studies

Some studies employ both approaches, or a study of one type can lead to a study of the other type. For example, a Total Maximum Daily Load (TMDL) program (a parameter estimation study) can lead to the execution and performance monitoring of various point and nonpoint BMPs (a hypothesis testing study). Parameter estimation studies and hypothesis testing studies usually have different designs, sampling intensity requirements, and data analysis procedures. These are briefly described below.

Sampling Designs – Probabilistic vs. Targeted Designs

Most monitoring programs are based on either a probabilistic design or a targeted design. Probabilistic designs randomly select sampling sites and/or sampling times to provide a statistically unbiased assessment of the larger water body. Targeted designs select monitoring sites based on the existence of known existing problems or knowledge of future events, such as the installation of a BMP. More detailed information on sampling designs, including calculating the necessary number of samples, are further described in U.S. EPA, 1997 and Gilbert, 1987.

Both probabilistic and targeted sampling designs are intended to yield an estimate of the mean of the parameter of interest with a known accuracy – for example, average phosphorus concentrations in a lake during a field season, average number of mayflies in a river reach, or average stream bank erosion rate adjacent to a cattle pasture. Study objectives concerned with characteristics other than parameter means, such as the probability of sampling sediment contaminant hot spots, require a different approach and usually a greater number of samples, and are not discussed here. Hot spot studies are discussed in Gilbert, 1987.

Probabilistic Sampling Designs

Probabilistic sampling designs are ideal for collecting data from a specific area and/or time interval that may be extrapolated to other, unsampled areas and/or time intervals with a known statistical confidence.

<u>Simple Random Sampling</u>

In simple random sampling, every potential sample (in statistical jargon, the sampling unit) in the larger universe of all possible samples (the population) has an equal chance of being collected. Simple random sampling is appropriate when there are no major trends, cycles or patterns in the target population – for example:

- well-mixed lakes during the growing season,
- well-mixed rivers under dry weather conditions, and
- sediments in relatively homogenous deposits, like deposition zones close to the mouths of rivers.

<u>Stratified Random Sampling</u>

If the parameter of interest exhibits spatial or temporal trends, cycles or patterns (i.e., is temporally or spatially heterogeneous), stratified random sampling will produce a better estimation of the parameter mean. Examples of spatially or temporally heterogeneous environments or populations include:

- sediment deposits over large areas,
- water quality during a rain event, or over a full year,
- fish or macroinvertebrate populations in different habitats (pools, riffles, runs, etc.), and
- geomorphic dimensions in different stream orders.

Systematic Sampling

In systematic sampling, the first sample is taken from a randomly chosen starting point or time, and subsequent samples are collected at set distances or times from the first sample. An example would be a project intended to characterize a 10-mile reach of river that is limited by budgetary constraints to a total of 10 samples. The first sample would be collected at a random location in the first river mile, and the remaining nine samples taken at one-mile increments thereafter. Gilbert (1987) recommends systematic sampling when investigating long-term trends or seasonal cycles.

Other probabilistic sampling designs, such as multiple systematic sampling, systematic stratified sampling, cluster sampling, two-staged sampling, and double sampling, are discussed in U.S. EPA, 1997 and Gilbert, 1987.

Targeted Sampling Designs

Targeted designs select monitoring sites based on known existing problems or knowledge of future events such as the installation of a BMP. Targeted sampling designs can be combined with probabilistic designs. For example, subjectively chosen sampling sites might be added to a study intended to characterize sediment quality in a large reservoir. Most of the reservoir would be sampled using a random or stratified random scheme, while extra, subjectively chosen stations could be added to sediment deposits near known industrial outfalls.

Subjective Sampling

Subjective sampling is commonly used (perhaps overused) when much is known about the system monitored, and the geographic scope of the system is limited. Subjective sampling is best used in a reconnaissance survey to generally characterize conditions prior to additional sampling using a more rigorous survey design. Other legitimate uses of subjective sampling include:

- sampling upstream and downstream of a suspected pollution source,
- investigations of the extent of an algae bloom in a lake, and
- preliminarily assessing the extent of streambank erosion in a watershed by making observations from road crossings.

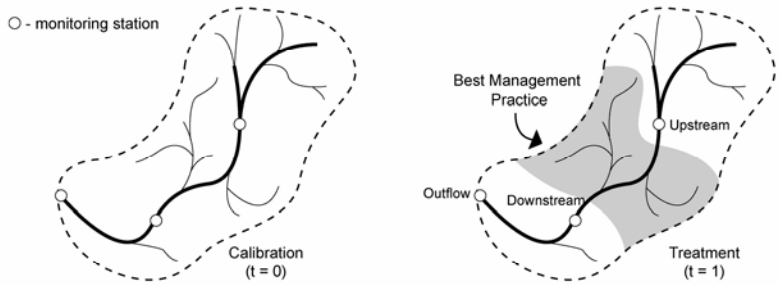
Estimates of the spatial or temporal extent of an impairment derived from subjective sampling are not necessarily reflective of conditions at other locations or times – that is, **they cannot be used to extrapolate to unsampled areas**.

Paired Watershed and Nested Paired Watershed

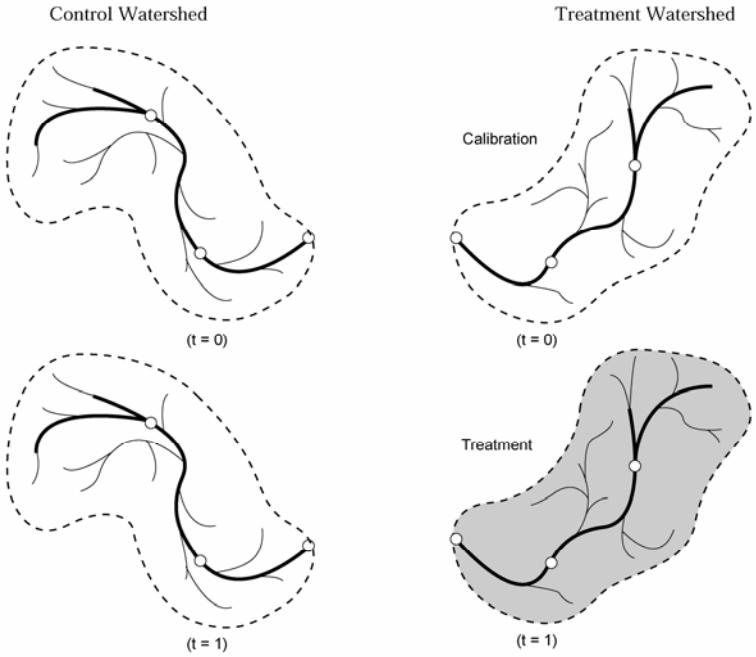
A paired watershed or a nested paired watershed sampling design is very useful for assessing the effectiveness of best management practices (BMPs), or the severity of pollution problems. In

a paired watershed sampling design, two watersheds are sampled – one is a control (or reference) watershed and the other is a treatment watershed (i.e. receives the BMP. See Figure 7). It is essential that the two watersheds be as similar as possible (other than the presence of the BMP in one), in terms of geology, hydrology, rainfall patterns, vegetation types, etc. The reference documents for selecting reference locations cited earlier should be consulted for details.

Figure 7. Graphic of nested paired and paired watershed study designs.



A) Nested Paired Watershed Study Design



B) Paired Watershed Study Design Adapted from U.S. EPA, 1997

In a nested paired watershed design, a single watershed is sampled, with one or more sampling locations both upstream and downstream of the BMP (Figure 7). This is also called an "above-and-below" or "control-impact" study design.

In both paired watershed and nested paired watershed designs, samples are collected before the BMP is installed (calibration, t = 0) and after (treatment, t = 1), so that both temporal and spatial variation can be assessed. This is crucial to accurately interpreting the data, and is called a Before-After/Control-Impact (BACI) design. BACI designs are especially useful for evaluating BMP effectiveness.

Additional Sampling Site Selection Issues – Where and How Many

Other recommendations for conducting environmental studies besides the choice of sampling designs include:

- Water sampling sites can be placed at the confluence of major tributaries to a major river, lake, reservoir or coastal area to isolate portions of the watershed and determine the relative contribution of each tributary to the overall pollution load. This technique is especially useful for mass balance studies.
- Water quality studies of lakes or reservoirs should sample the inlet(s) and outlet. This technique is also used in mass balance studies.
- Water quality studies of lakes or reservoirs should also consider seasonal stratification, wherein the water body exhibits distinct upper and lower layers (epilimnion and hypolimnion, respectively) in the summer which often contain significantly different concentrations of parameters like dissolved oxygen, chlorophyll or nutrients. Studies of vertically stratified water bodies often use a stratified random sampling or stratified targeted sampling design.
- Streams can also be stratified, but horizontally (across the channel) rather than vertically. Stratified sampling designs can be employed, or some reconnaissance sampling can identify well-mixed areas in the river cross-section (often, the middle or deepest portion of the stream channel).
- Sediment quality surveys often focus on deposition areas containing fine sediments (especially silts), since many contaminants preferentially adsorb to fine grained sediment. Sediment deposition areas can be found with a reconnaissance survey or by consideration of sediment transport mechanisms.
- When faced with horizontally or vertically stratified water or sediment environments, or with temporally variable situations, it is tempting to combine, or composite, individual samples into a single sample intended to represent spatially or temporally “average” conditions. This can result in significant cost savings. Sample compositing should be used with great caution, however, because the “information content” or statistical usefulness of a composite sample is much lower than the individual samples used to create it. Appropriate compositing schemes include flow-weighted composites to characterize storm events or certain cross-channel water quality conditions.

A key aspect of any study design is how many samples to collect (known as ‘n’). Each of the probabilistic survey designs described here have a slightly different formula for calculating ‘n’, and these are described in the EPA and Gilbert references mentioned earlier. Other resources for calculating ‘n’ for different monitoring objectives are found at the following web sites: http://calculators.stat.ucla.edu/powercalc/ or http://www.epa.gov/earth1r6/6wq/ecopro/watershd/monitrng/tools/sampling.htm. .

Survey Design Examples

Below are two examples of designing a sampling survey for specific study objectives. Both are abbreviated, emphasizing issues of study design but minimizing issues like the details of sample collection or data analysis.

Example #1: Evaluating the Effectiveness of a Streambank Stabilization Project

Streambank erosion can be a significant cause of sedimentation problems in rivers. If the erosion is due to local land use problems rather than watershed-wide alterations to the hydrologic regime, it is often appropriate to install a physical BMP appropriate to the cause of the problem (e.g., cattle exclusion, riparian plantings, streambank regrading and bioengineering, etc.). This example is generic to any of these BMPs.

Monitoring Objective: Evaluate the effectiveness of the physical BMP in reducing the erosion of streambank soils.

Historic Data: Historic site-specific streambank erosion rates are seldom available, and this example assumes there are no data for this stream.

Survey Design:

Selection of Parameters: The primary parameters directly related to the study objective are bank erosion rate as measured by erosion pins, and hydrologic data gathered from a nearby USGS gage station (if available) or a temporary gage station. Secondary parameters of potential interest include expressions of in-stream conditions like substrate embeddedness (inexpensive) and sediment grain size distribution via a pebble count (inexpensive), and perhaps instream macroinvertebrate or fish community data (relatively expensive).

Number and Location of Stations: This is a hypothesis testing study, and is best performed with a nested paired watershed/BACI sampling design. Specifically, erosion pins would be (a) installed upstream of the BMP installation (the control), and within the BMP location (the impacted area, which will be a reach of the stream channel), and (b) installed and monitored in both areas before and after the BMP is installed. The number of pins installed will depend on the length of stream restored and is subjective, but there should be at least five pins installed horizontally near the water line at both the upstream and BMP sampling locations if the streambank is less than 2'-3' tall. If the bank is taller, additional pins should be installed vertically up the face of the bank, as well as horizontally near the water line (Rathbun, unpublished data).

Data on the stream discharge (cubic feet per second) would be collected at the gage station for each storm that occurred during the study period.

Data for the secondary parameters should also be collected in the control and impacted areas, before and after BMP installation.

Frequency and Duration of Sampling: Pin heights should be measured after each major rain storm for at least one field season. Stream discharge data should be collected for each "major" event (which should be defined before the study begins, and will depend on the responsiveness of the stream to rain events; 0.1" or 0.2" over 24 hours are common targets).

The secondary parameters will have their own appropriate sampling frequencies; embeddedness estimates and pebble counts could be performed every time the erosion pins are measured, and macroinvertebrate and fish populations could be assessed once a year.

Data Analysis: Average erosion rates (cm/year) can be calculated directly from the field data. Mass loadings of eroded streambank soil (pounds/foot of streambank/year) can be calculated from the erosion rate data if the density of the soil is known or assumed.

The secondary parameters, if measured, will also have their own data analysis procedures.

Hypothesis tests like a Student's t-test or analysis of variance (ANOVA) would be applied to the before-after/control-impact data for each parameter, to establish whether the BMP:

- reduced the soil erosion rate in the treated area,
- reduced the mass loading of eroded soil to the stream,
- altered the grain size distribution of the bedded sediments in or downstream of the treated area, or
- improved the biotic communities in the treated stream reach.

The relationship between erosion rate or mass loadings, and stream discharge during each storm, would be assessed using linear regression. Stream discharge would be the independent variable and erosion rate or loading the dependent variable. It would be very desirable to have data for at least 20 storm events, although this would likely require more than one or even two field seasons; five to 10 storm events would be more realistic for a 1-2 year study.

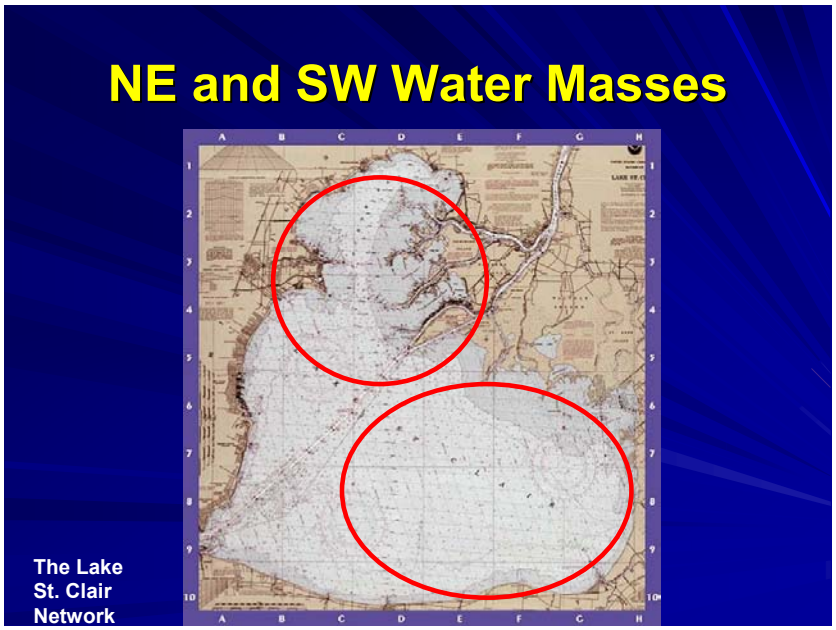
Example #2: Survey Design for Assessing the Status of Chlorophyll *a* in Lake St. Clair

Chlorophyll *a* is commonly used as an indication of trophic status in lakes, with higher concentrations indicating nutrient enrichment due to phosphorus inputs from agricultural practices, sewage treatment plants, and other sources (i.e. "eutrophication").

Monitoring Objective: Determine typical chlorophyll *a* concentrations in Lake St. Clair over a single field season.

Historic Data: Leach (1980) identified two distinct and consistent water "masses" in Lake St. Clair; a northwestern water mass (NW) consisting primarily of Lake Huron water flowing from the main channels of the St. Clair River, and a southeastern water mass (SE) consisting primarily of water from the Ontario tributaries (Thames River, Sydenham River, etc.) (Figure 8). Leach also found that (a) water quality was consistently better in the NW water mass than the SE water mass over a five-year period, and (b) a single sampling station in each water mass was sufficient for characterizing water quality conditions (chloride, temperature, nitrate, chlorophyll *a*, particulate organic carbon, and secchi disk transparency) in that mass.

Figure 8. Prominent Water Masses in Lake St. Clair.



Over the period of 1975 to 1980, Lang, et al. (1988) found that loadings of phosphorus from the Sydenham River (232 metric tonnes/year) and the Thames River (788 tonnes/year) dominated tributary loadings to the lake, and were considerably greater than loadings from the most significant U.S. tributary source, the Clinton River (128 tonnes/year). These data suggest that phosphorus concentrations, and therefore presumably chlorophyll *a* concentrations, in the two water masses may be expected to be different. Consequently, sampling the two water masses separately, through either a subjective sampling design or a stratified random sampling design, would be appropriate.

Sampling by the Michigan Department of Natural Resources in 1973 found that chlorophyll *a* concentrations averaged 4.2 µg/L in the Michigan side of the lake – primarily the NW water mass (n = 12 samples each month, from July through September; average variance for the 3 months = 2.9 µg/L).

Survey Design:

Selection of Parameters: The primary parameter directly related to the study objective is chlorophyll *a*. Total phosphorus and/or ortho phosphorus might also be measured, although the correlation between phosphorus concentrations and chlorophyll concentrations is often weak due to lag times in algae growth rates. Secondary parameters of potential interest include dissolved oxygen and water temperature (inexpensive, compared to total phosphorus analyses), secchi transparency (inexpensive), and algae enumeration and identification (expensive).

Number and Location of Stations: This is a parameter estimation study, and given Leach's findings that the NW and SE water masses are relatively homogeneous internally but different from each other, it can be addressed with either a targeted sampling design (one sampling site subjectively assigned to the middle of each water mass) or a stratified random sampling design (one sampling site randomly selected from a grid of multiple potential sampling sites).

Frequency of Sampling:

Using the MDNR data as input, the EPA sample number calculator cites above yielded the following results:

Accuracy of Mean Estimate	Number of Samples to Collect from Each Water Mass*
± 0.5 µg/L	133
± 1.0 µg/L	35
± 2.0 µg/L	11

* To estimate the mean concentration in each water mass to within the µg/L value specified in the first column, at a 95% level of confidence.

Note that increasing the accuracy of the estimate of the mean chlorophyll *a* concentration increases the number of samples to be collected. This is always true; greater accuracy requires greater effort. The required accuracy, and therefore the required number of samples, will depend on the objective of the study. If an accuracy of ± 1.0 µg/L is sufficient for the study objectives, and given Leach's findings about the homogeneity of the two water masses in the lake, plus knowing that chlorophyll *a* concentrations are most consistent in the summer, the following sampling scenarios would be adequate to determine the typical chlorophyll *a* concentration in each water mass:

- Collect a water sample from a single station in each water mass, three times a week from the beginning of June to the end of August (14 weeks; yields 42 samples)
- Collect a water sample from each of three stations in each water mass, once a week for the same time period (yields 42 samples). This scenario has the benefit of confirming Leach's findings that the water masses are homogeneous.

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Considerations for Coordinating Monitoring

The sections below provide a description of the elements necessary for a coordinated monitoring approach for the Lake St. Clair watershed. This strategic plan focuses on widely applicable monitoring strategies, rather than specific recommendations for addressing individual monitoring needs or improving individual monitoring programs. More specific recommendations can be found in the previous gap analysis. Therefore, the analysis below summarizes findings from the gap analysis and makes recommendations for measures to improve the monitoring network as a whole.

The sections below follow a logical and somewhat linear order. This is meant mostly to provide a simple framework for discussion. Recommendations should be prioritized and addressed on a cost-effectiveness basis.

Monitoring Coordination Committee

The creation of a broad-based monitoring coordination committee was identified through the Lake St. Clair monitoring strategic planning process as the primary component needed for

developing a comprehensive, coordinated, long-term monitoring strategy for the Lake St. Clair watershed. The function of this committee would be to establish monitoring needs in the watershed, maintain the inventory of current monitoring programs, coordinate U.S. monitoring organizations and direct future regional monitoring in a way that best meets the needs of the Lake St. Clair watershed.

A number of regional monitoring programs throughout the country have been developed to address specific regional environmental concerns. Although the approaches of each of these monitoring programs differ, their analysis may prove to be useful when developing the Lake St. Clair monitoring coordination committee and strategic plan. A selection of regional monitoring programs are discussed below.

- **Southern California Coastal Water Research Project** (SCCWRP) is a joint powers, publically funded agency formed in 1969 to address the effects of watsewater and other discharges to the Southrn California coastal marine environment. It formed because several government agencies had a common mission that could better be addressed by pooling resources and knowledge in one central organization. The mission of SCCWRP is to gather the necessary scientific information so that member agencies can effectively, and cost efficiently, protect the Southern California marine environment.

  SCCWRP is governed by a commission composed of nine members, including representatives of city, county, state and federal government agencies responsible for monitoring and protecting the marine environment. Included in this group are the cities of Los Angeles and San Diego; the County Sanitation Districts of Los Angeles and Orange Counties; the Los Angeles, San Diego, and Santa Ana Regional Water Quality Control Boards; the State Water Resources Control Board; and the U.S. Environmental Protection Agency.

  In 1989, the National Research Council (NRC) conducted a review of monitoring in the Southern California Coast and found that despite the $17 million spent annually it was not possible to properly assess the status of the Southern California marine environment. The NRC found that nearly all monitoring was clustered in only five percent of the region, methodologies used by agencies were incomparable, and data storage differences limited data analysis and comparability possibilities.

  At that point the SCCWRP, with the approval of regional regulatory agencies, developed a monitoring strategy that called for regional monitoring agencies (which included 63 agencies) to abandon their independent monitoring programs every fifth year to contribute to a regional monitoring effort directed by SCCWRP scientists. By waiving normal regulatory requirements in exchange for participation in the regional effort, regulatory agencies were able to encourage most monitoring agencies to participate. Regional monitoring reports are currently available for 1994 and 1998 and data is being collected for 2003. (http://www.sccwrp.org/)

- **The South Florida Water Management District Water Quality Monitoring Program** monitors surface water in a variety of locations, including canals, pumping stations, agricultural discharges and many other types of aquatic environments. The district also monitors sediments and fish for a variety of pollutants. The majority of the water quality monitoring programs provide data for

legal mandates, such as the Everglades Forever Act and the Lake Okeechobee Protection Plan. Other government agencies assist in water quality sampling in Florida Bay, Everglades National Park and Biscayne Bay. Some state, federal and private laboratories also assist with water quality analyses. (http://www.sfwmd.gov/org/ema/envmon/wqm/)

- The **Long Term Resource Monitoring Program** is being implemented by the U.S. Geological Survey (USGS) in cooperation with the five Upper Mississippi River System states (Illinois, Iowa, Minnesota, Missouri, and Wisconsin), with guidance and overall program responsibility provided by the U.S. Army Corps of Engineers. Authorized under the Water Resources Development Act of 1986 (Public Law 99-662) as an element of the Corps' Environmental Management Program, the mission of this program is to provide decision makers with the information needed to maintain the integrity of the Upper Mississippi River ecosystem. The long-term goals of the program are to understand the system, determine resource trends and impacts, develop management alternatives, manage information, and develop useful products. (http://www.umesc.usgs.gov/ltrmp.html)

To be effective, the Lake St. Clair monitoring coordination committee should be comprised of representatives from all levels of monitoring organizations in the region. It will be essential for the committee to communicate and coordinate beyond immediate members into the larger monitoring community. The focus of the monitoring committee will be on broad watershed-wide monitoring goals, rather than more geographically- or media-focused goals that drive most monitoring programs.

A number of potential frameworks for this coordination committee have been proposed. These include:

- An informal monitoring coordination committee comprised of a network of representatives from various monitoring organizations in the watershed;
- A "super-watershed" monitoring coordination committee that would build upon watershed and subwatershed plans to ensure that Lake St. Clair watershed monitoring goals are met; and
- An independently-funded and driven organization established through congressional or state mandate or bilateral agreement to conduct essential monitoring and synthesize data being collected by other organizations.

The most effective method for monitoring coordination would likely come from an independent monitoring body with a congressional, state or regional mandate to oversee monitoring in the watershed. Although this approach may ultimately be the most effective, it will also be the most financially and politically challenging. The most immediate feasible approach is to allow for the evolution of such a monitoring body by first developing a committee based on representation from monitoring agencies in the region. Using a phased approach to create a monitoring coordination body would allow the group to develop products and support upon which to base a proposal for independent funding.

The committee would also coordinate binationally through the Monitoring Upper Great Lakes Connecting Channels (MUGLCC) committee so that monitoring is effectively coordinated across the international boundary and along the entire connecting channel corridor.

Recommendations

- Create a U.S. monitoring coordination committee to develop and implement a comprehensive, coordinated, long-term monitoring strategy for the U.S. portion of the Lake St. Clair watershed. The main objectives of the committee would be to:
  a. Establish a priority list of detailed monitoring needs in the watershed;
  b. Encourage the sharing of data and information among all interested U.S., Canadian, and tribal/First Nation authorities;
  c. Coordinate monitoring among monitoring organizations toward basinwide needs;
  d. Direct future regional monitoring in a way that best meets basinwide monitoring needs; and
  e. Coordinate with binational monitoring efforts such as the MUGLCC committee.

Monitoring Goals and Objectives

In general, monitoring programs and scientific studies are established to generate, collect and analyze information. Monitoring data can be used to better protect human health, to determine ecosystem health and to evaluate the impacts of pollution on the environment. At the same time, monitoring can also provide important insights into changes in the ecosystem. Routine water quality, air quality and ecosystem monitoring programs provide background information and allow the analysis of trends over time. Specific studies may focus on emerging issues to collect and evaluate the information needed to develop policies and address impacts. Periodic studies help to assess both the status of the ecosystem and the success or failure of corrective actions.

In order to maximize the utility of monitoring data, it is important to consider not only what information is being collected but also how and why the information is being collected. Monitoring purposes or objectives are important when considering a merger of information from disparate programs within a single watershed like Lake St. Clair. Although information about the same parameter may be collected by two different programs, if the program objectives are appreciably different, the data may not be compatible. For example, a monitoring program that collects chemical parameters from surface water locations to determine status and trends will likely utilize different techniques than one that collects chemistry data to establish loadings or determine pollutant source identification. On the other hand, there are situations such as beach monitoring and illicit discharge monitoring where two programs collect similar data that can prove to be mutually beneficial. Data collected through watershed monitoring can aid in the prediction of beach contamination and consequently serve as a very useful beach monitoring tool. The first step in any comparative analysis of monitoring data should be a comparison of program objectives.

Recommendations

- Programs with conflicting goals or objectives should be examined for areas of compromise or adaptation to better accommodate watershed-wide goals.
- Effort should be directed at aligning program objectives to allow for an effective merger of information from disparate programs.

Spatial Monitoring Network Design

Consideration of the spatial design of monitoring programs is a key component to the monitoring strategic plan. A spatial monitoring framework should be designed for each key monitoring objective in the region. Each spatial monitoring design should consider the elements described in this section.

One key concern when considering spatial sampling design is determining the minimum statistically valid sampling locations possible for the area in question. Without the minimum number of sampling sites, data collected will not be able to provide usable results to establish trends or determine sources. There are currently formulas in place that will calculate these values. Please see the 'Creation of Sampling Strategy' for an example.

Another key consideration is to choose sampling locations that are most likely to be representative of the system as a whole. Depending on the monitoring objective, this could be based on a number of environmental situations, such as land use, geology, or pollutant source.

An additional component to creating a spatial monitoring framework is to determine where monitoring is currently being performed. Sampling location expansion can only be considered after there is an understanding of current sampling spatial patterns.

Where possible, a spatial analysis has been performed for each of the previously identified monitoring needs in the gap analysis. The brief summaries below show findings from the monitoring inventory. This information can be used as the starting point for developing a more detailed spatial sampling program.

Habitat and Biodiversity

Macroinvertebrate Sampling

A number of programs sample macroinvertebrate population health throughout the state. The broadest state run program samples every major watershed in the state on a rotating five-year cycle. USGS samples benthic macroinvertebrates throughout Macomb, Oakland, and Sanilac counties. There are additional programs that sample in the Clinton and St. Clair watersheds.

Assessing Quality of Habitat and Natural Communities

A single program covers the entire Lake St. Clair watershed, but also extends across the entire state. Several other efforts monitor aspects that relate to habitat or focus on more narrowly defined habitat (i.e. habitat of individual fish species).

Monitoring Fish and Wildlife Community Health

Michigan and Ontario administer broad programs to track sport fish populations in the lake and St. Clair River. Further, there are a few programs that assess fish populations in tributaries. While the monitoring of sportfish appears adequate, monitoring for other fish species may be lacking. Monitoring for non-fish wildlife species is sparse. The Michigan Natural Features Inventory and the Marsh Monitoring Program are the only programs with significant coverage of a range of species and St. Clair basin geography.

Human Health

Establishing Fish Advisories

Fish contaminant sampling is clustered primarily along the St. Clair and Clinton rivers and in Lake St. Clair.

Monitoring Drinking Water

Each drinking water treatment facility throughout the Lake St. Clair watershed is required to maintain and monitor post-treatment drinking water. Source water monitoring is being performed at various locations throughout the watershed.

Determining Beach Safety

Beach monitoring for *E. coli* is conducted on at least a weekly basis throughout the summer months at five beaches along the Lake St. Clair shore south of Point Huron. The beach at New Baltimore Park is monitored, but no other beaches inside Anchor Bay are regularly monitored. St. Clair County monitors an additional 17 coastal beaches at unknown locations. Inland beaches are regularly monitored only in Oakland County and a few other locations in other counties. There appears to be no ongoing monitoring of open lake conditions in Lake St. Clair that may result in beach contamination.

Land Use

Monitoring Impacts of Land Use on Water Quality

With their Geographic Information System Inventory of land-based data and their Environmental Stewardship Community Inventory of community master plans and ordinances, Oakland County appears to be collecting some level of sustainable zoning and master planning data. In addition, Southeast Michigan Council of Governments' (SEMCOG) Aerial Photography and Demographic Data provide information for four counties in the Lake St. Clair watershed including Wayne, Oakland, Macomb and St. Clair. Sanilac and Lapeer counties have no known consolidated regional planning data and all counties other than Oakland appear to lack focused data collection on sustainable zoning and master planning as they relate to water resources and natural area protection.

Identifying Pollutant Sources

Monitoring pollutant sources in the Lake St. Clair watershed appears to be relatively well-distributed throughout the basin.

Monitoring Combined Sewer Overflow (CSO)/Sanitary Sewer Overflow (SSO) Events

Only a few combined and separated sewers are directly monitored in the basin. All sewer monitoring is conducted in Oakland and Macomb counties. Other programs exist that monitor surface water for impacts from sewer overflow events in streams and at beaches, but this data cannot be directly related to sewers.

Identifying Illicit Discharges

The Macomb County Health Department is currently focusing on identifying illicit discharges in the north branch of the Clinton River and Anchor Bay. Macomb County Public Works administers a similar program in Anchor Bay and Lake St. Clair. They also manage the Bear Creek Clean Water Initiative which identifies sources of *E. coli* contamination in Bear Creek. St. Clair County Health Department's Illicit Discharge Elimination Program (IDEP) focuses on the elimination of improper connections in Anchor Bay and the Pine River. The Oakland County Drain Commissioner's Office manages Oakland County's IDEP that focuses on the elimination of improper connections to the storm sewer system.

Supporting Flood Forecasting

The Hydraulic Discharge Measurements program, managed by the U. S. Army Corps of Engineers Detroit District, collects river velocity, magnitude and direction at about 20 sites in

the St. Clair and Detroit Rivers. The Flood Forecasting program, managed by the Lower Thames Valley Conservation Authority, provides flood forecasting information through collection of precipitation data.

Identifying Contaminant Sources

Programs which manage and monitor hazardous waste occurrence have a widespread sampling distribution throughout the basin. Another program managed by Environment Canada, the National Pollutant Release Inventory (NPRI), monitors pollutants released in Canada.

General Monitoring

Assessing Water Quality

Water quality monitoring in the region appears to be fairly well-represented. Monitoring sites were identified throughout the entire watershed. The most intense sampling appears to be taking place in Oakland and Macomb counties, but it is important to look at each program separately to determine which parameters are being sampled at each location.

Assessing Sediment Quality

Although much of the Lake St. Clair watershed is currently being monitored for sediment quality, there may be a need to expand coverage into areas of St. Clair, Lapeer, and Sanilac counties including the Bell, Pine and Black rivers.

Monitoring Air Quality

The majority of air quality monitoring appears to be focused in the more heavily populated and industrially intense Detroit metro and St. Clair River regions.

Weather Monitoring

Two operational buoys in Lake St. Clair measure various physical parameters including wind, air, and surface water conditions. There is an extensive precipitation monitoring program in Macomb, Oakland, and Wayne counties, but no data collection occurs for other weather parameters such as wind or atmospheric conditions. Based on available information, it appears as if Sanilac, Lapeer and St. Clair counties have no weather monitoring programs.

Monitoring Water Flow and Conditions

Most of the water flow and physical condition monitoring in the Lake St. Clair watershed appears to be focused in Oakland and Macomb counties and in the St. Clair and Detroit rivers. Sampling in St. Clair, Sanilac, Lapeer, and Wayne counties, as well as in Lake St. Clair, is very limited.

Quantifying Atmospheric Deposition

Quantifying atmospheric deposition in the Lake St. Clair watershed is addressed most directly by one monitoring program, the Integrated Atmospheric Deposition Network (IADN), which includes two stations in the Lake St. Clair watershed. The majority of air quality monitoring appears to be focused in the more heavily populated and industrially intense Detroit metro and St. Clair River regions.

Tracking Total Maximum Daily Load (TMDL)

One approved TMDL has been developed in the Lake St. Clair watershed along Crapaud Creek, where monitoring continues to be focused on determining the success of pollution control

activities. Ten additional TMDLs are scheduled for development addressing different stream segments in the watershed.

Delisting Areas of Concern

There are no known programs focused on monitoring conditions for delisting Areas of Concern within the Lake St. Clair watershed.

Monitoring Permit Compliance

Monitoring permit compliance in the Lake St. Clair watershed appears to be relatively well-distributed throughout the basin.

Recommendations

- Determine the statistically valid number of sampling sites and maintain at least that many sampling locations for each area under consideration.
- Identify key sampling locations that may be representative of the system being sampled.
- Consider current monitoring locations and, if appropriate, expand sampling into areas where currently none exist.

Temporal Monitoring Network Design

Along with spatial design, the temporal design of a monitoring strategic plan is an important consideration. It is important to consider each monitoring need and its temporal sampling requirements. Temporal patterns based on parameters rather than entire programs will often yield the most useful results and will produce data that can be compared across programs. Combining program data from yearly sampling programs and monthly sampling programs, for instance, could have very limited utility in many cases. Determining the appropriate temporal scale for sampling and making this information available to all parties interested in monitoring will greatly increase the utility of information collected.

Temporal monitoring patterns should be developed based on the type of sampling conditions. Storm-event samples, low-flow samples, regular-interval samples or continuous monitoring all meet different monitoring objectives and require varied sampling frequency. Consideration of the scientifically credible number of yearly observations is necessary for a statistically defensible sampling scheme. Without a minimum number of samples, it is possible that data collected would have little to no value.

According to the monitoring inventory, sampling programs vary considerably when considering the temporal design. It is difficult to comment specifically on the temporal scales currently being addressed by sampling programs. The depth of the monitoring inventory did not allow for complete temporal analysis of all parameters sampled for each program. There is, however, a large amount of temporal information available that can be searched for on a case by case basis. Such an analysis would be better conducted by experts more familiar with needed sampling frequencies associated with individual monitoring objectives.

Recommendations

- Consider basing temporal sampling schemes on parameters rather than sampling programs.

- Consider the scientifically credible number of yearly observations that are necessary for a statistically defensible sampling scheme.
- Consider what type of monitoring event (storm-event, low-flow, regular-interval or continuous monitoring) meets the objectives for the program. Each of these monitoring events will require a different sampling frequency.
- Coordinate sampling frequency among monitoring programs that need to merge their data or results for a watershed-wide analysis.

Parameters to be sampled

Identification of the important parameters to sample must be based on monitoring needs and objectives. Coordination of the parameters sampled at a given location and frequency will increase the effectiveness of each sampling program. Multiple objectives could be satisfied if a coordinated approach to parameter selection was undertaken throughout the basin.

Parameter selection should be based on previously identified monitoring needs. Only after an analysis of the data required to address each monitoring need is established, can a coordinated approach among monitoring organizations begin. The information available in the monitoring inventory can serve as the starting point for coordinating sampling parameter selection. It may be possible for individuals in the field to add a few additional parameters for use by other programs in the watershed, with little additional cost. Program managers should utilize the monitoring inventory to seek these opportunities. As mentioned earlier in the strategic plan, in order to maximize coordination and utility of monitoring data, it will be important to address the issue of location and frequency as related to each sampling parameter.

Another consideration when selecting sampling parameters is development of a set of indicators that could be monitored throughout the basin in a coordinated fashion. There may be a number of key indicator parameters that would provide data with basinwide value. The set of indicators would be established by the monitoring coordination committee.

Recommendations

- Identify specific parameters that need to be sampled to meet each monitoring need.
- Program managers should seek to cooperate, where appropriate, to collect additional parameters for colleagues, thereby maximizing the utility of field time.
- When considering parameter selection, consider the location and frequency to increase the effectiveness of coordination across programs.
- The monitoring coordination committee should select a set of indicators with basinwide value and monitor these parameters in a coordinated fashion throughout the basin.

Creation of Sampling Strategy

The creation of a statistically sound sampling strategy is a key component to a well-constructed monitoring program. Factors to be taken into consideration when designing a monitoring program include identifying monitoring objective, parameter selection, sampling design, site selection, and data analysis method. These factors, as well as others, are discussed in more detail in the previous section "Guidelines to consider when designing a monitoring program."

Methods Comparability

In areas where multiple programs are addressing the same monitoring need for the Lake St. Clair watershed, it will be necessary to examine the comparability of methods employed by each program. The monitoring inventory includes some basic information about methodologies, but generally, this information is not detailed enough to determine comparability of results. Comparisons of methodologies in the field are likely the best means to assure this. The monitoring coordination committee should prioritize the monitoring needs, develop indicators, and conduct a methods comparability analysis. For high priority needs, the committee should encourage all relevant program managers to meet and compare methodologies to determine if the results from different methodologies will be useable together for a watershed-wide analysis.

The comparability analysis should examine each step of the data collection and analysis process. The examination should include, among other items, field collection methods and sample certification, preservation and transport methods, analytical methods, and laboratory comparability or accreditation. When possible, the organizations participating in the comparability analysis should strive to establish and document standard methods to be used throughout the watershed. All standard methods can then be compiled into a compendium to be distributed centrally through the monitoring committee.

The monitoring committee and methods technical groups will first need to compare the watershed-wide monitoring objectives to program objectives (see previous section for discussion of monitoring objectives). Methods standards should be broad enough to allow for program-level variation as long as the broad-scale objectives for the Lake St. Clair watershed are met.

Examples of monitoring needs that may need further methods comparability include macroinvertebrate sampling and various water quality measures. In the case of macroinvertebrate sampling, there are several local organizations that engage in this type of monitoring for different stream segments in the watershed. To aggregate or report results from these programs across the watershed, it will be necessary to ensure that the samples are indeed comparable. Some methodological questions, among others, that might be asked would include:

- From what type of habitat(s) are samples taken?
- How many samples are included from an individual site location?
- What specific method was used to collect each sample?
- What is the level of experience and knowledge of collectors and taxonomic identifiers?
- To what taxonomic level are collections identified?

The monitoring committee should review the gap analysis and determine which of the needs might require a methods comparability analysis.

Recommendations

- The monitoring committee should establish priority needs and have relevant organizations meet to conduct methods comparability analyses.
- Compile a standard methods compendium for the watershed.

Quality Assurance (QA) and Quality Control (QC)

Beyond direct comparisons to establish comparable methods, in order to combine results from different programs, it is necessary that an agreed-upon level of data quality be assured for each

program. To establish an appropriate level of quality, QA/QC measures must be in place and documented for each program. At a minimum, similar programs should share their QA/QC plan among their peers as well as with any third-party conducting further analysis or reporting for the watershed. Some considerations to be addressed in QA/QC plans should include method quality objectives (MQO) and related method detection levels, precision, accuracy, use of replicates, duplicates, lab blanks and trip blanks, chain-of-custody, and data validation and verification.

Standards for developing quality plans exist at varying levels of government and industry. The most widely used quality management system is the International Standardization Organization (ISO) 9000 series (see www.iso.ch). This series caries a certification process and includes instructions for developing quality management systems for a diverse range of organizations. For environmental science projects, the U.S. EPA has developed a process for creating Quality Assurance Project Plans (QAPP). The Great Lakes National Program Office (GLNPO) has tailored the QAPP process for projects in the Great Lakes region (see www.epa.gov/glnpo/fund/qareqs.html). These and other examples can be used to guide discussion on tailoring quality standards to the needs within the Lake St. Clair watershed. The monitoring committee should agree on a level of QA/QC certification for data to be used in watershed-level analyses.

Recommendations

- Share QA/QC plans between relevant programs and with the monitoring committee.
- Establish QA/QC standard(s) for data to be used in watershed analyses.
- Use certified laboratories for all water analyses.

Metadata Requirements

One of the most important ways to enable monitoring coordination is for program managers to include complete metadata records. Metadata records should cover all elements of data collection, processing and analysis. Metadata allows potential external users of monitoring data to determine if the data is truly compatible with other data sets. The metadata can be transferred, as well, so that it is retained with any combined data sets.

The monitoring committee should agree on a set of core data elements that should be included in standard metadata sets to be shared. There are several efforts underway to standardize metadata elements. The most well-developed in the United States is the set developed by the Federal Geographic Data Committee (FGDC) for geographically referenced data (see www.fgdc.gov). A more simplified metadata content standard known as the Dublin Core (see http://dublincore.org) has been developed to cover a wider range of data collection. It features only 15 elements and leaves out the heavy focus on geospatial attributes. These examples can be used as models for discussing appropriate standards for monitoring data collected in the Lake St. Clair watershed.

Recommendations

- All participating monitoring programs in the Lake St. Clair watershed should develop comprehensive metadata to accompany their monitoring data sets.
- The monitoring committee should develop a set of minimum metadata standards specific to monitoring needs.

Data Analysis Comparability

In many cases it is most useful to share post-analysis results rather than the raw data itself. However, in order for assessments or reports to be combined or compared, one must first ensure that comparable analytical techniques were used to generate results. Most commonly this refers to the statistical tests that are used to generate comparisons. Depending on the statistical tests used and the underlying assumptions made, the same data set can yield very different results. Again, the results depend on the study objectives, but even with identical objectives, it is possible to utilize different, yet scientifically defensible analytical methods which yield different results.

The National Water Quality Monitoring Council (NWQMC) has produced a technical document that examines these issues in the context of water quality assessments (Griffith, et al., 2001). They found that, with common null hypothesis testing, several important considerations are often overlooked. These include distribution assumptions, flow adjustment and power analysis. The document concludes that standardized analytical techniques need to be developed nationally, while also recognizing the need to apply different techniques to meet the objectives of individual studies.

The monitoring committee should develop a set of standard analytical techniques and statistical tests for particular monitoring needs, where appropriate, on a priority need basis. These standards can be tailored to monitoring needs and developed at the same time as other standards mentioned previously. If standards development is not possible, relevant programs should, at a minimum, conduct a comparative analysis of analytical techniques in use in order to determine the degree of impact the techniques have on the final results.

Recommendation

- The monitoring committee should develop standard analytical techniques on a priority need basis.

Reporting Needs

The final consideration for establishing an effective monitoring network for the Lake St. Clair watershed is the development of a consistent reporting framework for the region. As the inventory results indicate, there are many different monitoring programs in the watershed – each with a somewhat different purpose. A coherent and comprehensive reporting mechanism needs to be established to assist resource managers in making broad-level decisions, inform the public about the status and trends in the watershed, and show the cumulative value of monitoring data to all parties. This may not necessarily be accomplished through a single report. An option would be to split the report into a "State of" report for general audiences and a technical report that includes more of the monitoring foundation for resource managers and decision makers.

A report of this type is also being recommended in the Lake St. Clair Comprehensive Management Plan, so other collaborators may be able to contribute to the document's production. The monitoring committee should determine a strategy for regularly producing a monitoring report. Several questions (and possibly others) will need to be answered, such as:

- Who is the target audience(s)?

- How should monitoring results and conclusions be presented?
- What entity should be responsible for producing and maintaining the report?
- What is the best format for effective distribution to the target audience?
- How often should the report be produced?

All the previous recommendations need not be addressed before developing the first report for the Lake St. Clair watershed. In fact, these reports should be presented as dynamic works in progress. It will be more important to generate a report early in the process to show progress and gain support from the wider community.

In addition to comprehensive "State of" reports, it has been recommended that an event reporting mechanism for spills and other unnatural or unusual environmental events be developed. This type of reporting is necessary to keep the public informed of health and ecosystem threats in a time frame that allows for defensive actions to be taken.

Recommendation

- The monitoring committee should develop a strategy to generate regular reports on monitoring results for the Lake St. Clair watershed.
- The monitoring committee should develop an event reporting mechanism for spills and other environmental events.

Funding

Obviously, the development of a coordinated monitoring network will require human and financial resources. It is important that the monitoring committee receive sufficient funding to operate. These resources need not be substantial, especially if participating organizations contribute directly to developing elements of the network. Still, the committee will require staff dedicated at least partially toward facilitating and organizing the committee's work and coordinating the development of committee products. Additionally, further resources may be needed to address priority monitoring gaps.

This additional funding can be sought through several different approaches. One approach would be to have one or two agencies assume the leadership role in establishing the network and serve to organize and facilitate the monitoring committee. These agencies should have a large role in monitoring in the watershed. Priority monitoring gaps would be best addressed by individual agencies. A second approach would be to solicit funds from each participating organization in the form of operational dues for the monitoring committee. The committee could then independently hire or contract staff. A final suggested approach would be to develop a proposal for external funding to be used directly by the monitoring committee. Several funding organizations could be approached including governmental granting programs and charitable foundations. There may be other options for funding as well. In all likelihood, the monitoring committee will need to be creative in its approach to secure sustainable funding.

Recommendation

- The monitoring committee should establish a financial plan for supporting staff and addressing monitoring gaps.

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