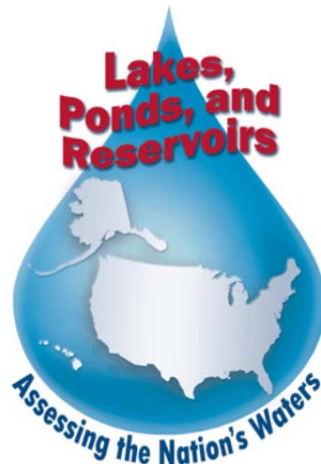




United States Environmental Protection Agency
Office of Water
Washington, DC
EPA 841-B-11-006

2012 National Lakes Assessment Quality Assurance Project Plan

Version 1.0, May 15, 2012



Approval Page



18 May 2012

Amina Pollard

Date

2012 National Lakes Assessment Project Leader

U.S. EPA Office of Water



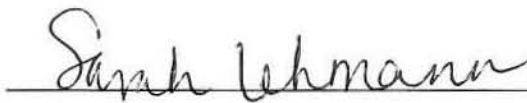
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Office of Wetlands, Oceans, and Watersheds Quality Assurance Officer

U.S. EPA Office of Water

Quality Assurance Project Plan Review & Distribution Acknowledgement & Commitment to Implement the National Lakes Assessment 2012

We have read the Quality Assurance Project Plan, Site Evaluation Guidelines, Field Operations Manual, and Laboratory Operations Manual for the 2012 National Lakes Assessment listed below. Our agency/organization, agrees to abide by its requirements for work performed under the 2012 National Lakes Assessment. Check appropriate boxes.

- Quality Assurance Project Plan
- Site Evaluation Guidelines
- Field Operations Manual
- Laboratory Operations Manual

Name (printed)

Title (Cooperator's Principal Investigator)

Organization

Signature

Date

NOTICE

The intention of the 2012 National Lakes Assessment (NLA 2012) is to provide a comprehensive “State of the Lakes” assessment for lakes, ponds, and reservoirs across the United States. The complete documentation of overall project management, design, methods, and standards is contained in this Quality Assurance Project Plan and companion documents, including:

2012 National Lakes Assessment: Site Evaluation Guidelines (EPA 841-B-11-005)

2012 National Lakes Assessment: Field Operations Manual (EPA 841-B-11-003)

2012 National Lakes Assessment: Laboratory Operations Manual (EPA 841-B-11-004)

This document, Quality Assurance Project Plan (QAPP), contains elements of the overall project management, data quality objectives, measurement and data acquisition, and information management for NLA 2012. The complete QAPP includes this document and its associated Field Operations Manual (FOM), Laboratory Operations Manual (LOM), and Site Evaluation Guidelines (SEG), which together comprise the integrated set of QAPP documents. Methods described in this document are to be used specifically in work relating to the NLA 2012. All project cooperators should follow these guidelines. Mention of trade names or commercial products in this document does not constitute endorsement or recommendation for use.

The suggested citation for this document is:

USEPA. 2012. 2012 National Lakes Assessment. Quality Assurance Project Plan. EPA 841-B-11-006. U.S. Environmental Protection Agency, Washington, DC

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LIST OF ACRONYMS

ANC	acid neutralizing capacity
CO ₂	carbon dioxide
CPR	cardiopulmonary resuscitation
DBH	diameter at breast height
DI	deionized
DO	dissolved oxygen
DOC	dissolved organic carbon
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
ETOH	ethyl alcohol
FOM	Field Operations Manual
GIS	geographic information system
GPS	global positioning device
HDPE	high density polyethylene
H ₂ S	hydrogen sulfide
LOM	Lab Operations Manual
MPCA	Minnesota Pollution Control Agency
NALMS	North American Lakes Management Society
NH ₄	ammonium
NIST	National Institute of Standards
NO ₃	nitrate
OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyl
P-Hab	physical habitat
QA	quality assurance
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
QCCS	quality control check solution
QRG	Quick Reference Guide
SEG	Site Evaluation Guidelines
SOPs	Standard Operating Procedures
TN	total nitrogen
TOC	total organic carbon
TP	total phosphorus
TSS	total suspended solids
TVS	total volatile solids
USGS	United States Geological Survey

DISTRIBUTION LIST

This QAPP, which includes the associated manuals or guidelines, will be distributed to the following: EPA, States, Tribes, universities, labs, and contractors participating in the 2012 National Lakes Assessment (NLA). EPA Regional Survey Coordinators are responsible for distributing the NLA QAPP to State and Tribal Water Quality Agency staff or other cooperators who will perform the field sampling and laboratory operations. The Logistics Coordinator will distribute the QAPP and associated documents to participating project staff at their respective facilities and to the project contacts at participating laboratories, as they are determined. If the QAPP is updated, the project lead will distribute the relevant materials via email to necessary participants.

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1 EXECUTIVE SUMMARY

1.1 Background

Several recent reports have identified the need for improved water quality monitoring and analysis at multiple scales. In response, the U.S. EPA Office of Water (OW), in partnership with EPA's Office of Research and Development (ORD), EPA regional offices, states and tribes and other partners, has begun a program to assess the condition of the nation's waters via a statistically valid approach. Often referred to as probability-based surveys, these assessments, known as the National Aquatic Resource Surveys (NARS), report on core indicators of water condition using standardized field and lab methods and utilize integrated information management (IM) plans to ensure confidence in the results at national and ecoregional scales.

The NLA 2012, which builds upon the previous 2007 NLA aims to address two key questions about the quality of the nation's lakes and reservoirs:

- What percent of the nation's lakes are in good, fair, and poor condition for key indicators of water quality, ecological health, and recreation?
- What is the relative importance of key stressors such as nutrients?

The surveys are also designed to help expand and enhance state monitoring programs. Through these surveys, states and tribes have the opportunity to collect data that can be used to supplement their existing monitoring programs or to begin development of new programs.

1.2 Project Organization

Overall project coordination is conducted by EPA's Office of Water (OW) in Washington, DC, with technical support from the ORD's Western Ecology Division (WED) in Corvallis, Oregon. Each of the EPA Regional Offices has identified regional coordinators to assist in implementing the survey and coordinate with the state/tribal crews who collect the water and sediment samples following NLA 2012 protocols. The U.S. Geological Survey is partnering with EPA on the analysis for several indicators. EPA began planning the NLA 2012 with state, tribal, and other federal partners in 2010 and is continuing this partnership effort. EPA expects to report the results in December 2014 in compliance with the Data Quality Act.

1.3 Quality Assurance Project Plan

The purpose of this QAPP is to document the project data quality objectives and quality assurance/quality control measures that will be implemented in order to ensure that the data collected meets those needs. The plan contains elements of the overall project management, data quality objectives, measurement and data acquisition, and information management for the NLA 2012 and identifies where these elements are described in detail. This QAPP and its associated documents, the Field Operations Manual, Laboratory Operations Manual and Site Evaluation Guidelines, are interdependent, integrated and together make up the full QAPP for the National Lakes Assessment 2012.

1.4 Information Management Plan

Environmental monitoring efforts that amass large quantities of information from various sources present unique and challenging data management opportunities. To meet these challenges, the NLA 2012 employs a variety of well-tested information management (IM) strategies to aid in the functional

organization and ensured integrity of stored electronic data. IM is integral to all aspects of the NLA 2012 from initial selection of sampling sites through the dissemination and reporting of final, validated data.

A technical workgroup convened by the EPA Project Leader is responsible for development of a data analysis plan that includes a verification and validation strategy. These processes are summarized in the data analysis plan section of this QAPP. Validated data are transferred to the central database managed by EMAP information management support staff located at the Western Ecology Division facilities in Corvallis. This database is known as the National Aquatic Resource Surveys Information Management System (NARS IM). All validated measurement and indicator data from the NLA 2012 are eventually transferred to EPA's Water Quality Exchange (WQX) for archival in EPA's STORET warehouse for public accessibility. NLA 2012 IM staff provides support and guidance to all program operations in addition to maintaining NARS IM.

1.5 NLA 2012 Design

EPA used an unequal probability design to select 904 lakes and reservoirs greater than 1 hectare in size (note: in NLA 2007, the lower size limit was 4 ha) in the continental United States. The design also includes revisits to 96 lakes during the sampling season for quality assurance purposes including evaluation of the ability of an indicator to distinguish *among* sites from differences *within* individual sites. To improve our ability to assess changes since NLA 2007, the design includes revisits to approximately 50% (398 lakes) of the sites sampled in 2007 (resample lakes). Related designs were also completed for sampling of lakes on Oahu, Hawaii and the North Slope of Alaska.

1.6 Field Operations

Sample collection for NLA 2012 is designed to be completed during the index period of May through the end of September 2012. Field data acquisition activities are implemented in a consistent manner across the entire country. Each site is given a unique ID which identifies it throughout the pre-field, field, lab, analysis, and data management phases of the project. Specific procedures for evaluating each sampling location and for replacing non-sampleable sites are documented in 2012 NLA Site Evaluation Guidelines (SEG, EPA-841-B-11-005).

NLA 2012 indicators include: algal toxins (microcystins), benthic macroinvertebrates, physical habitat, phytoplankton, sediment dating, sediment diatoms, triazine pesticide screen, water chemistry and chlorophyll A, and zooplankton. Additional research indicators include: dissolved carbon and methane, macrophytes, and sediment mercury. Field measurements and sampling methods are outlined in the 2012 NLA Field Operations Manual (FOM, EPA 841-B-11-004). Field crews are trained on these methods at a required EPA-sponsored training session. Field sampling assistance visits will be completed for each field crew for quality assurance.

1.7 Laboratory Operations

NLA 2012 laboratory analyses are conducted either by state/tribal-selected labs or "National Laboratories" set up by EPA to conduct analyses for any state/tribe which so elects. The designated National Laboratories and state/tribal labs must comply with the QA/QC requirements described in this document and in the 2012 National Lakes Assessment: Laboratory Operations Manual (LOM, EPA 841-B-11-004). Any laboratory selected to conduct analyses with NLA 2012 samples must demonstrate that it can meet the quality standards presented in this 2012 NLA QAPP and LOM.

1.8 Peer Review

Surveys undergo a thorough peer review process, where the scientific community and the public are given the opportunity to provide comments on the report. Cooperators have been actively involved in the development of the overall project management, design, indicator selection, and methods.

EPA utilizes a three-tiered approach for peer review of the Survey report:

- internal and external review by EPA, states, other cooperators and partners,
- external scientific peer review, and
- public review.

Outside scientific experts from universities, research centers, and other federal agencies have been instrumental in indicator development and will continue to play an important role in data analysis.

2 PROJECT PLANNING AND MANAGEMENT

2.1 Introduction

Several recent reports have identified the need for improved water quality monitoring and analysis at multiple scales. In 2000, the General Accounting Office (USGAO 2000) reported that EPA, states, and tribes collectively cannot make statistically valid inferences about water quality (via 305[b] reporting) and lack data to support key management decisions. In 2001, the National Research Council (NRC 2000) recommended EPA, states, and tribes promote a uniform, consistent approach to ambient monitoring and data collection to support core water quality programs. In 2002, the H. John Heinz III Center for Science, Economics, and the Environment (Heinz Center 2002) found that there is inadequate data for national reporting on fresh water, coastal and ocean water quality indicators. The National Association of Public Administrators (NAPA 2002) stated that improved water quality monitoring is necessary to help states and tribes make more effective use of limited resources. EPA's Report on the Environment 2003 (USEPA 2003) states that there is insufficient information to provide a national answer, with confidence and scientific credibility, to the question, 'What is the condition of U.S. waters and watersheds?'

In response to this need, OW, in partnership with states and tribes, has begun a program to assess the condition of the nation's waters via a statistically valid approach. The current assessment, the National Lakes Assessment 2012 (referred to as NLA 2012 throughout this document), builds upon the 2007 National Lakes Assessment, Wadeable Streams Assessment implemented by EPA to monitor and assess the condition of the nation's wadeable stream resources, as well as other NARS surveys such as the National Coastal Condition Assessment, the 2008-2009 National Rivers and Streams Assessment, and 2011 National Wetland Condition Assessment. The NLA 2012 effort will provide important information to states and the public about the condition of the nation's lake resources and key stressors on a national and regional scale.

EPA developed this QAPP to support project participants and to ensure that the final assessment is based on high quality data and known quality for its intended use, and information. The QAPP contains elements of the overall project management, data quality objectives, measurement and data acquisition, and information management for NLA 2012. EPA recognizes that states and tribes may add elements to the survey, such as supplemental indicators, that are not covered in the scope of this integrated QAPP. EPA expects that any supplemental elements are addressed by the states, tribes, or their designees, in a separate approved QAPP or an addendum to this QAPP. The 2012 NLA participants have agreed to follow this QAPP and the protocols and design laid out in this document, and its associated documents – the 2012 NLA FOM, LOM, and SEG.

This cooperative effort between states, tribes, and federal agencies makes it possible to produce a broad-scale assessment of the condition of the Nation's lakes with both confidence and scientific credibility. Through this survey, states and tribes have the opportunity to collect data that can be used to supplement their existing monitoring programs or to begin development of new programs.

The 2012 National Lakes Assessment has three main objectives:

- Estimate the current status, trends, and changes in selected trophic, ecological, and recreational indicators of the condition of the nation's lakes with known statistical confidence.
- Seek associations between selected indicators of natural and anthropogenic stresses and indicators of ecological condition.
- Assess changes between 2007 and 2012.

A 2012 NLA workgroup, comprised of EPA, state, and other partners, decided on a few improvements to the suite of original indicators. The additions include a triazine pesticide screen, a macrophyte indicator, and dissolved carbon. Modifications include adding a draw down component to physical habitat, adding littoral sampling for algal toxins, and using different zooplankton sampling nets. Finally, pathogens will no longer be included. In order to ensure we can track changes for modified indicators, we conducted pilot testing of the habitat and zooplankton protocols and will be collecting zooplankton using both the NLA 2007 and the NLA 2012 nets at approximately 250 random sites.

2.1.1 Project Organization

The responsibilities and accountability of the various principals and cooperators are described here and illustrated in Figure 2.1. Overall, the project will be coordinated by the Office of Water (OW) in Washington, DC, with support from EPA Western Ecology Division (WED) in Corvallis, Oregon. Each EPA Regional Office has identified a Regional EPA Coordinator who is part of the EPA crew providing a critical link with state and tribal partners. Cooperators will work with their Regional EPA Coordinator to address any technical issues. A comprehensive quality assurance (QA) program has been established to ensure data integrity and provide support for the reliable interpretation of the findings from this project. Technical Experts Workgroups will be convened to provide EPA with support for determining the best and most appropriate approaches for key technical issues, such as: (1) the selection and establishment of reference conditions based on least-disturbed sites and expert consensus for characterizing benchmarks for assessment of ecological condition; (2) selection and calibration of ecological endpoints and attributes of the biota and relationship to stressor indicators; (3) a data analysis plan for interpreting the data and addressing the objectives in a nationwide assessment; and (4) a framework for the reporting of the condition assessment and conveying the information on the ecological status of the nation's lakes.

Contractor support is provided for all aspects of this project. Contractors will provide support ranging from implementing the survey, sampling and laboratory processing, data management, data analysis, and report writing. Cooperators will interact with their Regional EPA Coordinator and the EPA Project Leader regarding contractual services.

The primary responsibilities of the principals and cooperators are as follows:

Project Leader: Amina Pollard

- Provides overall coordination of the project and makes decisions regarding the proper functioning of all aspects of the project.
- Makes assignments and delegates authority, as needed to other parts of the project organization.
- Leads the Lakes Steering Committee and establishes needed technical workgroups.
- Interacts with EPA Project Team on technical, logistical, and organizational issues on a regular basis.

EPA Field Logistics Coordinator: Marsha Landis

- EPA employee who functions to support implementation of the project based on technical guidance established by the EPA Project Leader and serves as point-of-contact for questions from field crews and cooperators for all activities.
- Tracks progress of field sampling activities.

EPA Project QA Lead: Sarah Lehmann

- Provides leadership, development, and oversight of project-level quality assurance for NARS.

- Assembles and provides leadership for a NLA 2012 Quality Team.
- Maintains official, approved QAPP
- Maintains all training materials and documentation
- Maintains all laboratory accreditation files

EPA Technical Advisor: Steven Paulsen

- Advises the Project Leader on the relevant experiences and technology developed within ORD that may be used in this project.
- Facilitates consultations between NLA personnel and ORD scientists.

Information Management Coordinator: Marlys Cappaert

- A contractor who functions to support implementation of the project based on technical guidance established by the EPA Project Leader and Alternate EPA Project Leader oversees all sample shipments and receives data forms from the Cooperators.
- Oversees all aspects of data entry and data management for the project.

EPA QA Officer, Office of Wetlands, Oceans and Watersheds: Virginia Fox-Norse

- Functions as an independent officer overseeing all Quality Assurance (QA) and quality control (QC) activities.
- Responsible for ensuring that the QA program is implemented thoroughly and adequately to document the performance of all activities.

Regional EPA Coordinators

- Assists EPA Project Leader with regional coordination activities.
- Serves on the Technical Experts Workgroup and interacts with Project Facilitator on technical, logistical, and organizational issues on a regular basis.
- Serves as primary point-of-contact for the Cooperators.

Steering Committee (Technical Experts Workgroup): States, EPA, academics, other federal agencies

- Provides expert consultation on key technical issues as identified by the EPA Coordination crew and works with Project Facilitator to resolve approaches and strategies to enable data analysis and interpretation to be scientifically valid.

Cooperator(s): States, Tribes, USGS, others

- Under the scope of their assistance agreements, plans and executes their individual studies as part of the cross jurisdictional NLA 2012 and adheres to all QA requirements and standard operating procedures (SOPs).
- Interacts with the Grant Coordinator, Project Facilitator and EPA Project Leader regarding technical, logistical, organizational issues.

Field Sampling Crew Leader

- Functions as the senior member of each Cooperator's field sampling crew and the point of contact for the Field Logistics Coordinator.
- Responsible for overseeing all activities of the field sampling crew and ensuring that the Project field method protocols are followed during all sampling activities.

Field Logistics Coordinator: Chris Turner, Great Lakes Environmental Center (GLEC)

- A contractor who functions to support implementation of the project based on technical guidance established by the EPA Field Logistics Coordinator and the Project Leader

- Serves as point-of-contact for questions from field crews and cooperators for all activities.
- Tracks progress of field sampling activities.

2.1.2 Project Schedule

Training and field sampling will be conducted in 2012. Sample processing and data analysis will be completed by 2013 in order to publish a report in 2014. Figure 2.2 gives an overview of the major tasks leading up to the final report.

2.2 Scope of QAPP

This QAPP addresses the data acquisition efforts of the 2012 NLA, which focuses on the sampling of lakes across the United States in 2012. Data from approximately 1000 lakes (selected with a probability design) located within the contiguous 48 states will provide a comprehensive assessment of the nation's lakes. Quality information, requirements, and procedures are contained in the QAPP and its accompanying documents: the SEG, FOM, and LOM. Much of the detailed quality assurance information is in the companion documents to avoid redundancy. In these cases, the QAPP directs you to the primary sources of this information.

2.2.1 Field Operations

All field operations information is available in the FOM.

Field operations are implemented for the NLA 2012 based on guidance developed by EMAP (Baker and Merritt 1990), experience from NLA 2007, advice from the NARS team, and through consultation with a steering committee comprised of various state, tribal, federal, and regional agencies. Funding for states and tribes to conduct field data collection activities is provided by EPA under Section 106 of the Clean Water Act. The project lead initiates field operations preparation by working with the Design Team (led by ORD in Corvallis) to revise, as needed, the target population and sample frame and to identify state/tribal or other organization-requested intensifications/modifications. The Design Team selects sampling locations. The Project Lead distributes the list of sampling locations to the EPA Regional NLA Coordinators, states, and tribes and to other partners (e.g. the Forest Service per the 2011 MOA). See the Site Evaluation Guidelines for the detailed design documentation.

With the sampling location list, state and tribal field crews can begin site reconnaissance on the primary sites and alternate replacement sites and begin work on obtaining permission to access each site.

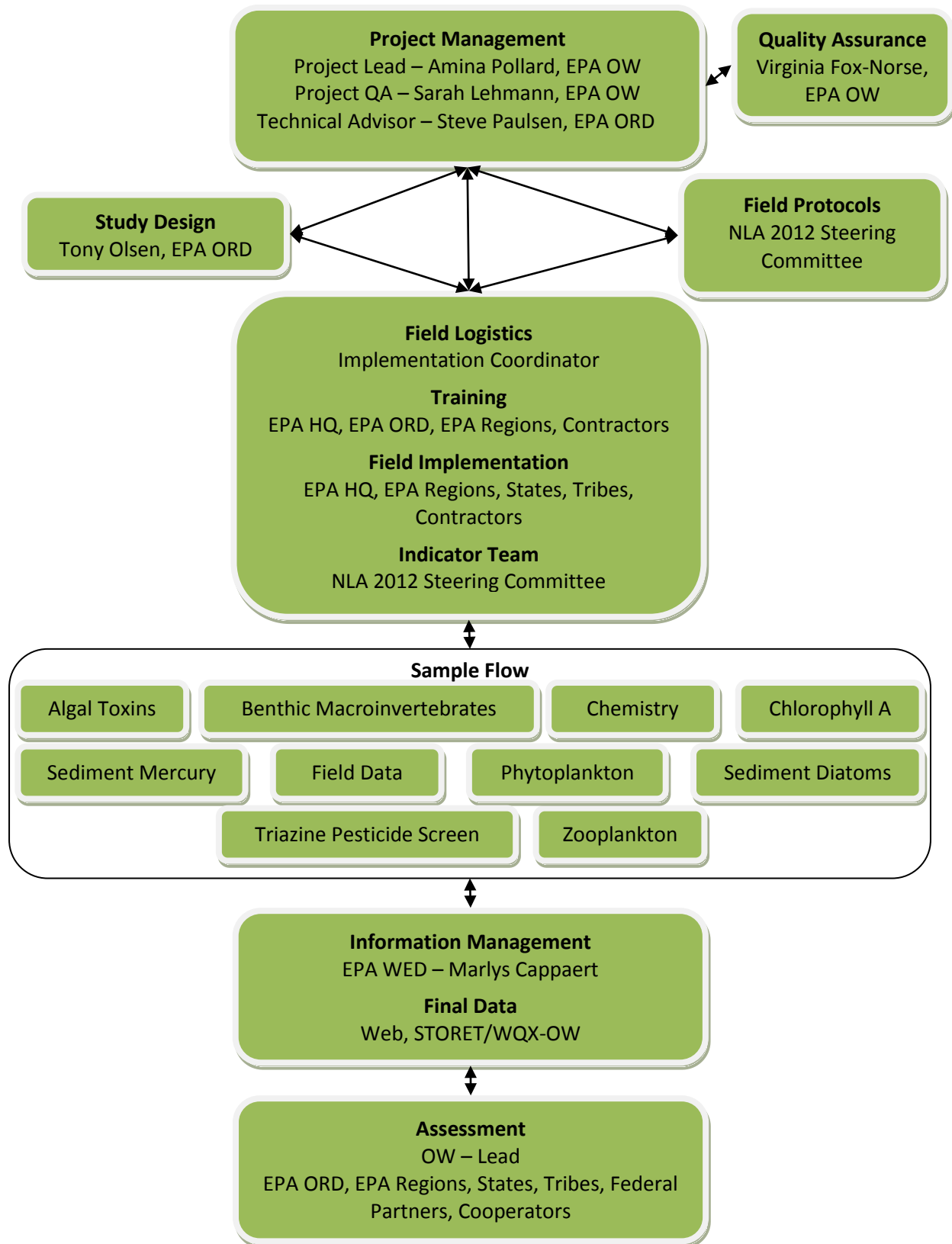


Figure 2.1 National Lakes Assessment 2012 project organization chart.

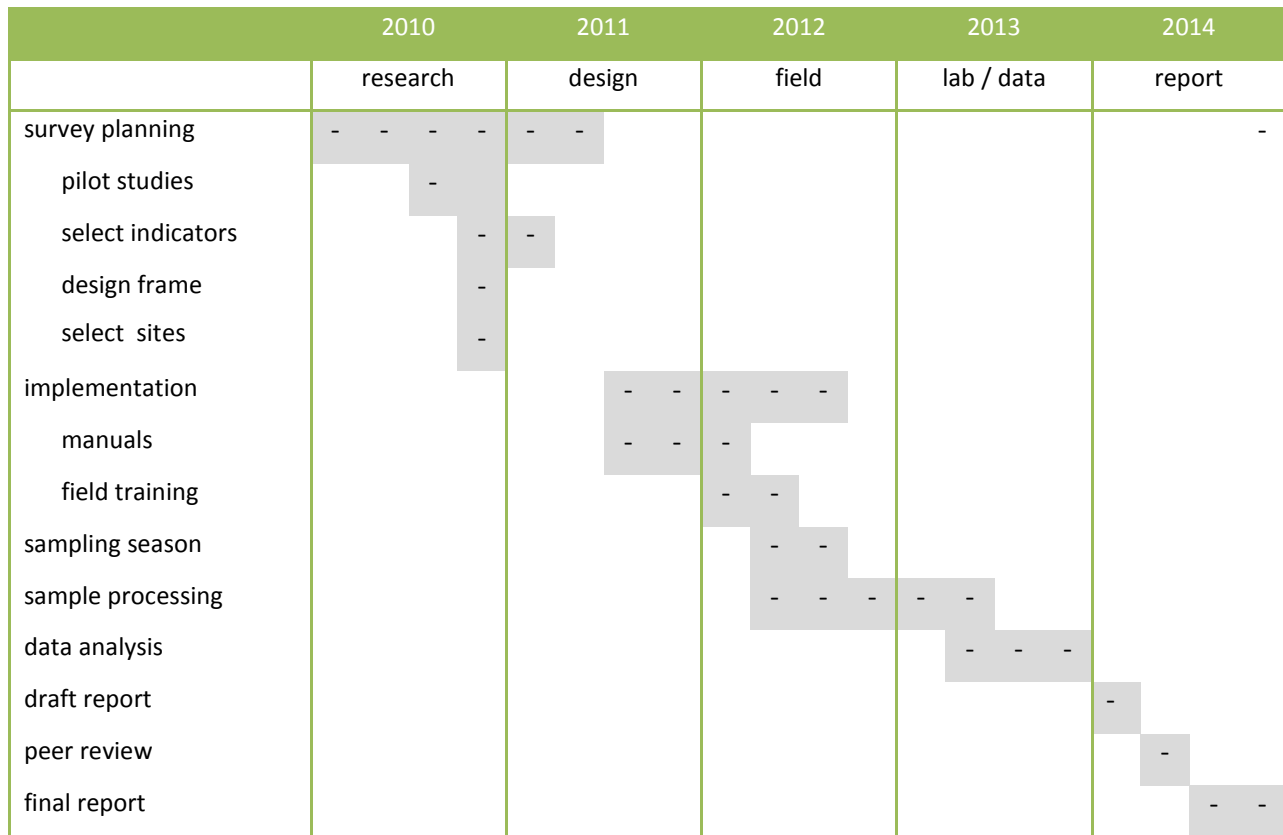


Figure 2.2 National Lakes Assessment 2012 project timeline.

Specific procedures for evaluating each sampling location and for replacing non-sampleable sites are documented in the *2012 NLA SEG*. Field crews will procure scientific collecting permits from State, Tribal, and Federal agencies, as needed. The field crews will use standard field equipment and supplies. Field Crew Leaders from states and tribes will work with EPA Regional Coordinators and the NARS Information Management (IM) Center to coordinate equipment and supply requirements. This helps to ensure comparability of protocols across states. Detailed lists of equipment required for each field protocol, as well as guidance on equipment inspection and maintenance, are contained in the FOM.

Field measurements and samples are collected by trained crews. Each Field Crew Leader must be trained at an EPA-sponsored training session prior to the start of the field season, along with as many crew members as possible. EPA will provide the three-day training sessions in a number of locations around the country for cooperators and contractors. It is strongly encouraged that field crews attend all three days of training. The training program stresses hands-on practice of methods, comparability among crews, collection of high quality data and samples, and safety. All field crews providing field operational support to NLA 2012 must adhere to the provisions of this integrated QAPP, FOM, and SEG. Trainers will maintain a list of all personnel trained and provide the information to the NLA Project Lead and the QA Project Lead.

Training documentation will be maintained by the NARS QA Lead in NLA 2012 QA files. Field crews may not operate without a trained field crew leader present.

Table 2.1 Field training sessions for NLA 2012

Date	Training Location	Primary Trainees
13-15 MAR 2012	Unicoi State Park, Helen, GA	Train the trainer
26-28 MAR 2012	Cacapon State Park, Berkeley Springs, WV	DE, DC, MD, PA, VA, WV, NJ
3-5 APR 2012	Lake Murray State Park, Ardmore, OK	LA, AR, OK, NM, TX
10-12 APR 2012	Golden, CO	CO, MT, ND, SD, UT, WY
17-19 APR 2012	Lawrence, KS	IA, KS, MO, NE
24-26 APR 2012	Moss Landing, CA	AZ, CA, HI, NV
8-10 MAY 2012	North Chelmsford, MA	CT, ME, MA, NH, RI, VT, NY
	Madison, WI	IL, IN, MI, MN, OH, WI
12-14 JUN 2012	Olympia, WA	AK, ID, OR, WA

Evaluation and assistance visits will be conducted with each Field Crew early in the sampling and data collection process, and corrective actions will be conducted in real time. These visits provide EPA with a basis for the uniform evaluation of the data collection techniques, and an opportunity to conduct procedural reviews to minimize data loss due to improper technique or interpretation of program guidance. The field visits evaluations will be based on the uniform training, plans, and checklists. For more information on field assistance visits see Section 8 of the FOM.

A variety of methods may be used to access a lake. Some sampling locations require crews to hike in, transporting all equipment in backpacks. For this reason, ruggedness and weight are important considerations in the selection of equipment and instrumentation. Crews may need to camp out at the sampling location and may need to provide themselves with the necessary camping equipment.

The site verification process is outlined in the NLA 2012 SEG and FOM. All methods used in the field are fully documented in step-by-step procedures in the NLA 2012 FOM. The manual also contains detailed instructions for completing documentation, labeling samples, any field processing requirements, and sample storage and shipping. Field communications will be through Field Crew Leaders, and will involve regularly scheduled conference calls or contacts with the NLA 2012 Communications Center.

Standardized field data forms are the primary means of data recording. For NLA 2012 crews will have the option to use paper or electronic forms. On completion, the data forms are reviewed by a person other than the person who initially entered the information. Prior to departure from the field site, the field crew leader reviews all forms and labels for completeness and legibility and ensures that all samples are properly labeled and packed. This review process will be done for either form of data collection (paper or electronic).

Upon return from field sampling to the office, field crews using paper forms send completed data forms to the information management staff at WED in Corvallis, Oregon for entry into a computerized database. Field crews using electronic forms send completed forms via email as soon as they have access to email. At WED, the IM team review electronic data files independently to verify that values are consistent with those recorded on the field data form or original field data file (see Section 4.1.4).

Field crews store or package samples for shipment in accordance with instructions contained in the NLA 2012 Field Operations Manual, including taking precautions so holding times are not exceeded. Samples which must be shipped are delivered by field crews to a commercial carrier; copies of bills of lading or other documentation are maintained by the crew. Using the tracking form, crews notify the NARS IM

Center about sample shipment; thus, tracking procedures can be initiated quickly in the event samples are not received. Chain-of-custody forms are completed by the crews for all transfers of samples, with copies maintained by the field crew. The IM team will follow up with field crews about any missing samples and/ or incomplete files.

The field operations phase is completed with collection of all samples or expiration of the sampling window.

2.2.2 Overview of Laboratory Operations

Holding times for surface water samples vary with the sample types and analytes. Some analytical measurements begin during sampling (e.g., *in situ* profiles) while others are not initiated until sampling has been completed (e.g., phytoplankton, zooplankton). Analytical methods are summarized in the NLA 2012 LOM.

Chemical, physical, or biological analyses may be performed by cooperator or contractor laboratories. Laboratories providing analytical support must have the appropriate facilities to properly store and prepare samples and appropriate instrumentation and staff to provide data of the required quality within the time period dictated by the project. Laboratories are expected to conduct operations using good laboratory practices. The following are general guidelines for analytical support laboratories:

- A program of scheduled maintenance of analytical balances, water purification systems, microscopes, laboratory equipment, and instrumentation.
- Verification of the calibration of analytical balances using class "S" weights which are certified by the National Institute of Standards and Technology (NIST).
- Verification of the calibration of top-loading balances using NIST-certified class "P" weights.
- Checking and recording the composition of fresh calibration standards against the previous lot. Acceptable comparisons are less than or equal to two percent of the theoretical value. (This acceptance is tighter than the method calibration criteria.)
- Recording all analytical data in bound logbooks in ink, or on standardized recording forms.
- Verification of the calibration of uniquely identified daily use thermometers using NIST-certified thermometers.
- Monitoring and recording (in a logbook or on a recording form) temperatures and performance of cold storage areas and freezer units (where samples, reagents, and standards may be stored). During periods of sample collection operations, monitoring must be done on a daily basis.
- An overall program of laboratory health and safety including periodic inspection and verification of presence and adequacy of first aid and spill kits; verification of presence and performance of safety showers, eyewash stations, and fume hoods; sufficiently exhausted reagent storage units, where applicable; available chemical and hazardous materials inventory; and accessible material safety data sheets for all required materials.
- An overall program of hazardous waste management and minimization, and evidence of proper waste handling and disposal procedures (90-day storage, manifested waste streams, etc.).
- If needed, having a source of reagent water meeting American Society of Testing and Materials (ASTM) Type I specifications for conductivity (< 1 $\mu\text{S}/\text{cm}$ at 25 °C; ASTM 1984) available in sufficient quantity to support analytical operations.

- Appropriate microscopes or other magnification for biological sample sorting and organism identification.
- Approved biological identification and taxonomic keys/guides for use in biological identification (zooplankton, phytoplankton, diatoms, benthic macroinvertebrates) as appropriate
- Labeling all containers used in the laboratory with date prepared contents, and initials of the individual who prepared the contents.
- Dating and storing all chemicals safely upon receipt. Chemicals are disposed of properly when the expiration date has expired.
- Using a laboratory information management system to track the location and status of any sample received for analysis.
- Reporting results electronically using standard formats and units compatible with NARS IM (see LOM for data templates). These files will be labeled properly by referencing the indicator and/or analyte and date.

All laboratories providing analytical support to NLA 2012 must adhere to the provisions of this integrated QAPP and LOM. Laboratories will provide information documenting their ability to conduct the analyses with the required level of data quality prior to data analysis. Different requirements will be provided based on the type of analysis being done by the lab (i.e. chemistry vs. biological analyses).

Labs will send the documentation to the Quality Assurance Lead at EPA Headquarters (or other such designated parties) in NLA 2012 QA files. Such information may include the following, depending on the evaluation by the Quality Assurance Lead:

- Signed Quality Assurance Project Plan by the Lab performing analysis
- Signed Laboratory Form
- Valid Accreditation or Certification
- Laboratory's Quality Manual and/or Data Management Plan
- Method Detection Limits (MDL)
- Demonstration of Capability (DOC)
- Results from inter-laboratory comparison studies
- Analysis of performance evaluation samples
- Control charts and results of internal QC sample or internal reference sample analyses to Document achieved precision, bias, accuracy

Other requirements may include:

- Participation in calls regarding lab procedures and processes with participating labs
- Participation in a lab technical assessment or audit
- Participation in performance evaluation studies
- Participation in inter-laboratory sample exchange

All qualified labs shall work with the NARS IM Center to track samples as specified in Section 5 of the LOM.

2.2.2.1 Water Chemistry and Chlorophyll A Lab Quality Evaluation

The NLA 2012 Quality Team has enlisted the expertise of the Region 3 Environmental Science Center for expert review of the water chemistry laboratories. Participating labs will send requested documentation

to the Region 2012 NLA QA Team for evaluation of qualifications. The NLA 2012 Quality Team will maintain these records in the project QA file.

2.2.2.2 Biological Lab Quality Evaluation

The NLA 2012 Quality Team requested and, whenever possible, reviewed the past performance of biological laboratories. The biological laboratories shall adhere to the quality assurance objectives and requirements as specified for the pertinent indicators in the LOM.

2.2.3 Data Analysis and Reporting

A technical data analysis and reporting workgroup convened by the EPA Project Leader is responsible for development of a data analysis plan that includes a verification and validation strategy. These processes are summarized in the data analysis sections of this QAPP. Validated data are transferred to the central database managed by information management support staff located at WED in Corvallis. Information management activities are discussed further in Section 4. Data in the WED database are available to Cooperators for use in development of indicator metrics. All validated measurement and indicator data from NLA 2012 are eventually transferred to EPA's Water Quality Exchange (WQX) and then the National STORET warehouse.

2.2.4 Peer Review

The NLA 2012 report will undergo a thorough peer review process, where the scientific community and the public will be given the opportunity to provide comments. Cooperators have been actively involved in the development of the overall project management, design, methods, and standards including the drafting of four key project documents:

- Quality Assurance Project Plan
- Site Evaluation Guidelines
- Field Operations Manual
- Laboratory Operations Manual

Outside scientific experts from universities, research centers, and other federal agencies have been instrumental in indicator development and will continue to play an important role in data analysis.

EPA will utilize a three-tiered approach for peer review of the Survey: (1) internal and external review by EPA, states, other cooperators and partners, (2) external scientific peer review, and (3) public review.

Once data analysis has been completed, cooperators will examine the results. Comments and feedback from the cooperators will be incorporated into the draft report. Following review by cooperators, the scientific peer review will occur. The public comment period will take place following incorporation of scientific peer review comments and other EPA and cooperator reviews. This public comment period is important to the process and will allow us to garner a broader perspective for clarifying the results before the final report is issued. The public peer review is consistent with the Agency and the Office of Management and Budget's (OMB's) revised requirements for peer review.

Below are the proposed measures EPA will implement for engaging in the peer review process:

- Follow the Agency's Information Quality Guidelines (IQG) and complete the IQG checklist
- Develop and maintain a public website with links to standard operating procedures, quality assurance documents, fact sheets, scientific peer review feedback, and final report

- Conduct technical workgroup meetings composed of scientific experts, cooperators, and EPA to evaluate and recommend data analysis options and indicators
- Complete data validation on all chemical, physical and biological data
- Conduct final data analysis with workgroup to generate assessment results
- Engage peer review contractor to identify external peer review panel
- Develop draft report presenting assessment results
- Develop final draft report incorporating input from cooperators and results from data analysis group to be distributed for peer a review
- Issue Federal Register (FR) Notice announcing document availability and hold public comment (30-45 days)
- Consider public comments and produce a final report

The proposed peer review schedule is provided below and is contingent upon timeliness of data validation and schedule availability for regional meetings and experts for data analysis workshop.

Proposed Schedule	Activity
May – December 2013	Data validation
March 2014	Data analysis workshop
May – August 2014	Internal peer review meetings (e.g., web conferences) with states, cooperators, participants
August 2014	Draft released for external peer review
October 2014	Draft released for public review

3 DATA QUALITY OBJECTIVES

It is a policy of the U.S. EPA that Data Quality Objectives (DQOs) be developed for all environmental data collection activities following the prescribed DQO Process. DQOs are qualitative and quantitative statements that clarify study objectives, define the appropriate types of data, and specify the tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions (USEPA 2006). Data quality objectives thus provide the criteria to design a sampling program within cost and resource constraints or technology limitations imposed upon a project or study. DQOs are typically expressed in terms of acceptable uncertainty (e.g., width of an uncertainty band or interval) associated with a point estimate at a desired level of statistical confidence (USEPA 2006). The DQO Process is used to establish performance or acceptance criteria, which serve as the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of a study (USEPA 2006). As a general rule, performance criteria represent the full set of specifications that are needed to design a data or information collection effort such that, when implemented, it will generate newly-collected data that are of sufficient quality and quantity to address the project's goals (USEPA 2006). Acceptance criteria are specifications intended to evaluate the adequacy of one or more existing sources of information or data as being acceptable to support the project's intended use (USEPA 2006).

3.1 Data Quality Objectives

Target DQOs established for the NLA 2012 relate to the goal of describing the current status of selected indicators of the condition of lakes in the conterminous U.S. and ecoregions of interest. The formal statement of the DQO for national estimates is as follows:

- Estimate the proportion of lakes ($\pm 5\%$) in the conterminous U.S. that fall below the designated threshold for good conditions for selected measures with 95% confidence.

For the ecoregions of interest the DQO is:

- Estimate the proportion of lakes ($\pm 15\%$) in a specific ecoregion that fall below the designated threshold for good conditions for selected measures with 95% confidence.

For estimates of change, the DQOs are:

- Estimate the proportion of lakes ($\pm 7\%$) in the conterminous U.S. that have changed condition classes for selected measures with 95% confidence.

3.2 Measurement Quality Objectives

For each parameter, performance objectives (associated primarily with measurement error) are established for several different data quality indicators (following EPA Guidance for Quality Assurance Plans USEPA 2002). Specific measurement quality objectives (MQOs) for each parameter are presented in the indicator section of the LOM or FOM as appropriate. The following sections define the data quality indicators and present approaches for evaluating them against acceptance criteria established for the program.

3.2.1 Laboratory Reporting Level (Sensitivity)

For chemical measurements, requirements for the method detection limit (MDL) are typically established. The MDL is defined as the lowest level of analyte that can be distinguished from zero with 99 percent confidence based on a single measurement (Glaser et al., 1981). For the NLA, target long-

term MDL (LT-MDL, following Oblinger-Childress et al. 1999) values were established for each chemical analyte based on the anticipated range of concentrations expected, values required as thresholds for assigning lake condition based on chemical stressors (e.g., nutrients, acidification, salinity, etc.) or trophic state (oligotrophic vs. mesotrophic vs. eutrophic), and the capability of analytical laboratories to measure an analyte at low concentrations over time given available methods. The target LT-MDL values were then used as the basis for establishing reporting levels (RL, also known as minimal reporting levels). The RL values are designed to achieve a risk of $\leq 1\%$ for both false negatives and false positives (Oblinger Childress et al. 1999). The Laboratory Reporting Limit LRL is set as two times higher than the target LT-MDL value. Therefore, multiple measurements of a sample having a true concentration at the RL should result in the concentration being detected and reported 99 percent of the time (Oblinger Childress et al. 1999).

Target MDL and RL values are based on the presumption that a laboratory will be receiving samples from across the US. Laboratories analyzing NLA samples from a more restricted region may have modified target RL values based on the range of expected concentrations and required thresholds values. A modified RL for a "regional" laboratory cannot be greater than a required threshold value that will be used in the NLA assessment. The objective for NLA is to minimize the number of values reported as "estimated" by an individual laboratory (i.e., between an estimated MDL and the laboratory RL).

For chemical analyses, all participating laboratories will monitor their target RL values by one (or both) of the following approaches:

- 1) for every calibration curve, include a calibration standard with an analyte concentration equal to the RL.
- 2) Monitor the RL by including a Quality Control Sample with a concentration equal to the RL with each analytical batch. Results of each QCS analysis must meet the acceptance criteria established for precision and bias (Section 3.2.3).

Laboratories are encouraged to conduct evaluations of analytical performance using samples at the target RLs established based on a "national" laboratory (receiving samples from across the US). These studies provide an indication of the confidence that can be placed on "estimated" results reported by the laboratory.

Estimates of RLs (and how they are determined) are required to be submitted with analytical results. Analytical results associated with RLs that exceed the objectives are flagged as being associated with unacceptable RLs. Analytical data that are below the estimated RLs, but above the laboratory's MDL are reported, but are flagged as "estimated" values (detected but not quantified). Values below the MDL should be reported (if possible), but flagged as being below the MDL. If a laboratory has to report values below the MDL as being equal to the MDL, this must be clearly stated in the metadata submitted with any analytical results to avoid the misuse of these results in assessment analyses.

3.2.2 Field Measurements

Since analytical (or field) precision, bias, and accuracy of field measurements will not be monitored separately during the NLA 2012, a revisit site approach will be taken to help evaluate the quality of data. The survey design incorporates a plan for repeated sampling of a subset of sites (including a subset of 398 lakes that was originally sampled in NLA 2007). Data from these repeat visits provide estimates of important components of variance to evaluate the performance of ecological indicators, evaluate the capability of the survey design to estimate status vs. detect trend, and to potentially reduce bias in the population estimates by "deconvoluting" the variance. These variance components are presented in Table 3.1. If estimates of these components are available from other studies, they are used in

conjunction with the project requirements to evaluate alternative design scenarios (Larsen et al. 1995, 2001, 2004). Status estimates are influenced most by the interaction (if multiple years are required to complete sampling) and residual variance components. Residual variance is composed of temporal variance within a sampling period confounded with measurement error of various types. If the magnitude of residual variance is sufficiently large to impact status estimates (see above), then relative magnitudes of the interaction variance and various components of residual variance are examined to determine if any reduction can be achieved in the future. Interaction variance can only be reduced by increasing the sample size. Index variance can be reduced by either increasing the number of sites, increasing the number of times a site is visited within a year, reducing the length of the index period, or by reducing measurement error. Trend detection is evaluated using the equation to determine the variance in the slope of the trend (Table 3.1). In the equation, residual variance also includes the interaction component. For multi-site networks such as the national aquatic resource assessments, trend detection is most sensitive to coherent year variance, which can only be reduced by extending the time period for monitoring (Larsen et al. 1995, 2001, 2004). If residual variance is large relative to the coherent year variance, then trend detection within a fixed time period can be improved by increasing the number of sites sampled each year, increasing the number of times each site is sampled within a year, or by reducing measurement error.

Table 3.1 Important variance components for aquatic resource assessments.

Model for status estimation		Model for trend detection
$\sigma_{total}^2 = \sigma_{sites}^2 + (\sigma_{year}^2 + \sigma_{site \times year}^2 + \sigma_{residual}^2)$		$var(slope) = \frac{\frac{\sigma_{sites}^2}{N_{sites}} + \left(\sigma_{year}^2 + \frac{s_{residual}^2}{N_{sites}} \right)}{\sum_{i=1}^{years} (y_i - \bar{Y})^2}$
and		
$\sigma_{residual}^2 = \sigma_{within\ year}^2 + \sigma_{error}^2$		and
		$s_{residual}^2 = \sigma_{site \times year}^2 + \frac{\sigma_{residual}^2}{N_{visit}}$
Components in parentheses represent “extraneous” variance		
Variance Component	Description	
σ_{sites}^2	Observed variance among all sites or streams sampled over multiple-year sampling cycle. If sites are revisited across years, this effect can be eliminated	
σ_{year}^2	Coherent variance across years that affects all sites equally, due to regional-scale factors such as climate or hydrology Principal effect on trend detection, reduced only by increasing number of years	
$\sigma_{site \times year}^2$	“Interaction” variance occurring at each site across years that affects each site independently. Principal effect on status, reduce by increasing number of sites	
$\sigma_{residual}^2$	“Residual” variance: Includes temporal variance at each site within a single index period ($\sigma_{within\ year}^2$) confounded with measurement error (σ_{error}^2) due to acquiring the data from the site (e.g., sample collection and analysis) Principal effect on status, If $\sigma_{index}^2 \gg \sigma_{error}^2$ reduce by increasing number of sites or altering index period If σ_{error}^2 is large relative to σ_{index}^2 , then modify sampling and analysis procedures	

For NLA 2012, 10 percent of all sample sites will receive repeat visits to determine temporal variability plus analytical variability within the index period. Revisit sites must be sampled at least 2-4 weeks apart to ensure that we are assessing temporal variability. Control measures to minimize measurement error among crews and sites will be employed. These control measures include the use of standardized field protocols provided in the FOM, consistent training of all crews, field assistance visits to all field crews, and availability of experienced technical personnel during the field season to respond to site-specific questions from field crews as they arise.

3.2.3 Chemical Precision, Bias, and Accuracy

Precision and bias are estimates of random and systematic error in a measurement process (Kirchmer, 1983; Hunt and Wilson, 1986, USEPA 2002). Collectively, precision and bias provide an estimate of the total error or uncertainty associated with an individual measurement or set of measurements. Systematic errors are minimized by using validated methods and standardized procedures across all laboratories. Precision is estimated from repeated measurements of samples. Net bias is determined from repeated measurements of solutions of known composition, or from the analysis of samples that have been fortified by the addition of a known quantity of analyte. For analytes with large ranges of expected concentrations, MQOs for precision and bias are established in both absolute and relative terms, following the approach outlined in Hunt and Wilson (1986). At lower concentrations, MQOs are specified in absolute terms. At higher concentrations, MQOs are stated in relative terms. The point of transition between an absolute and relative MQO is calculated as the quotient of the absolute objective divided by the relative objective (expressed as a proportion, e.g., 0.10 rather than as a percentage, e.g., 10%).

Precision in absolute terms is estimated as the sample standard deviation when the number of measurements is greater than two:

Equation 3.1

$$s = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n-1}}$$

where x_i is the value of the replicate, \bar{x} is the mean of repeated sample measurements, and n is the number of replicates. Relative precision for such measurements is estimated as the relative standard deviation (RSD, or coefficient of variation, [CV]):

Equation 3.2

$$RSD = \frac{s}{\bar{X}} \times 100$$

where s is the sample standard deviation of the set of measurements, and \bar{x} equals the mean value for the set of measurements.

Precision based on duplicate measurements is estimated based on the range of measured values (which equals the difference for two measurements).

The relative percent difference (RPD) is calculated as:

Equation 3.3

$$RPD = \left(\frac{|A - B|}{(A + B)/2} \right) \times 100$$

where A is the first measured value, B is the second measured value.

For repeated measurements of samples of known composition, net bias (B) is estimated in absolute terms as:

$$\text{Equation 3.4} \quad B = \bar{x} - T$$

where \bar{x} equals the mean value for the set of measurements, and T equals the theoretical or target value of a performance evaluation sample.

Bias in relative terms ($B[\%]$) is calculated as:

$$\text{Equation 3.5} \quad B(\%) = \frac{\bar{x} - T}{T} \times 100$$

where \bar{x} equals the mean value for the set of measurements, and T equals the theoretical or target value of a performance evaluation sample.

Accuracy is estimated for some analytes from fortified or spiked samples as the percent recovery. Percent recovery is calculated as:

$$\text{Equation 3.6} \quad \% \text{ recovery} = \frac{C_{is} - C_{ii}}{C_s} \times 100$$

where C_{is} is the measured concentration of the spiked sample, C_{ii} is the concentration of the unspiked sample, and C_s is the concentration of the spike.

For NLA 2012 each laboratory must monitor precision and bias for every sample batch by the analysis of internal QC samples. Labs will also report on percent recovery to determine accuracy. Labs must review and re-analyze samples associated with unacceptable QC sample results within one week. Labs should consult with the Project QA manager about any unacceptable results within one week and to verify that the appropriate corrective actions are taken.

3.2.4 Taxonomic Precision and Accuracy of Zooplankton, Phytoplankton, Diatoms and Benthic Macroinvertebrates

NLA 2012 will include two layers of quality assurance for biological assemblages: internal and external.

3.2.4.1 Internal quality assurance and quality control for biological data

Each laboratory will conduct internal, or within lab, quality assurance and quality control activities. Each lab must evaluate sorting efficiency of the NLA 2012 lab analysts. All lab analysts responsible for taxonomic identification must participate in an internal taxonomic verification check. The details of the sorting and taxonomic verifications can be found in the indicator-specific sections of the NLA 2012 LOM.

3.2.4.2 External quality assurance for biological data

Each laboratory will participate in external, or among lab, quality assurance. In general, external quality assurance takes two forms: (1) an independent taxonomist will re-analyze 10% of samples or (2) all of the labs participate in a round robin, where they swap 10% of samples among labs and re-analyze them. The details of the external quality assurance requirements (e.g., taxonomic resolution, calculations) are found in the indicator-specific sections of the NLA 2012 LOM.

For benthic invertebrates, sediment diatoms, phytoplankton, and zooplankton accuracy of taxonomy will be qualitatively evaluated through specification of target hierarchical levels (e.g., family, genus, or species); and the specification of appropriate technical taxonomic literature or other references (e.g., identification keys, voucher specimens). To calculate taxonomic precision, EPA will randomly select 10 percent of the samples for re-identification by an independent, outside taxonomist or laboratory. Comparison of the results of whole sample re-identifications will provide a Percent Taxonomic Disagreement (PTD) calculated as:

$$\text{Equation 3.7} \quad PTD = \left[1 - \left(\frac{comp_{pos}}{N} \right) \right] \times 100$$

where $comp_{pos}$ is the number of agreements, and N is the total number of individuals in the larger of the two counts. The lower the PTD, the more similar the taxonomic results and the greater the overall taxonomic precision. An MQO of 15% is recommended for taxonomic difference (overall mean <15% is acceptable). Individual samples exceeding 15% are examined for taxonomic areas of substantial disagreement, and the reasons for disagreement investigated.

In addition, we will calculate percent similarity between the taxonomic labs. Percent similarity is a measure of similarity between two communities or two samples (Washington 1984). Values range from 0% for samples with no species in common, to 100% for samples which are identical. It is calculated as follows:

$$\text{Equation 3.8} \quad PSC = 1 - 0.5 \sum_{i=1}^K |a - b|$$

where: a and b are, for a given species, the relative proportions of the total samples A and B, respectively, which that species represents. An MQO of ≥85% is recommended for percent similarity of taxonomic identification. If the MQO is not met, the reasons for the discrepancies between analysts will be discussed. If a major discrepancy is found in how the two analysts have been identifying organisms, the last batch of samples that have been counted by the analyst under review may have to be re-counted.

Sample enumeration is another component of taxonomic precision. Final specimen counts for samples are dependent on the taxonomist, not the rough counts obtained during the sorting activity.

Comparison of counts is quantified by calculation of percent difference in enumeration (PDE), calculated as:

$$\text{Equation 3.9} \quad PDE = \left(\frac{|Lab1 - Lab2|}{Lab1 + Lab2} \right) \times 100$$

An MQO of 5% is recommended (overall mean of ≤5% is acceptable). Individual samples exceeding 5% are examined to determine reasons for the exceedance.

Corrective actions for samples exceeding these MQOs can include defining the taxa for which re-identification may be necessary (potentially even by third party), for which samples (even outside of the 10% lot of QC samples) it is necessary, and where there may be issues of nomenclatural or enumeration problems. Specific corrective actions are identified in the indicator sections of the LOM.

Taxonomic accuracy is evaluated by having individual specimens representative of selected taxa identified by recognized experts. Samples will be identified using the most appropriate technical

literature that is accepted by the taxonomic discipline and reflects the accepted nomenclature. Specific references are identified in the indicator sections in the LOM. Any lab or taxonomist who believes these are not sufficient must contact the EPA NLA Project Leader and Project QA Coordinator to discuss options. The Integrated Taxonomic Information System (ITIS, <http://www.itis.usda.gov/>) will be used to verify nomenclatural validity and spelling. A reference collection will be compiled as the samples are identified. If necessary, specialists in several taxonomic groups will verify selected individuals of different taxa, as determined by the NLA workgroup.

3.2.5 Completeness

Completeness requirements are established and evaluated from two perspectives. First, valid data for individual parameters must be acquired from a minimum number of sampling locations in order to make subpopulation estimates with a specified level of confidence or sampling precision. The objective of this study is to complete sampling at 95% or more of the 1000 initial sampling sites. Percent completeness is calculated as:

Equation 3.10
$$\%C = \frac{V}{T} \times 100$$

where V is the number of measurements/samples judged valid, and T is the total number of planned measurements/samples. Within each indicator, completeness objectives are also established for individual samples or individual measurement variables or analytes. These objectives are estimated as the percentage of valid data obtained versus the amount of data expected based on the number of samples collected or number of measurements conducted. Where necessary, supplementary objectives for completeness are presented in the indicator-specific sections of the LOM.

In addition to evaluating completeness for each lab, the completeness objectives are established for each measurement *per site type* (e.g., probability sites, revisit sites, etc.). Failure to achieve the minimum requirements for a particular site type results in regional population estimates having wider confidence intervals. Failure to achieve requirements for repeat sampling (10% of samples collected) and revisit samples (10% of sites visited) reduces the precision of estimates of index period and annual variance components, and may impact the representativeness of these estimates because of possible bias in the set of measurements obtained.

3.2.6 Comparability

Comparability is defined as the confidence with which one data set can be compared to another (USEPA 2002). A performance-based methods approach is being utilized for water chemistry and chlorophyll a analyses that defines a set of laboratory method performance requirements for data quality. Following this approach, participating laboratories may choose which analytical methods they will use for each target analyte as long as they are able to achieve the performance requirements as listed in Table 9.4 of the LOM. Requirements for Reporting limits may be modified for regional laboratories based on the expected range of concentrations and required threshold values for assessing condition. For all parameters, comparability is addressed by the use of standardized sampling procedures and analytical methods by all sampling crews and laboratories. Comparability of data within and among parameters is also facilitated by the implementation of standardized quality assurance and quality control techniques and standardized performance and acceptance criteria. For all measurements, reporting units and format are specified, incorporated into standardized data recording forms, and documented in the information management system. Comparability is also addressed by providing results of QA sample data, such as estimates of precision and bias, conducting methods comparison studies when requested by the grantees and conducting inter-laboratory performance evaluation studies among state,

university, and NLA 2012 contract laboratories. See indicator specific sections of the LOM for more information when appropriate.

3.2.7 Representativeness

Representativeness is defined as "the degree to which the data accurately and precisely represent a characteristic of a population parameter, variation of a property, a process characteristic, or an operational condition" (USEPA 2002). At one level, representativeness is affected by problems in any or all of the other data quality indicators.

At another level, representativeness is affected by the selection of the target surface water bodies, the location of sampling sites within that body, the time period when samples are collected, and the time period when samples are analyzed. The probability-based sampling design should provide estimates of condition of surface water resource populations that are representative of the region. The individual sampling programs defined for each indicator attempt to address representativeness within the constraints of the *response design*, (which includes when, where, and how to collect a sample at each site). Holding time requirements for analyses ensure analytical results are representative of conditions at the time of sampling. See indicator specific sections of the LOM for more information and Appendix D of the FOM for more information.

4 SAMPLING DESIGN AND SITE SELECTION

The overall sampling program for the NLA 2012 project requires a randomized, probability-based approach for selecting lakes where sampling activities are to be conducted. Details regarding the specific application of the probability design to surface waters resources are described in Paulsen et al. (1991) and Stevens (1994).

4.1 Probability Based Sampling Design and Site Selection

The target population for this project includes all lakes, reservoirs, and ponds within the 48 contiguous United States greater than 1 hectare (2.5 acres) in surface area that are permanent water bodies. Lakes that are saline due to tidal influence are excluded as are those used for aquaculture, disposal-tailings, sewage treatment, evaporation, or other unspecified disposal use. The National Hydrography Dataset (NHD, 1:100,000 scale) was employed by EPA to derive a list of lakes for potential inclusion in the survey. The overall sample size was set to include 1000 lake sampling events, of which 904 are discrete lake samples and 96 are revisits. 398 of these sites were selected from the sites sampled in 2007 to provide a robust number of sites that we will use to evaluate change between the 2007 and the 2012 lakes assessments.

A Generalized Random Tessellation Stratified (GRTS) survey design for a finite resource was used for site selection. Lake selection for the survey provided for six size class categories (1-4 ha, 4-10 ha, 10-20 ha, 20-50 ha, 50-100 ha, >100 ha), as well as spatial distribution across the lower 48 states and nine aggregated Omernik Level 3 ecoregions (for more information see www.epa.gov/wed/pages/ecoregions/level_iii_iv.htm). EPA developed another subset of lakes for states that may want to do state level assessments (to increase the overall sample size to 50 per state). An additional 5,221 lakes were selected as potential replacement lakes (oversample sites). The oversample is used to replace a candidate lake that is determined to be non-target or to replace a target lake that is not accessible due to landowner denials, physical barriers, or safety concerns. Crews must take replacement sites from the Oversample List in the order that they appear in the site list (numerically by SITE_ID). Skipping over sites on the list compromises the integrity of the survey design and complicates the assessment analyses. It is important to assign a final status to all sites on the list regardless of whether they end up being sampled.

Design Sites for the 2012 National Lakes Assessment

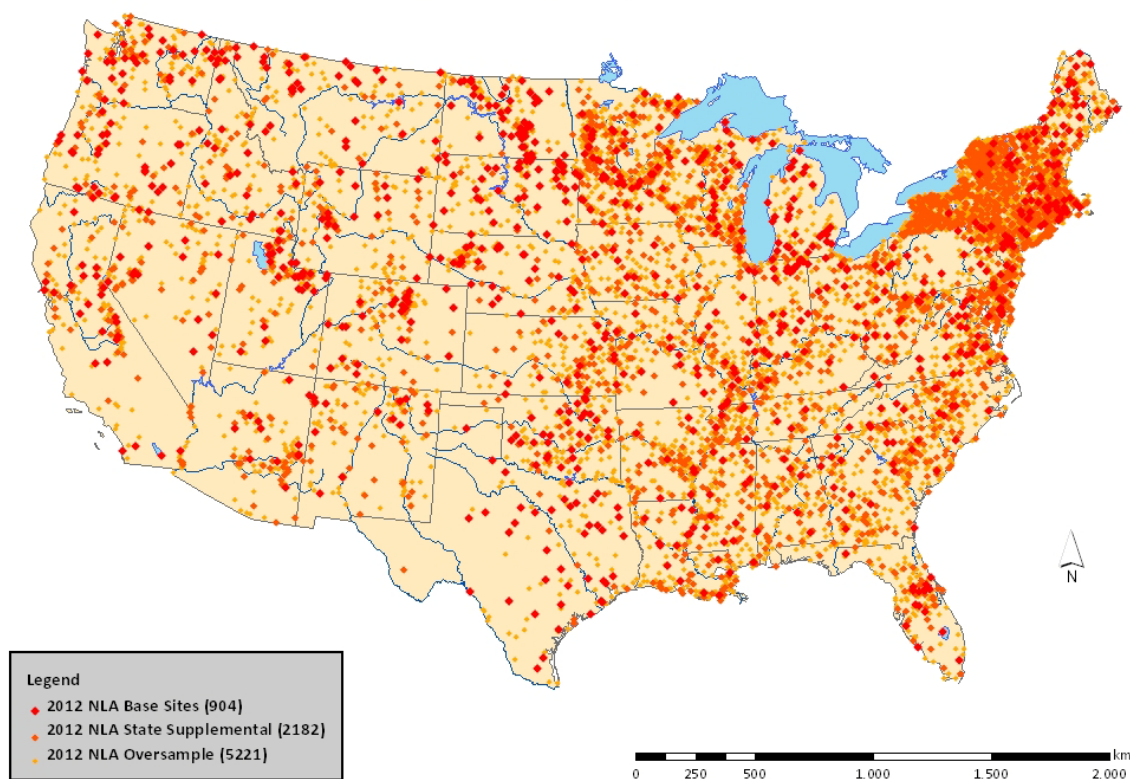


Figure 4.1 Design sites for the 2012 National Lakes Assessment.

Complete documentation is included in Appendix B in the Site Evaluation Guidelines document.

4.2 Reference Site Selection

EPA selected a set of potential reference sites to sample in NLA 2012. This hand-picked set of candidate sites comes from three sources. First, the EPA NLA team went through a chemical screening exercise to identify reference lakes from NLA 2007 sites, where NLA 2012 revisit lakes were excluded. Second, EPA assembled a panel to examine land cover around 1-4 HA lake from the NLA 2007 design. Although they were excluded from the sampling process in 2007, these lakes were in the original draw for NLA 2007 and have a broad spatial distribution. Finally, EPA hopes to augment the reference lake pool in the plains ecoregions, which had relatively few reference lakes in NLA 2007, with a combined effort of land cover analysis and suggestions from state and federal partners.

Although crews will sample these potential reference sites during this field season, the final set of reference lakes, i.e., those that EPA will use in the assessment, will be determined after the complete set of data is returned. At that point, EPA will run a set of screening criteria similar to that used in NLA 2007 (USEPA 2009).

5 INFORMATION MANAGEMENT

Environmental monitoring efforts that amass large quantities of information from various sources present unique and challenging data management opportunities. To meet these challenges, the NLA 2012 employs a variety of well-tested information management (IM) strategies to aid in the functional organization and ensured integrity of stored electronic data. IM is integral to all aspects of the NLA 2012 from initial selection of sampling sites through the dissemination and reporting of final, validated data. And, by extension, all participants in the NLA 2012 have certain responsibilities and obligations which also make them a part of the IM system. This “inclusive” approach to managing information helps to:

- Strengthen relationships among NLA 2012 cooperators.
- Increase the quality and relevance of accumulated data.
- Ensure the flexibility and sustainability of the NLA 2012 IM structure.

This IM strategy provides a congruent and scientifically meaningful approach for maintaining environmental monitoring data that will satisfy both the scientific and technological requirements of the NLA 2012.

5.1 Roles and Responsibilities

At each point where data and information are generated, compiled, or stored, the NLA 2012 team must manage the information. Thus, the IM system includes all of the data-generating activities, all of the means of recording and storing information, and all of the processes that use data. The IM system also includes both hardcopy and electronic means of generating, storing, organizing and archiving data, and the effort to achieve a functional IM process is all encompassing. *To that end, all participants in the NLA 2012 play an integral part within the IM system.* The following table provides a summary of the IM responsibilities identified by NLA 2012 group. Specific information on the field crew responsibilities for tracking and sending information is found in the FOM.

Table 5.1 Summary of IM responsibilities.

NLA 2012 Group	Contact	Primary Role	Responsibility
Field Crews	State/tribal partners and contractor or other field crews (regional EPA, etc.)	Acquire in-situ measurements and prescribed list of biotic/abiotic samples at each site targeted for the survey	<p>Complete and review field data forms and sample tracking forms for accuracy, completeness, and legibility.</p> <p>Ship/fax field and sample tracking forms to NARS IM Center so information can be integrated into the central database</p> <p>Work with the NARS IM Center staff to develop acceptable file structures and electronic data transfer protocols should there be a need to transfer and integrate data into the central database</p> <p>Provide all data as specified in FOM, SEG or as negotiated with the NLA Project Leader.</p> <p>Maintain open communications with NARS IM Center regarding any data issues</p>
Analytical Laboratories	State/tribal partners and contractors	Analyze samples received from field crews in the manner	<p>Review all electronic data transmittal files for completeness and accuracy (as identified in the QAPP).</p> <p>Work with the NARS IM Center staff to develop file structures and electronic data transfer protocols for</p>

		appropriate to acquire biotic/abiotic indicators/measurements requested.	electronically-based data. Submit completed sample tracking forms to NLA 2012 IM Center so information can be updated in the central database Provide all data and metadata as specified in the laboratory transmittal guidance section of the QAPP or as negotiated with the NLA Project Leader. Maintain open communications with NLA 2012 IM Center regarding any data issues.
IM Center staff	USEPA ORD NHEERL Western Ecology Division-Corvallis, Contractors	Provides support and guidance for all IM operations related to maintaining a central data management system for NLA 2012	Develop/update field data forms. Plan and implement electronic data flow and management processes. Manage the centralized database and implement related administration duties. Receive, scan, and conduct error checking of field data forms. Monitor and track samples from field collection, through shipment to appropriate laboratory. Receive data submission packages (analytical results and metadata) from each laboratory. Run automated error checking, e.g., formatting differences, field edits, range checks, logic checks, etc. Receive verified, validated, and final indicator data files (including record changes and reason for change) from QA reviewers. Maintain history of all changes to data records from inception through delivery to WQX. Organize data in preparation for data verification and validation analysis and public dissemination. Implement backup and recovery support for central database. Implement data version control as appropriate.
Project Quality Assurance Manager	USEPA Office Of Water	Review and evaluate the relevancy and quality of information/data collected and generated through the NLA 2012 surveys.	Monitor quality control information. Evaluate results stemming from field and laboratory audits. Investigate and take corrective action, as necessary, to mitigate any data quality issues. Issue guidance to NLA 2012 Project Leader and IM Center staff for qualifying data when quality standards are not met or when protocols deviate from plan.
Steering Committee	NLA Project Lead and other team members,	Provide technical recommendations related to data analysis, reporting	Provide feedback and recommendations related to QA, data management, analysis, reporting and data distribution issues Review and comment on QA and information management

	EPA Regional and ORD staff, States, tribes, other federal agencies	and overall implementation	documentation (QAPP, data templates, etc).
Data Analysis and Reporting Team	USEPA Office of Water, ORD WED, Partners	Provide the data analysis and technical support for NLA 2012 reporting requirements	<p>Provide data integration, aggregation and transformation support as needed for data analysis.</p> <p>Provide supporting information necessary to create metadata.</p> <p>Investigate and follow-up on data anomalies using identified data analysis activities.</p> <p>Produce estimates of extent and ecological condition of the target population of the resource.</p> <p>Provide written background information and data analysis interpretation for report(s).</p> <p>Document in-depth data analysis procedures used.</p> <p>Provide mapping/graphical support.</p> <p>Document formatting and version control.</p> <p>Develops QA report for management.</p>
Data Finalization Team	TBD	Provides data librarian support	<p>Prepare NLA 2012 data for transfer to USEPA public web-server(s).</p> <p>Generate data inventory catalog record (Science Inventory Record).</p> <p>Ensure all metadata is consistent, complete, and compliant with USEPA standards.</p>

5.1.1 State/ Tribe-Based Data Management

Some state or tribal partners will be managing activities for both field sampling and laboratory analyses and would prefer to handle data management activities in-house. While the NARS program encourages states to use these in-house capabilities, it is imperative that NLA 2012 partners understand their particular role and responsibilities for executing these functions within the context of the national program. If a state chooses to do IM in-house, the state will perform all of the functions associated with the following roles:

- Field Crew—including shipping/faxing of field data forms to the IM Coordinator (NLA 2012 paper or electronic field forms must be used and the original field forms must be sent to the NARS IM Center as outlined in the NLA 2012 FOM).
- Quality Control Team for laboratory data
- To some extent, Quality Assurance Manager for laboratory results
- All data will flow from the state to the NARS IM Center. Typically, the state will provide a single point of contact for all things related to NLA 2012 data. However, it may be advantageous for the NARS IM Center staff to have direct communication with the state-participating laboratories to facilitate the transfer of data—a point that may be negotiated between the primary state

contact, the regional coordinator and the NLA 2012 Project Leader (with input from the NARS IM Center staff).

- Data transfers to the NARS IM Center must be timely. States must submit all initial laboratory results (i.e., those that have been verified by the laboratory and have passed all internal laboratory QA/QC criteria) in the appropriate format to NARS IM Center by May 2013, in order to meet NLA 2012 product deadlines.
- Data transfers must be complete. For example, laboratory analysis results submitted by the state must be accompanied by related quality control and quality assurance data, qualifiers code definitions, contaminant/parameter code cross-references/descriptions, test methods, instrumentation information and any other relevant laboratory-based assessments or documentation related to specific analytical batch runs.
- The state or Tribe will ensure that data meet minimum quality standards and that data transfer files meet negotiated content and file structure standards.

The NARS IM Center will provide the necessary guidance for IM requirements. Each group that will perform in-house IM functions will incorporate these guidelines as is practicable or as previously negotiated.

5.2 Overview of System Structure

In its entirety, the NARS IM system includes site selection and logistics information, sample labels and field data forms, tracking records, map and analytical data, data validation and analysis processes, reports, and archives. NARS IM staff provides support and guidance to all program operations in addition to maintaining a central database management system for the NLA data.

The central repository for data and associated information collected for use by NLA 2012 is a secure, access-controlled server located at WED-Corvallis.

This database is known as the NARS IM. Data are stored and managed on this system using the Structured Query Language (SQL). Data review (e.g., verification and validation) and data analysis (e.g., estimates of status and extent) are accomplished primarily using programs developed in either (SAS) or R language software packages.

5.2.1 Data Flow

The NLA 2012 will accumulate large quantities of observational and laboratory analysis data. To appropriately manage this information, it is essential to have a well-defined data flow model and documented approach for acquiring, storing, and summarizing the data. This conceptual model (Figure 5.1) helps focus efforts on maintaining organizational and custodial integrity, ensuring that data available for analyses are of the highest possible quality.

5.2.2 Simplified Description of Data Flow

There are several components associated with the flow of information, these are:

- Communication—between the NARS IM Center and the various data contributors (e.g., field crews, laboratories and the data analysis and reporting team)—is vital for maintaining an organized, timely, and successful flow of information and data.
- Data are *captured* or acquired from four basic sources — field data transcription, laboratory analysis reporting, automated data capture, and submission of external data files (e.g., GIS data)—encompassing an array of data types: site characterization; biotic assessment; sediment and tissue contaminants; and water quality analysis. Data capture generally relies on the

- transference of electronic data, e.g., optical character readers and email, to a central data repository. However, some data must be transcribed by hand in order to complete a record.
- Data repository or *storage*—provides the computing platform where raw data are archived, partially processed data are staged, and the “final” data, assimilated into a final, user-ready data file structure, are stored. The raw data archive is maintained in a manner consistent with providing an audit trail of all incoming records. The staging area provides the IM Center staff with a platform for running the data through all of its QA/QC paces as well as providing data analysts a first look at the incoming data. This area of the data system evolves as new data are gathered and user-requirements are updated. The final data format becomes the primary source for all statistical analysis and data distribution.
 - Metadata—a descriptive document that contains information compliant with the Content Standards for Digital Geospatial Metadata (CSDGM) developed by the Federal Geographic Data Committee (FGDC).

ECOLOGICAL INDICATOR FIELD AND LABORATORY DATA FLOW

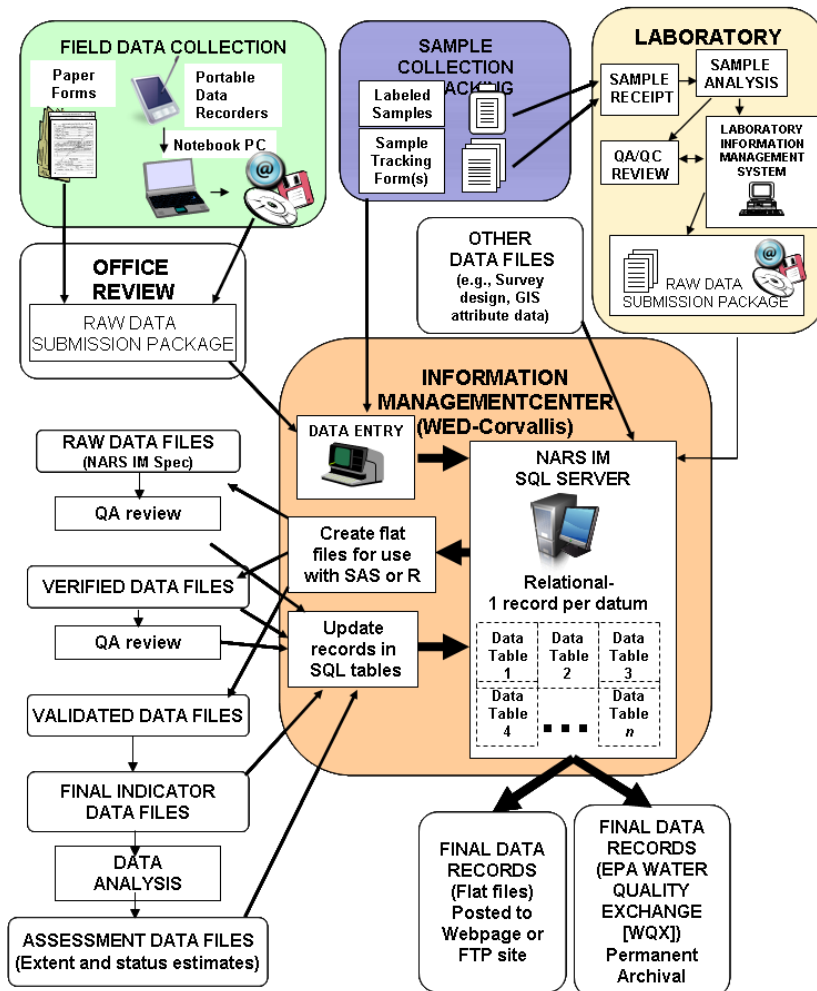


Figure 5.1 Conceptual model of data flow into and out of the master SQL database for the NLA 2012.

The following sections describe core information management standards, data transfer protocols, and data quality and results validation. Additionally, section 5.4 describes the major data inputs to the

central database and the associated QA/QC processes used to record, enter, and validate measurement and analytical data collected.

5.2.3 Core Information Management Standards

The development and organization of the NARS IM system is compliant with current EPA guidelines and standards. Areas addressed by these policies and guidelines include, but are not limited to, the following:

- Taxonomic nomenclature and coding;
- Locational data;
- Sampling unit identification and reference;
- Hardware and software; and
- Data catalog documentation.

NLA 2012 is committed to compliance with all applicable regulations and guidance concerning hardware and software procurement, maintenance, configuration control, and QA/QC. To that end, the NLA 2012 team has adopted several IM standards that help maximize the ability to exchange data within the study and with other aquatic resource surveys or similar large-scale monitoring and assessment studies (e.g. NARS, past EMAP and R-EMAP studies). Specific information follows.

5.2.4 Data Formats

5.2.4.1 Attribute Data

- SQL Tables
- SAS Data Sets
- R Data Sets
- American Standard Code for Information Interchange (Ascii) Files: Comma-Separated values, or space-delimited, or fixed column

5.2.4.2 GIS Data

- ARC/INFO native and export files; compressed .tar file of ARC/INFO workspace
- Spatial Data Transfer Standard (SDTS; FGDC 1999) format available upon request

5.2.4.3 Standard Coding Systems

- Sampling Site: (EPA Locational Data Policy; EPA 1991)
- Coordinates: Latitude and Longitude in decimal degrees (± 0.002)
- Datum: NAD83
- Chemical Compounds: Chemical Abstracts Service (CAS 1999)
- Species Codes: Integrated Taxonomic Information System when possible
- Land cover/land use codes: Multi-Resolution Land Characteristics ; National Hydrography Dataset Plus Version 1.0 (NHDPlus 2005)

5.2.5 Public Accessibility

While any data created using public funds are subject to the Freedom of Information Act (FOIA), some basic rules apply for general public accessibility and use.

- Program must comply with Data Quality Act before making any data available to the public and person generating data must fill out and have a signed Information Quality Guidelines package before any posting to the Web or distribution of any kind.
- Data and metadata files are made available to the contributor or participating group for review or other project-related use from NARS IM or in flat files before moving to an EPA-approved public website.
- Data to be placed on a public website will undergo QA/QC review according to the approved QAPP.
- Only “final” data (those used to prepare the final project report) are readily available through an EPA-approved public website.

As new guidance and requirements are issued, the NARS IM staff will assess the impact upon the IM system and develop plans for ensuring timely compliance.

5.3 Data Transfer Protocols

Field crews are expected to send in hard copies of field forms or use the provided electronic field forms containing *in situ* measurement and event information to the NARS IM Center defined in the FOM for submission. Laboratories will submit electronic data files. Field crews and labs must submit all sample tracking and analytical results data to the NARS IM Center in electronic form using a standard software package to export and format data. Data submission templates for laboratories are included in the LOM. Examples of software and the associated formats are:

Software	Export Options (file extensions)
Microsoft Excel®	xls, xlsx, csv, formatted txt delimited
Microsoft Access®	mdb, csv, formatted txt delimited
SAS®	csv, formatted txt delimited
R	csv, formatted txt delimited

All electronic files must be accompanied by appropriate documentation (e.g., metadata, laboratory reports, QA/QC data and review results). This documentation must contain sufficient information to identify field contents, field formats, qualifier codes, etc. It is very important to keep EPA informed of the completeness of the analyses. Labs may send files periodically, before all samples are analyzed, but EPA must be informed that more data are pending if a partial file is submitted. All data files sent by the labs must be accompanied by text documentation describing the status of the analyses, any QA/QC problems encountered during processing, and any other information pertaining to the quality of the data. Following is a list of general transmittal requirements each laboratory or state-based IM group should consider when packaging data for electronic transfer to the IM Center:

- Provide data in row/column data file/table structure – see attachment D in LOM for templates. All cooperators and contractors should further consider the following:
 - Include NLA site and sample ID provided on the sample container label in a field for each record (row) to ensure that each data file/table record can be related to a site visit.
 - Use a consistent set of column labels.
 - Use file structures consistently.
 - Use a consistent set of data qualifiers.
 - Use a consistent set of units.
 - Include method detection limit (MDL) as part of each result record.

- Include reporting limit (RL) as part of each result record.
- Provide a description of each result/QC/QA qualifier.
- Provide results/measurements/MDL/RL in numeric form.
- Maintain result qualifiers (e.g., <, ND) in a separate column.
- Use a separate column to identify record-type. For example, if QA or QC data are included in a data file, there should be a column that allows the IM staff to readily identify the different result types.
- Include laboratory sample identifier.
- Include batch numbers/information so results can be paired with appropriate QA/QC information.
- Include “true value” concentrations, if appropriate, in QA/QC records.
- Include a short description of preparation and analytical methods used to (where appropriate) either as part of the record or as a separate description for the test(s) performed on the sample. For example, EPAxxx.x, ASTMxxx.x, etc. Provide a broader description (e.g., citation) if a non-standard method is used.
- Include a short description of instrumentation used to acquire the test result (where appropriate). This may be reported either as part of the record or as a separate description for each test performed on the sample. For example, GC/MS-ECD, ICP-MS, etc.
- Ensure that data ready for transfer to NARS IM are verified and validated, and results are qualified to the extent possible (final verification and validation are conducted by EPA).
- Data results must complement expectations (analysis results) as specified by contract or agreement.
- Identify and qualify missing data (why are the data missing?).
- Submit any other associated quality assurance assessments and relevant data related to laboratory results (i.e., chemistry, nutrients). Examples include summaries of QC sample analyses (blanks, duplicates, check standards, matrix spikes) standard or certified reference materials, etc.), results for external performance evaluation or proficiency testing samples, and any internal consistency checks conducted by the laboratory. For requirements, please see specific indicator sections of this QAPP and lab SOP.

Labs will work with the NARS IM Coordinator to establish a data load process into NARS IM.

5.4 Data Quality and Results Validation

Data quality is integrated throughout the life cycle of the data. This includes development of appropriate forms, labels etc. for capturing data as well as verifying data entry, results, and other assessments. Indicator workgroup experts, the data analysis and reporting team submit any recommended changes to the Project QA Coordinator who recommends and submits any changes (deletions, additions, corrections) to the NARS IM data center for inclusion in the validated data repository. All explanation for data changes is included in the record history.

5.4.1 Design and Site Status Data Files

The site selection process described in Section 3 produces a list of candidate sampling locations, inclusion probabilities, and associated site classification data (e.g., target status, ecoregion, etc.). The Design Team provides this file to the NLA 2012 Project Leader, who in turn distributes to the IM staff, and field coordinators. Field coordinators determine ownership and contacts for acquiring permission to access each site, and conduct site evaluation and reconnaissance activities. Field Crews document information from site evaluation and reconnaissance activities following the Site Evaluation Guidelines (SEG) and the Field Operations Manual (FOM). The site evaluation spreadsheets and verification forms

are submitted to the Project Lead by the field crews. The NARS IM Center compiles all information such as ownership, site evaluation, and reconnaissance information for each site into a “site status” data file. Any missing information from the site status data file is identified and a request is made by the NARS IM Center to the field crew (or site evaluator) to complete the record.

5.4.2 Sample Collection and Field Data

Field crews record sampling event observational data in a standard and consistent manner using field data collection forms (Appendix E of the NLA 2012 FOM). Prior to initiation of field activities, the NARS IM staff works with the indicator leads and analytical support laboratories to develop standardized field data forms and sample labels. Adhesive labels, completed by the field crews, have a standard recording format and are affixed to each sample container. Field protocols include precautions to ensure that label information remains legible and the label remains attached to the sample.

Table 5.2 Summary sample and field data quality control activities.

Quality Control Activity	Description and/or Requirements
Contamination Prevention	All containers for individual site sealed in plastic bags until use; specific contamination avoidance measures covered in training
Sample Identification	Pre-printed labels with unique ID number on each sample
Data Recording	Data recorded on pre-printed forms of water-resistant paper; field sampling crew reviews data forms for accuracy, completeness, and legibility
Data Qualifiers	Defined qualifier codes used on data form; qualifiers explained in comments section on data form
Sample Custody	Unique sample ID and tracking form information entered in LIMS; sample shipment and receipt confirmed
Sample Tracking	Sample condition inspected upon receipt and noted on tracking form with copies sent to ORD Technical Lead and/or IM
Data Entry	Data entered using customized entry screens that resemble the data forms; entries reviewed manually or by automated comparison of double entry
Data Submission	Standard format defined for each measurement including units, significant figures, and decimal places, accepted code values, and required field width
Data Archival	All data records, including raw data, archived in an organized manner. For example, following verification/validation of the last submission into the NARS database, it is copied to a terabit external hard drive and sent to the Project Leader for inclusion in his project file, scheduled as 501, permanent records. Processed samples and reference collections of taxonomic specimens submitted for cataloging and curing at an appropriate museum facility

NLA 2012 provides two options for completing field forms: electronic data entry using pre-developed forms on your laptop or smart phone or “traditional” paper. Paper forms are printed for field crews on water resistant paper. Copies of the field data forms and instructions for completing each form are documented in the NLA 2012 FOM. Recorded data – whether through e-forms or paper – are reviewed

upon completion of data collection and recording activities by the Field Crew Leader. Field crews check completed data forms and sample labels before leaving a sampling site to ensure information and data were recorded legibly and completely. Errors are corrected by field crews if possible, and data considered as suspect are qualified using a flag variable. The field sampling crew enters explanations for all flagged data in a comments section. Field crews transmit e-forms to the NARS IM Staff by selecting the “submit” button as described in the FOM. Field crews ship completed paper field data forms to the NARS IM staff for entry into the central database management system.

All samples are tracked from the point of collection. Field crews ensure that copies of the shipping and custody record accompany all sample transfers; other copies are transmitted to the IMC. The IMC tracks samples to ensure that they are delivered to the appropriate laboratory, that lost shipments can be quickly identified and traced, and that any problems with samples observed when received at the laboratory are reported promptly so that corrective action can be taken if necessary. Detailed procedures on shipping and sample tracking can be found in the Field Operations Manual.

Procedures for completion of sample labels and field data forms and use of PCs are covered extensively in training sessions. General QC checks and procedures associated with sample collection and transfer, field measurements, and field data form completion for most indicators are listed in Table 5.3. Additional QA/QC checks or procedures specific to individual indicators are described in the NLA 2012 Lab Operations Manual.

5.4.3 Laboratory Analyses and Data Recording

Upon receipt of a sample shipment, analytical laboratory receiving personnel check the condition and identification of each sample against the sample tracking record. Each sample is identified by information written on the sample label. Any discrepancies, damaged samples, or missing samples are reported to the NARS IM staff and NLA 2012 Project Lead electronically.

Most of the laboratory analyses for the NLA 2012 indicators, particularly chemical and physical analyses, follow or are based on standard methods. Standard methods generally include requirements for QC checks and procedures. General laboratory QA/QC procedures applicable to most NLA 2012 indicators are described in. Additional QA/QC procedures specific to individual indicator and parameter analyses are described in the LOM. Biological sample analyses are generally based on current acceptable practices within the particular biological discipline. Some QC checks and procedures applicable to most NLA 2012 biological samples are described in the LOM.

Table 5.3 Summary laboratory data quality control activities.

Quality Control Activity	Description and/or Requirements
Instrument Maintenance	Follow manufacturer’s recommendations and specific guidelines in methods; maintain logbook of maintenance/repair activities
Calibration	Calibrate according to manufacturer’s recommendations; recalibrate or replace before analyzing any samples
QC Data	Maintain control charts, determine LT-MDLs and achieved data attributes; include QC data summary (narrative and compatible electronic format) in submission package
Data Recording	Use software compatible with NARS IM system check all data entered against the original bench sheet to identify and correct entry errors.

	Review other QA data (e.g., condition upon receipt, etc.) for possible problems with sample or specimen.
Data Qualifiers	Use defined qualifier codes; explain all qualifiers
Data Entry	Automated comparison of double entry or 100% manual check against original data form
Submission Package	Includes: <ul style="list-style-type: none"> • Letter by laboratory manager • Data • Data qualifiers and explanations • Electronic format compatible with NARS IM • Documentation of file and database structures • Metadata: variable descriptions and formats • Summary report of any problems and corrective actions implemented

A laboratory's IM system may consist of only hardcopy records such as bench sheets and logbooks, an electronic laboratory information management system (LIMS), or some combination of hardcopy and electronic records. Laboratory data records are reviewed at the end of each analysis day by the designated laboratory onsite QA coordinator or by supervisory personnel. Errors are corrected by laboratory personnel if possible, and data considered as suspect by laboratory analysts are qualified with a flag variable. All flagged data are explained in a comments section. Private contract laboratories generally have a laboratory Quality Assurance Plan and established procedures for recording, reviewing, and validating analysis data.

Once analytical data have passed all of the laboratory's internal review procedures, the lab prepares and transfers a submission package using the prescribed templates in the LOM. The contents of the submission package are largely dictated by the type of analysis (physical, chemical, or biological).

Remaining sample material and voucher specimens may be transferred to EPA's designated laboratory or facilities as directed by the NLA 2012 Project Lead. All samples and raw data files (including logbooks, bench sheets, and instrument tracings) are to be retained by the laboratory for 3 years or until authorized for disposal, in writing, by the EPA Project Leader. Deliverables from contractors and cooperators, including raw data, are permanent as per EPA Record Schedule 258. EPA's project records are scheduled 501 and are also permanent.

5.4.4 Data Review, Verification, and Validation Activities

Raw data files are created from entry of field and analytical data, including data for QA/QC samples and any data qualifiers noted on the field forms or analytical data package.

5.4.4.1 Paper Forms

The NARS IM Center either optically scans or transcribes information from field collection forms into an electronic format (sometimes using a combination of both processes). During the scanning process, incoming data are subjected to a number of automated error checking routines. Obvious errors are corrected immediately at the time of scanning. Suspected errors that cannot be confirmed at the time of scanning are qualified for later review by someone with the appropriate background and experience (e.g., a chemist or aquatic ecologist). The process continues until the transcribed data are 100% verified or no corrections are required.

5.4.4.2 Electronic Forms

The NARS IM Center directly uploads information from the electronic field collection forms into their database. During the upload process, incoming data are subjected to a number of automated error checking routines. Omissions and errors are automatically noted in an email message to the field crew lead.

5.4.4.3 Additional Review

Additional validation is accomplished by the NARS IM Center staff using a specific set of guidelines and executing a series of programs (computer code) to check for: correct file structure and variable naming and formats, outliers, missing data, typographical errors and illogical or inconsistent data based on expected relationships to other variables. Data that fail any check routine are identified in an “exception report” that is reviewed by an appropriate scientist for resolution.

The NARS IM Center brings any remaining questionable data to the attention of the QA manager and individuals responsible for collecting the data for resolution.

The HQ QA lead evaluates all data to determine completeness and validity. Additionally, the data are run through a rigorous inspection using SQL queries or other computer programs such as SAS or R to check for anomalous data values that are especially large or small, or are noteworthy in other ways. Focus is on rare, extreme values since outliers may affect statistical quantities such as averages and standard deviations.

The HQ QA lead examines all laboratory quality assurance (QA) information to determine if the laboratory met the predefined data quality objectives - available through the QAPP.

Some of the typical checks made in the processes of verification and validation are described in Table 5.4. Automated review procedures may be used. The primary purpose of the initial checks is to confirm that each data value present in an electronic data file is accurate with respect to the value that was initially recorded on a data form or obtained from an analytical instrument. In general, these activities focus on individual variables in the raw data file and may include range checks for numeric variables, frequency tabulations of coded or alphanumeric variables to identify erroneous codes or misspelled entries, and summations of variables reported in terms of percent or percentiles. In addition, associated QA information (e.g., sample holding time) and QC sample data are reviewed to determine if they meet acceptance criteria. Suspect values are assigned a data qualifier. They will either be corrected, replaced with a new acceptable value from sample reanalysis, or confirmed suspect after sample reanalysis. For biological samples, species identifications are corrected for entry errors associated with incorrect or misspelled codes. Errors associated with misidentification of specimens are corrected after voucher specimens have been confirmed and the results are available. Files corrected for entry errors are considered to be raw data files. Copies of all raw data files are maintained in the centralized NARS IM System.

Any suspect data will be flagged for data qualification.

The NARS IM staff, with the support of the NLA 2012 Quality Team, correct and qualify all questionable data. Copies of the raw data files are maintained in NARS IM, generally in active files until completion of reporting and then in archive files. Redundant copies of all data files are maintained and all files are periodically backed up.

Table 5.4 Data review, verification, and validation quality control activities.

Quality Control Activity	Description and/or Requirements
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Review any qualifiers associated with variable	Determine if value is suspect or invalid; assign validation qualifiers as appropriate
Determine if MQOs and project DQOs have been achieved	Determine potential impact on achieving research and/or program objectives
Exploratory data analyses (univariate, bivariate, multivariate) utilizing all data	Identify outlier values and determine if analytical error or site-specific phenomenon is responsible
Confirm assumptions regarding specific types of statistical techniques being utilized in development of metrics and indicators	Determine potential impact on achieving research and/or program objectives

In the final stage of data verification and validation, exploratory data analysis techniques may be used to identify extreme data points or statistical outliers in the data set. Examples of univariate analysis techniques include the generation and examination of box-and-whisker plots and subsequent statistical tests of any outlying data points. Bivariate techniques include calculation of Spearman correlation coefficients for all pairs of variables in the data set with subsequent examination of bivariate plots of variables having high correlation coefficients. Multivariate techniques have also been used in detecting extreme or outlying values in environmental data sets (Meglen, 1985; Garner et al., 1991; Stapanian et al., 1993).

The Quality Team reviews suspect data to determine the source of error, if possible. If the error is correctable, the data set is edited to incorporate the correct data. If the source of the error cannot be determined, the Quality Team qualifies the data as questionable or invalid. Data qualified as questionable may be acceptable for certain types of data analyses and interpretation activities. The decision to use questionable data must be made by the individual data users. Data qualified as invalid are considered to be unacceptable for use in any analysis or interpretation activities and will generally be removed from the data file and replaced with a missing value code and explanatory comment or flag code. After completion of verification and validation activities, a final data file is created, with copies transmitted for archival and for uploading to the centralized IM system.

Once verified and validated, data files are made available for use in various types of interpretation activities; each activity may require additional restructuring of the data files. These restructuring activities are collectively referred to as "data enhancement." In order to develop indicator metrics from one or more variables, data files may be restructured so as to provide a single record per lake.

5.5 Data Transfer

Field crews may transmit data electronically; hardcopies of completed data and sample tracking forms may be sent via express courier service. Copies of raw, verified, and validated data files are transferred from the QA lead to the IM staff for inclusion in the central IM system. All transfers of data are conducted using a means of transfer, file structure, and file format that has been approved by the IM staff. Data files that do not meet the required specifications will not be incorporated into the centralized data access and management system.

5.5.1 Database Changes

The NARS IM Center staff complete data corrections at the lowest level to ensure that any subsequent updates will contain only the most correct data. The NARS IM Center sends back laboratory results found to be in error to the originator (lab) for correction. After the originator makes any corrections, the entire batch or file is resubmitted to the NARS IM Center. The NARS IM Center uses these resubmissions to replace any previous versions of the same data.

The NARS IM Center uses a version control methodology when receiving files. Incoming data are not always immediately transportable into a format compatible with the desired file structures. When this situation occurs, the IM staff creates a copy of the original data file, which then becomes the working file in which any formatting changes will take place. The original raw data will remain unchanged. This practice further ensures the integrity of the data and provides an additional data recovery avenue, should the need arise.

All significant changes are documented by the NARS IM Center staff. The NARS IM Center includes this information in the final summary documentation for the database (metadata).

After corrections have been applied to the data, the NARS IM Center will rerun the validation programs to re-inspect the data.

The NARS IM Center may implement database auditing features to track changes.

5.6 Metadata

Federal Geographic Data Committee, Content standard for digital geospatial metadata, version 2.0. FGDC-STD-001-1998 (FGDC 1998).

5.7 Information Management Operations

5.7.1 Computing Infrastructure

Electronic data are collected and maintained within a central server housed at WED using a Windows Server 2003 R2 (current configuration) or higher computing platform in SQL native tables for the primary data repository and SAS® native data sets or R datasets for data analysis. Official IM functions are conducted in a centralized environment.

5.7.2 Data Security and Accessibility

The NARS IM Center ensures that all data files in NARS IM are protected from corruption by computer viruses, unauthorized access, and hardware and software failures. Guidance and policy documents of EPA and management policies established by the IM Technical Coordination Group for data access and data confidentiality are followed. Raw and verified data files are accessible only to the NLA2012 collaborators. Validated data files are accessible only to users specifically authorized by the NLA 2012 Project Leader. Data files in the central repository used for access and dissemination are marked as read-only to prevent corruption by inadvertent editing, additions, or deletions.

Data generated, processed, and incorporated into the IM system are routinely stored as well as archived on redundant systems by the NARS IM Center. This ensures that if one system is destroyed or incapacitated, IM staff can reconstruct the databases. Procedures developed to archive the data, monitor the process, and recover the data are described in IM documentation.

Data security and accessibility standards implemented for NLA 2012 IM meet EPA's standard security authentication (i.e., username, password) process in accordance to EPA's *Information Management Security Manual* (1999; EPA Directive 2195 A1) and EPA Order 2195.1 A4 (2001D). Any data sharing requiring file transfer protocol (FTP) or internet protocol is provided through an authenticated site.

5.7.3 Life Cycle

Data may be retrieved electronically by the NLA 2012 team, partners and others throughout the records retention and disposition lifecycle or as practicable (See section 4.8).

5.7.4 Data Recovery and Emergency Backup Procedures

The NARS IM Center maintains several backup copies of all data files and of the programs used for processing the data are maintained. Backups of the entire system are maintained off-site by the NARS IM Center. The IM process used by the NARS IM Center for NLA 2012 uses system backup procedures. The NARS IM Center backs up and archives the central database according to procedures already established for WED and NARS IM. All laboratories generating data and developing data files are expected to establish procedures for backing up and archiving computerized data.

5.7.5 Long-Term Data Accessibility and Archive

All data are transferred by OW's Water Quality Exchange (WQX) team working with the NARS IM Team to U.S. EPA's agency-wide WQX data management system for archival purposes. WQX is a repository for water quality, biological, and physical data and is used by state environmental agencies, EPA and other federal agencies, universities, and private citizens. Data from the NLA 2012 project will be run through an Interface Module in an Excel format and uploaded to WQX by the WQX team. Once uploaded, states and tribes and the public will be able to download data (using Oracle software) from their region. Data will also be provided in flat files on the NARS website.

5.8 Records Management

Removable storage media (i.e., CDs, diskettes, tapes) and paper records are maintained in a centrally located area at the NARS IM Center. Paper records will be returned to OW once the assessment is complete. The IM Team identifies and maintains files using standard divisional procedures. Records retention and disposition comply with U.S. EPA directive 2160 Records Management Manual (July, 1984) in accordance with the Federal Records Act of 1950.

6 INDICATORS

6.1 Summary

You will find detailed, indicator-specific design, collection method, sample handling, and quality control procedures for field operations in the Lakes Assessment 2012 Field Operations Manual. Similarly, you will find detailed, indicator-specific sample handling, laboratory procedure, and quality control procedures for laboratory operations in the Lakes Assessment 2012 Laboratory Operations Manual. Quality assurance objectives for physical habitat, which does not collect samples or have laboratory analysis associated with its measurements, are in the data analysis plan of this document. A summary of the QA procedures and the Indicator QA Coordinators is shown in Table 6.1

6.1.1 Sampling Design

Field crews will collect samples from an index site and/or littoral sites on each lake as described in the National Lakes Assessment 2012 Field Operations Manual.

6.1.2 Sampling and Analytical Methods

6.1.2.1 Sample Collection

Detailed sample collection and handling procedures are described in the National Lakes Assessment 2012 Field Operations Manual.

6.1.2.2 Analysis

Detailed analysis procedures are described in the National Lakes Assessment 2012 Laboratory Operations Manual.

6.1.3 Quality Assurance Objectives

Quality assurance objectives are described in detail in the National Lakes Assessment 2012 Laboratory Operations Manual.

6.1.4 Quality Control Procedures: Field Operations

You will find detailed design, collection, sample handling and quality control procedures for field operations in the Lakes Assessment 2012 Field Operations Manual.

6.1.5 Quality Control Procedures: Laboratory Operations

Specific information about sample receipt, processing, and analysis are in National Lakes Assessment 2012 Laboratory Operations Manual.

6.1.6 Data Management, Review, and Validation

Detailed information about data management, review, and validation are in National Lakes Assessment 2012 Laboratory Operations Manual.

Table 6.1 Summary of indicator QA procedures and coordinators.

Indicator	Lab Verification	Method Verification	Lab Analyses QA	Taxa Requirements	Indicator QA Coordinator	QA Analyst
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Algal Toxins (microcystin)	Audit documentation SOPs	Methods Call	Interlab comparison Lab duplicates	N/A	Amina Pollard	TBD
Benthic Macro-invertebrates	Taxa QC samples Audit documentation SOPs	Methods Call	Outside Lab QA Taxonomist to review 10% of samples - photos Reconciliation calls	Species	Richard Mitchell	TBD
Phytoplankton	Taxa QC samples Audit documentation SOPs	Methods Call	Outside Lab QA Taxonomist to review 10% of samples - photos Reconciliation calls	Species	Richard Mitchell	TBD
Sediment Carbon	Responsibility of USGS				Amina Pollard	TBD
Sediment Dating	SOPs	Methods Call		N/A	Marsha Landis	TBD
Sediment Diatoms	SOPs	Methods Call	Outside Lab QA Taxonomist to review 10% of samples - photos Reconciliation calls	Species	Richard Mitchell	TBD
Sediment Mercury	Responsibility of USGS				Amina Pollard	TBD
Triazine Pesticide Screen	Prior Experience SOPs	Methods Call	Duplicates Standard Solution	N/A	Marsha Landis	TBD
Water Chemistry and Chlorophyll A	Review by EPA Region III Environmental Science Center		Methods Call	N/A	Dave Peck	TBD
Zooplankton	Taxa QC samples Audit documentation SOPs	Methods Call	Outside Lab QA Taxonomist to review 10% of samples - photos Reconciliation calls	Species	Richard Mitchell	TBD

7 ASSISTANCE VISITS

Assistance visits will be a component of the QA program for the 2012 NLA. Both these sections have been explained clearly in the 2012 National Lakes Assessment FOM and LOM and therefore are not included here.

7.1 Field Evaluation and Assistance Visit Plan

Please see the Field Operations Manual for details.

7.2 Laboratory Evaluation and Assistance Visit Plan

Please see the Lab Operations Manual for details.

8 DATA ANALYSIS PLAN

The Data Analysis Plan describes the general process used to evaluate the data for the survey. It outlines the steps taken to assess the condition of the nation's lakes and identify the relative impact of stressors on this condition. Results from the analysis will be included in the final report and used in future analysis. The data analysis plan will likely be refined and clarified as the data are analyzed by EPA and states.

8.1 Data Interpretation Background

The basic intent of data interpretation is to evaluate the occurrence and distribution of parameters throughout the population of lakes in the United States within the context of regionally relevant expectations for least disturbed reference conditions. This is presented using a cumulative distribution function or similar graphic. For most indicators the analysis will also categorize the condition of water as good, fair, or poor. Because of the large-scale and multijurisdictional nature of this effort, the key issues for data interpretation are unique and include: the scale of assessment, selecting the best indicators, defining the least impacted reference conditions, and determining thresholds for judging condition.

8.1.1 Scale of assessment

This will be the second national report on the ecological condition of the nation's lakes using comparable methods. EPA selected the sampling locations for the assessment using a probability based design, and developed rules for selection to meet certain distribution criteria, while ensuring that the design yielded a set of lakes that would provide for statistically valid conclusions about the condition of the population of lakes across the nation. A challenge that this mosaic of waterbodies poses is developing a data analysis plan that allows EPA and other partners to interpret data and present results at a large, aggregate scale.

8.1.2 Selecting the best indicators

Indicators should be applicable across all reporting units, and must be able to differentiate a range of conditions. The Agency formed a steering committee for these discussions. The Committee, comprised of state representatives from each of the EPA regions, provides advice and recommendations to the Agency on matters related to the NLA 2012. This committee was able to develop and refine indicators and sampling methodologies.

EPA developed screening and evaluation criteria which included indicator applicability on a national scale, the ability of an indicator to reflect various aspects of ecological condition, and cost-effectiveness.

8.1.3 Defining least impacted reference condition

Reference condition data are necessary to describe expectations for biological conditions under least disturbed setting. We will use an approach similar to that used in NLA 2007, which is described in detail in the NLA 2007 Technical Appendix (EPA 841-R-09-001a) (USEPA 2009).

8.1.4 Determining thresholds for judging condition

This reference site approach is then used to set expectations and benchmarks for interpreting the data on lake condition. The range of conditions found in the reference sites for an ecoregion describes a distribution of those biological or stressor values expected for least disturbed condition. The benchmarks used to define distinct condition classes (e.g., good, fair, poor / least disturbed, intermediate, most disturbed) will be drawn from this reference distribution. EPA's approach is to

examine the range of values for a biological or stressor indicator in all of the reference sites in a region, and to use the 5th percentile of the reference distribution for that indicator to separate the most disturbed of all sites from moderately disturbed sites. Using the 5th percentile means that lakes in the most disturbed category are worse than 95% of the best sites used to define reference condition. Similarly, the 25th percentile of the reference distribution can be used to distinguish between moderately disturbed sites and those in least disturbed condition. This means that lakes reported as least disturbed are as good as 75% of the sites used to define reference condition.

8.2 Geospatial Data

Geospatial data is an integral part of data analysis for the NLA 2012, as it has been for all other surveys. The following activities are anticipated: review of coordinate data and corrections, pourpoint (the outlet of the lake) identification, watershed delineations, and computing landscape metrics. We anticipate that through the site evaluation process, lakes that have changed or are inaccurately represented in the National Hydrography Dataset will be noted and provided to those that update the NHD.

8.3 Datasets Used for the Report

The datasets available for use in the report were developed base on analytical methods selected during the NLA data analysis workshop. Many of the analytical methods used in the survey stem from discussions, input, and feedback provided by the National Lakes Assessment Steering Committee. Many of the methods are an outgrowth of the testing and refinement of the existing and developed methods and the logistical foundation constructed during the implementation of the Environmental Monitoring and Assessment Program (EMAP) studies from 1991 through 1994, from a New England pilot study conducted in 2005, from focused pilot studies for methods development, and from various state water quality agency methods currently in use.

The survey will use indicators to assess trophic status, ecological integrity, and the recreational value of lakes.

8.3.1 Trophic status

Lakes are typically classified according to their trophic state. Three variables, chlorophyll, Secchi disk depth, and total phosphorus, will be used by EPA to estimate biomass and define the trophic state of a particular lake. Other variables will be measured in conjunction with the trophic state variables to supplement and enhance understanding of lake processes that affect primary productivity.

8.3.2 Ecological integrity

Ecological integrity describes the ecological condition of a lake based on different assemblages of the aquatic community and their physical habitat. The indicators include plankton (phytoplankton and zooplankton), benthic macroinvertebrates, diatoms, and the physical habitat of the shoreline and littoral zone.

8.3.3 Recreational value

Recreational indicators address the ability of the population to support recreational uses such as swimming, fishing and boating. The protection of these uses is one of the requirements in the Clean Water Act under 305(b). The extent of algal toxins (microcystin) and mercury will serve as the primary indicators of recreational value.

8.4 Indicator Data Analysis

8.4.1 Algal Toxins

Cyanobacterial (blue-green algal) blooms are common midsummer to late fall events that occur in many lakes and reservoirs throughout the United States. Algal toxin production has been identified as a significant potential human health problem that has been associated with many of these bloom events. However, little is known about the general occurrence of algal toxins in the pelagic zones of these water bodies, where extensive blooms are less likely to occur than in near-shore areas.

The data analysis team will analyze the total (whole water) concentrations of microcystins (total) in lakes and reservoirs throughout the United States using a standardized immunoassay test. In addition, the data analysis team will analyze and interpret the data for microcystin occurrence and concentration in the context of other environmental data that is collected as part of the lake assessment (e.g. nutrients, phytoplankton, chlorophyll, turbidity, specific conductance, pH).

8.4.2 Benthic Macroinvertebrate and Zooplankton Assemblages

Benthic macroinvertebrate and zooplankton assemblage will be analyzed using both multimetric indices (MMI) and observed/expected indices (O/E) models. The MMI approach summarizes various assemblage attributes, such as composition, tolerance to disturbance, trophic and habitat preferences, as individual metrics or measures of the biological community. Candidate metrics are evaluated for aspects of performance and a subset of the best performing metrics are combined into an index known as a Macroinvertebrate Index of Biotic Condition. This index is then used to rank the condition of the resource.

The predictive model or O/E approach estimates the expected taxonomic composition of an assemblage in the absence of human stressors, using a set of least-disturbed sites and other variables related to natural gradients, such as elevation, lake size, latitude and longitude. The resulting models are then used to estimate the expected taxa composition (taxa richness) at each site sampled. The number of expected taxa actually observed at a site is compared to the number of expected taxa as an Observed Expected ratio or index. Departure from a ratio of one indicate that the taxonomic composition in the sample differs from that expected under least -disturbed conditions. The greater the departure from one, the greater the sample differs from the least disturbed condition.

8.4.3 Physical Habitat

8.4.3.1 Quality assurance objectives and procedures

MQOs are presented in Table 8.1. General requirements for comparability and representativeness are addressed in Section 2. The MQOs given in Table 8.1 represent the maximum allowable criteria for statistical control purposes. Precision is determined from results of revisits (field measurements) taken on a different day and by duplicate measurements taken on the same day.

Table 8.1 Physical habitat measurement data quality objectives

Variable or Measurement	Precision	Accuracy	Completeness
Field Measurements and Observations	±10%	NA	90%

Specific quality control measures are listed in Table 8.2 for field measurements and observations.

Table 8.2 Physical habitat field quality control

Check Description	Frequency	Acceptance Criteria	Corrective Actions
QUALITY CONTROL			
Check totals for cover class categories (vegetation type, substrate, cover)	Each station	Sum must be reasonable	Repeat observations
Check completeness of station depth measurements	Each station	Depth measurements for all stations	Obtain best estimate of depth where actual measurement not possible
DATA VALIDATION			
Estimate precision of measurements based on repeat visits	2 visits	Measurements should be within 10 percent	Review data for reasonableness; Determine if acceptance criteria need to be modified

8.4.3.2 Shoreline human disturbances

The presence or absence of 12 predefined types of human land use or disturbance will be recorded for each of the 10 stations. As part of the NLA 2012, additional human disturbances will be separately identified outside of, but adjacent to, the plots. For each of the 12 disturbance categories, we will calculate the proportion of lakeshore stations where the disturbance is observed on each lake. Proportions will be weighted according to the proximity of the disturbance before computing the whole-lake metrics. Weightings will be 1.0 for disturbance observations within the riparian sample plots and 0.33 for those behind or adjacent to the plots. Two types of summary metrics will be calculated by synthesizing all the human disturbance observations. The first, a measure of the extent of shoreline disturbance, will be calculated as the proportion of stations at which one or more human disturbances were observed. The second, a measure of disturbance intensity, will be calculated as the mean number of human disturbance types observed at each of the 10 shoreline stations.

8.4.3.3 Riparian vegetation

Riparian vegetation type and areal cover will be visually estimated in three layers: the canopy (>5 m high), mid-layer (0.5–5 m high) and ground cover (<0.5 m high). Coniferous and deciduous vegetation is distinguished in the canopy and mid-layer; woody and herbaceous vegetation is distinguished in the mid-layer and ground cover. As was done in NLA 2007, cover will be estimated in four classes: absent (0), sparse (0-10%), moderate (10-40%) and heavy (40-75%) and very heavy (>75%). Simple whole-lake metrics are calculated by assigning the cover class mid-point value to each station's observations and then averaging those cover values across all 10 stations. Summary metrics are calculated for each lake by summing the areal cover or tallying the presence of defined combinations of riparian vegetation layers or vegetation types.

8.4.3.4 Aquatic macrophytes

Using the same cover classes as for riparian vegetation, areal covers of nearshore emergent, floating, and submerged aquatic macrophytes are each estimated visually. Simple and summary aquatic macrophyte metrics will be calculated for each lake in the same fashion as for riparian vegetation.

8.4.3.5 Fish concealment features

The presence or absence of eight specified types of fish concealment features will be recorded within each 10-m × 15-m littoral plot. The areal cover of each type will be assigned to one of three cover classes (0, 0-10%, >10%). Simple metrics for each type of fish concealment feature are calculated as the proportion of littoral stations with the particular concealment feature present. Summary metrics will be calculated as the mean number of concealment types per station. We will use the areal cover class designation to unweight very sparse cover in the calculation of both simple and summary fish cover metrics (i.e., the areal cover designations of 0, 0-10% and >10% were respectively assigned values of 0, 0.2, and 1.0).

8.4.3.6 Shoreline and littoral bottom substrate

Visual estimates of areal cover of 9 defined substrate types (bedrock, boulders, cobble, gravel, sand, silt/clay/muck, woody debris, organic matter, and vegetation) will be made separately for the 1-m shoreline band and the bottom within the 10-m × 15-m littoral plot. Cover classes are the same as for riparian vegetation, with the same modification to include an additional higher cover class. In cases where the bottom substrate cannot be observed directly, observers will use a clear plastic viewing bucket, a 3-m plastic (PVC) sounding tube, or an anchor to examine or obtain samples of bottom sediments.

Simple metrics describing the lake-wide mean cover of littoral and shoreline substrate in each cover class size category will be obtained by averaging the cover estimates at each station, using the cover class midpoint approach described for riparian vegetation. Three substrate summary metrics will be calculated for both shoreline and littoral bottom substrates. First will be the mean cover of the dominant substrate type. Second and third will be measures of the central tendency and variety of substrate size. Because the size categories are approximately logarithmic, we will calculate a cover-weighted mean substrate size class and its standard deviation; we will rank the substrate classes by size from 1 to 6, weighting them by their lakewide mean cover, and then averaging weighted cover or computing its variance across size classes.

8.4.3.7 Littoral depth, bank characteristics and other observations

Lake depth 10 m offshore will be measured using SONAR, sounding line, or sounding tube. Field crews will estimate the bank angle based on high and low water marks, the vertical and lateral range in lake water level fluctuation. They will also note the presence of water surface scums, algal mats, oil slicks, and sediment color and odor. Whole-lake metrics for littoral depth and water level fluctuations are calculated as arithmetic averages and standard deviations. For bank angle classes and qualitative observations of water surface condition, sediment color, and odor, we will calculate the proportion of stations where the described features are present.

8.4.3.8 Human Disturbances in Riparian/Littoral

12 Simple metrics describe presence (proportion of shore) with: buildings, commercial land use, lawns, developed parkland, roads/railroads, docks/boats, trash/landfill, seawalls/revetments, rowcrop agriculture, pasture, orchards, other human activities.

2 Summary metrics describe mean number of disturbance types observed per station and proportion of shoreline with human disturbance of any type.

8.4.3.9 Riparian Vegetation Structure

8 *Simple metrics* describe areal cover of trees >0.3 m diameter at breast height (DBH) and <0.3 m DBH in canopy layer; woody and herbaceous vegetation in mid-layer; barren ground and woody, herbaceous, and inundated vegetation in ground cover layer.

6 *Summary metrics* describe aggregate covers in canopy + mid-layer, woody vegetation in canopy + mid-layer, and canopy + mid-layer + ground cover layers; presence of vegetation in canopy layer; presence in both canopy and mid-layer.

8.4.3.10 Littoral Aquatic Macrophytes

Simple metrics describe cover of emergent, floating, and submergent macrophytes; and presence of macrophytes lakeward from the shoreline observation plot.

2 *Summary metrics* describe mean combined cover and proportion of shoreline with macrophytes present.

8.4.3.11 Shoreline and Littoral Substrate Type and Size

14 *Simple metrics* separately describing shoreline and littoral substrate: areal cover estimates of bedrock (>4000 mm), boulder (250–4000 mm), cobble (64–250 mm), gravel (2–64 mm), sand (0.06–2.0 mm), soil or silt/clay/muck (<0.06 mm), and vegetation or woody debris (if concealing substrate).

6 *Summary metrics* (3 for shore and 3 for littoral bottom) estimating cover-weighted mean size class, size class variance, and the areal cover of the dominant substrate type.

8.4.3.12 Littoral Fish Cover

8 *Simple metrics* estimating proportion of shore zone with various fish cover types: boulder, rock ledge, brush, inundated live trees, overhanging vegetation, snags >0.3 m diameter, aquatic macrophytes, and human structures (e.g., docks, enhancement structures).

Summary metrics describing the mean number of fish cover types.

8.4.3.13 Littoral Depth, Banks, and Level Fluctuations

7 *Simple metrics* describing mean depth and depth variation among sampling station, bank angle, and apparent height and extent of vertical and horizontal lake water level fluctuations.

1 *Summary metric* describing spatial variation of station depths on lake.

8.4.3.14 Miscellaneous Habitat Variables

7 *Simple metrics* describing proportion of sampling sites with sediment odor (petrol, H₂S,) sediment colors (black, brown, other), and water surface films (oil, algal mat, other).

1 *Summary metric* describing proportion of sampling sites with surface film of any type.

8.4.4 Phytoplankton Assemblages

Phytoplankton will be collected as an integrated sample in open water. Both abundance and biovolume on a species-specific basis will be determined. The raw data will be used in multiple data analysis techniques, metrics and indices, such as Centrales/ Pennales ratios, Palmer's WQ Index and other diversity indices.

8.4.5 Sediment Dating

Lead-210 (210-Pb) concentrations will be assessed in sediment samples from the bottom 2-cm of sediment cores in natural lakes, which provides a relative estimate of the time of deposition of sediment. Decay of uranium in the earth's crust releases the gas radon. This gas produces 210Pb by decay in the atmosphere. The lead isotope enters the water through precipitation. In the water phase 210Pb is adsorbed to particulate matter and together they are deposited in the sediment of lakes and ponds. 210Pb decays with a half life of approximately 22 years. The remaining amount of 210Pb in these sediment samples will reveal its relative age. Owing to the 22-year half life, this 210Pb method covers the past period of 75-100 years.

8.4.6 Sediment Diatoms

Sediment diatoms will be sampled in the deepest part of the lake (up to 50 meters), or the midpoint of a reservoir, using a sediment core sampling device. Diatoms will be analyzed/ identified in the sediment surface fraction and in a deep fraction (i.e., 35 to 45 cm). Comparison of these fractions provides an indication of both current and historical lake condition with respect to stressors such as nutrients (phosphorus) and sediment loadings. Comparison of the diatoms found in deep and surface fractions can also provide insight to the structure and composition of algal communities under pristine conditions as well as inform on the temporal and spatial trends of eutrophication.

8.4.7 Sediment Mercury

Mercury levels (total and methyl) will be determined from the sediment core samples to compare to existing national mercury distribution databases. These samples will be collected from the sediment diatom core samples, from the upper portion of the core. Comparisons will be made among lakes, relative to their mercury concentrations.

8.4.8 Triazine Pesticide Screen

Triazine occurrence and concentration will be determined from lake water samples. Comparisons will be made among lakes, relative to land use in the watershed and other water quality characteristics (e.g., nutrient concentrations).

8.4.9 Trophic Status

The trophic state of lakes will be analyzed using chlorophyll *a* concentrations, which is considered the most accurate estimator of trophic state. Trophic state will be assessed using chlorophyll *a* concentration thresholds, as follows: oligotrophic, <2 µg/L; mesotrophic, 2 to 7 µg/L; eutrophic, 7 to <30 µg/L; and hypereutrophic, ≥30 µg/L. These categories will be used to rank the condition of lakes relative to their trophic state.

8.4.10 Water Chemistry, Chlorophyll *a* and Secchi Depth

A wide array of water chemistry parameters will be measured, including DO, pH, total N, total P, clarity, TOC/DOC, color, ANC and primary productivity. Values for these parameters and their distribution will be reported. Water chemistry analysis is critical for interpreting the biological indicators. Chlorophyll *a*, Secchi depth and nutrient measurements will be used to determine trophic level indices, such as the Carlson Index. Temperature profiles will be used to determine degree of lake stratification.

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APPENDIX A: LABORATORY LIST

National Lakes Assessment 2012 Contract Laboratory List

Analysis	Contact	Contractor	Contractor No. & Task No.	Project Officer
Algal Toxins (microcystin)	Richard Mitchell EPA/HQ 202-566-0644			
Benthic Macroinvertebrates	Richard Mitchell EPA/HQ 202-566-0644			
Phytoplankton	Richard Mitchell EPA/HQ 202-566-0644			
Sediment Dating	Marsha Landis EPA/HQ 202-564-2858	Wisconsin State Lab of Hygiene 2601 Agriculture Drive Madison, WI 53718		
Sediment Diatoms	Richard Mitchell EPA/HQ 202-566-0644			
Triazine Pesticide Screen	Marsha Landis EPA/HQ 202-564-2858	Wisconsin State Lab of Hygiene 2601 Agriculture Drive Madison, WI 53718		
Water Chemistry	Dave Peck EPA/COR 541-754-4463	Dynamac Corp. c/o U.S.EPA 200 SW 35th St. Corvallis, OR 97333 541-754-4463	EP-D-06-013 Work Assignment 1-06	Kathy Martin U.S. EPA NHEERL-WED 200 S.W. 35th St. Corvallis, OR 97333 541-754-4502
Zooplankton	Richard Mitchell EPA/HQ 202-566-0644			

National Lakes Assessment 2012 Federal Partners Laboratory List

Analysis	Contact
Dissolved Carbon	USGS
Sediment Mercury	USGS