R-WD-16-02

New Hampshire Department of Environmental Services Water Monitoring Strategy

New Hampshire Department of Environmental Services
PO Box 95
29 Hazen Drive
Concord, NH 03302-3503
(603) 271-8865

Prepared by
David E. Neils
Chief Water Pollution Biologist
Director, Jody Connor Limnology Center

Thomas S. Burack
Commissioner

Clark Freise
Assistant Commissioner

Eugene J. Forbes
Director
Water Division

March 2016

Table of Contents

I. Executive Summary

The Watershed Management Bureau (WMB) at the New Hampshire Department of Environmental Services (NHDES) is responsible for monitoring and assessing the quality of the state's surface waters. In order to fulfill this responsibility, the WMB gathers many thousands of water quality samples each year. The water monitoring strategy will help guide the effort to ensure that the goals set forth by the WMB are effectively reached. The strategy addresses WMB's monitoring plans from 2014 - 2024.

The goals of the strategy are the collection of high quality data for the purpose of making informed and accurate water management decisions and communication to the public the status of the health and safety of the state's waters. It is designed to fulfill the dual purpose of satisfying the requirements of the 2003 Environmental Protection Agency (EPA) guidance document entitled "Elements of a state water monitoring and assessment program" (EPA 2003); and serving as a "manual" to NHDES in implementing its surface water monitoring programs and the use of the data that is gathered.

The strategy focuses on NHDES' monitoring efforts of the state's inland surface waters, namely lakes/ponds and rivers/streams, but also includes a summary description of the monitoring activities in coastal waters and wetlands. With approximately 17,000 miles of rivers/streams and over 1,200 lakes/ponds, these surface waters represent important ecological, recreational, and economic resources. The decision to focus on these waterbody types was based on an acknowledged need for a more collaborative approach to data collection and utilization. The revised approach integrates multiple monitoring programs within NHDES and makes full use of volunteer collected data. Collectively, the strategy makes efficient use of limited monitoring resources for sampling New Hampshire's surface waters, sets forth a plan for data usage and outlines a timetable for reporting.

The strategy is organized around a basic conceptual model designed to achieve specific water quality-based objectives. At the center of the model are three design components:

1) **Probability-based water quality surveys**: a statistical approach to understand overall conditions state-wide.
2) **Trend-based monitoring:** a long term commitment to track the trajectory of important water quality indicators over time.
3) **Synoptic (or site specific) monitoring:** Short term collection of summary water quality data in a coordinated fashion from targeted, site-specific locations for the purpose of maintaining a current statewide dataset.

Probability-based monitoring refers to the random selection of a subset of sample locations that are representative of the entire population of a particular waterbody type. By collecting data from each of the randomly selected sites the overall condition of the waterbody type can be predicted with a known level of confidence. Probability surveys represent a cost effective means for estimating and reporting on the physical, chemical, and biological conditions by waterbody type and the factors that affect these conditions at a particular point in time.

NHDES probability surveys build on the National River/Streams and National Lakes Assessments, used by EPA to periodically report on the quality of the nation's waters. The NHDES strategy will add to, or intensify, the sampling of the national probability sites that occur in New Hampshire once every 10 years for each major waterbody type in order to complete a statewide assessment of conditions. State-wide condition reports are planned for 2017 for rivers/streams and 2021 for lakes/ponds.

Trend monitoring will help to explain how conditions are changing over time. NHDES trend monitoring is designed to detect water quality trends in the state through repeated monitoring visits to a set number of sites over the long term. Trend monitoring for rivers and streams will consist of 40 sites that are spread out relatively evenly across large watersheds (8-digit hydrologic unit codes; HUC 8s). These stations will include rivers and streams of many sizes, and represent a number of different upstream land use patterns. Data collection, analysis, and reporting will be completed primarily by NHDES staff with assistance, but will also include data collected through the Volunteer River Assessment Program (VRAP). Trend monitoring for lakes and ponds will consist of a minimum of 84 waterbodies. The waterbodies will include different lake trophic classes and be represented by a variety of land use patterns. Data collection for trend lakes and ponds will be completed through the Volunteer Lakes Assessment Program (VLAP) with analysis and reporting by NHDES staff. Waterbody-specific trend reports are scheduled for completion every five years.

Last, synoptic monitoring is designed to provide a structured framework for short-term, focused water quality monitoring efforts (usually 1-year) in surface waters in order to maintain a current statewide catalog of waterbody conditions. In order to generate data from across the state, a rotating basin approach will be implemented that is based on 81 medium sized watersheds (HUC 10s). Annual monitoring efforts will be focused in eight to 10 of these watersheds allowing for a complete statewide rotation within 10 years. Specific sampling locations will be determined by NHDES staff during the winter months prior to the upcoming field season and based on a variety factors including data age, waterbody designated use status, location of permitted facilities, evaluation of restoration efforts, and public use intensity. A data summary report will be issued at ten year intervals. For the period covered in this version of the water monitoring strategy, a synoptic monitoring data summary report will be prepared in 2024 covering the period from 2013 - 2022.

Taken together, these three approaches provide the necessary structure to ensure that the data are collected with a specific goal in mind. The strategy relies on the incorporation of surface water data collected across programmatic boundaries to achieve a series of objectives while simultaneously providing a broad view of water quality conditions across New Hampshire.

1. Introduction

The implementation of an effective and efficient surface water quality monitoring program serves as the foundation for informed water management decisions. The collection, analysis, and reporting of water quality data educates resource managers and the public on waterbody conditions, the factors that affect these conditions, and the geographical context where protection or restoration measures may be necessary. As part of this foundation, the US Environmental Protection Agency (EPA) requires that states receiving section 106 Clean Water Act (CWA) funding prepare and submit a water monitoring strategy. The strategy is designed to be forward thinking and inclusive of all waterbody types (e.g., lakes, rivers, streams, wetlands, coastal waters).

In order to fulfill this requirement, the New Hampshire Department of Environmental Services (NHDES) developed its surface water monitoring strategy in 2005 (NHDES 2005). NHDES serves as the agency in New Hampshire responsible for implementing the CWA with a primary goal of restoring and maintaining the chemical, physical, and biological integrity of its water resources. In support of this goal, NHDES monitors its surface waters in order to satisfy federal reporting requirements [CWA section 305(b) and 303(d), 319, and 406], assist in regulatory decisions, and for use in planning activities (TMDLs, Section 319). The standards by which NHDES assesses the quality of its waters are outlined state law RSA 485-A and further clarified in administrative rule Env-Wq 1700. Water quality data collected in support of these efforts are subject to strict quality assurance measures and managed within a comprehensive data management system.

In its 2005 strategy, the NHDES focused on the importance of making data-driven management decisions, clearly stating the purposes for the collection of water quality data and the value of maintaining a mechanism for anaging high quality, well documented data that is accessible for multiple uses. The 2005 effort accurately recognized NHDES' needs with respect to instituting a basic model for the valuation of current and new surface water monitoring efforts and the subsequent management of the data collected through these programs. The outcome of the strategy has been a gradual movement towards monitoring programs that generate information that is directly linked to measurable environmental outcomes through the quantification of water quality conditions. As evidence of this progress, NHDES now has one of the most advanced processes for evaluating water quality data for its biennial 305(b)/303(d) reporting requirements, dramatically increased its Total Maximum Daily Load (TMDL) productivity, become more efficient in completing Section 401 water quality certifications, and remained current in the development of new or renewal of existing water quality criteria. Further, much of NHDES’ water quality data are now stored in a single, unified, agency-wide database known as the Environmental Monitoring Database (EMD). To date, the EMD houses over 32,000 individual monitoring stations from 702 individual projects, and millions of individual results. Data generated by the NHDES and outside organizations are entered through automated lab imports, batch uploads, and manual entry. The data can then flow directly to EPA's STORET/WQX using a node to node transfer. In general, data which meets the minimum WQX requirements is flowed within one year of collection. In most cases, this includes all data collected by NHDES staff and over 200 volunteer monitoring organizations that pass mandatory quality assurance criteria (e.g., calibration, sample replication, data recording). Occasionally, particularly with respect to biological data, data transfers are impractical due to the time necessary to standardize the data in a format compatible with STORET/WQX therefore uploads have been less numerous. In total, however, the pathway envisioned through NHDES' 2005 monitoring strategy was realized and greatly benefited the agency.

While the 2005 strategy increased NHDES water quality monitoring effectiveness through a data driven water management process, it provided minimal direction for the collective design, implementation, and ultimate usage of data collected across multiple monitoring programs. The revised strategy herein focuses NHDES' surface water monitoring efforts through the implementation of a unified monitoring design and the identification of individual programs responsible for the collection of the data. The design is one that meets the objectives of the CWA and is also used to inform the general public of the conditions of New Hampshire surface waters and the factors affecting them. Further, the design will, to the extent possible, maintain a current catalog of data that can be used for a variety of purposes that includes reviewing and developing water quality standards, determining designated use attainment, TMDL development, documenting waterbody restoration efforts, and permitting needs. The revised strategy does not abandon the direction outlined in 2005, but builds upon the concept of maximizing the use of data to evaluate waterbody conditions through quantifiable measures within a structured approach to data collection and evaluation.

2. Overview

The revised strategy covers a 10 year timeframe (2014 - 2024) and is designed to fulfill a dual purpose: 1) satisfy the requirements of the 2003 EPA guidance document entitled "Elements of a state water monitoring and assessment program" (EPA 2003); and 2) serve as a "manual" to NHDES in implementing is surface water monitoring programs and use of the data that is gathered through these programs. The latter was recognized by NHDES staff as an important need in order to maximize program efficiency and accountability. To this end, the revised strategy is organized around a basic conceptual model (Figure 1). The strategy is based on the goal of collecting and using of water quality data for water management decisions and communication to the public of waterbody conditions. At the center of the model are three primary monitoring program design components (synoptic, trend, probability) which are intended to feed data directly to a series of objectives. The design components represent the major organizational components of the strategy described below.

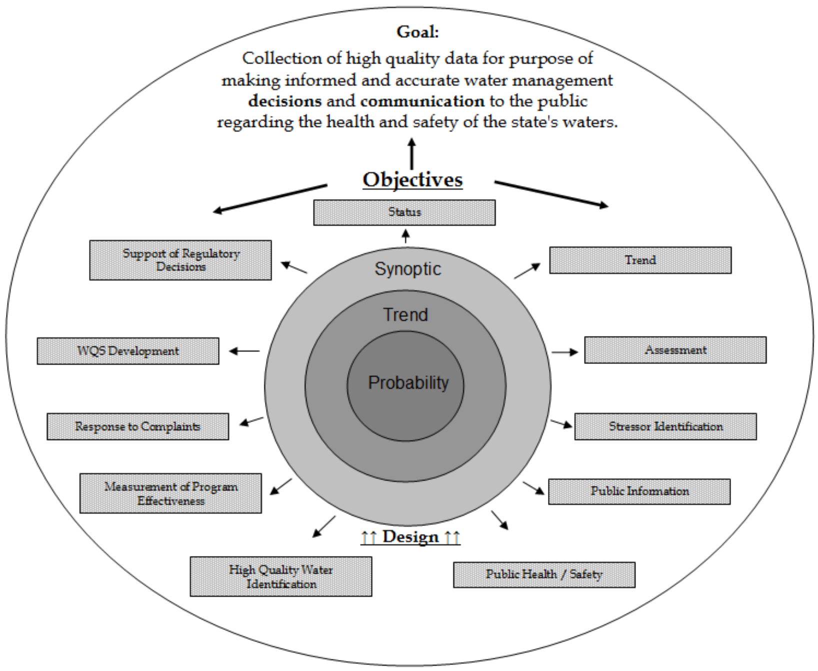
EPA supplies funds in support of these activities through Section 106 of the CWA including Monitoring Initiative Funds. These funds are designed to improve state comprehensive monitoring and assessment programs. Each of the major design components and related activities outlined below represent enhancements to NHDES surface water monitoring elements enabled through these funds and are intended to become part of its ongoing activities in the future.

For each design component, this report contains:

- A brief description of its purpose including its relation to the specific objectives outlined in the strategy.
- The identification of the individual monitoring programs which will be responsible for data collection, the specific uses of the data, and design implementation.
- Indicators that will be used to address the evaluation of water quality conditions and how these data will be reported.
- An evaluation of the basic data qualities (central tendency and variation) to better understand the capacity for reporting on status and trends.

- The expected data sources, data management, and quality assurance measures that will be utilized.
- A “needs assessment” that identifies the resources needed to implement the program.
- A defined schedule for reporting on water quality conditions associated with each of the primary components of the strategy.

Figure 1. Conceptual design of NHDES surface water monitoring strategy.



By organizing the strategy in this manner, the final product will serve as a useful document that guides NHDES' surface water monitoring activities.

The strategy focuses primarily on NHDES' monitoring efforts of the state's inland surface waters, namely lakes/ponds and rivers/streams. With approximately 17,000 miles of rivers/streams and over 1,200 lakes/ponds, these surface waters represent important ecological, recreational and economic resources. The decision to focus on these waterbody types was based on an acknowledged need for a more collaborative approach to data collection and utilization. The revised approach integrates multiple monitoring programs within NHDES and makes full use of data collected by trained volunteers including the required quality assurance measures and data management needs across programmatic boundaries.

Data generated from each of the primary monitoring components will have multiple uses. First the data will be used to complete the respective reports outlined below including statewide waterbody type condition reports, trend analyses of important water quality indicators, and statewide watershed summary reports that include data from individual waterbodies. Second, the data will feed directly into NHDES’ integrated surface water assessment report [305(b)/303(d)] that are completed biennially and require EPA review and approval prior to finalizing. Third, waterbody assessment outcomes based on the data are used in consideration for the selection 319 grant projects including waterbody restoration where impairments have been identified, development of TMDLs, and protection of high quality waters. The data will also be used in support of water quality criteria development and revisions supported through Section 106 funds such as nutrients, water temperature, and toxicants. Lastly, where restoration activities or water quality improvements have been made, data will be used to verify program effectiveness.

In order to satisfy the requirement by EPA that each state's strategy address its monitoring of all water resource types, this version of the strategy also includes a summary of the monitoring efforts for coastal waters (see section 9) and wetlands (see section 10). These summaries do not conform strictly to the organization of other sections of the strategy as outlined above, but provide a reasonable synopsis of the 10 elements of a state water monitoring and assessment program.

In developing the strategy it is important to recognize that it is limited to NHDES' current staffing, field, and laboratory resources and assumes that these remain stable for the period of time which this version of the strategy covers. Since the current strategy represents a major enhancement to NHDES surface water monitoring commitments, the continued availability and use of EPA Monitoring Initiative Funds towards these efforts will play a vital role in its success. In some cases, future enhancement of the monitoring design described below may require NHDES to reach beyond its resources and programs. Partnerships between NHDES and outside entities [NH Fish and Game, United State Geologic Survey (USGS), United States Forest Service (USFS), United States Fish and Wildlife Service (USFWS), universities, etc.) are viewed as a necessary part of future iterations of the water monitoring strategy in order to make best use of the water quality data that are collected from the state's surface waters and move towards common goals. However, while the strategy recognizes these needs, its current focus is on crafting and successfully implementing a unified monitoring effort that efficiently directs NHDES' limited resources for surface water monitoring.

3. Implementation

NHDES' surface water monitoring strategy, to a large extent, is already being implemented through its existing monitoring programs. The design described below capitalizes on these ongoing efforts, with some modification, through a coordinated approach to make effective use of the data for the purposes of meeting the objectives of the CWA, namely:

- Reporting on waterbody status and trends;
- Establishing, reviewing, and revising water quality standards;
- Determining water quality standards attainment;
- Identifying impaired waters;
- Identifying causes and sources of water quality impairments;
- Supporting the implementation of water management programs; and
- Supporting the evaluation of program effectiveness.

The NHDES Watershed Management Bureau (WMB) is the primary entity responsible for implementing the State of New Hampshire's surface water monitoring programs. Within the Bureau, 15 different programs collect surface water quality data (Table 1). These efforts are diverse in nature and range from of the collection of basic water quality parameters from inland

and coastal waters to programs specifically designed to protect public health and safety. These programs collectively generate in excess of 100,000 data points annually and rely on data collected by NHDES staff, as well as data gathered through two citizen-volunteer programs. Many of these programs are dedicated wholly or in part to satisfying NHDES' CWA Section 106 grant fund obligations with respect to the "establishment and operation of appropriate devices, methods, systems, and procedures necessary to monitor, and to compile and analyze data on the quality of navigable waters" [CWA Section 106(e)(1)]. NHDES' monitoring strategy is also designed to support the agency's commitments to EPA in implementing water management programs (e.g., Sections 303, 305, 319, 402) required by the CWA and evaluating their effectiveness.

Table 1. NHDES Watershed Management Bureau surface water quality monitoring programs.

Program	Description	Effort
Lake Survey	Trophic status determination; primary lake monitoring effort by internal staff	~ 30-40 lakes / ponds per year
VLAP	Lake assessment; volunteer collected data	~170 lakes / ponds 1 – 5 times per year
River Trend	Repetitive river sampling; 20+ years of data; NHDES staff	40 stations, 3 times per summer
River Synoptic	Synoptic surveys; ~15 years of data; NHDES staff	~20 stations 3 times per summer
VRAP	River assessment; volunteer collected data	~ 30 individual groups; ~300 stations, 1 to many times per year
Biomonitoring	Biological assessment wadeable streams	~30 stations / year
Hg in fish	Mercury in fish tissue	~100 – 150 fish / year
Acid outlet	Long term acidification trends	20 lake outlets 2 times / year
Acid precipitation	Long term trends in acid precipitation	~50 events / year
Exotic plant tracking	Identify and track exotic plant infestations	60 - 75 waterbodies / year
Beach sampling	Beach openings / postings based on bacteria prevalence	160 freshwater & 16 coastal beaches
Shellfish	Examine sanitary quality of state's tidal waters to ensure molluscan harvest safety	• Shoreline pollution source identification • Water quality sampling- 70-75 stations / month • Paralytic shellfish parasite monitoring
TMDL	Impairment source quantification and reduction	Variable depending on need
Pools/Spas	Construction, design, operation, and safety of artificial bathing facilities	>500 inspections / year >750 individual water quality results / year
Complaints	Receive and respond to water quality concerns from public	>50 annually

Where possible, each of these programs is used to implement a portion of the monitoring strategy. In some cases, specific programs are not included in the individual design components but are still considered important in tracking water quality for the purposes of public health and safety.

Beyond these formal programs, NHDES is periodically involved in state and regional collaborations that further define water quality conditions. Examples of past projects include the New England Wadeable Stream (NEWS) project, establishment of a regional stream monitoring network in undisturbed streams (e.g., regional monitoring network), regional efforts to characterize the prevalence of mercury in fish tissue, and simultaneous collection of water quality samples from the Connecticut River. Since the projects are not regular, they are considered opportunistic projects and not included here in the strategy. NHDES makes every effort to participate in these efforts as resources allow and with respect to the perceived value of the information that will be produced.

4. Goal and Objectives

The overall goal of NHDES' approach to surface water quality monitoring is:

> **The collection of data necessary to make informed surface water management decisions and report on the health of the state's waters, including the factors that affect their quality.**

The goal is based on NHDES' obligation and responsibility in acting as the stewards of its public water resources and satisfying the requirements of the CWA. The goal will be achieved, in part, through the following objectives:

1) ***Report on the status of all surface waterbodies –*** Focused monitoring efforts will be conducted as necessary to report on the statewide condition of the major waterbody types (lakes/ponds, rivers/streams, wetlands, coastal waters). Results of these efforts will become part of the state's 305(b) / 303(d) integrated water quality report to EPA and summarized biennially for communication to the public.

2) ***Determine trends in important surface water quality indicators -*** Surface water quality monitoring will be completed repetitively at a fixed network of stations in order to report on trends in the most important environmental indicators and to identify emerging indicators that could become important in tracking environmental conditions in the future. The trend monitoring network will be spatially stratified for tracking statewide and regional trends as they relate to local, regional, and global environmental stressors.

3) ***Collect data in support of water quality assessments -*** All data produced as a result of NHDES' monitoring programs will be utilized, to the extent possible, in completing water quality assessments for each designated use and serve as the basis for reporting on the status of individual waterbodies, including the identification of impaired waterbodies requiring restorative actions (TMDLs). These assessments will be included in NHDES biennial 305(b)/303(d) integrated water quality reported to EPA.

4) ***Identify the stressors that affect water quality -*** NHDES will conduct surface water monitoring in a manner that relates the condition of its waterbodies to the factors that affect these observations. Where possible, accessory information on environmental conditions such as rainfall, air quality, landscape change, and climatic conditions will be incorporated in the analyses of stressor impacts on surface water quality conditions.

5) ***Provide public information* -** Communication of results of water quality monitoring efforts is critically important to NHDES. The monitoring program design will provide high quality data sufficient for producing timely, accurate, and understandable reports to the public regarding the condition of the state's waterbodies. Information produced from these data will include daily advisory or closure updates, reports on overall status and trends, and a constantly updated portfolio of data from individual waterbodies to satisfy public inquires.

6) ***Ensure public health and safety*** - NHDES' water monitoring strategy calls for the continuation of its programs designed to track water quality parameters related to public health and safety including bacteria and cyanobacteria at the state’s public bathing facilities.

7) ***Identify high quality waters* -** Strategic monitoring of surface waters will allow NHDES to identify and describe its high quality waters. These efforts will assist in classifying surface waters based on their natural characteristics, establishing water quality expectations, guiding protection efforts, and setting restoration targets.

8) ***Measure of program effectiveness* -** To the extent possible, NHDES' water monitoring strategy will provide assistance to evaluate the success of surface water quality protection and restoration efforts. These include Section 319 projects, TMDL implementation plans, and efforts to control and prevent exotic species infestations.

9) ***Response to complaints* -** In order to better serve the public and be responsive to potentially harmful environmental circumstances, surface water monitoring will include the collection of samples based on complaints. Sampling in this realm will be episodic and focused on the nature and location of the complaints.

10) ***Development and implementation of water quality criteria* -** The water monitoring strategy is designed to generate high quality data on a statewide basis that can be used to support the development and implementation of new or revised water quality criteria. In some cases, additional special studies may need to be conducted in order to complete this objective. However, to the extent possible, the strategy will provide the necessary body of evidence to document baseline conditions.

11) ***Support of regulatory decisions / actions* -** Water quality data will be collected to assist in making decisions regarding regulatory activities permitted or reviewed by NHDES. Data will be made available to other regulatory entities for consideration in permit issuance or renewal. The strategy also supports the collection or use water quality data for enforcement actions.

5. Monitoring Design

In order to meet the overall goal and objectives of the NHDES monitoring strategy, three basic design components will be implemented:

1) ***Probability monitoring* -** Randomized selection of sample locations by individual waterbody type (e.g., lakes/ponds, rivers/streams, etc.).

2) ***Trend monitoring* -** Repetitive monitoring of fixed stations.

3) ***Synoptic monitoring* -** Short-term (e.g., single year) targeted monitoring of individual waterbodies or waterbody segments based on a standardized statewide selection process and/or specific issues related to a waterbody in order to obtain a basic "snap-shot" of water quality conditions at a single point in time.

Surface water monitoring may also be completed outside primary design components and include multi-year special project efforts with distinct start and end points. These efforts will be completed on an “as needed” basis where resources are sufficient.

NHDES will complete probability-based monitoring projects, to the extent possible, for each of its waterbody types (lakes/ponds, rivers/streams, coastal waters, wetlands). Probability-based monitoring will serve to report on the statewide status of each waterbody type and the factors that relate to overall waterbody condition. Trend monitoring will track important water quality parameters over the long term from a representative set of waterbodies that are distributed across the landscape and range the spectrum of natural and anthropogenic conditions in New Hampshire. Synoptic monitoring will be completed to determine the condition of individual waterbodies for a variety of purposes, including assessment, regulatory, or planning purposes. The relation of each of the design components to the strategy’s objectives are outlined in Table 2.

Table 2. NHDES monitoring objectives and relation to monitoring design components.

Monitoring Strategy Objectives	**Monitoring Design**		
	Probability-Based	Trend	Synoptic
Status of All Waters	x		
Trend		x	
Assessment		x	x
Stressor Identification	x	x	x
Public Information	x	x	x
Public Health / Safety		x	x
High Quality Water Identification		x	x
Measurement of Program Effectiveness			x
Response to Complaints			x
WQS Development		x	x
Support of Regulatory Decisions		x	x

Collectively, these three approaches will be inclusive of multiple surface sampling programs at NHDES. The design components define each program's individual contribution to the overall monitoring strategy and provide a unified approach for NHDES in the collection and reporting of surface water quality data. The following sections describe specifically how each approach in the monitoring design will be implemented. It is important to recognize, however, that there are important monitoring efforts that occur specifically for programmatic purposes that do not necessary fit neatly within the monitoring design as described below.

6. Probability-based monitoring

Probability monitoring refers to the randomized selection of a set of sample locations that are representative of the entire population from a particular waterbody type. By collecting data from each of the randomly selected sites the overall condition of the waterbody type can be predicted with a known level of confidence. Probability surveys represent a cost-effective means for estimating and reporting on the physical, chemical, and biological conditions by waterbody type and the factors that affect these conditions at a particular point in time.

Probability-based surveys have been implemented by the EPA since 2000 to evaluate the overall condition of the nation's surface waters (fresh and marine). These surveys are completed on a 5-year rotating schedule by waterbody type (Table 3). To date, NHDES has participated in the national wadeable streams assessment (2004-05), national lakes assessment (2007, 2012), national rivers and stream assessment (2009-10, 2013-14), and the national wetland condition assessment (2011). NHDES remains committed to future participation in these surveys at the national level.

6.1 Statewide Intensifications

NHDES will also complete, to the extent possible, statewide probability-based surveys of individual waterbody types. Statewide probability surveys will include the collection of data from additional randomly selected sites in conjunction with those included in the national surveys. In this manner, a statewide survey for each waterbody type will be an extension of the national survey but at an intensified level of sampling.

In general, it is expected that the statewide intensification will include approximately 50 randomly selected sampling locations per waterbody type. Based on past experiences, this represents 30 to 35 additional sites above and beyond the national survey and a significant investment of state resources to complete. For this reason, statewide intensifications for specific waterbody type are planned to occur over multiple years within each EPA national survey "round" and once every 10 years (Table 3).

As currently planned, NHDES' statewide intensification commitment are limited to lakes/ponds and rivers/streams. A statewide probability survey of wetlands will eventually be added once NHDES fully develops its wetland sampling and assessment methodology (See section 10). In 2000-2005, 2010, and 2015 EPA-led probability-based assessments of coastal waters were conducted through a cooperative effort between NHDES and the University of New Hampshire. NHDES will continue to participate in EPA-led surveys of coastal waters but does not intend to “intensify” the survey design for a state-level assessment. The monitoring programs in NH’s coastal waters are already sufficient for NHDES to make water quality assessments of nearly 100% of its coastal waters.

Table 3. Schedule (2007 - 2021) of national and state-scale probability surveys.

Waterbody type	Year														
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Lakes/ponds-EPA	X					X					X				
Lakes/ponds-Intensification		X	X									X	X	X	
Rivers/streams-EPA		X	X				X	X				X	X		
Rivers/streams-Intensification			X	X				X	X	X					
Coastal-EPA				X					X					X	
Wetlands-EPA					X					X					X
	ROUND 1					ROUND 2					ROUND 3				
	COMPLETE									UPCOMING					

For statewide probability surveys, a series of water quality parameters have been identified in Table 4 that will serve as the primary indicators for reporting on water quality conditions with respect to designated uses. The table below also identifies the expected reporting units for each waterbody type. Analysis of the data to estimate statewide conditions for individual waterbody types will follow the tools developed and made available through the EPA's Office of Research and Development, National Health Environmental Effects Research Laboratory, Western Ecology Division (http://www.epa.gov/nheerl/arm/analysispages/monitanalysisinfo.htm).

Table 4. Statewide probability-based survey reporting units, designated uses, and potential indicators.

Waterbody Type	Reporting Units	Designated Uses for Reporting	Potential Indicators
Rivers / Streams	Percent of total number of river / stream miles (1:24,000 NHD)	Primary Contact Recreation	Bacteria (*E. coli*)
		Aquatic Life Use	Invertebrates, Fish, pH, Dissolved oxygen, Habitat, Nutrients (Total phosphorus / Total nitrogen)
Lakes / Ponds	Percent of total number of lakes / ponds ≥ 10 acres (1:24,000 NHD)	Primary Contact Recreation	Bacteria (*E. coli*), Chlorophyll *a*, Presence of cyanobacteria scum
		Aquatic Life Use	Chlorophyll *a*, Total phosphorus, pH, Dissolved oxygen, Exotic plants, Acid neutralizing capacity

6.2 Data Sources, Quality Assurance, and Data Management

Data collection for probabilistic field surveys will be completed by NHDES staff using standardized procedures that are either documented in an EPA approved quality assurance project plan (QAPP) or a standard operating procedure (SOP). Prior to any data analysis, all data will be reviewed for completeness, accuracy, and precision. Once data verification is complete, the NHDES Environmental Monitoring Database (EMD) will serve as the primary data repository. Subsequently, where possible, raw data will be flowed to EPA's STORET/WQX using a node to node transfer.

6.3 Project Costs / Needs

The completion of probability-based monitoring surveys will rely of staff from the NHDES Watershed Management Bureau and not linked to particular monitoring program(s). For each waterbody type where intensification is to be completed, a project manager will be appointed and the field staff identified. Overall estimated lab costs and staffing needs for the rivers/streams and lakes/ponds are detailed in Tables 5 and 6, respectfully.

Table 5. Estimated costs and needs associated with a statewide probability-based survey for rivers and streams.

Rivers / Streams Statewide Probability-based Estimated Costs / Needs				
Estimated Laboratory Costs				
	Single Event Parameter Cost*	E. coli costs**	Nutrient costs**	Invertebrate costs
Per site	$225	$60	$171	$270
Number of sites	30	50	50	30
QC cost estimate	$675	$300	$855	
Total cost by category	$7,425	$3,300	$9,405	$8,100
Total cost / site (no inverts)				$456
Total cost / site (includes inverts)				$726
Total lab costs				$28,230
* Single event parameters include total suspended solids (TSS), alkalinity, hardness, total organic carbon, calcium, sodium, magnesium, potassium, sulfate. ** Assumes samples collected 3x per year during summer months. Additional parameters collected 3x per year will include chloride, specific conductance, pH, dissolved oxygen, water temperature.				
Staffing Needs				
1 field crew (6 staff) @ 1 site / day x 50 sites = 50 days over multiple years Total number staff days = 300 (once / 10 years)				

Table 6. Estimated costs and needs associated with a statewide probability-based survey for lakes and ponds.

Lakes / Ponds Statewide Probability-based Estimated Costs / Needs			
Estimated Laboratory Costs			
	Single Event Parameter Cost*	E. coli costs**	Nutrient costs**
Per site	$160	$60	$171
Number of sites	36	36	36
QC cost estimate	$640	$240	$700
Total cost by category	$6,400	$2,400	$6,856
Total lab costs			$15,656
* Single event parameters include total suspended solids (TSS), alkalinity, hardness, total organic carbon, calcium, sodium, magnesium, potassium, sulfate ** Assumes samples collected 3x per year during summer months Additional parameters collected 1x per year will include chloride, specific conductance, pH, dissolved oxygen / water temperature profile			
Staffing Needs			
1 field crew (4 staff) @ 1 site / day x 50 sites = 50 days over multiple years Total number staff days = 200 (once / 10 years)			

6.4 Reporting

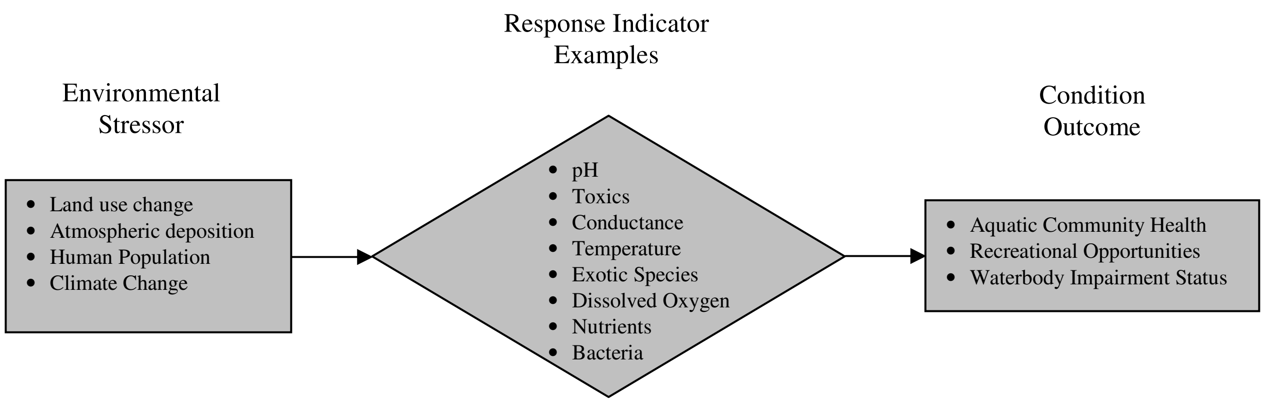
Probability surveys will be used to communicate the status of condition for individual waterbody types on a statewide basis in a succinct and understandable format to the public. Specifically, statewide probability survey designs and reporting will be completed with a known margin of error. The results of probability-based surveys will be utilized, in part, to understand the stressors that are most prevalent and their overall impact on waterbody condition. Reports of study results will be completed approximately 2 years following the termination of sampling. However, based on previous experience, report timing will, in large part, depend on the availability of data collected through the national surveys. These data are managed by EPA and must undergo a thorough review process prior to becoming available to the states. Once these data are made available and the final "condition" ratings are released by EPA, NHDES will prepare a statewide waterbody-specific status report. Currently, NHDES plans on statewide condition reports being drafted and available for review in 2017 for rivers and streams and 2021 for lakes and ponds (Appendix A). Once complete, a summary of survey results will be included in biennial 305(b)/303(d) integrated water quality report to EPA.

7. Freshwater Trend Monitoring Network

Trends in New Hampshire's surface water quality will be determined from fixed network of monitoring stations that are repetitively sampled over the long term. At this time, trend monitoring efforts are focused on lakes/ponds and rivers/streams. Future updates to the monitoring strategy will incorporate wetlands once field sampling and assessment protocols have been tested and finalized. See Section 10 for a summary of wetland monitoring activities. Trends in New Hampshire's coastal water quality are monitored and reported primarily through a partnership of entities including NHDES, the University of New Hampshire (UNH), EPA, and various municipal organizations. These efforts, in large part, are coordinated through the Piscataqua Regional Estuaries Partnership (PREP; See 2013 State of Estuaries Report). For a summary of monitoring activities with New Hampshire’s marine water see Section 9.

For the rivers/streams and lakes/ponds waterbody types the design of the trend monitoring network is partially based on a stressor - response - condition conceptual model (Figure 2). Under this model, environmental stressors will be identified and related to the observed responses in water quality indicators. In turn, responses in water quality indicators will be related to surface water condition outcomes. To the extent possible, trend monitoring will incorporate data collected from sites across a range of environmental stressors in order to track trends and make comparisons to the response indicators and overall condition outcomes.

Figure 2. Surface water trend monitoring conceptual model for tracking stressor - response - condition outcomes.



In order for the trend network to be effective, the data it produces must be capable of answering specific questions. Only in this manner will a trend network serve to satisfy the objectives outlined in the strategy. The three general questions of interest for the trend network are:

1) ***Are surface water quality conditions in New Hampshire improving, deteriorating, or remaining constant over time?***

2) ***At what rate are trends changing over time?***

3) ***Are trends related to suspected environmental stressors?***

In order to answer these questions, quantifiable measures were developed for each indicator. The data source feeding individual indicators was identified and evaluated for its relevance (relation to environmental stressors and condition outcomes), methods of collection, explanation of data qualities, and the timeframe for which trends are reported.

The design of the trend network is described separately for rivers/streams and lakes/ponds. The description includes a review of the primary monitoring programs responsible for data generation, a spatial framework that establishes a geographically diverse register of sample stations, the identification of waterbody descriptors (size, trophic status, etc.) that are built into the design, and the environmental stressors considered for site selection.

7.1 Rivers and Streams

Trend monitoring in New Hampshire rivers and streams will be accomplished by the integration of data collected from three current monitoring programs administered by NHDES: the Ambient Rivers Monitoring Program (ARMP), the Biomonitoring program, and the Volunteer Rivers Assessment Program (VRAP). NHDES recognizes that there are additional sources of data outside the agency that could be considered in tracking surface water quality trends, but has decided to focus on its own data here to ensure it is collected and used in the most effective and efficient manner. By integrating three programs, NHDES is committed to collecting and analyzing data from 40 stations statewide for its trend monitoring efforts. To accomplish this goal, NHDES will rely on its own staff and citizen volunteer water quality monitors.

Historically, NHDES had repetitive surface water quality records from 17 rivers stations monitored through the ARMP dating back to 1990. Traditionally, ARMP trend stations were focused in central and southern portions of that state and represented exclusively by large rivers. These stations were visited three times during the summer months and samples analyzed for 20 separate water quality parameters (Table 7). Since its inception, the trend stations monitored through the ARMP have generated over 20,000 data records. Thus, past data from the ARMP will serve as an important component of NHDES' trend monitoring for large rivers (>4th order). As in the past, the focus of trend monitoring at a limited number of historic ARMP stations will continue to be on physical and chemical parameters. Future monitoring at these stations will include the use of continuous data loggers to ensure that sufficient data are gathered in order make a full assessment of the applicable designated uses at least once within a five year period.

Table 7. Historic ARMP water quality parameters.

Parameter	Abbreviation	Units
Dissolved Oxygen	DO	Percent saturation (%); Concentration (mg/L)
pH	pH	Units
Specific Conductance	Sp. Cond.	µg/L
Chlorophyll *a*	Chl *a*	mg/L
Chloride	Cl	mg/L
Escherichia coli	E. coli	counts/100 mls
Nitrate / Nitrite	NO_2 / NO_3	mg/L
Total Kjeldahl Nitrogen	TKN	mg/L
Total Phophorus	TP	mg/L
Total Solids	TS	mg/L
Total Suspended Solids	TSS	mg/L
5-day Biochemical Oxygen Demand	BOD5	mg/L
Alkalinity	Alk	mg/L $CaCO_3$
Hardness	Hard	mg/L $CaCO_3$
Aluminum	Al	mg/L
Total Organic Carbon	TOC	mg/L
Calcium	Ca	mg/L
Magnesium	Mg	mg/L
Sodium	Na	mg/L
Postassium	K	mg/L
Sulfate	SO_4	mg/L

The biomonitoring program was established by NHDES in 1997 to assess the condition of biological communities. Since that time, the biomonitoring program has focused on gathering data that resulted in the development of mature biological indices for fish and macroinvertebrates for most wadeable streams. To date, the biomonitoring program has physical, chemical, and biological data from nearly 400 unique stations. Through these efforts the biomonitoring program has developed the capacity to effectively sample 40 or more stations a year for a full suite of parameters. The biomonitoring program's role in the trend monitoring network is to dedicate a portion of this capacity to repetitively sample a fixed set of stations that are representative of the biological assemblages that occur in wadeable streams. The data produced from these efforts will be used to track the trends in aquatic community condition through the use of biological indices. Repetitive sampling of the biological communities at trend sites will also be used calibrate and revise biological indices when necessary. Lastly, full assessments of the applicable designated uses will be possible annually at trend sites where biological samples are collected.

The Volunteer River Assessment Program (VRAP) was established in 1999 and has grown to include approximately 30 active groups. The program relies on over 200 volunteers to collect water quality data from approximately 250 stations on an annual basis. Of these groups, at least eight have 10 or more years of data and an additional eight have five or more years of data. Thus, the efforts of these dedicated volunteers provide an important source of data for tracking trends on New Hampshire's rivers and streams while simultaneously reducing the efforts required by NHDES staff to collect water quality data. Since many of the rivers and streams sampled under the VRAP program are wadeable, the biological indices developed under the biomonitoring program are also applicable and will be used in conjunction with physical and chemical parameters to track trends in water quality. Designated use assessments at trend stations collected through the VRAP program will be completed either annually (wadeable streams) or once every five years (non-wadeable rivers or streams).

Taken collectively, 39 river monitoring stations were established as of 2012 that can be considered to be long term monitoring stations (Map 1). Of these, 17 were monitored by the ARMP for over 20 years. Additionally, in 2012, the biomonitoring program established 9 new stations as a demonstration of its ability to dedicate a portion of its efforts towards trend monitoring. Similarly, the VRAP program established long term monitoring stations at 13 locations to assist volunteer groups in tracking the water quality characteristics in their river of interest over the long term. In total this comes close to the goal of 40 river or stream trend monitoring stations. However, seven of the historic ARMP stations were discontinued and eight new stations added in order to establish a trend network that is more geographically diverse, representative of small, medium, and large rivers, and includes streams across a range of human development intensity (See Appendix B for complete list of river trend sites). The sections below describe, in detail, how these stratification requirements are met and the revised roster of trend monitoring stations.

7.1.1 Spatial Framework

The 8-digit hydrologic unit code (HUC8) was used as the basic framework to evaluate the past and future extent of trend monitoring stations. HUC8s in New Hampshire range in size from 186 to 1,673 square miles and include watersheds located in the largely undeveloped, less populated, forested northern sections of New Hampshire to the more densely populated, urban and suburban southern and eastern sections of the state. The HUC8 watersheds also represent differences in natural environmental factors across the state such as climate, geology, vegetation, and hydrology. Thus, a geographically diverse trend network will capture these natural and anthropogenic differences that occur across the New Hampshire landscape.

The revised trend monitoring network for rivers and streams reflects the goal of establishing at least one station in each HUC8 (Table 8, Map 2). The occurrence of several sample stations within a single HUC8s, in some instances, serves to meet the stratification goals outlined below based on stream size and the percentage of developed lands. A full roster of the sample locations by HUC8 is provided in Appendix B.

Map 1. 2012 river and stream long term monitoring stations.

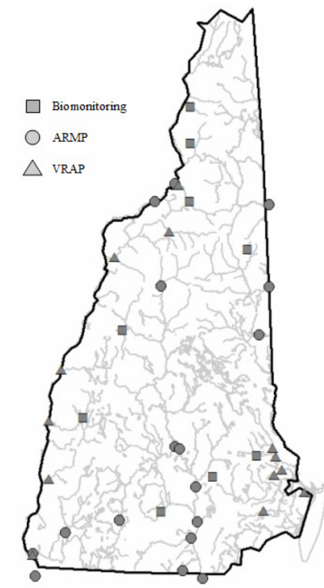
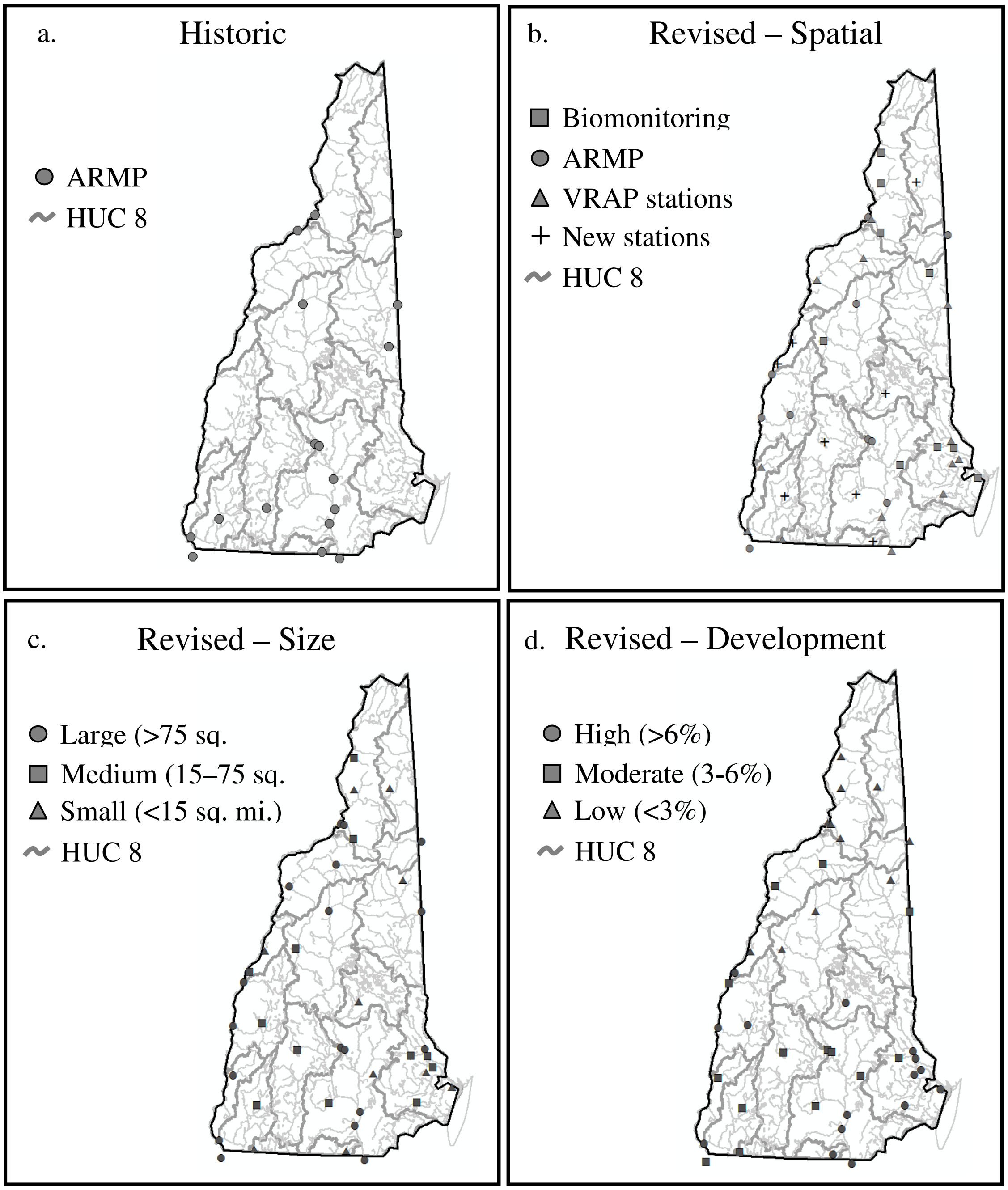


Table 8. Eight-digit hydrologic unit code (HUC8) breakdown of historic and revised river/stream trend monitoring sites.

HUC_8	HUC_8 Name	Number of Sites		Explanation of change
		Historic	Revised	
1040001	Upper Androscoggin	0	1	Add 1 new station.
1040002	Lower Androscoggin	1	1	No change.
1060002	Saco	2	2	Discontinue 1 ARMP (03-OSS). Add 1 new station.
1060003	Piscataqua-Salmon Falls	0	7	Add 7 new stations.
1070001	Pemigewasset	1	2	Add 1 new station.
1070002	Winnipesaukee River	0	1	Add 1 new station.
1070003	Contoocook	2	2	Discontinue 1 ARMP (25J-CTC). Add 1 new station.
1070004	Nashua	1	1	Discontinue 1 ARMP (06-NSH). Add 1 new station.
1070006	Merrimack River	5	6	Discontinue 1 ARMP (16-MER). Add 2 new stations.
1080101	Upper Connecticut	1	5	Add 4 new stations.
1080103	Waits	1	2	Discontinue 1 ARMP (53-CNT). Add 2 new stations.
1080104	Upper Connecticut-Mascoma	0	2	Add 2 new stations.
1080106	Black-Ottauquechee	0	3	Add 3 new stations.
1080107	West	0	1	Add 1 new station.
1080201	Middle Connecticut	3	3	Discontinue 2 ARMP (16-ASH, 02-ASH). Add 2 new stations.
1080202	Miller	0	1	Add 1 new station.

Map 2. Historic and revised rivers and streams trend monitoring network.



7.1.2 Stream size

Size was chosen as an important characteristic to stratify the river and stream trend monitoring network. Stream size is generally represented either by stream order or upstream drainage area and is an important variable to consider when describing the natural variability in the physical, chemical, hydrological, and biological characteristics that are observed.

Based on the 1:24,000 National Hydrography Dataset (NHD), New Hampshire contains nearly 16,000 miles of rivers and streams with approximately 89% of these miles distributed in smaller streams (≤ 3rd order), 9% in medium-sized rivers (4th & 5th order), and just 2% from large rivers (6th and 7th orders) (Table 9).

Table 9. Miles of streams and rivers by stream order in New Hampshire.

Stream Order	1	2	3	4	5	6	7	Total
Miles	8,804	3,399	1,869	860	513	266	121	15,832

For the trend monitoring network, sampling locations were placed in one of three categories (small, medium, large). The boundaries for these categories were selected based on known natural differences in biological communities and the observed transitions in the physical characters that structure these communities. Specifically, NHDES has identified an upstream drainage area of 15 square miles as an important transition point in differentiating among the major types of wadeable streams when applying both its fish and macroinvertebrate indices of biotic integrity. In general, wadeable streams with drainage areas less than 15 square miles (small) in New Hampshire, with some exceptions in southern sections of the state or at low elevations, are dominated by coldwater taxa. In contrast, wadeable streams with drainage greater than 15 square miles (medium) can contain both cold and warmwater taxa depending on their geographic location and elevation and are best described as 'transitional' streams.

In order to discriminate medium from large streams, a second size-based boundary was identified based on 394 unique sample locations contained in the NHDES biomonitoring unit's database as of 2011. Of these, 349 (89%) had drainage areas less than 75 square miles and serve as a reasonable boundary to separate medium-sized wadeable streams (≤4th order) from non-wadeable rivers (large). Further, most rivers with drainage areas greater than 75 square miles in New Hampshire tend to be dominated by warmwater taxa.

In application, the revised trend monitoring network for rivers and streams represents a departure from previous efforts that were exclusively centered on large rivers through the ARMP. Instead, it emphasizes the collection of data from more small to medium sized rivers and more accurately represents the true distribution of river and stream miles in New Hampshire (Table 10). In this manner, NHDES will be able to interpret the immediate effects of the stressors impacting water quality at smaller scales while also depicting the integrated effect of multiple stressors at larger scales. Overall, the resultant impacts of the stressors will be tracked through condition outcomes such as benthic macroinvertebrate community condition, as well as trends in pH and dissolved oxygen. A full roster of the sample locations by stream size category is provided in Appendix B.

Table 10. Stratification of the historic and revised river and stream trend monitoring network based on upstream watershed drainage area.

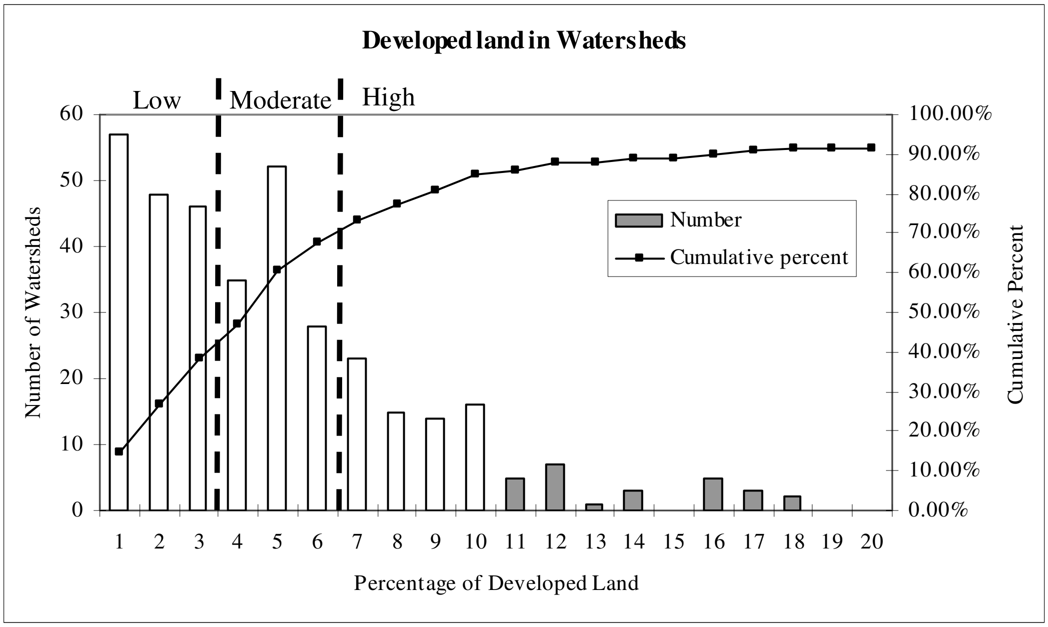
Category	Program	Number of Sites	
		Historic	Revised
Small <15 sq. mi. drainage area	ARMP	0	0
	VRAP	0	2
	Biomonitoring	0	8
	Total	**0**	**10**
Medium 15-75 sq. mi. drainage area	ARMP	0	0
	VRAP	0	3
	Biomonitoring	0	9
	Total	**0**	**12**
Large >75 sq. mi. drainage area	ARMP	17	10
	VRAP	0	8
	Biomonitoring	0	0
	Total	**17**	**18**

7.1.3 Environmental stressors

The percentage of developed land, as estimated through the 2006 National Land Cover Database (NLCD), was used as the primary means for stratifying sample locations for the river and stream trend monitoring network in order to track trends in water quality conditions with respect to potential anthropogenic stressors. Developed lands are associated with higher population densities, more intensive road networks, higher percentages of impervious cover, point source discharges of pollution sources, and more frequent modifications to the natural hydrologic regime. Collectively, the prevalence of these stressors is important to consider and can negatively impact water quality conditions. While other environmental stressors, such as atmospheric deposition and climate change are also important factors that may affect water quality, the extent of developed land within a given watershed was chosen because of the potential to observe changes in environmental quality based on local activities.

Breakpoints to stratify river and stream trend monitoring stations were based on the cumulative distribution properties of the population of biomonitoring stations that have been sampled to date under the assumption that they are generally representative of the development patterns across New Hampshire. According to a 2010 report from the Society for the Protection of New Hampshire Forests (SPNHF), 82% of the land in New Hampshire is forested (Sundquist 2010). Of the nearly 400 locations previously sampled by the biomonitoring program, the median percentage of forested lands, based on the 2006 NLCD, within the each watershed was identical (82%). Conversely, the median percentage of developed lands from watersheds previously sampled by the biomonitoring program was 4% with 90% of these watersheds having developed land percentages less than 16% (Figure 3). Based on these findings, low, moderately, and highly developed watershed categories were established from the percentage of developed lands using 3% and 6% as the categorical breakpoints.

Figure 3. Culmulative frequency distribution of percentage of developed land within watersheds previously sampled by the NHDES biomonitoring program. Vertical dashed lines are development category thresholds.



The revised trend monitoring network for rivers and streams is specifically designed with the intent of tracking and reporting on the trajectory of important water quality indicators over time with respect to land use. The revised design is more equally balanced across the range of the percentage of developed land observed in New Hampshire (Table 11). The end result is that the revised river and stream trend monitoring network will provide the necessary long term data for tracking baseline water quality conditions in relatively undeveloped watersheds in comparison to watersheds where development is more prevalent. A full roster of the sample locations by development category is provided in Appendix B.

Table 11. Stratification of the historic and revised river and stream trend monitoring network based on percentage of developed land in the upstream watershed.

Category	Program	Number of sites	
		Historic	Revised
Low (<3% development)	ARMP	2	2
	VRAP	0	1
	Biomon	0	8
	Total	**2**	**11**
Moderate (3-6% development)	ARMP	8	5
	VRAP	0	5
	Biomon	0	5
	Total	**8**	**15**
High (>6% development)	ARMP	7	3
	VRAP	0	8
	Biomon	0	3
	Total	**7**	**14**

7.1.4 Indicators

Trend monitoring in rivers and streams will be focused on the collection of data records for meaningful water quality parameters in order to track changes in water quality conditions over time. A full list of water quality parameters scheduled for collection is provided in Table 12. A select set of these parameters will serve as primary "indicators" of water quality conditions. The sections below provide a description of these indicators, why they were included, and the expected frequency of collection. For each parameter, specific questions have been identified for which the data will be used along with the anticipated procedures needed to answer these questions. A brief summary of the data qualities is provided in order to establish a basic understanding of trend detection expectations. Lastly, for each parameter, the means by which the data will be obtained and stored is identified.

Table 12. Water quality parameters collected as part of the NHDES river and stream trend monitoring network.

Parameter	Analysis Location	Primary (P) or Accessory (A) Indicator
Water Temperature	Field	P
pH	Field	P
Dissolved Oxygen	Field	P
Specific Conductance	Field	P
Macroinvertebrates	Field	P
Nitrate + Nitrite Nitrogen	DHHS PHL-WAL	P
Total Kjldahl Nitrogen	DHHS PHL-WAL	P
Total Phosphorus	DHHS PHL-WAL	P
Chlorophyll a (non-wadeable sites only)	JCLC	A
Calcium	DHHS PHL-WAL	A
Magnesium	DHHS PHL_WAL	A
Sodium	DHHS PHL-WAL	A
Potassium	DHHS PHL-WAL	A
Total Organic Carbon	DHHS PHL-WAL	A
Sulfate	DHHS PHL-WAL	A
Hardness	DHHS PHL-WAL	A
Acid Neutralizing Capacity	DHHS PHL-WAL	A
Bacteria	DHHS PHL-WAL	A
Total Suspended Solids	DHHS PHL-WAL	A
Chloride	JCLC	A

7.1.4.1 Specific Conductance

Specific conductance is a measure of the water's ability to carry an electrical current and reflects the concentration of dissolved solids. Ions such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, iron, and aluminum all contribute to specific conductance levels. These ions originate from natural (bedrock) and anthropogenic (fertilizers, road salt, stormwater, septic systems, agricultural practices) sources.

In New Hampshire, in-stream specific conductance levels are typically low (median = 137 µmhos / cm; D. Neils, Unpublished data) and reflective of the rock formations types (granite) over which most streams flow. Higher in-stream specific conductance levels have been associated with urbanized watersheds that have a greater percentage of impervious cover and greater road density (Deacon et al. 2005). Impervious cover and, more specifically, road density are linked to greater inputs of sodium and chloride ions as a result of road deicing (Trowbridge et al. 2010, Daley et al. 2009).

For the rivers and streams trend network, specific conductance will be measured using field meters fitted with a calibrated probe. Data will be collected a minimum of 3 - 5 times as discrete, one-time measures during individual site visits. In some cases, specific conductance data may also include a representative sub-sample of a continuous data record produced from a data logger deployment.

Question(s) parameter will be used to answer:

1) ***What is the incidence of increasing, decreasing, and stable trends in specific conductance statewide?***

   Measure: Number of trend sites with a significant trend (increasing / decreasing) or no detectable trend. If a significant trend is detected, the rate of change will be determined.

   Data analysis: Linear regression or the Mann-Kendall test of median specific conductance levels by year for individual trend sites. Data will be limited to the defined index period (June - September) and include all representative data points reported within the respective river segment (=AUID) for each trend station. A significant trend is defined as one that has ≤ 5% chance of occurring at random ($\alpha \leq 0.05$). Each reporting period will add 15 or more points to the trend analysis. Rates of change for significant trends will be represented by the slope of the trend line. Percent change will be reported by dividing the rate of change by the overall median.

2) ***What is the percentage of trend locations that have higher (lower or similar) level of specific conductance in the last five years compared to the previous five year interval?***

   Measure: Number of trend sites with mean specific conductance levels that are significantly different in the current 5-year period than the previous 5-year period divided by the total number of trend sites.

   Data analysis: Analysis of variance (ANOVA) or an equivalent non-parametric test of specific conductance levels between the current and previous reporting period. Data for the analysis will be limited to a defined index period (June - September) and include all data points reported within the respective river segment (=AUID) for each trend station. A significant difference in mean specific conductance levels between reporting periods is defined as one that has a 5% chance of occurring at random ($\alpha \leq 0.05$). Data from an entire reporting period will be consolidated for the computation of summary statistics and used in completing each analysis.

3) ***What percentage of trend sites is in the upper 75th percentile of the statewide distribution of specific conductance levels?***

   Measure: The number of trend sites in the upper 75th percentile of the statewide frequency distribution divided by the total number of trend sites. A plot of the percentage of sites in the upper percentile category over time and record of individual trend site percentiles will be produced.

   Data analysis: Answering this question includes two components: 1) a statewide frequency distribution of specific conductance measures from all river segments where data is available; and 2) a 5-year mean computation for individual trend stations. The statewide frequency distribution will be computed from specific conductance measures from all "RIV" AUIDs (river segments) from 1990 through the last year included in the reporting period. Individual station measures will be consolidated by AUID. All AUIDs with 10 or more specific conductance measures will be used to create the statewide frequency distribution and computation of the mean, median, 25th, and 75th percentiles. The 5-year mean specific conductance level at individual trend sites will be computed from the current year going back 5 years.

Data Qualities:

Specific conductance data in NHDES' records are abundant and show a moderate level of variability (Table 13). Based on these data, within station variability is approximately 30% (Mean coefficient of variation) and a power analysis of simulated data indicated that trends using linear regression will be detectable within 10 years if levels double over that same time period at a given site. More subtle trends may be detectable at sites where specific conductance measures are more consistent or numerous.

Table 13. NHDES surface water specific conductance data record summary and expected ability to detect trends.

Number of Observations	Median (µmhos / cm)	Mean of Standard Deviations*	Mean Coefficients of Variation*	Variability Category	Expected trend detection capacity (10 year doubling)	Expected trend detection capacity (25 year doubling)
31,091	137	49.4	0.30	Medium	Yes	No

* Statistics are based on repeated measures within the same river segment (e.g., assessment unit)

7.1.4.2 Nutrients

Nutrients, namely nitrogen and phosphorus, are vital components to ecosystem primary production. However, in aquatic systems, when nutrient levels are increased beyond those that naturally occur, plant and algal growth can become excessive. The resulting effects can lead to water quality impairment as measured by the ability of a waterbody to support aquatic life and recreational uses. EPA recognizes nutrients as the leading cause of water quality impairment in the United States and reported that approximately 30 percent of the stream miles in the "most disturbed condition" could be attributed to either phosphorus or nitrogen (EPA 2006). Nutrients from instream water samples originate naturally from soil, rocks, and rainwater. Unnatural nutrient sources are primarily fertilizers, sewage, animal waste, and erosion. These unnatural sources are often carried by stormwater.

Median total nitrogen (TN) and total phosphorus (TP) concentrations of all water samples analyzed from New Hampshire rivers and streams from 1990 - 2009 were 0.539 and 0.015 mg/L, respectively (D. Neils, Unpublished data; TN: n=1,878 samples, 140 AUIDs; TP: n=26,096 samples, 677 AUIDs). However, when the data was limited to samples collected from sites with minimal human disturbance (defined as having a median specific conductance <50µmhos), the natural, background concentrations of TN and TP were 0.345 and 0.010 mg/L, respectively (D. Neils, Unpublished data; TN: n=155 samples, 19 AUIDs; TP: n=8,506 samples, 186 AUIDs).

The primary factors contributing to instream nutrient concentrations beyond the natural background are related to point and non-point source contributions. In a study of the watersheds draining to New Hampshire's Great Bay by the Piscataqua Regional Estuaries Partnership (PREP), approximately 30% of the nitrogen load was attributed to point sources and 70% to non-point sources (PREP 2013). For the river and stream trend network, in-stream nutrient levels will be expressed through concentrations of TN and TP measured from June through September. Discrete samples will be collected and submitted for laboratory analysis 3 - 5 times annually.

Question(s) parameter will be used to answer:

1) ***What is the incidence of increasing, decreasing, and stable trends in nutrient concentrations statewide?***

   Measure: Number of trend sites with a significant trend (increasing / decreasing) or no detectable trend. If a significant trend is detected, the rate of change will be computed.

   Data analysis: Linear regression or Mann-Kendall test of median nutrient concentrations (TP and TN) by year for individual trend sites. Data will be limited to the defined index period (June - September) and include all data points reported within the respective river segment (=AUID) for each trend station. A significant trend is defined as one that has ≤ 5% chance of occurring at random ($\alpha \leq 0.05$). Each reporting period will add 15 or more points to the trend analysis. Rates of change for significant trends will be represented by the slope of the trend line. Percent change will be reported by dividing the rate of change by the overall median.

2) ***What is the percentage of trend locations that have higher (lower or similar) nutrient concentrations in the current five years compared to each of the previous reporting periods?***

   Measure: Number of trend sites with mean nutrient concentrations (TP and TN) that are significantly different in the current 5-year period than the previous 5-year period divided by the total number of trend sites.

   Data analysis: Analysis of variance (ANOVA) or an equivalent non-parametric test of nutrient concentrations (TP and TN) between the current and previous reporting period. Data for the analysis will be limited to a defined index period (June - September) and include all data points reported within the respective river segment (=AUID) for each trend station. A significant difference in mean nutrient concentrations between reporting periods is defined as one that has a 5% chance of occurring at random ($\alpha \leq 0.05$). Data from an entire reporting period will be consolidated for the computation of summary statistics and used in completing each analysis.

3) ***What percentage of sites is in the upper 75th percentile of the statewide distribution of nutrient (TP and TN) concentrations?***

   Measure: Number of trend sites in the upper 75th percentile of the statewide frequency distribution divided by the total number of trend sites.

   Data analysis: Answering this question includes two components: a statewide frequency distribution of nutrient concentrations from all river segments where data is available and a 5-year mean computation for individual trend stations. The statewide frequency distribution will be computed separately for TN and TP from all "RIV" AUIDs (river segments) from 1990 through the last year included in the reporting period. Individual station measures will be consolidated by AUID. All AUIDs with 10 or more measures will be used to create the statewide frequency distribution and computation of the mean, median, 25th, and 75th percentiles. The mean TN and TP concentration at individual trend sites will be computed from the current year going back 5 years.

Data Qualities:

TP data in NHDES' records are abundant and show a high level of variability (Table 14). Based on these data within station variability is approximately 73% (Mean coefficient of variation). A power analysis of simulated data indicated that trends may not be detectable within 10 years if levels double over that same time period at a given site. However, if data variability is lower, then trend detection may be possible.

TN data in NHDES' records are moderately abundant and show a moderate level of variability (Table 14). Based these data, within station variability is approximately 38% (Mean coefficient of variation) and a power analysis of simulated data indicated that trends will be detectable within 10 years if levels double over that same time period at a given site. More subtle trends may be detectable at sites where TN measures are less variable.

Table 14. NHDES surface water total phosphorus and total nitrogen concentration data record summary and expected ability to detect trends.

Parameter	Number of Observations	Median (mg/L)	Mean of Standard Deviations	Mean Coefficients of Variation	Variability Category	Expected trend detection capacity (10 year doubling)	Expected trend detection capacity (25 year doubling)
TP (mg/L)	27,818	.018	.023	.73	High	No	No
TN (mg/L)	4,041	.451	.185	.38	Medium	Yes	No

7.1.4.3 pH

The acidic qualities of surface water, as measured through pH, influence the types and abundances of aquatic organisms that are able to persist over time in a given waterbody. Surface waters with a pH below 5 are considered highly acidified resulting in significant negative impacts to the aquatic community. However, deleterious chronic impacts to aquatic communities may occur in waters with pH levels less than 6.5. Conversely, excessively high pH levels, above 8.0, are also outside the range considered to be supportive of a healthy biological community.

The pH of surface water is influenced by the geologic, vegetative, and physical landscape characteristics within the watershed, as well as local land use history and atmospheric deposition patterns. The ability of water to resist acidification, measured as alkalinity, is a key component to protecting a waterbody from becoming acidified and in allowing it to recover once it becomes acidified. Waters that have low alkalinity are particularly susceptible to, and lack the ability to be resilient from, acidification.

Acid precipitation, as a result of fossil fuel combustion, is a well-documented phenomenon in the northeastern United States that causes significant negative impacts to surface waters (Driscol et al. 2001). For New Hampshire, the draft 2012 305(b) report of surface water quality indicates that approximately 20% of the state's river miles were listed as impaired for pH. An approximately 50% reduction in the emission of the pre-cursors [sulfur dioxide (SO_2); nitric oxides (NO_X)] to acid precipitation has occurred in the northeast since the 1990 Clean Air Act amendments, thus water quality improvements are expected; however, are likely to take years to be realized due to naturally low alkalinity values (EPA 2010, NHDES 2004).

A summary of NHDES pH water quality data records from 1990 through 2012 indicates the median pH from 720 river segments with 5 or more records was 6.49 (D. Neils, Unpublished data). Records of alkalinity from the same time period for 107 river segments, regardless of the number of records per segment, indicated the median alkalinity was 6.20 mg/L.

For the rivers and streams trend network, pH will be measured using data sondes fitted with a calibrated probe. Data will be collected a minimum of three to five times as discrete, one-time measures during individual site visits. In some cases, annual median pH levels may also include a representative sub-sample of a continuous data record produced from a data logger deployment. Measures of alkalinity concentrations will occur one to two times per year through water samples collected during individual site visits. Data used for trend analyses of pH will be collected from June through September. Alkalinity data will be plotted annually as a secondary indicator of acidification.

Question(s) parameter will be used to answer:

1) What is the incidence of increasing, decreasing, and stable trends in pH levels statewide?

Measure: Number of trend sites with a significant trend (increasing / decreasing) or no detectable trend in pH. If a significant trend is detected, the rate of change will be determined.

Data analysis: Linear regression or the Mann-Kendall test median pH for individual trend sites. Data will be limited to the defined index period (June - September) and include all data points reported within the respective river segment (=AUID) for each trend station. A significant trend is defined as one that has ≤ 5% chance of occurring at random ($\alpha \leq 0.05$). At each site, a reporting period will add 15 or more points to the trend analysis. Rates of change for significant trends will be represented by the slope of the trend line. Percent change will be reported by dividing the rate of change by the overall median.

2) What is the percentage of trend locations that have higher (lower or similar) pH levels in the current five years compared to each of the previous reporting periods?

Measure: Number of trend sites with mean pH levels that are significantly different in the current 5-year reporting period than the previous 5-year reporting period divided by the total number of trend sites.

Data analysis: Analysis of variance (ANOVA) or an equivalent non-parametric test of pH levels between the current and previous reporting period will be used. Data for the analysis will include all data points reported within the respective river segment (=AUID) for each trend station. A significant difference in means between reporting periods is defined as one that has a 5% chance of occurring at random ($\alpha \leq 0.05$). Data from an entire reporting period will be consolidated for the computation of summary statistics and used in completing each analysis.

3) What percentage of sites is in the lower 25th percentile of the statewide distribution of pH levels?

Measure: Number of trend sites in the lower 25th percentile of the statewide frequency distribution for pH levels divided by the total number of trend sites.

Data analysis: Answering this question includes two components: a statewide frequency distribution of the means from all river segments where data are available and a 5-year mean for individual trend stations for each parameter. The statewide frequency distribution will be computed from pH measures from all "RIV" AUIDs (river segments) from 1990 through the last year included in the reporting period. Individual station measures will be consolidated by AUID. All AUIDs with 10 or more pH measures will be used to create a statewide frequency distribution and computation of the mean, median, 25th, and 75th percentiles. The mean pH level at individual trend sites will be computed from data ending in the year of the current reporting cycle going back 5 years.

Data Qualities:

Data in NHDES' records indicated that pH measures are abundant and show a low level of variability (Table 15). Based these data, within station variability is approximately 4% (Mean coefficient of variation) and a power analysis of simulated data indicated that trends will be detectable within 10 years if levels double over that same time period at a given site. Since pH is measured on logarithmic scale, a doubling of pH would correspond to a very large (one million times) change in actual acidity. Trends in pH are typically expressed in terms of pH units but the actual change in acidity must be considered when interpreting the results. More subtle trends may be detectable at sites where pH measures are less variable.

Table 15. NHDES rivers and streams pH data record summary and expected ability to detect trends.

Number of Observations	Median (pH units)	Mean of Standard Deviations	Mean Coefficients of Variation	Variability Category	Expected trend detection capacity (10 year doubling)	Expected trend detection capacity (25 year doubling)
29,133	6.43	0.28	0.04	Low	Yes	Yes

7.1.4.4 Biological Condition

The biological condition of aquatic systems can be measured directly through the use of biotic indices. Indirectly, the ability of aquatic systems to support natural biological communities can be measured through surrogate water quality measures, such as dissolved oxygen. A decline in biotic condition is reflective of the waterbody's inability to support a natural, adaptive, and integrated community of aquatic organisms. The biological condition of individual sites can be affected by a single or multiple stressors that include stormwater, excessive nutrients, degraded habitat, acidification, and toxics. In New Hampshire, NHDES has developed biological indices for macroinvertebrates and fish in wadeable streams (typically ≤4th order) and uses dissolved oxygen as a surrogate indicator of aquatic life use support for larger rivers (typically ≥5th order).

For wadeable streams, the trend monitoring network will rely on NHDES' benthic index of biotic integrity (B-IBI) to track trends in aquatic community condition. The B-IBI is based on benthic macroinvertebrates and is comprised of 7 measures of biotic condition. These measures are combined into a single index score that ranges from 0 to 100 with 100 indicating the best condition. B-IBI score ratios reflect the ratio of a site's score to its applicable condition threshold. Score ratios of <1.0 indicate that an individual site's macroinvertebrate community condition was lower than that of samples collected from un-impacted (e.g., reference) streams with similar characteristics. Sites with B-IBI score ratios ≥ 1.0 are considered to be fully supportive of aquatic life use. For trend monitoring sites where the B-IBI is applicable, three replicate macroinvertebrate samples will be collected from each site annually and used to compute a single overall site-specific B-IBI score.

For larger rivers, dissolved oxygen will be used to represent the ability of the water body to potentially support a representative aquatic community. Low dissolved oxygen levels are typically reflective of rivers with of an overabundance of aquatic life resulting from elevated nutrient loads (eutrophication) or have sluggish flows and higher water temperatures in or below impounded areas.

Low dissolved oxygen concentration events are cyclical in most New Hampshire rivers and streams and occur usually during the early morning hours. Therefore, these events are best captured by means of a continuous data loggers deployed over a set period of time. For this reason, within a given reporting period (5-years), at least one continuous 7 - 10 day data record will be collected during the period of June 1 through September 30 for each non-wadeable trend monitoring site. For each continuous record, DO readings (concentration and percent saturation) will be taken at 15-minute increments resulting in between 672 - 960 data records.

Benthic Index of Biotic Integrity (B-IBI) (applicable to wadeable sites ONLY):

1) ***What is the incidence of increasing, decreasing, and stable trends in B-IBI scores statewide?***

   Measure: Number of trend sites with a significant trend (increasing / decreasing) or no detectable trend. If a significant trend is detected, the rate of change will be computed.

   Data analysis: Linear regression or the Mann-Kendall test of the annual B-IBI score by year for individual trend sites. A significant trend is defined as one that has ≤ 5% chance of occurring at random ($\alpha \leq 0.05$). Each reporting period will add 15 points (3 replicates / year x 5 years) to the trend analysis. Rates of change for significant trends will be represented by the slope of the trend line. Percent change will be reported by dividing the rate of change by the overall median.

2) ***What is the percentage of trend locations that have higher (lower or similar) B-IBI scores in the current five years compared to each of the previous reporting periods?***

   Measure: Number of trend sites with mean B-IBI scores that are significantly different in the current 5-year reporting period than the previous 5-year reporting period divided by the total number of trend sites.

   Data analysis: Analysis of variance (ANOVA) or an equivalent non-parametric test of B-IBI scores between current and previous reporting period. A significant difference in mean B-IBI scores between reporting periods is defined as one that has a 5% chance of occurring at random ($\alpha \leq 0.05$). Data from an entire reporting period will be consolidated for the computation of summary statistics and used in completing each analysis.

3) ***What percentage of sites is in the upper 75th percentile of the statewide distribution of B-IBI score ratios?***

   Measure: Number of trend sites in the upper 75th percentile (lower 25th) of the statewide B-IBI score ratio frequency distribution divided by the total number of trend sites. A plot of the percentage of sites in upper and lower percentile categories over time and record of individual trend site percentiles will also be produced.

Data analysis: Answering this question includes two components: a statewide frequency distribution of B-IBI scores from all river segments where data is available and a 5-year median computation for individual trend stations. The statewide frequency distribution will be computed from all applicable "RIV" AUIDs (river segments) from 1997 through the last year included in the reporting period. Where multiple benthic samples occur within the same AUID, the respective B-IBI score ratios will be consolidated into a single median B-IBI score ratio. All AUIDs with B-IBI score ratios will be used to create the statewide frequency distribution and computation of the median, 25th, and 75th percentiles. The median B-IBI score ratio at individual trend sites will be computed from data ending in the year of the current reporting cycle going back 5 years.

Data Qualities:

B-IBI scores represent single measures within a given year. To date, NHDES has minimal data from repeat visits to sample stations over time. However, the data used to generate B-IBI scores are a result of three replicate samples that can be compared to estimate the variation at a sample location within a given year. The variation in replicate B-IBI scores was relatively low (mean standard deviation = 4.62, coefficient of variation = 7%) (Table 16). It is expected that the year-to-year variation in B-IBI scores at individual sites will be higher than those observed within a given year, and that these differences will be partially attributable to natural environmental conditions. However, without inter-annual estimates of variation, the ability to detect trends in B-IBI scores is unknown.

Table 16. NHDES macroinvertebrate benthic IBI data record summary.

Number of Observations	Median (B-IBI score)	Mean of Standard Deviations*	Mean Coefficients of Variation*	Variability Category	Expected trend detection capacity (10 year doubling)	Expected trend detection capacity (25 year doubling)
1,023	65.4	4.62	0.07	-----	-----	-----

* Statistics computed from three replicate samples at individual sampling locations. Means are averages across all sample locations.

Dissolved Oxygen (applicable to non-wadeable sites ONLY):

1) Is the frequency of exceedances of the instantaneous dissolved oxygen criteria increasing, decreasing, or remaining stable?

Measure: The frequency of exceedance at individual sites will be the percentage of the total number of days that have a median 1-hour instantaneous dissolved oxygen concentration below the applicable water quality criteria.

Data analysis: The percentage will be computed as the number of hours where the median hourly concentration is less than 5.0 mg/L divided by the total number of hours for which continuous data records exist within a given reporting period. Frequencies will be reported for individual sites and used to qualitatively characterize the occurrences of exceedance over time.

2) Is the frequency of exceedances of the daily average dissolved oxygen criteria increasing, decreasing, or remaining stable?

Measure: The frequency of exceedance at individual sites will be the percentage of the total number of days that do not meet the applicable daily average water quality criteria.

<u>Data analysis:</u> The percentage will be computed as the number of days where the mean daily dissolved oxygen percent saturation is less than 75% divided by the total number of days for which continuous data records exist within given reporting period. Frequencies will be reported for individual sites and used to qualitatively characterize the extent of exceedance over time.

Data Qualities:

Data in NHDES' records indicated that dissolved oxygen measures are abundant and show a low level of variability (Table 17). Based on these data, within station variability is approximately 12% (Mean coefficient of variation) for percent saturation measures and 19% for concentration measures. A power analysis of simulated data indicated that trends will be detectable within 10 years if levels are reduced in half over that same time period at a given site. More subtle trends may be detectable at sites where dissolved oxygen measures are less variable.

Table 17. NHDES rivers and streams dissolved data record summary and expected ability to detect trends.

Parameter	Number of Observations	Median	Mean of Standard Deviations	Mean Coefficients of Variation	Variability Category	Expected trend detection capacity (10 year doubling)	Expected trend detection capacity (25 year doubling)
DO (% saturation)	5,021	88.5%	9.09	0.12	Low	Yes	Yes
DO (mg/L)	5,229	9.14 mg/L	1.65	0.19		Yes	Yes

7.1.4.5 Water Temperature

Aquatic organisms have a wide variety of thermal requirements. Some species of animals or plants prefer cool water temperatures while others flourish in warmer waters. In addition, some species can exist across a wide range of water temperatures whereas others have a more restrictive thermal range. In New Hampshire, a majority of wadeable streams are supportive of cold water species, such as trout, while large rivers, with some exceptions, tend to be more commonly dominated by warm water species.

A number of local factors can have an impact on water temperature including latitude, elevation, stream size, quantity and maturity of riparian vegetation, rate of flow, percent of impervious surfaces contributing stormwater, thermal discharges, impoundments, presence of detention basins, and groundwater. Climate change represents a global threat to the natural distribution of aquatic communities as well (Isaak and Rieman 2012; Staudinger et al. 2012). An increase in water temperatures will likely reduce habitat available to coldwater species (Isaak et al. 2012).

NHDES has collected 139 continuous water temperature records since 2006 from 87 unique locations. The records include hourly water temperature readings from June through September in most instances. In a recent analyses of these data, preliminary findings indicate that there are distinct differences between the median water temperatures supportive of three basic fish assemblage types: coldwater, transitional (a.k.a. cool) water, and warmwater. Further, these data provide a baseline by which to track long term changes in water temperature moving forward.

For the rivers and streams trend network, water temperature will be measured at each site using continuous water temperature data loggers. The data loggers will be deployed in early summer and retrieved in early fall and include approximately 2,880 data records per site (120 days x 24 hourly readings).

1) ***What is the incidence of increasing, decreasing, and stable trends in maximum water temperatures statewide?***

   Measure: Number of trend sites with a significant trend (increasing / decreasing) or no detectable trend. If a significant trend is detected, the rate of change will be computed.

   Data analysis: Linear regression or the Mann-Kendall test of the median water temperature for warmest 7-day period for each trend site within the annual data record. The warmest 7-day period is defined as 7 consecutive days that has the highest 7-day running mean water temperature. The reported value will be the median of the 7-day period. Data for the computation of an annual median will be limited to the defined index period (June 1 – September 30). A significant trend is defined as one that has ≤ 5% chance of occurring at random ($\alpha \leq 0.05$). Each reporting period will add 5 points (5 years) to the trend analysis.

2) ***What is the percentage of trend locations that have a higher (lower or similar) water temperature in the current reporting period compared to previous reporting periods?***

   Measure: Number of trend sites with summer water temperatures that are significantly different in the current 5-year reporting period than the previous 5-year reporting period divided by the total number of trend sites.

   Data analysis: Analysis of variance (ANOVA) or an equivalent non-parametric test of temperatures between current and previous reporting period. For each reporting period the maximum median 7-day running mean water temperature will be computed for each year. The median will be computed from the 7-day running mean values for each respective date within a given reporting period (5 annual measures / period). The reporting period will be from June 1 - September 30. A significant difference in water temperature between reporting periods is defined as one that has a 5% chance of occurring at random ($\alpha \leq 0.05$).

3) ***What is the duration of exceedance of water temperature benchmarks?***

   Measure: The percentage of consecutive days that temperature benchmarks are exceeded for individual trend sites.

   Data analysis: For each trend site, the percentage will be computed as the greatest number of consecutive days fish assemblage water temperature benchmarks are exceeded divided by the total number of days of the annual continuous water temperature record with the reporting period. The daily 7-day running mean water temperature will represent the daily measure to compare against water temperature benchmarks. The expected fish assemblage type for each site will be identified according to NHDES (NHDES 2011). Water temperature benchmarks for expected fish assemblage type are as follows as indicated in Table 17.

Table 17. Water temperature benchmarks (7-day running mean) for expected fish assemblage types.

Expected fish assemblage type	Water temperature benchmark (^oC)*
Coldwater	18
Transitional water	20
Warmwater	24

* Water temperature benchmarks DO NOT represent NH water quality criteria. They are a consolidation of known thermal limits and analysis of existing data records.

The duration of exceedance will be reported for individual sites and used to qualitatively characterize if water temperature benchmark exceedance durations are changing over time.

Data Qualities:

NHDES water temperature data of the warmest 7-day consecutive period indicate a low level data variability. However, the magnitude of water temperature increases a 10 - 25 year period are likely to be low. If a 5^oC increase over 25 years were to occur, significant trends in water temperature have a 52%, 91%, and 98% chance of being detected at coldwater, transitional water, and warmwater streams, respectively (Table 18). Higher trend detection percentages are reflective of lower variability in the observed data collected to date. More subtle trends may be detected if data variability is lower.

Table 18. NHDES rivers and streams water temperature data record summary and expected ability to detect trends.

Expected fish assemblage type	Number of Records	Median (^oC)	Standard Deviation	Coefficient of Variation	Variability Category	Expected trend detection capacity (5^oC increase over 25 yrs)*
Coldwater	49	19.5	2.78	0.14	Low	52%
Transitional water	49	21.2	1.69	0.08		91%
Warmwater	37	23.8	1.57	0.07		98%

* Trend detection capacity is based on the percentage of significant linear regressions (α=0.95) obtained from 250 simulated iterations based on a synthetic dataset.

7.1.4.6 Accessory Indicators

Several additional water quality parameters will be collected at each of the river and stream trend monitoring stations (Table 19). These parameters were selected as accessory indicators since they are of common interest for a variety of reasons in determining water quality conditions, but are known to be either highly variable or occur at low concentrations. Data for these parameters will be collected primarily by NHDES staff or VRAP volunteers, but may, in some instances, include data collected by other sources. Sampling frequency for these parameters will generally be once during the summer months (June - September), but may include additional samples during other times of the year. Results for each of the parameters will be obtained through the collection of discrete water samples that are submitted for laboratory analysis. Although no formal trend analyses will be completed for these parameters, standard descriptive statistics (mean, median, etc.) will be tabulated for each reporting period. As with the primary trend indicators, raw data for the accessory indicators will be quality assured and stored in the NHDES EMD.

Table 19. Accessory water quality indicators for the NHDES rivers and streams trend network.

Parameter	Symbol
Total Organic Carbon	TOC
Total Suspended Solids	TSS
Hardness	Hard
Calcium	Ca^{+2}
Magnesium	Mg^{+2}
Sodium	Na^{+1}
Potassium	K^{+1}
Chloride	Cl^{-1}
Sulfate	$SO4^{-2}$
Bacteria	----
Chlorophyll *a*	Chl a

7.1.5 Data Sources, Quality Assurance, and Data Management

River and streams trend monitoring data will be generated primarily by NHDES staff and citizen volunteers (VRAP) using field instruments, collection of discrete samples for laboratory analysis, by means of continuous data loggers, or through the capture of biological organisms for laboratory identification. Data collection for all trend monitoring activities will be completed under EPA approved quality assurance project plans (QAPP) or a NHDES standard operating procedures (SOP) (See Table 39 below). All data will be stored in the NHDES EMD. Prior to acceptance, all data will be reviewed for completeness, accuracy, and precision. Once data verification is complete, raw data will be flowed from NHDES' EMD to EPA's STORET/WQX using a node to node transfer to the extent possible.

In some cases, trend data may be collected and submitted to NHDES by alternative sources for a variety of unknown purposes. The quantity of data submitted by alternative sources cannot be determined at this time but is likely to account for a small percentage of the overall data. In these instances, a full review of the quality assurance measures will be completed prior to data acceptance and inclusion in trend reporting. Only data marked as "valid" in the EMD will be incorporated into the trend analysis and reporting phase.

7.1.6 Project costs / needs

The completion of river and stream trend monitoring surveys will rely primarily on staff from the NHDES Watershed Management Bureau. A total of 40 sites will be sampled annually 3 times during the summer months. Data collection will rely on two 2-person field crews. Overall estimated lab costs and staffing needs for the rivers/streams trend monitoring are detailed in Table 20.

Table 20. Estimated costs and needs associated with rivers and streams trend monitoring.

Rivers / Streams Trend Monitoring Estimated Costs / Needs				
Estimated Laboratory Costs				
	Single Event Parameter Cost*	E. coli costs**	Nutrient costs**	Invertebrate costs
Per site	$225	$60	$171	$270
Number of sites	40	40	50	30
QC cost estimate	$900	$240	$684	
Total cost by category	$9,900	$2,640	$7,524	$8,100
Total cost / site (no inverts)				$456
Total cost / site (includes inverts)				$726
Total lab costs				$28,164
* Single event parameters include total suspended solids (TSS), alkalinity, hardness, total organic carbon, calcium, sodium, magnesium, potassium, sulfate. ** Assumes samples collected 3x per year during summer months. Additional parameters collected 3x per year will include chloride, specific conductance, pH, dissolved oxygen, water temperature.				
Staffing Needs				
2 field crews (2 staff / crew) @ 3 sites / day x 40 sites = ~7 days / sample round 3 rounds of sampling = ~21 days total / year 21 days x 4 staff = 84 staff days / year				

7.1.7 Reporting

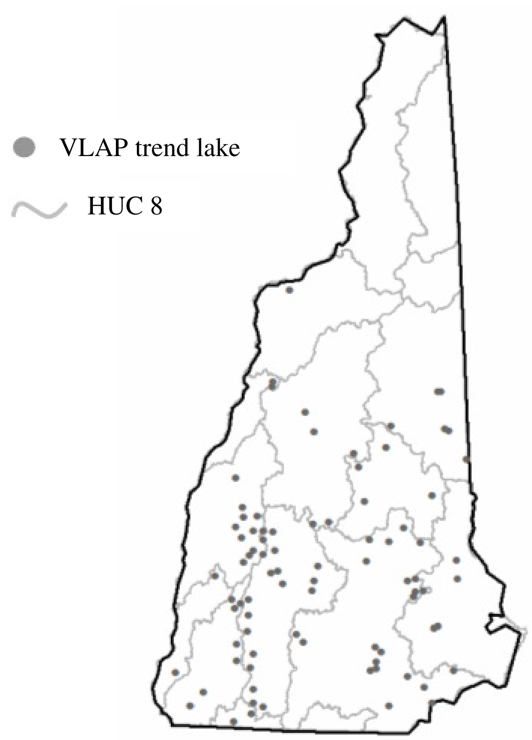
A summary report will be issued at five year intervals based on the schedule in Appendix A. For the period covered in this version of the water monitoring strategy the first river and stream trend report will be drafted and available for review by 2018. The report will cover the trend monitoring period from 2012 - 2016. A second river and stream trend report will be completed in 2022 that covers the monitoring period from 2017 - 2021. Both reports will document, to the extent possible, the outcome of each of the primary indicators detailed above and provide a general summary of the accessory indicators. In addition to the summary report, the data collected as part of monitoring effort will be used to make water quality assessments for the biennial 305(b)/303(d) Integrated Report to Congress.

7.2 Lakes and Ponds

Trend monitoring in New Hampshire lakes and ponds will be accomplished by utilizing data collected through the Volunteer Lake Assessment Program (VLAP). The VLAP program was initiated in 1985 and has grown to produce annual water quality data from approximately 175 lakes and ponds. VLAP data are collected by citizen volunteers following an EPA approved QAPP and submitted to NHDES for analysis. NHDES biologists also visit the volunteer groups on a regular basis to ensure the use of proper field techniques and to assist in data collection. Thus, the data collected through the VLAP program are high quality and continuously available for data analysis. The utilization of VLAP data for trend analysis and reporting will build upon the individual annual and regional biennial summary reports that are currently prepared by NHDES staff for organizations that collect the data.

A total of 83 VLAP lakes and ponds have collected data for 10 or more years at a frequency of 3 - 5 times per summer (Map 3). These waterbodies will serve as the primary basis for monitoring trends in water quality conditions of New Hamsphire's lakes and ponds. In addition, bacteria (*E. coli,* cyanobacteria) data from up to 160 freshwater beaches will be utilized to report on trends in the condition of popular bathing locations. NHDES will also draw upon aquatic plant surveys to report on trends in the frequency and extent of exotic aquatic plant infestations.

Map 3. Volunteer Lake Assessment Program (VLAP) lakes and ponds included in the NHDES trend monitoring network.



Similar to rivers and streams trend network, lake and pond trend reporting will include a select number of important physical, chemical, and biological indicators of water quality. Along with trend reporting, sufficient monitoring will be completed in order make a full assessment of the applicable designated uses at least once within a five year period for each waterbody. The lake and pond trend network is described in detail below with respect to its geographic distribution, waterbody trophic status, and land use characters. The following sections also include a description of the trend indicators chosen for reporting and the specific analyses expected to be used for measuring these outputs.

7.2.1 Spatial Framework

The 8-digit hydrologic unit code (HUC 8) was used as the basic framework to evaluate the extent of VLAP waterbodies included in the lake and pond trend monitoring network. In total there are over 1,200 lakes and ponds that are part of the NHDES waterbody catalog. The number of lakes and ponds in each HUC 8 ranges from 7 - 245 (Table 21). There are 2 - 22 VLAP waterbodies per HUC 8 included in the lake and pond trend monitoring network. Four HUC 8s are without a waterbody in the lake and pond trend monitoring network. In general, the highest concentration of lakes and ponds in the trend monitoring network are in the Dartmouth-Lake Sunapee region of the state, with the remaining waterbodies distributed relatively equally in the southern two-thirds of the state. Northern sections of New Hampshire are lacking lakes and ponds in the trend monitoring network. Additional waterbodies could be added in these regions in the future if volunteer groups are interested in participating in VLAP. A full roster of the lakes, ponds, and freshwater beaches is provided in Appendices C and D.

Table 21. Frequency of New Hampshire lakes and ponds by HUC8 and the respective number of VLAP lakes included in the lakes and pond trend monitoring network.

VLAP Trend Lakes and Ponds			
HUC 8		Total Number	VLAP Trend Count
1040001	Upper Androscoggin	43	0
1040002	Lower Androscoggin	7	0
1060002	Saco	105	6
1060003	Piscataqua-Salmon Falls	127	3
1070001	Pemigewasset	110	5
1070002	Winnipesaukee River	64	4
1070003	Contoocook	147	17
1070004	Nashua	9	0
1070006	Merrimack River	245	22
1080101	Upper Connecticut	59	0
1080103	Waits	44	1
1080104	Upper Connecticut-Mascoma	21	2
1080106	Black-Ottauquechee	88	12
1080107	West	38	2
1080201	Middle Connecticut	101	7
1080202	Miller	27	2
TOTAL		1,235	83

7.2.2 Trophic Class

Trophic class is a statement of a lake's level of biological productivity. Lakes with differing levels of biological production often exhibit different characteristics, such as nutrient concentrations, algal densities, aquatic plant abundance, water clarity, or dissolved oxygen levels. Lake productivity is a reflection of the natural characters of the landscape and the human activities that alter land use patterns. Understanding and analyzing the trends in water quality conditions with respect the frequency of lakes and ponds within the major trophic classes is necessary to evaluate changes based on those human activities.

Over the course of the past 35 years, NHDES has sampled and produced trophic ratings for 760 waterbodies, with the largest percentage of those falling in the mesotrophic class and nearly equal percentages in the oligo- and eutrophic classes (Table 22). The population of lakes and ponds included in the trend monitoring network is broken down similarly, but with slightly less representation by eutrophic lakes.

Table 22. Trophic class ratings for lakes and ponds previously sampled by NHDES and the respective number of VLAP lakes and ponds included in the trend monitoring network.

VLAP Trend Lakes and Ponds		
Trophic Class	Total Number	VLAP Trend Count
Oligotrophic	199 (26%)	31 (37%)
Mesotrophic	395 (52%)	46 (55%)
Eutrophic	166 (22%)	6 (7%)
Total	760	83

Trend results will be categorized by trophic class in order to better understand their relative susceptibility and resiliency to water quality stressors, such as local land use alteration, regional acidification patterns, or global climate change.

7.2.3 Environmental stressors

The percentage of developed land, as estimated through the 2006 National Land Cover Database (NLCD), was used to categorize lakes and ponds included in the trend monitoring network in order to track trends in water quality conditions with respect to potential anthropogenic stressors. As noted above in the river and stream trend network section, land development can be associated with multiple stressors that can collectively affect water quality conditions. Further, these stressors are typically local in nature and are best managed by local activities and decisions.

Categorical breakpoints in the percentage of developed land for lakes and ponds included in the trend monitoring network were the same as those used for rivers and streams and follow the same overall justification. That is, they provide a generalized representation of the current land use patterns across the state. Table 23 provides the breakdown of VLAP lakes and ponds by development class categories.

Table 23. Development class frequency for VLAP lakes included in the lake and pond trend network.

VLAP Trend Lakes	
Development Class	Count
Low (<3%)	16
Moderate (3 - 6%)	32
High (>6%)	35

7.2.4 Indicators

Trend monitoring for lakes and ponds will be focused on the collection of data records for meaningful water quality parameters in order to track changes in water quality conditions over time. The parameters selected for trend monitoring will serve as "indicators" of water quality conditions (Table 24). The sections below provide a description of parameters selected to serve as indicators of water quality conditions, why they were included, and scheduled frequency of collection. For each parameter, specific questions have been identified along with the anticipated analysis procedures for answering these questions. A brief summary of the data qualities are provided in order to establish a basic understanding of the data and the trend detection expectations.

Table 24. Water quality parameters collected as part of the NHDES lake and pond trend monitoring network.

Parameter	Analysis Location	Primary (P) or Accessory (A) Indicator
Chlorophyll *a*	JCLC	P
pH	JCLC	P
Specific conductance	JCLC	P
Cyanobacteria	JCLC	P
Total phosphorus	DHHS PHL-WAL	P
Bacteria	DHHS PHL-WAL	P
Secchi disc transparency	Field	P
Exotic aquatic plants	Field	P
Dissolved oxygen	Field	A
Alkalinity	JCLC	A
Ice in/out records	Field	A
Water temperature	Field	A

7.2.4.1 Specific Conductance

Specific conductance is a measure of water's ability to carry an electrical current and reflects the concentration of dissolved solids. Ions such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, iron, and aluminum all contribute to specific conductance levels. These ions originate from natural (bedrock) and anthropogenic (fertilizers, road salt, stormwater, septic systems, agricultural practices) sources.

In New Hampshire, in-lake specific conductance levels are typically low (median 1976 - 2008 = 40 µmhos / cm; N=768; NHDES 2008a) and reflective of the typical rock formations (granite) over which most of the lakes lie. Higher in-lake specific conductance levels are typically associated with urbanized watersheds that have a greater percentage of impervious cover and greater road density (Deacon et al. 2005). Impervious cover and, more specifically, road density are linked to greater inputs of sodium and chloride ions as a result of road deicing (Trowbridge et al. 2010, Daley et al. 2009).

For the VLAP lakes and ponds included in the trend network, specific conductance levels will be based on summer epilimnetic samples submitted to NHDES and measured using laboratory benchtop meters. Data will be collected a minimum of 3 - 5 times as discrete, one-time measures from samples collected and submitted by VLAP volunteers. In some cases, annual median specific conductance levels may include additional data collected by others sources but deemed acceptable by NHDES.

Question(s) parameter will be used to answer:

1) ***What is the incidence of increasing, decreasing, and stable trends in specific conductance statewide?***

   <u>Measure:</u> Number of lakes and ponds with a significant trend (increasing / decreasing) or no detectable trend. If a significant trend is detected, the rate of change will be determined.

Data analysis: Linear regression or the Mann-Kendall test of median annual specific conductance levels by year for individual trend waterbodies. Data will be limited to the defined index period (June - September) and include all data points for the given "deep spot" sample location for each respective trend lake or pond. A significant trend is defined as one that has ≤ 5% chance of occurring at random ($\alpha \leq 0.05$). Each reporting period will add between three to five data points per year to the trend analysis. Rates of change for significant trends will be represented by the slope of the trend line. Percent change will be reported by dividing the rate of change by the overall median.

2) *What is the percentage of lakes and ponds that have higher (lower or similar) level of specific conductance in the current five years compared to the previous reporting period?*

Measure: Number of trend waterbodies with mean specific conductance levels that are significantly different in the current 5-year reporting period than each previous 5-year reporting period divided by the total number of trend sites.

Data analysis: Analysis of variance (ANOVA) or an equivalent non-parametric test of specific conductance levels between current and previous reporting period. Data for the analysis will be limited to a defined index period (June - September) and include all data points reported for the given "deep spot" sample location for each respective trend lake and pond. A significant difference in mean specific conductance levels between reporting periods is defined as one that has a 5% chance of occurring at random ($\alpha \leq 0.05$). Data from an entire reporting period will be consolidated for the computation of summary statistics and used in completing each analysis.

3) *What percentage of lakes and ponds is in the upper 75th percentile of the statewide distribution of specific conductance levels?*

Measure: Number of trend waterbodies in the upper 75th percentile of the statewide frequency distribution divided by the total number of trend sites. A plot of the percentage of sites in the upper percentile category over time and record of individual trend site percentiles will be produced.

Data analysis: Answering this question includes two components: a statewide frequency distribution of specific conductance measures from all lakes and ponds where data is available and a 5-year median computation for individual trend waterbodies. The statewide frequency distribution will be computed from the median specific conductance level of individual lake and ponds from the respective water samples collected from the corresponding layer (epilimnion) and location (deep spot) as is used for the trend waterbodies. Data included in the statewide frequency distribution will be from all lakes and ponds for which data exists from 1990 through the last year included in the reporting period.
Only waterbodies with two or more specific conductance measures will be used to create the statewide frequency distribution and computation of the median, 25th, and 75th percentiles. The 5-year median specific conductance level at trend waterbodies will be computed from data ending in the year of the current reporting cycle going back five years.

Data Qualities:

VLAP specific conductance data indicate a low to moderate level of variability (18-25%) (Table 25). Based historic data, the mean rates of change in specific conductance for waterbodies with significant linear regressions range from 0.80 - 9.3 µmhos/cm/yr depending on trophic class. If specific conductance levels were to change (increase or decrease) by 20 µmhos/cm over the next 20 years, it is estimated that significant trends would be detectable for oligotrophic lake and ponds, but not for meso- or eutrophic lakes and ponds. If however, changes in specific conductance were greater than 20 µmhos/cm then is it likely that the ability to detect trends for meso- and eutrophic lakes would be greater. Similarly, for waterbodies where the data variability is low, more subtle changes in specific conductance may be detectable.

Table 25. NHDES lakes and ponds specific conductance data record summary and expected ability to detect trends.

Trophic Class	Number of Lakes	Number with Sig. Linear Trend	Number of Records	Median (µmhos/cm)	Mean of Standard Deviations	Mean of Coefficients of Variation	Mean rate of change*	Future Trend detection capacity**
Oligotrophic	31	15	1,887	54.70	14.50	0.25	0.80	Y
Mesotrophic	46	19	2,892	52.90	19.41	0.18	1.42	N
Eutrophic	6	4	292	125.80	66.56	0.22	9.30	N

* Mean rate of change is average line slope of VLAP waterbodies with a minimum of 10 years of data that have significant linear regressions.

** Future trend detection capacity is based on an increase in specific conductance of 20 µmhos/cm over a 20 years.

7.2.4.2 Nutrients

Nutrients are vital parts to ecosystem primary production. However, in aquatic systems, when nutrient levels are increased beyond those that naturally occur, plant and algal growth can become excessive. The resulting effects can lead to water quality impairment as measured by the ability of waterbodies to support aquatic life and recreational uses. In lakes and ponds, phosphorus is widely accepted as the limiting nutrient controlling the growth of plants and algae.

The median total phosphorus (TP) concentration from 772 lake surveys completed from 1976 through 2008 through the Lake Survey Program was 12 µg/L (NHDES 2008a). However, these data were wide ranging depending on lake trophic state. Typically, waterbodies that experience excessive plant or algal growth have total phosphorus concentrations in excess of 20 µg/L.

For the lake and pond network, epilimnetic nutrient levels will be expressed through TP concentrations measured from June through September. Discrete samples will be collected by VLAP volunteers and submitted for laboratory analysis 3 - 5 times annually.

Question(s) parameter will be used to answer:

1) ***What is the incidence of increasing, decreasing, and stable trends in nutrient concentrations statewide?***

   Measure: Number of trend waterbodies with a significant trend (increasing / decreasing) or no detectable trend. If a significant trend is detected, the rate of change will be computed.

   Data analysis: Linear regression or the Mann-Kendall test of annual median TP concentrations by year for individual trend waterbodies. Data will be limited to the defined index period (June - September) and include all data points for the given "deep spot" sample location for each respective trend lake or pond. A significant trend is defined as one that has ≤ 5% chance of occurring at random ($\alpha \leq 0.05$).

Each reporting period will add three to five points per year to the trend analysis. Rates of change for significant trends will be represented by the slope of the trend line. Percent change will be reported by dividing the rate of change by the overall median.

2) ***What is the percentage of trend locations that have higher (lower or similar) nutrient concentrations in the current five years compared to the previous reporting period?***

Measure: Number of trend waterbodies with mean TP concentrations that are significantly different in the current 5-year reporting period than the previous 5-year reporting period divided by the total number of trend sites.

Data analysis: Analysis of variance (ANOVA) or an equivalent non-parametric test of TP concentrations between current and previous reporting period. Data for the analysis will be limited to a defined index period (June - September) and include all data points reported for the given "deep spot" sample location for each respective trend lake and pond. A significant difference in mean TP concentrations between reporting periods is defined as one that has a 5% chance of occurring at random ($\alpha \leq 0.05$). Data from an entire reporting period will be consolidated for the computation of summary statistics and used in completing each analysis.

3) ***What percentage of sites is in the upper 75th percentile of the statewide distribution of nutrient concentrations?***

Measure: Number of trend lakes and ponds in the upper 75th percentile of the statewide frequency distribution of TP divided by the total number of trend lakes and ponds. A plot of percentage of sites in upper percentile category over time and record of individual trend site percentiles will be produced.

Data analysis: Answering this question includes two components: a statewide frequency distribution of TP concentrations from all lakes and ponds where data is available and a 5-year TP median concentration for individual trend waterbodies. Data included in the statewide frequency distribution will be from all lakes and ponds for which data exists from 1990 through the last year included in the reporting period. Only waterbodies with two or more TP concentration data points will be used to create the statewide frequency distribution and computation of the median, 25th, and 75th percentiles. The 5-year median TP concentration at trend waterbodies will be computed from data ending in the year of the current reporting cycle going back five years.

Data Qualities:

VLAP total phosphorus data indicate a moderate level of variability (25 - 36%) (Table 26). Based on historic data, the mean rates of change in total phosphorus for waterbodies with significant linear regressions ranged from 0.13 (oligotrophic lakes) to 0.19 (mesotrophic lakes) µg/L/yr. If total phosphorus concentrations were to double (or half) over the next 20 years, it is estimated that significant trends would be detectable for oligotrophic and mesotrophic lakes and ponds. At this time, trends in total phosphorus have not been detected in any of the eutrophic lakes and ponds. For all trophic classes, subtle trends in total phosphorus will have the greatest likelihood of being detected where the data variability is low.

Table 26. NHDES lakes and ponds total phosphorus data record summary and expected ability to detect trends.

Trophic Class	Number of Lakes	Number with Sig. Linear Trend	Number of Records	Median (µg/L)	Mean of Standard Deviations	Mean of Coefficients of Variation	Mean rate of change*	Future Trend detection capacity**
Oligotrophic	31	7	1,887	6.0	3.32	0.32	0.13	Y
Mesotrophic	46	10	2,856	10.0	4.18	0.25	0.19	Y
Eutrophic	6	0	288	18.0	13.5	0.36	----	----

* Mean rate of change is average line slope of VLAP waterbodies with a minimum of 10 years of data that have significant linear regressions in total phosphorus.

** Future trend detection capacity is based on a doubling or halving of total phosphorus concentrations over a 20 year period.

7.2.4.3 pH

The pH of surface water is influenced by the geologic, vegetative, and physical landscape characteristics within the watershed, as well as local land use history and atmospheric deposition patterns. The ability to resist acidification, measured as water's alkalinity, is a key component to protecting a waterbody from becoming acidified and in allowing it to recover once it becomes acidified. Waters that have low alkalinity are particularly susceptible to acidification.

The draft 2012 305(b) report for New Hampshire's surface water quality indicates that approximately 37% of the state's lake and pond assessment units were listed as impaired for pH. A summary of pH water quality data records from 1976 through 2008 from the Lake Survey Program indicates the median pH from 780 lakes and pond was 6.5 (NHDES 2008a). Similarly, records of alkalinity from the same time period for 781 lakes and ponds, indicated that the median alkalinity was 4.9 mg/L (R. Estabrook unpublished data; summer, epilimnion samples).

For the lakes and ponds included in the trend network, pH will serve as the primary indicator of acidification. The data will be based on summer epilimnetic samples submitted to NHDES and measured using laboratory benchtop meters. Data will be generated 3 - 5 times per year as discrete, one-time measures from samples collected by VLAP volunteers. In some cases, annual pH measures may include additional data collected by others sources but deemed acceptable by NHDES.

Question(s) parameter will be used to answer:

1) ***What is the incidence of increasing, decreasing, and stable trends in pH levels statewide?***

   Measure: Number of trend lakes and ponds with a significant trend (increasing / decreasing) or no detectable trend in pH. If a significant trend is detected, the rate of change will be computed.

   Data analysis: Linear regression or the Mann-Kendall test of annual median pH by year for individual waterbodies. Data for the computation of annual medians will be limited to the defined index period (June - September) and include all data points for the given "deep spot" sample location for each respective trend lake or pond. A significant trend is defined as one that has ≤ 5% chance of occurring at random ($\alpha \leq 0.05$). Each reporting period will add three to five points per year to the trend analysis. Rates of change for significant trends will be represented by the slope of the trend line. Percent change will be reported by dividing the rate of change by the overall median.

2) What is the percentage of trend locations that have higher (lower or similar) pH levels in the current five years compared to the previous reporting period?

Measure: Number of trend lakes and ponds with mean pH levels, respectively that are significantly different in the current 5-year reporting period than each previous 5-year reporting period divided by the total number of trend sites.

Data analysis: Analysis of variance (ANOVA) or an equivalent non-parametric test of pH levels between current and the previous reporting period. Data for the analysis will be limited to a defined index period (June - September) and include all data points reported for the given "deep spot" sample location for each respective trend lake and pond. A significant difference between reporting periods is defined as one that has a 5% chance of occurring at random ($\alpha \leq 0.05$). Data from an entire reporting period will be consolidated for the computation of summary statistics and used in completing each analysis.

3) What percentage of sites is in the lower 25th percentile of the statewide distribution of pH levels?

Measure: Number of trend lakes and ponds in the lower 25th percentile of the statewide frequency distribution for pH divided by the total number of trend sites. A plot of percentage of sites in lower percentile category over time and record of individual trend site percentiles will be produced.

Data analysis: Answering this question includes two components: a statewide frequency distribution of median measures from all lakes and ponds where data is available and the 5-year median measure for individual trend waterbodies. The statewide frequency distribution will be computed from the median pH of individual lakes and ponds collected from the corresponding layer (epilimnion) and location (deep spot) that is utilized for the trend waterbodies. Data included in the statewide frequency distribution will be from all lakes and ponds for which data exists from 1990 through the last year included in the reporting period. Only waterbodies with two or more pH measures will be used to create the respective statewide frequency distribution and computations of the median, 25th, and 75th percentiles. The 5-year median pH level at trend waterbodies will be computed from data ending in the year of the current reporting cycle going back five years.

Data Qualities:

VLAP pH data indicate a low level of variability (4%) (Table 27). Based on historic data, the mean rates of change in pH for waterbodies with significant linear regressions ranged from 0.014 - 0.017 units/yr depending on trophic class. If pH concentrations were to change (increase or decrease) by 0.5 units over the next 20 years, it is estimated that significant trends would be detectable for all lake and pond trophic classes. For all trophic classes, more subtle trends in pH may be detected where the data variability is low within years and exhibits a consistent increase (or decrease) over time.

Table 27. NHDES VLAP lake and pond pH data record summary and expected ability to detect trends.

Trophic Class	Number of Lakes	Number with Sig. Trend	Number of Records	Median (units)	Mean of Standard Deviations	Mean of Coefficients of Variation	Mean rate of change*	Future Trend detection capacity**
Oligotrophic	31	8	1,897	6.66	0.24	0.04	0.016	Y
Mesotrophic	46	9	2,843	6.70	0.27	0.04	0.014	Y
Eutrophic	6	1	291	6.86	0.25	0.04	0.017	Y

* Mean rate of change is average line slope of VLAP waterbodies with a minimum of 10 years of data that have significant linear regressions in pH.

** Future trend detection capacity is based on a 0.5 unit change in pH over a 20 years.

7.2.4.4 Water Clarity

Water clarity is directly related to the amount of suspended material in the water column. Variation in water clarity is expected based a waterbody's productivity (concentration of suspended algae), underlying geology, and type and quantity of sediment deposits. Waterbodies with unnaturally high production levels, due to excessive nutrient concentrations, will have lower water clarity than unproductive lakes. Similarly, waterbodies with an abundant supply of fine sediments that remain suspended have poorer clarity than those with fewer fine sediments. Poor water clarity can impede the growth of macrophytes, inhibit the success of visual predators, and be indicative of excessive deposition of organic matter and sediment. In cases where excessive deposition of organic matter or sediment occurs, secondary water quality impacts, such as low dissolved oxygen levels or high nutrient concentrations may result.

In New Hampshire lakes and ponds, water clarity is most commonly measured by way of Secchi disc transparency to the nearest tenth of a meter. The median Secchi disc transparency reading of 663 lakes and ponds sampled from 1976 - 2008 through the Lake Survey Program was 3.2 meters, with readings ranging from 0.4 to 13 meters (NHDES 2008a). In general, water clarity measures that exceed 4.5 meters are considered exceptional, those between 2 and 4.5 meters are considered good, and measures less than 2 meters are poor.

For the lakes and ponds included in the trend network, water clarity will be based on summer Secchi disc readings reported to NHDES through the VLAP program. Data will be collected a minimum of 3 - 5 times as discrete, one-time measures made by VLAP volunteers. In some cases, the annual median Secchi disc readings may include additional data collected by other sources but deemed acceptable by NHDES.

Question(s) parameter will be used to answer:

1) ***What is the incidence of increasing, decreasing, and stable trends in water clarity statewide?***

   Measure: Number of trend lakes and ponds with a significant trend (increasing / decreasing) or no detectable trend water clarity. If a significant trend is detected, the rate of change will be computed.

   Data analysis: Linear regression or the Mann-Kendall test of annual median water clarity by year for individual waterbodies. Data for the computation of annual medians will be limited to the defined index period (June - September) and include all data points for the given "deep spot" sample location for each respective trend lake or pond. A significant trend is defined as one that has ≤ 5% chance of occurring at random ($\alpha \leq 0.05$). Each reporting period will add three to five points per year to the trend analysis. Rates of change for significant trends will be represented by the slope of the trend line. Percent change will be reported by dividing the rate of change by the overall median.

2) ***What is the percentage of trend locations that have lower (higher or similar) water clarity measures in the current five years compared to each of the previous reporting period?***

Measure: Number of trend lakes and ponds with mean water clarity measures that are significantly different in the current 5-year reporting period than each previous 5-year reporting period divided by the total number of trend sites.

Data analysis: Analysis of variance (ANOVA) or an equivalent non-parametric test of water clarity measures between current and previous reporting period. Data for the analysis will be limited to a defined index period (June - September) and include all data points reported for the given "deep spot" sample location for each respective trend lake and pond. A significant difference between reporting periods is defined as one that has a 5% chance of occurring at random ($\alpha \leq 0.05$). Data from an entire reporting period will be consolidated for the computation of summary statistics and used in completing each analysis.

3) ***What percentage of sites are in the lower 25th percentile of the statewide distribution of water clarity measures?***

Measure: Number of trend lakes and ponds in the lower 25th percentile of the statewide frequency distribution for water clarity divided by the total number of trend sites. A plot of percentage of sites in lower percentile category over time and record of individual trend site percentiles will be produced.

Data analysis: Answering this question includes two components: a statewide frequency distribution of median Secchi disc transparency from all lakes and ponds where data is available and the 5-year median measure for individual trend waterbodies. The statewide frequency distribution will be computed for each trophic class from the median Secchi disc transparency of individual lakes and ponds. Data included in the statewide frequency distribution will be from all lakes and ponds for which data exists from 1990 through the last year included in the reporting period. Only waterbodies with two or more Secchi disc transparency readings will be used to create the each respective statewide frequency distribution and computations of the median, 25th, and 75th percentiles. The 5-year median Secchi disc transparency at trend waterbodies will be computed from data ending in the year of the current reporting cycle going back five years. Placement of trend lakes and ponds on the statewide frequency distribution will be according to each trend waterbody's respective trophic class. Trophic class assignments will be according to the "best" historic rating recorded by NHDES.

Data Qualities:

VLAP Secchi disc transparency data indicate a low level of variability (13-17%) (Table 28). Based on historic data, the mean rates of change in Secchi disc transparency for waterbodies with significant linear regressions ranged from 0.045 - 0.078 m/yr depending on trophic class. If Secchi disc transparencies were to be reduced in half (or double) over the next 20 years, it is estimated that significant trends would be detectable for all lake and pond trophic classes. For all trophic classes, more subtle trends in Secchi disc transparency may be detected where the data variability is low within years and exhibits a consistent increase (or decrease) over time.

Table 28. NHDES VLAP lake and pond Secchi disc transparency data record summary and expected ability to detect trends.

Trophic Class	Number of Lakes	Number with Sig. Trend	Number of Records	Median (m)	Mean of Standard Deviations	Mean of Coefficients of Variation	Mean rate of change*	Future Trend detection capacity**
Oligotrophic	31	11	1,862	6.00	1.27	0.13	0.078	Y
Mesotrophic	46	11	2,890	3.40	0.66	0.15	0.045	Y
Eutrophic	6	3	289	2.44	0.64	0.17	0.05	Y

* Mean rate of change is average line slope of VLAP waterbodies with a minimum of 10 years of data that have significant linear regressions in Secchi disc transparency.

** Future trend detection capacity is based on a doubling or halving in Secchi disc transparency over a 20 year period.

7.2.4.5 Biological Production

The productivity of a waterbody is a measure of the rate of biomass accumulation. Natural production rates are affected by the various factors such as light availability, temperature, and the underlying geology and soil characteristics that supply nutrients. Anthropogenic increases in production rates are most often associated with nutrient loading from fertilizers, excessive soil erosion, or waste disposal. Where waterbody productivity is increased beyond its natural rate, water quality conditions often decline. For example, in situations where there are dense and prolonged algal blooms, decreases in dissolved oxygen can result due to increased microbial decomposition of organic material.

Primary production is most often measured through estimates of chlorophyll *a* concentrations in lakes and ponds. Chlorophyll-*a* is a pigment found in plants and serves as an indicator of the abundance of suspended algae. For New Hampshire lakes and ponds, chlorophyll-*a* concentrations less than 5 µg/L are considered good, between 5 and 15 µg/L as fair, and greater than 15 µg/L poor. Water quality records of 776 New Hampshire lakes and pond from 1976 - 2008 indicate the median chlorophyll-a concentration of "deep spot" epilimnetic water samples was 4.58 µg/L (NHDES 2008a). The draft 2012 305(b) report for New Hampshire's surface water quality indicates that 90 assessment units were above the thresholds assigned to lakes and ponds (~6% of lake and pond assessment units).

For the VLAP lakes and ponds included in the trend network, chlorophyll-*a* concentrations will be based on summer epilimnetic samples submitted to NHDES using standard spectrophotometric analysis methods. Data will be collected a minimum of 3 - 5 times as discrete, one-time measures from samples collected and submitted by VLAP volunteers. In some cases, annual median chlorophyll-a concentrations may include additional data collected by others sources but deemed acceptable by NHDES.

Question(s) parameter will be used to answer:

1) ***What is the incidence of increasing, decreasing, and stable trends in chlorophyll-a statewide?***

   Measure: Number of trend lakes and ponds with a significant trend (increasing / decreasing) or no detectable trend in chlorophyll-a concentrations. If a significant trend is detected, the rate of change will be computed.

   Data analysis: Linear regression or the Mann-Kendall test of annual median chlorophyll-*a* concentration by year for individual waterbodies. Data for the computation of annual medians will be limited to the defined index period (June - September) and include all data points for the given "deep spot" sample location for each respective trend lake or pond. A significant trend is defined as one that has ≤ 5% chance of occurring at random ($\alpha \leq 0.05$). Each reporting period will add three to five points per year to the trend analysis. Rates of change for significant trends will be represented by the slope of the trend line. Percent change will be reported by dividing the rate of change by the overall median.

2) ***What is the percentage of trend locations that have lower (higher or similar) chlorophyll-a concentrations in the current five years compared to the previous reporting period?***

   Measure: Number of trend lakes and ponds with mean chlorophyll-*a* concentrations that are significantly different in the current 5-year reporting period than each previous 5-year reporting period divided by the total number of trend sites.

   Data analysis: Analysis of variance (ANOVA) or an equivalent non-parametric test of chlorophyll-*a* concentrations between current and previous reporting period. Data for the analysis will be limited to a defined index period (June - September) and include all data points reported for the given "deep spot" sample location for each respective trend lake and pond. A significant difference between reporting periods is defined as one that has a 5% chance of occurring at random ($\alpha \leq 0.05$). Data from an entire reporting period will be consolidated for the computation of summary statistics and used in completing each analysis.

3) ***What percentage of sites are in the upper 75th percentile (lower 25th) of the statewide distribution of chlorophyll-a concentrations?***

   Measure: Number of trend lakes and ponds in the upper 75th percentile (lower 25th) of the statewide frequency distribution for chlorophyll-*a* divided by the total number of trend sites. A plot of percentage of sites in each percentile category over time and record of individual trend site percentiles will be produced. Placement of trend waterbodies on a statewide frequency distribution curve will be done with respect to trophic class (See data analysis).

   Data analysis: Answering this question includes two components: a statewide frequency distribution of median chlorophyll-*a* concentrations from all lakes and ponds where data is available and the 5-year median measure for individual trend waterbodies. The statewide frequency distribution will be computed for each trophic class from the median chlorophyll-*a* concentration of individual lakes and ponds. Data included in the statewide frequency distribution will be from all lakes and ponds for which data exists from 1990 through the last year included in the reporting period. Only waterbodies with two or more chlorophyll-*a* concentrations will be used to create the each respective statewide frequency distribution and computations of the median, 25th, and 75th percentiles. The 5-year median chlorophyll-*a* concentration at trend waterbodies will be computed from data ending in the year of the current reporting cycle going back five years. Placement of trend lakes and ponds on the statewide frequency distribution will be according the each trend waterbody's respective trophic class. Trophic class assignments will be according to the "best" historic rating recorded by NHDES.

Data Qualities:

VLAP chlorophyll *a* data indicate a low to moderate level of variability (35-49%) (Table 29). Based historic data, the mean rates of change in chlorophyll *a* concentrations for waterbodies with significant linear regressions ranged from 0.045 - 0.071 µg/L/yr depending on trophic class. If chlorophyll *a* concentrations were to double (or reduce by half) over the next 20 years, it is estimated that significant trends would be detectable for oligotrophic lakes and ponds. More subtle trends in chlorophyll *a* concentrations in mesotrophic or eutrophic lakes may be detected where the data variability is low within years and exhibits a consistent increase (or decrease) over time.

Table 29. NHDES VLAP lake and pond chlorophyll *a* data record summary and expected ability to detect trends.

Trophic Class	Number of Lakes	Number with Sig. Linear Trend	Number of Records	Median (µg/L)	Mean of Standard Deviations	Mean of Coefficients of Variation	Mean rate of change*	Future Trend detection capacity**
Oligotrophic	31	3	1,889	2.35	1.38	0.35	0.071	Y
Mesotrophic	46	10	2,885	4.35	3.51	0.36	0.37	N
Eutrophic	6	1	288	7.67	8.49	0.49	0.614	N

* Mean rate of change is average line slope of VLAP waterbodies with a minimum of 10 years of data that have significant linear regressions in chlorophyll *a* concentrations.

** Future trend detection capacity is based on a doubling or halving in the concentration of chlorophyll *a* over a 20 year period.

7.2.4.6 Primary Contact Recreation

Primary contact recreation refers to suitability of surface water for swimming with respect to pathogen concentrations. Waters with high pathogen inputs can be a human health risk. Pathogens that cause diseases such as gastroenteritis or *Giardiasis*, can be carried in the feces of humans, waterfowl, livestock, and domestic animals. The pathogens are transferred to public bathing areas when the feces of an infected warm-blooded animal enter a waterbody from nearby farms, septic systems, wildlife, storm drains, or unknown sources.

New Hampshire freshwater beach areas are assessed for primary contact recreation by measuring the concentration of *E. coli*, a common bacterium that is present in the fecal material of warm-blooded animals. If a beach area exceeds state water quality criteria (two or more samples ≥ 88 counts / 100 mL or one sample ≥ 158 counts / 100 mL), then an advisory is posted. In 2012, NHDES personnel performed 710 beach inspections at 160 freshwater beaches in 11 weeks (June - August). A total of 176 *E. coli* samples exceeded the state standards, resulting in the issuance of 56 advisories (S. Carlson, Pers. Comm).

Trends in primary contact recreation conditions at freshwater beaches will be tracked through the NHDES Beach Program. Beaches used for trend analysis will include only beaches that have been sampled at least twice per summer (June - August) in 8 out of the last 10 years. A total of 160 beaches have been identified that meet this criterion (Appendix D).

Question(s) parameter will be used to answer:

1) Is the percentage of the total number of beaches with advisories issued in a given year increasing, decreasing, or remaining stable?

Measure: The percentage of the total number of freshwater beaches sampled annually where an advisory is issued during the bathing season (June 1 - August 31).

Data analysis: Linear regression or the Mann-Kendall test of the percentage of freshwater beaches where an advisory has been issued by year. A significant trend is defined as one that has ≤ 5% chance of occurring at random ($\alpha \leq 0.05$). Each reporting period will add five points to the trend analysis. The percentage will be computed by summing number of beaches where an advisory is issued one or more times during the bathing season divided by the total number of beaches sampled in the respective bathing season.

2) Is the percentage of the total number of beach advisory days increasing, decreasing, or remaining stable?

Measure: The percentage of the total number of available bathing days annually when beach advisories are in place.

Data analysis: Linear regression or the Mann-Kendall test of the percentage of available bathing days when an advisory was in place by year. A significant trend is defined as one that has ≤ 5% chance of occurring at random ($\alpha \leq 0.05$). Each reporting period will add five points (5 years) to the trend analysis. The percentage will be computed by summing the number of bathing days for all freshwater beaches when an advisory is in place and dividing this number by the sum of all potential bathing days (normally 92 x total number of beaches; June 1 - August 31).

Data Qualities:

The frequency of beach advisories indicate a moderate level of variability (27%) based on 10 years of data and average approximately 20% of all beaches sampled annually (Table 30). Based on these data, if the percentage of beach advisories increase (or decrease) 5% each year for 20 years, trend detection is highly likely (100% based on 250 simulated linear regression iterations). Trends with a lower rate of change may be detected if data variability remains stable or is reduced.

Table 30. NHDES beach advisory data record summary and expected ability to detect trends.

Number of Records	Mean (%)	Standard Deviation	Coefficient of Variation	Variability Category	Expected trend detection capacity*
1,540	19.9	5.39	0.271	Moderate	100%

* Trend detection capacity is based on the percentage of significant regressions (p=0.95) obtained from 250 simulated iterations based on a synthetic dataset with a 5% annual increase in the percentage of beach advisories.

7.2.4.7 Exotic Aquatic Plant Infestations

Exotic aquatic plants pose a threat to the ecological, aesthetic, recreational, and economic values of freshwater resources (lakes, ponds, rivers and streams) primarily by forming dense growths or monocultures in critical areas of waterbodies that are important for aquatic habitat and recreational use. These dense stands can reduce the natural diversity of plant and animal species, alter water chemistry, modify dissolved oxygen concentrations, and impact the aquatic habitat structure that is native to the system.

Infestations of exotic aquatic plants occur commonly by way of plant fragments that become attached to aquatic recreational equipment, such as boats, motors, and trailers and can spread from waterbody to waterbody through transient boating activities. Once infested, these plants can rapidly spread to areas with suitable conditions through seed dispersal and fragment rooting.

Since the first exotic aquatic plant infestation in New Hampshire was discovered in 1965 in Lake Winnipesaukee, a total of 87 infestations in 78 waterbodies have been documented (NHDES 2013). Species present include variable milfoil (70 waterbodies), Eurasian milfoil (6 waterbodies), fanwort (9 waterbodies), water chestnut (1 waterbody), Brazilian elodea (1 waterbody), Curly-Leaf Pondweed (3 waterbodies), European Naiad (3 waterbodies), and Didymo (4 waterbodies).

NHDES takes an active role in monitoring the incidence and extent of exotic aquatic plant infestations through its Exotic Species Program. Freshwaters, including rivers, are assessed for the presence and extent of exotic aquatic plants, and, where found, the locations of occurrence are mapped and tracked regularly with geographic positioning systems (GPS) and geographic informational systems (GIS). Each year, roughly 80 surveys are performed across New Hampshire's waterbodies to identify new infestations or track existing infestations.

Question(s) parameter will be used to answer:

1) Is the number of infested waterbodies in New Hampshire increasing or remaining stable?

Measure: Total number of infested waterbodies over time.

Data analysis: No formal data analysis is required other than graphing and evaluating the trend in total number of infestations annually. Based on experience, infestation frequency (e.g., number of waterbodies) will either increase or remain stable (eradication of established infestations are uncommon). Thus, an increase will simply be determined by comparison to the number of infestations in the prior year. Likewise a stable trend will be reported when the number of infestations is the same as the prior year.

2) What is the area infested by exotic aquatic plants in each of the years within the current reporting period and how does it compare to the long-term annual mean?

Measure: Comparison of the total area (acres) documented as being infested with exotic aquatic plants in each year of the current reporting period to the previous 5-year mean total infestation area up to the beginning of the current reporting period.

Data analysis: No formal data analysis is required as the single number (total area infested) in each given year will be compared to the previous 5-year mean. Improving conditions will be interpreted as a decrease in the area of infestation within the reporting period and declining conditions as an increase in the area of infestation within the reporting period compared to the mean of the previous 5-years. The total number of waterbodies surveyed for infestation within a given year will be reported as a scaling factor.

3) Is the use of herbicides for the control of exotic aquatic plants in the current reporting period greater than, less than, or equal to the overall annual mean?

Measure: Comparison of the total area (acres) treated by herbicides for the control of exotic aquatic plants annually for each year of the current reporting period to the mean area treated using herbicides in the previous 5-year reporting period.

Data analysis: No formal data analysis is required as the single number (total acreage treated) in each given year will be compared to the mean area treated from the previous 5-year period. A reduction in use will be interpreted as less acreage treated by herbicides and an increase in use as more acreage treated. A running 10-year tally of the frequency of increased or decreased use of herbicides will also be reported.

4) Is the use of alternative control measures (e.g., suction harvesting, hand pulling, benthic barrier) for the control of exotic aquatic plants in the current reporting period greater than, less than, or equal to the overall annual mean?

Measure: Comparison of the total area (acres) treated by alternative measures for the control of exotic aquatic plants annually for each year of the current reporting period to the mean area treated using alternative measures in the previous 5-year reporting period.

Data analysis: No formal data analysis is required as the single number (total acreage of control) in each given year will be compared to the mean in the previous 5 years. An increase in the use of alternative measures will be interpreted as an increase in acreage and vice-versa for a reduction in the use of alternative measures. A running 10-year tally of the frequency of increased or decreased use of alternative control measures will also be reported.

Data Qualities:

A review of the data to date with respect to tracking the extent of exotic aquatic plant infestations includes records back as far as 1992. These records, however, were generated using a variety of inconsistent methods up until 2000. From 2000 to 2013, geo-referenced data were used to pinpoint infested areas on individual waterbodies using GPS and GIS technologies.

Records indicate that the extent of exotic aquatic plant infestations has ranged from 382 to 1,169 acres with a mean area of infestation over this time of 793 acres (Table 31). These data, however, were highly positively correlated with the number of surveys conducted. Since 2000, the number of areas surveyed has consistently increased from 10 in 2000 to 41 in 2013. In 2013, of the areas surveyed, the cumulative area of infestation was 1,158 acres.

Management of areas infested with exotic aquatic plants from 2000 to 2013 included the use of herbicides and alternative methods (e.g., hand harvesting, suction harvesting, benthic barriers). Herbicides were used to treat between 12 and 41 sites covering from 279 to 1,110 acres over this time period with a mean of 264 acres (Table 31). Herbicide use has increased over the past 13 years as new infestations are discovered. In 2013, 41 areas were treated with herbicide covering approximately 1,110 acres in total.

Records of alternative control methods are limited to the number of alternative control methods per waterbody. From 2000 to 2013, alternative control methods were used on 17 to 87 occasions annually with a mean of 36 (Table 31). Since 2000, the use of alternative control methods has increased consistently and is the preferred method of treatment whenever possible. In 2013, alternative control methods were used on 87 occasions in 46 waterbodies.

Table 31. Summary of exotic aquatic plant survey results and treatments from 2000 - 2013.

Metric	Range	Mean	Standard Deviation	Survey / Treatment Frequency
Infested Acres	382 - 1169	793	303	10-41 waterbodies surveyed
Acres treated w/ Herbicide	279 - 1110	264	296	12-41 sites treated
Use of alternative control methods	17 - 87	36	23	8 - 46 waterbodies treated

7.2.4.8 Cyanobacteria Occurrence

Cyanobacteria are photosynthetic bacteria found naturally in lakes, streams, and ponds. Cyanobacteria do not usually cause recreational or aesthetic problems. However, unsightly and potentially harmful blooms can form when excess nutrients find a way into a lake. Cyanobacteria usually exist on the lake bottom during the winter months. In the spring, increased water temperature and light cause cyanobacteria to move toward the lake surface.

Some cyanobacteria produce toxins that can adversely affect livestock, domestic animals, and humans when critical levels are reached. According to the World Health Organization (WHO), toxic cyanobacteria are found worldwide in both inland and coastal waters. The first reports of toxic cyanobacteria in New Hampshire occurred in the 1960s and 1970s. Regionally, several dogs died in 1999 after ingesting toxic cyanobacteria from a bloom in Lake Champlain. The WHO has documented acute impacts to humans from cyanobacteria from the US and around the world as far back as 1931. While most human health impacts have resulted from ingestion of contaminated drinking water, cases of illnesses have also been attributed to swimming in cyanobacteria infested waters.

Cyanobacteria beach advisories are issued by NHDES when greater than 50% of an algal bloom is identified to be cyanobacteria. NHDES has issued 88 cyanobacteria beach advisories since 2000 (S. Carlson Pers. Comm.). To alert lake users of cyanobacteria blooms on lakes without designated beaches or in areas of a lake far from a designated beach, NHDES developed cyanobacteria lake warnings. Cyanobacteria lake warnings are issued when blooms cover a significant portion of a lake with a large concentration of cyanobacteria. NHDES has issued 44 lake warnings since 2008.

NHDES takes an active role in monitoring the incidence and extent of cyanobacteria blooms in lakes through its beach inspection program. During the summer months, approximately 160 freshwater beaches are sampled three times for signs of cyanobacteria blooms. As biology staff visit lakes throughout the state, any suspect bloom is sampled and recorded. Additionally, citizen complaints of suspect cyanobacteria occurrences submitted to the department are investigated.

Question(s) parameter will be used to answer:

1) ***Is incidence of lake-wide cyanobacteria warnings increasing, decreasing, or remaining stable over time?***

Measure: Total number lake-wide warnings issued within each year of the current reporting period.

Data analysis: No formal data analysis is scheduled other than graphing and evaluating the trend in total number of warnings issued on an annual basis within the current reporting period and comparing these data to previous years and the long term mean.

2) Are incidences of swimming beach-related cyanobacteria advisories increasing, decreasing, or remaining stable over time?

Measure: Total number swimming beach-related cyanobacteria advisories issued within each year of the current reporting period.

Data analysis: No formal data analysis is scheduled other than graphing and evaluating the trend in total number of advisories issued on an annual basis within the current reporting period and comparing these data to previous years and the long term mean.

Data Qualities:

Cyanobacteria beach advisory records date back to 2003. Since 2003, a total of 92 advisories have been issued. Annually the number of advisories has ranged from 1 to 15 with a mean of 8

advisories per year (Table 32). Lake-wide cyanobacteria warnings were first issued in 2008 and have ranged from 1 to 15 per year with a mean of 7. In total, 44 lake-wide cyanobacteria warnings have been issued.

Table 32. Incidence of NHDES issued cyanobacteria beach advisories and lake-wide warnings from 2003 - 2013.

Warning Type	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Mean	Standard Deviation	Cumulative Total
Beach Advisory	1	3	5	6	11	14	15	10	10	9	8	8.4	4.34	92
Lake Warning	--	--	--	--	--	15	10	12	4	1	2	7.3	5.79	44

7.2.4.9 Accessory Indicators:

Additional water quality parameters will be collected at each of the lakes and ponds included in the trend monitoring network (See Table 24, above). These parameters were selected as accessory indicators since they are of common interest for a variety of reasons in determining water quality conditions and may prove to be useful indicators in the future. Data for these parameters will be collected primarily by NHDES staff or VLAP volunteers, but may, in some instances, include data collected by other sources. Sampling for these parameters will be during the summer months (June - September), primarily, but may include additional samples during other times of the year. Results for each of the parameters will be obtained through the collection of discrete water samples that are submitted for laboratory analysis, field collection, or observation. Although no formal trend analyses will be completed for these parameters, standard descriptive statistics (mean, median, etc.) will be tabulated for each reporting period.

As with the primary trend indicators, raw data for the accessory indicators will be quality assured and stored in the NHDES EMD.

7.2.5 Data Sources, Quality Assurance, and Data Management

Lake and pond trend monitoring data will be generated by citizen volunteers (VLAP) and NHDES biologists using field instruments, collection of discrete samples for laboratory analysis, or through the capture of biological organisms for laboratory identification. Data collection for all trend monitoring activities will be completed under EPA approved quality assurance project plans (QAPP) or a NHDES standard operating procedures (SOP). All data will be stored in the NHDES EMD. Prior to acceptance, all data will be reviewed for completeness, accuracy, and precision. Once data verification is complete, raw data will be flowed, when possible, from NHDES' EMD to EPA's STORET/WQX using a node to node transfer.

In some cases, trend data may be collected and submitted to NHDES by alternative sources for a variety of unknown purposes. The quantity of data submitted by alternative sources cannot be determined at this time but is likely to account for a small percentage of the overall data. In these instances, a full review of the submitting entity's quality assurance measures will be completed prior to data acceptance and inclusion in trend reporting. Any data included in trend reporting that is generated by outside sources will also be stored in the EMD and may be flowed to EPA's STORET/WQX at the data owner's request. Only data marked as "valid" in the EMD will be incorporated into the trend analysis and reporting phase.

7.2.6 Project costs / needs

Data used for the analysis of water quality trends in lakes and ponds will be produced primarily through NHDES' VLAP program. Laboratory costs to process these samples are split between volunteers and NHDES. Sampling events will occur three or more times per summer at 83 or more lakes. Costs associated with the production of data to track bathing beach conditions will be NHDES' responsibility through its beach program and based on bacterial samples collected two to three times per summer at 150 freshwater beaches. Costs associated with tracking exotic aquatic plant species infestations are tied to field activities of the Exotic Species Program.

Collectively, the implementation of these programs relies on three full time staff people and five interns. Their tasks include the coordination and completion of the field activities necessary to produce the data required to assess the indicators. Since these activities do not occur on a set schedule it is not possible to provide a detailed estimate of staffing needs as with the other monitoring programs. In most instances some phase of lakes and ponds trend monitoring will occur every day during the field season (May - September). Table 33 provides an estimate of laboratory costs and staffing needs.

Table 33. Lakes and ponds trend monitoring estimated costs and needs.

Lakes / Ponds Trend Monitoring Estimated Costs / Needs			
Estimated Laboratory Costs			
	VLAP Program related lab services costs*	BEACH program related lab services costs**	Totals***
Per sample event cost estimate	$80	$20	
Number of samples	1	3	
Number of events	3	2	
Number of sites	83	150	
Total lab costs	$19,920	$18,000	$37,920
* VLAP costs include total phosphorus, sp. conductance, pH, alkalinity, and chlorophyll *a* ** BEACH costs are for E. coli *** Total costs exclude field parameters and microscopic identification			
Staffing Needs			
VLAP - 1 full time staff (coordinate volunteer field activities); 2 interns (complete quality assurance visits; process laboratory samples). BEACH - 1 full time staff (coordinate field activities, process advisories); 2 interns (complete sample collection and submission). Exotic - 1 full time staff, 2 interns (complete field surveys).			

7.2.7 Reporting

A summary report will be issued at five year intervals based on the schedule in Appendix A. For the period covered in this version of the water monitoring strategy the first lake and pond trend report will be drafted and available for review by 2019. The report will cover the trend monitoring period from 2012 - 2016. A second lake and pond trend report will be completed for review in 2023 and cover the monitoring period from 2017 - 2021. Both reports will document, to the extent possible, the outcome of each of the primary indicators detailed above and provide a general summary of the accessory indicators.

8. Freshwater Synoptic Monitoring

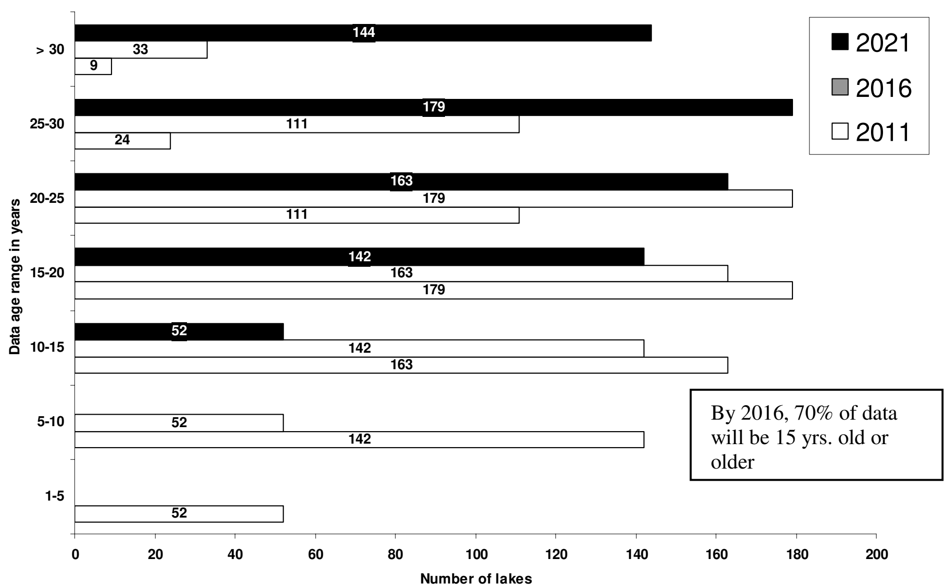
Synoptic water quality monitoring is a general term defined as a systematic approach to monitoring. The benefits of NHDES' synoptic monitoring program are that they provide an opportunity to collect and disseminate information from waterbodies that are not otherwise monitored, yet are important recreational or ecological resources of the state. More specifically, synoptic monitoring will include a targeted selection of waterbodies based on a systematic statewide watershed rotation and include waterbody visitations for the purposes of designated use assessment, regulatory investigation, restoration documentation, lake or pond trophic status determination, or water quality data cataloging of public waterbodies.

Up until 2007 targeted monitoring accounted for the majority of the surface water quality monitoring efforts by NHDES. For lakes and ponds, beginning in 1975, 40 - 50 waterbodies were sampled annually as part of its Lake Survey Program and resulted in a catalog of data for nearly 800 lakes and ponds. Similarly, starting in the mid-1980s, 50 or more river and stream sampling stations were visited annually as part of the Ambient River Monitoring Program resulting in nearly 900 stations on individual river or stream segments. While these data continue to be valuable, there has been a general reduction in the generation of more recent data.

Since 2007 targeted surface water quality monitoring efforts have been completed almost entirely through NHDES' volunteer monitoring programs; the Volunteer Lake Assessment Program (VLAP) and the Volunteer River Assessment Program (VRAP). To the credit of these two popular and extremely valuable programs, a core body of water quality data has been maintained for the waterbodies where these groups exist. However, for those waterbodies without volunteer groups or are not included in the trend monitoring network, there are no current programs dedicated to completing targeted monitoring of surface water quality. If unchanged, the result will be a plethora of data from a select set of waterbodies, but little to no current information from many of the state's water resources.

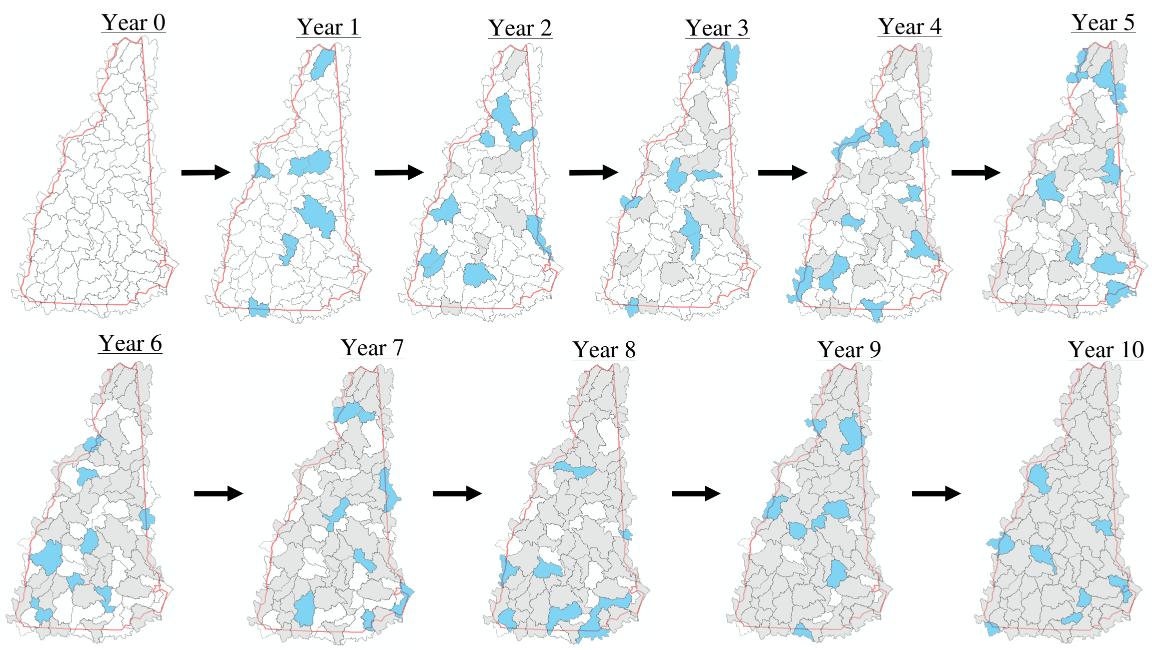
Based on a review of the data collected through the Lake Survey Program, without a renewed monitoring effort, approximately 70% of the data will be 15 years or older by 2016 (Figure 4). As a result, NHDES will not be able to update the trophic status of individual lakes, an important determinant in quantifying the cumulative impacts of anthropogenic influences such as stormwater inputs, excessive nutrient loading, and shoreline development. A similar situation would also occur for the rivers and streams without a refocused effort to collect data from targeted sample locations.

Figure 4. Data age by year for the NHDES lake survey program.



To address this need, NHDES will institute a renewed, yet limited, effort to collect targeted water quality data from surface waters where data is needed but might otherwise go unsampled. Synoptic monitoring by NHDES in this manner will be rooted in the use of a stratified rotating basin approach centered on the 10-digit hydrologic unit code (HUC 10; n=81) as a way to systematically generate statewide data on a watershed basis. At a minimum, the new approach would include sampling of a least one representative lake or pond and one representative river segment in 8 to 10 HUC 10s every year. In this manner, a full statewide rotation of each HUC 10 watershed would be completed on a 10-year cycle. HUC 10s designated for sampling by NHDES staff in any given year will be spatially distributed throughout the state (Figure 5) and based on a predetermined schedule (Appendix E). A spatially balanced approach was selected to track the effects of widespread uncontrollable environmental events (e.g., drought) throughout the state and not incorrectly associating them with a particular region as is possible with a geographically focused rotating sampling design. The statewide rotational design is made possible by the relatively small geographic area of New Hampshire allowing field personnel to travel to and from most locations in the state on any given day or sampling multiple watersheds within a pre-planned timeframe.

Figure 5. Geographic representation of scheduled rotation of HUC 10 target watersheds for synoptic monitoring. White (unsampled), blue (sampled in respective year), grey (sampled in previous years).



Unlike probability and trend monitoring, synoptic monitoring based on the rotational design is meant to be flexible in order to satisfy specific water quality data needs. For this reason, the selection of waterbodies slated for sampling will be done annually, based on the rotational schedule, but through input from NHDES staff and others where possible. In this manner, NHDES staff responsible for planning water quality monitoring efforts will provide communication of the targeted HUC 10 watersheds to be sampled within any given year and hold a series of pre-field season meetings to determine monitoring needs and make final selections for sampling in the upcoming field season. Monitoring will be focused on lakes/ponds or river/stream segments where water quality data is determined to be unavailable, unreliable, or out-of-date. Targets for data needs will also include a review of water quality assessment outcomes. These will identify where additional data would be beneficial in updating the designated use status of individual assessment units for 305(b) reporting requirements.

The flexibility of NHDES' synoptic monitoring excludes it from the requirement of selecting specific water quality indicators for measurement. Instead, the parameters selected for monitoring will be those most suited to fulfill the needs of the investigations. However, the ability of NHDES to satisfy the needs that are identified will be balanced with available resources. In most cases, monitoring will be limited to the collection of data for standard physical, chemical, and biological parameters at a frequency of one to three times during the summer months. In some cases, specialized surveys may be completed that include standard or unique parameters that are monitored at an increased frequency, over an extended temporal period, or at an intensified spatial distribution where needs are identified and new or expanded funding sources exist.

8.1 Lakes and Ponds

As currently planned, targeted synoptic monitoring for lakes and ponds will occur through a renewed Lake Survey Program. The Lake Survey Program draws heavily from the field protocols and trophic rating processes used in the past by the NHDES to maintain a consistent data collection and analysis process. In total, 23 different physical, chemical, and biological parameters are proposed for collection and analysis (Table 34). In addition, limnological characters, such as flushing rate, mean depth, and shoreline configuration will also be calculated.

Table 34. Lake and ponds synoptic monitoring parameters.

Parameter	Analysis Location
Plant Community Assessment *	Field
Secchi Disk Depth**	Field
Oxygen Profile**	Field
Temperature Profile**	Field
Bathymetry *	Field
Nitrate + Nitrite Nitrogen**	DHHS PHL-WAL
Total Kjldahl Nitrogen**	DHHS PHL-WAL
Total Phosphorus**	DHHS PHL-WAL
Calcium*	DHHS PHL-WAL
Magnesium*	DHHS PHL_WAL
Sodium*	DHHS PHL-WAL
Potassium*	DHHS PHL-WAL
Total Organic Carbon*	DHHS PHL-WAL
Sulfate*	DHHS PHL-WAL
pH**	JCLC
Alkalinity**	JCLC
Conductivity**	JCLC
Apparent Color**	JCLC
Turbidity**	JCLC
Chloride**	JCLC
Phytoplankton*	JCLC
Zooplankton*	JCLC
Chlorophyll *a***	JCLC
* Parameters sampled only during first year; ** Parameters to be sampled once annually over 3 year period; see below.	

The Lake Survey Program will produce data over three years during the summer months (Table 35). Repeat visits over the course of three summers will be completed in an effort provide a more accurate representation of average water quality conditions. In addition, summer sampling will produce data during the growing season when lakes and ponds are most heavily used and likely to demonstrate water quality problems.

In total, the program will sample up to 10 new lakes per year and up to 30 total lakes within any given year once the program has been in place for three years (Table 35). In the first year of sampling for a given selection of lakes, field efforts would be focused in August and include the most intensive sampling. Sampling in the second and third years would be more rapid, completed in July the second year and June the third year, and focused only on water quality parameters that are quick and easy to collect.

Table 35. Lake trophic survey program sampling schedule 2013 - 2022.

Month of Sampling → Year of Sampling ↓	August	July	June	Maximum number to be sampled
2013	2013 selection*	x	x	10
2014	2014 selection*	2013 selection	x	20
2015	2015 selection*	2014 selection	2013 selection	30
2016	2016 selection*	2015 selection	2014 selection	30
2017	2017 selection*	2016 selection	2015 selection	30
2018	2018 selection*	2017 selection	2016 selection	30
2019	2019 selection*	2018 selection	2017 selection	30
2020	2020 selection*	2019 selection	2018 selection	30
2021	2021 selection*	2020 selection	2019 selection	30
2022	2022 selection*	2021 selection	2020 selection	30
* Each year of selection represents up to 10 lakes				

8.1.1 Project costs / needs

Field efforts for the Lake Survey Program are estimated to be up to 20 days within any given year, with 10 days of sampling in August and five days of sampling in each of June and July. The completion of lake/pond synoptic monitoring surveys will rely on staff from the NHDES Watershed Management Bureau within the Biology Section. Overall estimated lab costs and staffing needs are detailed in Table 36.

Table 36. Lakes and ponds synoptic monitoring estimated costs and needs.

Lakes / Ponds Synoptic Monitoring Estimated Costs / Needs			
Estimated Laboratory Costs			
	1st year cost	2nd year cost	3rd year cost
Per site	$197	$57	$57
Number of sites	10	10	10
QC cost estimate	$197	$57	$57
Total cost by category	$2,167	$627	$627
Total cost / site			$311
Total cost / cycle*			$3,421
Total cost / year			$3,421
* Cycle is one set of 10 lakes sampled over 3 consecutive years ** Total lab costs / years assumes 30 lakes per year are sampled			
Staffing Needs			
Year 1: 1 field crew (2 staff) @ 1 site / day x 10 sites = 20 staff days Year 2 & 3: 1 field crew (2 staff) @ 2 sites / day x 20 sites x 2 years = 20 staff days Total number of staff days = 40 / year			

8.2 Rivers and Streams

For rivers and streams, synoptic monitoring will be flexible and rely on NHDES staff input to plan where, when, and how to carry out these efforts. Monitoring needs may shift from year to year depending on programmatic needs, particularly with respect to documentation of restorative measures, designated use attainment determination, and anticipated data needs with respect to permitting. Data collection may include single or multiple visits within a year or spread across multiple years, if necessary. In some cases, the collection of continuous data over the course of multiple days may also be required.

As with lakes and ponds, 10 to 15 sample locations will be dedicated towards targeted synoptic monitoring for rivers and streams annually. If no particular needs are identified within a given watershed, the downstream-most point within the watershed will be selected for monitoring in order to be representative of the cumulative water quality conditions of the watershed. For each site selected for monitoring a final list of parameters as well as sampling frequency and duration will be prepared for review and approval. A standard list of water quality parameters that may be collected is provided in Table 37.

Table 37. Typical river and stream synoptic monitoring parameters.

Parameter	Analysis Location
Water Temperature	Field
pH	Field
Dissolved Oxygen	Field
Specific Conductance	Field
Nitrate + Nitrite Nitrogen	DHHS PHL-WAL
Total Kjeldahl Nitrogen	DHHS PHL-WAL
Total Phosphorus	DHHS PHL-WAL
Calcium	DHHS PHL-WAL
Magnesium	DHHS PHL_WAL
Sodium	DHHS PHL-WAL
Potassium	DHHS PHL-WAL
Total Organic Carbon	DHHS PHL-WAL
Sulfate	DHHS PHL-WAL
Hardness	DHHS PHL-WAL
Alkalinity	DHHS PHL-WAL
Bacteria	DHHS PHL-WAL
Chloride	JCLC
Chlorophyll *a*	JCLC

NHDES recognizes that there will be specific monitoring needs that do not coincide with the standard HUC10 rotation schedule and plans to accommodate these needs, to the extent possible, when they arise. Specifically, these needs will include monitoring to confirm designated use determinations, undertake or participate in special studies that are of high priority to the department (e.g., TMDLs), investigate water quality complaints, and assist in the collection of data towards regulatory actions. Consideration for the "special" monitoring needs will be included in annual surface water monitoring activity planning meetings.

8.2.1 Project costs / needs

Field efforts for river and stream synoptic monitoring are estimated to be between 9-12 days within any given year and utilize two staff people. The completion of river and stream synoptic monitoring will rely on staff from the NHDES Watershed Management Bureau. Overall estimated lab costs and staffing needs are detailed in Table 38.

Table 38. Rivers and stream synoptic monitoring estimated costs and needs.

Rivers / Streams Synoptic Monitoring Estimated Costs / Needs				
Estimated Laboratory Costs				
	Single Event Parameter Cost*	E. coli costs**	Nutrient costs**	Invertebrate costs
Per site	$225	$60	$171	$450
Number of sites	10	10	10	10
QC cost estimate	$225	$60	$171	
Total cost by category	$2,475	$660	$1,881	$4500
Total cost / site (no inverts)				$456
Total cost / site (includes inverts)				$906
Total lab costs				$9,516
* Single event parameters include total suspended solids (TSS), alkalinity, hardness, total organic carbon, calcium, sodium, magnesium, potassium, sulfate. ** Assumes samples collected 3x per year during summer months. Additional parameters collected 3x per year will include chloride, specific conductance, pH, dissolved oxygen, water temperature.				
Staffing Needs				
1 field crew (2 staff) @ 3 sites / day x 10 sites = 6 - 8 staff days / round 3 rounds of sampling = 18 - 24 staff days total / year				

8.3 Data Sources, Quality Assurance, and Data Management

Synoptic monitoring data will be generated NHDES staff working within the Watershed Management Bureau using field instruments, collection of discrete samples for laboratory analysis, or through the capture of biological organisms for laboratory identification. Data collection for all synoptic monitoring activities will be completed under EPA approved quality assurance project plans (QAPP) or a NHDES standard operating procedures (SOP). All data will be stored in the NHDES EMD. Prior to acceptance, all data will be reviewed for completeness, accuracy, and precision. Wherever possible, following data verification, raw data will be flowed from NHDES' EMD to EPA's STORET/WQX using a node to node transfer.

In some cases, synoptic data may be collected and submitted to NHDES by alternative sources for a variety of unknown purposes. The quantity of data submitted by alternative sources cannot be determined at this time but is likely to account for a small percentage of the overall data. In these instances, a full review of the submitting entity’s quality assurance measures will be completed prior to data acceptance and inclusion in trend reporting. Data that is generated by outside sources will also be stored in the EMD and subsequently flowed to EPA's STORET/WQX where possible. Only data marked as "valid" in the EMD will be incorporated into the reporting phase.

8.4 Reporting

An overall (lakes/pond and rivers/streams) synoptic monitoring data summary report will be issued at ten year intervals based on the schedule in Appendix A. For the period covered in this version of the water monitoring strategy a synoptic monitoring data summary report will be prepared in 2024. The report will cover the synoptic monitoring period from 2013 - 2022. The reports will provide a listing of the sites sampled, a data summary, watershed characteristics, trophic status ratings (lakes and ponds only), and, where possible, the designated use outcomes. Data collected as part of the synoptic component of the NHDES water monitoring strategy will be used to make assessments of conditions for the biennial 305(b)/303(d) Integrated Report to Congress.

9. Coastal and Estuarine Monitoring

New Hampshire has a comprehensive estuarine and coastal monitoring program that with multiple partners including NHDES, University of New Hampshire (UNH) and the Great Bay National Estuarine Research Reserve (GBNERR). The overall goal is to provide sufficient physical, chemical, and biological data necessary to track the overall health of NH marine resources. In general these programs are separated into two primary categories: 1) providing water quality data, especially within the Great Bay estuary; 2) determining the human health risks associated with bathing at coastal beaches and shellfish harvesting.

9.1 Strategy

NH estuarine and coastal monitoring efforts are focused on repetitive measures from a fixed network of monitoring locations. Data collected from these stations then serve as the basis for tracking trends in water quality conditions over time or making public health decisions (e.g., beach advisories or shellfish bed closures).

NHDES is also committed to completing marine probability-based sampling designs as directed by EPA. The National Coastal Assessment (NCA) is scheduled at five year intervals, and for this version of the monitoring strategy, planned for completion in summer 2015 and 2020. Typically, NHDES contracts out the funds for this effort to the most qualified professionals since it does not have adequate staff or equipment to complete this work itself. For 2015, NHDES contracted with the UNH Jackson Estuarine Laboratory (JEL). Data from this EPA sponsored effort is used to characterize the condition of the nation's coastal waters. Management, processing, and analysis of the data are done by the EPA staff under the national aquatic resource survey program.

9.2 Monitoring Programs and Design

9.2.1 Estuaries

For monitoring efforts associated with Great Bay and the Hampton-Seabrook estuaries a suite of 14 core condition indicators have been identified and reported on through the Piscataqua Regional Estuaries Partnership in their triennial State of the Estuaries Report (2013 PREP) (Table 39).

Table 39. Condition indicators and status from the 2013 State of the Estuaries Repot (PREP, 2013).

CONDITION INDICATORS: THE CURRENT STATE OF CONDITIONS IN THE ESTUARY		
Nutrient Concentration	↑	Between 1974 and 2011 data indicates a significant overall increasing trend for dissolved inorganic nitrogen (DIN) at Adams Point, which is of concern. When examining variability at other monitoring stations with shorter periods of data, no consistent patterns can be found. Recent data considered in the context of long-term data show no pattern or trend.
Microalgae		Microalgae (phytoplankton) in the water, as measured by chlorophyll-a concentrations, has not shown a consistent positive or negative trend in Great Bay between 1975-2011.
Macroalgae		Macroalgae, or seaweed, populations have increased, particularly nuisance algae and invasives.
Dissolved Oxygen (Bays)		State standards for dissolved oxygen are nearly always met in the large bays and harbors.
Dissolved Oxygen (Rivers)		State standards for dissolved oxygen in the tidal rivers are not met for periods lasting as long as several weeks each summer.
Eelgrass	↓	Data indicate a long-term decline in eelgrass since 1996 that is not related to wasting disease. Due to variability even recent gains of new eelgrass still indicate an overall declining trend.
Sediment Concentrations	↑	Suspended sediment concentrations at Adams Point in the Great Bay Estuary have increased significantly between 1976 and 2011.
Bacteria		Between 1989 and 2011, dry weather bacteria concentrations in the Great Bay Estuary have typically fallen by 50 to 92% due to pollution control efforts in most, but not in all, areas.
Shellfish Harvest Opportunities		Only 36% of estuarine waters are approved for shellfishing and, in these areas, periodic closures limited shellfish harvesting to only 42% of the possible acre-days in 2011. The harvest opportunities have not changed significantly in the last three years.
Beach Closures		Poor water quality prompted advisories extremely rarely in 2011. There are no apparent trends.
Toxic Contaminants	↓	The vast majority of shellfish tissue samples do not contain toxic contaminant concentrations greater than FDA guidance values. The concentrations of contaminants are mostly declining or not changing.
Oysters		The number of adult oysters decreased from over 25 million in 1993 to 1.2 million in 2000. The population has increased slowly since 2000 to 2.2 million adult oysters in 2011 (22% of goal).
Clams		The number of clams in Hampton-Seabrook Harbor is 43% of the recent historical average. Large spat or seed sets may indicate increasing populations in the future.
Migratory Fish		Migratory river herring returns to the Great Bay Estuary generally increased during the 1970-1992 period, remained relatively stable in 1993-2004, and then decreased in recent years.

Details of NHDES supported monitoring efforts that feed into this summary report are included below:

9.2.1.1 Eelgrass

Eelgrass (*Zostera marina*) is essential to estuarine ecology because it filters nutrients and suspended particles from water, stabilizes sediments, provides food for wintering waterfowl, and provides habitat for juvenile fish and shellfish, as well as being the basis of the estuarine food web. Healthy eelgrass both depends on and contributes to good water quality.

UNH has mapped the distribution of eelgrass every year from 1986 to 2014 in Great Bay. The entire Great Bay Estuary (Great Bay, Little Bay, tidal tributaries, Piscataqua River, Little Harbor, and Portsmouth Harbor) was mapped in 1996, and annually from 1999 through 2014. The method for eelgrass mapping follows an approved Quality Assurance Project Plan.

In 2015, NHDES is proving funding for UNH to map eelgrass habitat in the Great Bay Estuary using low-altitude, aerial photography to monitor percent cover and biomass at sites throughout the Bay. Remote sensing techniques are verified through standardized ground-truthing techniques that include boat-side and visual observations made by divers.

Currently, eelgrass data it is not incorporated into the EMD, but is used by NHDES in making water quality assessments of Great Bay. These assessments are detailed in NHDES biennial 305(b)/303(d) integrated water quality report.

9.2.1.2 Macroalgae

Tracking changes in macroalgae populations is a fundamental piece of information required for understanding how changes in the environmental conditions of Great Bay estuary affect biodiversity. Human population growth and climate change can influence nutrient loads and cycling as well as the suitability of various estuarine habitats to support macroalgal growth. Fluctuations in environmental conditions can favor different species at different times, creating opportunities for non-native invasive species to establish populations. Mats of macroalgae can also intercept the sunlight needed for eelgrass to grow, altering the habitat structure and food web.

NHDES is supporting efforts by UNH to continue previous work tracking changes in macroalgae populations in Great Bay. The purpose of this work is to better understand how changes in the environmental conditions affect biodiversity. Monitoring focuses on repetitive surveys of established survey plots to document macroalgal cover and biomass. Data collected as part of this effort will be managed by UNH and summarized in a written report.

Currently, eelgrass data it is not incorporated into the EMD, but is used by NHDES in making water quality assessments of Great Bay. These assessments are detailed in NHDES biennial 305(b)/303(d) integrated water quality report.

9.2.1.3 Water Quality

NHDES relies on multiple water quality programs to generate the necessary data to characterize water quality conditions in its estuaries. A general description of each of these programs is as follows:

National Estuary Research Reserve (NERR) - Water quality data is collected by UNH for the Great Bay National Estuarine Research Reserve (GBNERR) system wide monitoring program, GBNERR diel sampling, and at tidal water quality monitoring stations. These programs are established in the NHDES EMD with project identifiers of “NERRTWQ”, “NERRDIEL” and “JELTWQ”, respectively.

- NERRTWQ – The purpose of this project is to monitor trends in physicochemical, nutrient, and eutrophication parameters in Great Bay and its tributaries below the head of tide.
- NERRDIEL – The purpose of this project is to document the daily variability in nutrient and eutrophication parameters in estuarine waters.
- JELTWQ – The purpose of this project is to monitor trends in physicochemical, nutrient, and eutrophication parameters in tributaries that drain to Great Bay and Portsmouth Harbor.

Parameters **-** Water samples are analyzed for salinity, temperature, pH, DO, TSS, chlorophyll *a*, phaeopigments, ammonia, sum of nitrate and nitrite, orthophosphate, total dissolved nitrogen, particulate organic nitrogen, particulate organic carbon, silica, light attenuation, and bacteria.

Sampling frequency **-** Monthly samples are collected at low tide for all stations and high tide at two of the stations (GRBLR, GRBOR). Samples are not collected during January, February, and March.

Stations **-** Six sites: Squamscott R. (GRBSQ), Lamprey R. (GRBLR), Oyster R. (GRBOR), and middle of Great Bay (GRBGB), Adams Point (GRBAP), coastal marine laboratory in Portsmouth Harbor (GRBCML), and Squamscott River at Chapmans Landing (GRBCL).

NERR Sondes - Great Bay National Estuarine Research Reserve (GBNERR) and the University of New Hampshire (UNH) deploy continuous recording data sondes throughout the Great Bay to monitor water quality during the ice-free season to provide a record of physicochemical water quality in Great Bay and its major tributaries.

Parameters **–** Data sondes record salinity, water level, conductivity, temperature, pH, turbidity, and dissolved oxygen.

Sampling frequency **-** Measurements are made by data sondes at 15 or 30 minute intervals. The data sondes are deployed for two week periods during non-winter months (May to December).

Stations **-** Six sites: Great Bay (GRBGB), Squamscott River (GRBSQ), Lamprey River (GRBLR), and Oyster River (GRBOR), coastal marine laboratory in Portsmouth Harbor (GRBCML) and Salmon Falls River (GRBSF).

Tidal Tributary Monitoring Program (TTMP) - The purpose of this monitoring effort is to collect representative data on nitrogen, phosphorus, and suspended sediment concentrations from freshwater sections and head-of-tide locations within the tributaries to Great Bay. UNH staff is responsible for data collection.

Parameters **-** Samples are analyzed for total dissolved nitrogen, total nitrogen, total phosphorus, total suspended solids, ammonia, nitrate/nitrite, total suspended nitrogen, and non-purgeable organic carbon which is equivalent to dissolved organic carbon. Physicochemical parameters (water temperature, specific conductance, dissolved oxygen, and pH) are also collected.

Sampling frequency **–** Monthly samples collected from March to December.

Stations **-** The tributaries sampled include the Great Works River (02-GWR), Salmon Falls River (05-SFR), Cocheco River (07-CCH), Bellamy River (05-BLM), Oyster River (05-OYS), Lamprey River (05-LMP), Winnicut River (02-WNC), and the Exeter River (09-EXT).

9.2.1.4 Data Quality Assurance

The monitoring programs noted above are primarily managed by NHDES' partners who are separately responsible for creating and maintaining EPA approved QAPPs. Prior to acceptance of any data into its EMD, NHDES requires that these documents are current and the data meets the requirements include therein.

9.2.1.5 Data Management and Transfer

All data, with the exception of eelgrass and macroalgae data, are stored in the NHDES EMD. Prior to acceptance, all data will be reviewed for completeness, accuracy, and precision. Once data verification is complete, raw data can be flowed from NHDES' EMD to EPA's STORET/WQX using a node to node transfer whenever possible. Some data may not meet minimum WQX requirements and therefore cannot be sent.Transfer of data from the EMD to STORET is done periodically with a transfer goal of 1-year following data collection.

9.2.1.6 Reporting

Water quality data collected through the programs described above will continue to be used by PREP in generating publically consumable summaries of the overall health of NH estuaries. In addition, this data will be incorporated into NHDES assessment process and included in its biennial 305(b)/303(d) integrated water quality report.

9.2.2 Beach Monitoring

The coastal public beach inspection program is a NHDES managed, EPA funded program that collects water from coastal beaches to test for fecal bacteria to protect the public health of swimmers. NHDES personnel monitor16 coastal beaches on a weekly or bi-weekly basis during the summer swim season (June – August). When bacteria counts at designated public beaches are higher than the state criteria, an advisory is issued to notify the public approximately 24 hours after sampling. If a beach requires an advisory, additional sampling is completed until bacterial levels fall below the state criteria.

Data usage - The main goal of the program is to use the data collected to protect public health and inform the public of potential health risks at public beaches. Over time, data from beach sampling is used to determine the assessment status for the 303(d) impaired waterbodies list.

Monitoring approach - A targeted sampling approach is used to evaluate bacterial levels at each of coastal beaches. Samples are used to make daily beach posting decisions regarding public health and safety. Also, since data are collected from a static roster of sample locations they are used by PREP to report on trends.

Parameters measured - *Enterococci.* Additionally, six other physical parameters are collected during visits to beaches.

Method of data collection - Discrete data points are collected during each beach visit.

Number of records generated - In 2014, 272 beach inspections were conducted and 951 bacteria samples were processed.

Quality Assurance Measures - Quality assurance measures for beach sampling are one trip blank and one field duplicate for every ten samples collected during a sampling trip. Quality assurance measures are completed daily for coastal beach inspections. The EPA approved beach program QAPP was updated in April 2012.

Data Management and Transfer - All data will be stored in the NHDES EMD. Prior to acceptance, all data will be reviewed for completeness, accuracy, and precision. Once data verification is complete, raw data will be flowed from NHDES' EMD to EPA's STORET/WQX using a node to node transfer.

Reporting - Real-time beach advisory information is available at NHDES' homepage, via a daily Twitter feed, and an e-newsletter that is issued daily during beach season. Data generated on NH coastal beaches is included in annual reports that are publically available. In addition, this data is incorporated into NHDES assessment process and included in its biennial 305(b)/303(d) integrated water quality report.

9.2.3 Shellfish Program

The mission of the NHDES Shellfish Program is to examine the sanitary quality of the state's tidal waters in order to ensure that the molluscan shellfish in those waters meet standards for human consumption. To this end, the NHDES Shellfish Program: 1) evaluates the sanitary quality of all coastal shellfish growing waters in the state; 2) identifies and monitors pollution sources and other factors that render the state's shellfish resources unfit for human consumption; 3) works with partners and the public to eliminate pollution sources; and 4) coordinates with shellfish farmers and other agencies to site new aquaculture operations, plan harvesting activities, and prevent illness outbreaks.

Data usage - Data generated by the Shellfish Program are used to prepare and update sanitary survey reports for the eight major shellfish growing areas in the state's jurisdiction. Data generated by the program are also used to make daily and weekly management decisions regarding which harvesting areas are open/closed based on current information of public health threats such as red tide levels, recent rainfall, boating and mooring surveys, and others. These decisions are communicated to through a hotline message and internet-based tools.

Monitoring approach - The monitoring program implements a systematic random sampling program to maintain updated bacteria data on 75 monitoring stations in the state's tidal waters. Targeted data from event-based seawater and shellfish tissue testing after pollution events such as heavy rainfall events are used to supplement the ambient program and to support management decisions. Additional monitoring programs include: Red Tide monitoring, Shoreline Survey program, communication with operators of potential pollution sources, and a new monitoring program focused on *Vibrio sp.* bacteria risk assessment and viral indicators.

Parameters measured - Seawater and shellfish tissue sampling programs document: fecal coliform bacteria, water temperature, salinity, and other observations; Paralytic Shellfish Poison (PSP) toxin in blue mussels and other shellfish species; water temperatures near commercial oyster farms and *Vibrio sp.* bacteria levels in oysters; and Male Specific Coliphage levels in oysters and blue mussels.

Number of records generated - In 2014, the Shellfish Program accomplished the following:
• 65 rounds of sampling on tidal waters
• 969 seawater samples collected
• 18 rounds of sampling in response to rainfall events

- 64 red tide samples collected
- 341 commercial harvesting decisions generated
- 93 wastewater treatment facility calls evaluated
- 66 harvesting hotline updates implemented
- 1,376 properties surveyed and tracked
- 59 marina/mooring field surveys performed
- 875 pollution sources tracked

Quality Assurance Measures - The Shellfish Program operates under three EPA approved Quality Assurance Project Plans (QAPPs), dated May 2014, addressing Ambient Monitoring, Red Tide Monitoring, and Shoreline Survey Monitoring. The Shellfish Program is also required to complete a program audit every other year detailing any deviations from the methods and data criteria stated in the QAPPs and resolutions to those deviations. Information is managed in the NHDES EMD and in GIS format, and is used to support management decisions outlined in the sanitary surveys.

Data Management and Transfer – Most of the data is stored in the NHDES EMD. Prior to acceptance, all data will be reviewed for completeness, accuracy, and precision. Once data verification is complete, raw data will be flowed whenever possible from NHDES' EMD to EPA's STORET/WQX using a node to node transfer.

Reporting - A real-time shellfish bed closure hotline and internet-based alerts are available via the NHDES coastal atlas, a web-based application that is freely available and a phone-based "hotline". Sanitary survey reports are issue annually for each of eight growing areas. In addition, a more detailed triennial report is prepared for review by the US Food and Drug Administration (FDA). Ultimately, the data are incorporated into NHDES assessment process and included in its biennial 305(b)/303(d) integrated water quality report.

10. Wetlands Monitoring

New Hampshire's formerly glaciated landscape and its wetlands are diverse; from tidal salt marshes to northern white cedar swamps, silver maple floodplain forests to alpine bogs. In 2011, the New Hampshire Department of Environmental Services (DES), in coordination with EPA, developed a Wetland Program Plan to provide direction for DES and its partners to strengthen its wetlands program and protect wetlands and aquatic resources statewide. The New Hampshire Wetland Program Plan provides a framework and direction for the wetlands program activities 2011-2017 timeframe and references various monitoring and assessment-related activities (NHDES, 2011b).

A full account of NHDES' wetlands monitoring strategy was prepared for and submitted to EPA in 2013 (NHDES, 2013b). New Hampshire's wetland monitoring is still in the developmental phase but has over the past several years made significant progress in refining its ability to assess the condition of wetlands. In summary, the approach taken to date has included some work in each of EPA's suggested phases of development (Level 1, 2, 3) and the creation of a standardized catalog of wetlands tied to 23,626 distinct assessments units. Table 40 provides a chronology of the wetland monitoring and assessment work that New Hampshire has conducted in each level between 2008 and 2013.

Table 40. New Hampshire's wetland monitoring and assessment work 2008 – 2013.

Level of method applied[1]	Year completed/ field work conducted	Goal/Approach/Results
Level 1	2008	**Goal:** Make preliminary determinations as to what wetlands were likely to support aquatic life and those that were potentially unlikely to support aquatic life. **Approach:** Evaluated the condition of a wetland based on the condition of the 125m wetland buffer, specifically the percentage of impervious surface cover. **Threshold:** Based upon research indicating that when a watershed exceeds 10 percent impervious surface cover, exceedances of water quality criteria are likely. **Results:** Of a total of 23,626 wetland assessment units, 80 percent (18,909) were assessed as potentially supporting aquatic life and 20 percent (4,717), were assessed as potentially not supporting aquatic life (NHDES, 2008b).
	2010	**Goal:** Make preliminary determinations as to what wetlands were likely to support aquatic life and those that were potentially unlikely to support aquatic life. Assessment based on the 2010 revision of wetland assessment units. **Approach:** Similar to 2008 Level 1 assessment, except for evaluation of buffers. Evaluated the amount of each land cover class within each wetland buffer. **Results:** Eighty-two percent of the assessment units were identified as potentially supporting aquatic life and 18 percent assessed as potentially unlikely to support aquatic life (NHDES, 2010).
	2013	**Goal**: Create a more robust Level 1 assessment for aquatic life designated use **Approach:** Incorporate functional analysis elements developed for the Merrimack River Restoration Project under the DES Aquatic Resource Mitigation Fund (DES's in-lieu fee mitigation program) and the NH Method**.** **Results:** Scores generated will be used to identify potential reference sites, including those representing a gradient of human disturbance.
Level 2	2011	**Goal:** With the NH Natural Heritage Bureau (NHB), Department of Resources and Economic Development, adapt and apply a multi-level Ecological Integrity Assessment (EIA) method to quantify the status of known critical and at-risk wetlands. **Approach:** NHB applied the EIA approach to exemplary wetlands in its database and other wetlands in central and southern New Hampshire. **Results**: Developed the *Level 2.5 Ecological Integrity Assessment Manual*, documented the condition of wetlands at 99 sites, including additional priority wetlands and benchmark reference sites, and increased the knowledge of wetland resources for permitting activities.
	2011	**National Wetland Condition Assessment:** - DES applied the USA RAM (as well as Level 3 protocols) at 11 sites (with two revisits). Results are not yet available.
	2012	**Goal:** 1) Conduct a field-based comparison of four rapid assessment methods that are function- or condition-based for use in NH water quality and permitting program activities. 2) Evaluate application of criteria for successful mitigation projects. **Approach:** Applied the New Hampshire Method, Ecological Integrity Assessment (EIA v2.5) (Nichols and Faber-Langendoen, 2012) and Floristic Quality Assessment Index at 27 bogs and fens and five mitigation/restoration sites. **Results:** Information on usefulness of methods applied and appropriateness to mitigation. Identified other issues, such as use of non-native seed sources at mitigation sites (NHB, 2013).
Level 3	2011	**National Wetland Condition Assessment:** DES applied the Level 3 protocols at 11 sites (with two revisits). Results are not yet available.

[1] EPA. 2006. Application of Elements of a State Water Monitoring and Assessment Program for Wetlands. OWOW, Wetlands Division. U.S. Environmental Protection Agency, Washington, DC.

10.1 Monitoring Design

Currently, NHDES's top priority for wetlands monitoring is to select indicators and develop defensible thresholds for assessing wetlands condition using either Level 2 or 3 protocols. Once these are developed, it is anticipated that the monitoring design implemented will follow those described above for freshwater systems. Specifically, they will include regular participation in the EPA sponsored National Wetland Condition Assessment (NWCA) (e.g., probability-based sampling), the selection of a series of wetlands that are well distributed geographically to track conditions over time (e.g., trends), and annually sampling of wetlands within a rotating schedule of HUC 10 watersheds (e.g., synoptic).

10.2 Indicators

A key need identified in multi-stakeholder meetings on wetland-specific water quality standards is development of indicators and thresholds for determining if wetlands are supporting the designated use of aquatic life. NHDES will select indicators based on the objectives of the monitoring, the type of wetland, and resources available. Potential indicators, metrics, and methods for assessing wetland condition are provided in Table 41.

Table 41. Wetland condition indicators, metrics, and methods under consideration by NHDES.

Indicator	Potential Metrics	Potential Methods
Plant community health	Floristic Quality Indices, such as Mean C, FQI, Mean C_w, FQI_w, native taxa, species richness	Aerial photo interpretation, floristic survey
Invertebrate community health	Diversity indices, abundance, richness	D-net sweeps, funnel traps, artificial substrate sampling
Water quality measurements (where open water is present)	Phosphorus, nitrate-nitrite, temperature, dissolved oxygen (DO), pH	Hand held meters and grab samples
Landscape/ land use	Land use in watershed, proximity to wetland, impervious surfaces	Aerial photo interpretation, field confirmation

Once a series of indicators has been selected and tested, a formal wetlands condition index will be developed using minimally distributed wetlands and compared to wetlands with a high level of disturbance in order to establish numeric thresholds beyond which wetlands no longer support the expected aquatic life uses. A fully tested and vetted wetland condition index will then be used to complete formal water quality assessment purposes for inclusion into NHDES 305(b)/303(d) integrated water quality report. However, given limited staffing and funding, a definitive timeline for these milestones has not been established.

10.3 Quality Assurance

Wetlands monitoring currently conducted by NHDES is described in and covered under a QAPP approved by EPA in July 2014.

10.4 Data Management

NHDES's goal is to be able to enter all wetlands monitoring data into the EMD. However, it currently is only able to accept and store water quality and invertebrate data collected with respect to wetland monitoring. As wetland indicators are more completely developed and data collected, it is anticipated that the EMD will need to be modified to accommodate the different types of wetlands monitoring data (e.g., plant species list and characteristics, site data, landscape information). NHDES is committed to making the necessary modifications as resources allow so that the wetlands data are available to the public and used in water quality assessments.

For all wetland data that is able to be handled by the EMD, transfers to EPA's STORET/WQX will be done using a node to node transfer on an annual basis as staff resources exist to complete this task.

10.5 Reporting

NHDES will provide information about wetland monitoring and assessment to the public in an understandable format. As information is generated regarding wetlands condition by type or location, it will be made available to agencies, wetland professionals, local decision makers, and the general public in order to make informed decisions, particularly in the area of local land use.

NHDES will provide annual updates to EPA regarding progress and accomplishments related to the implementation of the wetlands monitoring and assessment strategy through NHDES' Measures Tracking and Reporting System (MTRS). The MTRS is an Oracle database used by DES to track major deliverables for each program, including those associated with the EPA Performance Partnership Grant and Wetland Program Development Grants.

As noted above, once a fully mature wetlands monitoring program is in place, the data will become part of NHDES formal water quality assessment process and the outcomes included in the state's 305(b)/303(d) biennial water quality report.

10.6 General Support and Program Gaps

NHDES currently has no established staff position(s) dedicated to wetlands monitoring and assessment. Wetland monitoring and assessment work conducted to date has utilized staff from four programs within two agencies. These efforts have been funded mostly by short term (two- to three-year) EPA Wetland Program Development Grants (WPDG) and the National Wetland Condition Assessment (NWCA).

The lack of long term dedicated funds towards wetland monitoring will significantly affect the ability of NHDES to implement and sustain a fully operational state wetland monitoring program. The WPDGs provide resources to develop a program, but not to support it. NHDES faces significant obstacles to adequately fund staff in its monitoring programs, including obtaining stable multi-year funding.

We estimate that to conduct a basic wetland monitoring program, NHDES would need at least two full-time staff plus an intern available during field season. Staff and equipment are needed to prepare quality assurance plans, support the monitoring field work, analyze samples, perform data/statistical analysis and interpretation, and summarize/report results. Sample analysis costs will likely include those for the identification and processing of biological samples such as vegetation and macroinvertebrates (the cost for identifying macroinvertebrates is expected to be significantly higher than for vegetation due to the specialized taxonomic skills needed for identification). Information technology (IT) support is also needed for GIS and to maintain and improve the EMD and facilitate data transfers to STORET/WQX. In addition, funding will also be needed to cover other typical costs of a field program such as fuel and vehicle maintenance, equipment and supplies, vehicle purchase, travel to meetings, and training to develop expertise of monitoring staff.

11. Data Quality Assurance and Control (QA/QC)

All federally funded programs conducting surface water monitoring are required to maintain a Quality Assurance Project Plan (QAPP). These plans spell out the project's organizational components, data generation and acquisition methods, project assessment techniques, and data quality verification requirements. NHDES maintains current QAPPs for all federally funded and several state funded surface water monitoring programs. For those state funded programs or activities where a formal QAPP has not been developed, a detailed project management plan (QMP) or standard operating procedure (SOP) has been developed. The surface water monitoring programs described above are covered primarily under five state-developed QAPPs, two federal QAPPs, and one state-level QMP (Table 39).

Table 42. Quality assurance / quality control documents associated with NHDES river/streams lakes/ponds probability, trend, and synoptic monitoring efforts.

Monitoring Design Component	Waterbody Type	QC/QC document
Probability	River/Stream	Ambient River Monitoring Program QAPP
		National River and Stream Assessment (NRSA) QAPP
	Lake/Pond	Lake Assessment Programs QAPP
		National Lake Assessment (NLA) QAPP
Trend	River/Stream	Ambient River Monitoring Program QAPP
		Volunteer River Assessment Program (VRAP) QAPP
	Lake/Pond	Volunteer Lake Assessment Program (VLAP) QAPP
		BEACH Program QAPP
		Exotic Species Program QAPP
Synoptic	River/Stream	Ambient River Monitoring Program QAPP
		VRAP QAPP
	Lake/Pond	Lake Assessment Programs QAPP
		VLAP QAPP
All	Wetlands	Wetland Assessment and Classification in New Hampshire QAPP
All	Shellfish	Shellfish Ambient Water Quality Monitoring QAPP Paralytic Shellfish Poison Monitoring QAPP Shellfish Sanitary Survey QAPP

Within each of these documents there are standardized procedures associated with each field protocol, operation and calibration of water quality instruments, and sample preservation and tracking to ensure and maintain data of high quality. Subsequent to data collection, a formal process for data review is required prior to acceptance into NHDES data management tools.

In addition, NHDES operates the Jody Conner Limnology Center (JCLC) in order to support its citizen volunteer surface water quality programs and process samples collected by its field staff. The successful operation of the JCLC relies on a continuously updated laboratory manual that details all of the procedures for the generation of high quality data. The manual includes details regarding water or specimen sample acceptance and tracking procedures and the use of bench top instruments, basic wet chemistry procedures, and microscopic analysis. The JCLC produces an annual workload report that details the number of analysis preformed by the laboratory and to track its QA/QC performance measures. In 2014, the JCLC completed over 12,000 analyses and met its QA/QC performance measures. A copy of the JCLC workload report was submitted to EPA and NHDES' commissioner's office for review. The report is also on file within the Watershed Management Bureau for public review if desired.

12. Data Management

Prior to 2003, monitoring data was stored in a variety of spreadsheets and databases. There was no common format and much of the metadata (e.g., analytical method, fraction type, sample collection method, etc.) was missing. In 2003, the Environmental Monitoring Database (EMD) was built as an in-house using Oracle in order to handle the physical/chemical data. The EMD was designed with federal reporting to EPA's STORET database in mind. The data stored in the miscellaneous spreadsheets and other databases was imported into the EMD and metadata was researched and added. Since the EMD's original creation, it has been expanded to include biological, habitat, tissue, and toxicity data.

Currently the EMD has an Oracle 10 back end and an Oracle Forms 6 front end. In the next few years, the front end will be redone in .NET since Oracle Forms 6 is no longer supported.

Surface water data are primarily hand entered or batch uploaded to the EMD via the web or historically via customized programs created by the Oracle developer. Data are generated by staff and also supplied by volunteers and other organizations.

The EMD has hundreds of projects (groupings of data) which contain thousands of stations. The stations have thousands of activities, which can be samples, measurements, or observations. Some stations also have related data logger installations and their records.

During manual entry of data, the EMD does enforce the entry of a minimum set of data elements. The batch upload process through the web applies the same rules as the database itself – in some cases even more. Several QA/QC reports are run monthly or quarterly to look for a variety of errors such as unreasonable values, missing metadata, and other issues. Staff also have their own QA/QC mechanisms (e.g., having one person enter the data and another person review the data for accuracy against the paper field forms).

Using our Exchange Network node, data are extracted from the EMD and formatted to meet the Water Quality Exchange (WQX) requirements in an XML file. Our node sends the XML file to the EPA's node where the file is validated and interrogated for completeness and structure. The data are sent as needed such as monthly for beach data during the beach season or at the end of the year for other projects after the data has been QA/QC'd by the program. To date, of the 16,312 surface water stations and their related 435,634 activities in the EMD, 4,949 (30%) and 143,881 (33%) have been sent to EPA, respectively.

Moving forward, every effort will be made by NHDES to submit data to the WQX within two years of collection wherever possible. In some cases, in particular with biological data, the data architecture in the WQX is incompatible with the form in which it is collected by NHDES. NHDES has worked to identify these areas of incompatibility and reported them to EPA and is waiting for solutions which will allow for more complete data uploads. Further, NHDES data management staff is limited and has focused on maintaining the operability of the EMD and transfer of data to WQX where data is deemed completed.

Currently within NH, finalized data are available to the public via the NHDES OneStop web site: http://www2.des.state.nh.us/OneStop/Environmental_Monitoring_Menu.aspx. For data that has been flowed to the federal repository, it can be accessed via STORET (http://www.epa.gov/storet/). If other data are needed and the request is approved by the program staff, customized reports can be created by the Data Management staff. The EMD will continue to serve as the primary data repository for surface water quality data in the future.

13. Data Analysis and Assessment

Biennial surface water quality assessments are required under the CWA. The CWA requires each state to submit two surface water quality documents to the U.S. Environmental Protection Agency (EPA) by April 1st of even numbered years. Section 305(b) of the CWA requires submittal of a report (commonly called the “305(b) Report”) that describes the quality of its surface waters and an analysis of the extent to which all such waters provide for the protection and propagation of a balanced population of shellfish, fish, and wildlife, and allow recreational activities in and on the water. The second document is typically called the “303(d) List” which is so named because it is a requirement of Section 303(d) of the CWA. The 303(d) List includes surface waters impaired by a pollutant that need a Total Maximum Daily Load (TMDL). The 303(d) List is not 'final' until approved by EPA.

In most cycles, the draft 303(d) List is sent out for public comments in February of the even numbered year to allow time for comment, response, and the finalization by April 1st. In several of the recent cycles, a combination of submittal dates and the approval time by EPA has extended the overall assessment timeline such that the final 303(d) List approval did not occur until the next cycle was actively in its assessment phase.

Water quality assessments are made using all readily available data. How data is used in the assessment depends largely on the quality and completeness of the submission. In general, scientifically sound and defensible evidence is needed to determine if a waterbody is meeting water quality standards or is impaired. Evidence that does not meet these criteria, however, is still useful as it provides a preliminary sense of water quality that can be used to guide future monitoring efforts/investigations designed to fill data gaps needed to make a final assessment. NHDES encourages anyone who has surface water data/information to submit it to NHDES electronically at any time.

The Comprehensive Assessment and Listing Methodology (CALM) describes how the department uses all data to make comparisons to Env-Wq 1700 and RSA 485-A:8 (NHDES 2012). The CALM describes, in detail, the process used to make surface water quality attainment decisions in accordance with state water quality standards. The CALM is intended as a translator document to bridge the gap between water quality criteria and actual sample data. However, nothing in the CALM precludes the department from using provisions of the water quality standards that are not specifically addressed. The current CALM document can be found at http://des.nh.gov/organization/divisions/water/wmb/swqa/documents/calm.pdf.

In order to complete, track, and store assessment outcomes, NHDES built a Supplemental-Assessment Database (SADB) in 2005 for the 2006 assessment cycle in Oracle. The SADB is biennially populated with data from the Environmental Monitoring Database (EMD).

The level of use of data in the SADB for the assessment process is driven by the source of the data (collection entity) and the associated QA/QC requirement of the collection entity. All data are run through the assessment process but the data from the sources with lower QA/QC requirements may be valuable for screening only. Conversely, data with rigorous QA/QC requirements can be used for final assessment outcome determinations. After final assessment determinations are made, cross check queries between the SADB and EPA's Assessment Database (EPA-ADB) are used to populate the EPA-ADB including the addition of probable source and Total Maximum Daily Load (TMDL) target date information which is not built into the SADB.

Assessments are based on surface waters shown on the 1:24,000 National Hydrography Dataset (NHD), which is consistent with EPA's national coverage. Surface waters for which data was available to make an assessment, but which were not shown on the base NHD coverage, were added to this coverage on a case-by-case basis and linked to the NHD. Within the waterbody catalog, each waterbody type is divided into smaller segments called assessment units (AUs) (Table 43). In general, AUs are the basic unit of record for conducting and reporting the results of all water quality assessments. AUs are intended to be representative of homogenous segments; consequently, sampling stations within an AU can be assumed to be representative of the segment. In general, the size of AUs should not be so small that they result in an unmanageable number of AUs for reporting. On the other hand, AUs should not be so large that they result in grossly inaccurate assessments.

Table 43. Assessment Units (AUs) included in the NHDES waterbody catalog during the 2012 305(b)/303(d) reporting.

Waterbody Type	Total Size		Total Number of Assessment Units
Rivers and Streams	16,963	Miles	5,923
Impoundments	22,435	Acres	1,235
Lakes and Ponds	162,743	Acres	1,558
Estuaries	17.98	Square Miles	72
Ocean	81.48	Square Miles	26
Wetland	286,696	Acres	52,313
Total			61,131 (8,818 without wetlands)

The Surface Water Quality website (http://des.nh.gov/organization/divisions/water/wmb/swqa/index.htm) is the main clearinghouse for current assessment information with new tools and information added as they are developed and needed. Watershed report cards cover each 12 digit Hydrologic Unit Code (HUC12), on average a 34-square mile area. Watershed Report Cards have three components: 1) REPORT CARD - A one-page summary of the overall use support for aquatic life, primary contact (e.g., swimming), secondary contact (e.g., boating), and fish consumption designated uses on every AU identification number (AUID); 2) HUC12 MAP - A map of the watershed with abbreviated labels for each AUID; 3) ASSESSMENT DETAILS - Anywhere from one to 40 pages with the detailed assessment information for every AUID in the report card and map. Watershed report cards have been built for the 2008, 2010, and 2012 assessments (http://des.nh.gov/organization/divisions/water/wmb/swqa/report_cards.htm). Access to GIS layers for the assessment units are located at the "cycle specific pages" (e.g., 2010) of the main assessment website. The process for accessing the 2012 GIS layers are described at http://des.nh.gov/organization/divisions/water/wmb/swqa/2012/documents/2012-gis-layers-aus.pdf.

14. Programmatic Evaluation

The strategy outline above spells out the specific programs involved in each of the various elements of the monitoring strategy and describes a detailed approach for collecting data and reporting results. NHDES intends to use the reporting deadline for each of the major design components as the primary opportunity to review the overall effectiveness of the monitoring design component for individual waterbody types. The review will entail an assessment to determine if the goals and objectives were met, if staffing was sufficient, and whether or not equipment and funding were adequate. Where shortfalls are noted, NHDES will determine what modifications are needed to meet these shortfalls. Where solutions are identified that can be implemented, monitoring programs will be adjusted.

In addition, interim, informal evaluations of program effectiveness will be made annually. These evaluations will be less intensive and likely include only minor changes to the program's implementation. Examples may include logistical changes, modifications to sampling protocols, incorporation of new sampling techniques, or equipment. In these cases the adjustments will be reflected in the respective program's QAPP.

Last, NHDES completes individual quality assurance reviews of its monitoring programs under its EPA approved Quality Management Plan (QMP) (NHDES 2015). These reviews serve as an additional measure to evaluate program effectiveness with respect to data quality. The foundation of the reviews includes first-party audits (self-audits) which are conducted by NHDES programs that manage environmental data. Managers identify and implement corrective actions necessary to improve program effectiveness with respect to data quality.

15. General Support and Infrastructure Planning

15.1 Rivers/Streams and Lakes/Ponds

For the river/stream and lake/pond waterbody types, the strategy described above is designed to capitalize on current staffing, equipment, and laboratory resources in a new and more efficient manner to accomplish the tasks that are outlined above. The source of funds relies on federal 106 funding provided by EPA through the performance partnership grant (PPG) including the supplemental monitoring initiative funds. NHDES has made a long term commitment to this monitoring design and will plan monitoring activities based on the continued availability of these funds to pay for full time staff, interns, equipment, and laboratory supplies. Additional funds will be needed to maintain the availability of these resources as staffing, equipment, and laboratory expenses increase.

15.2 Coastal Monitoring

As spelled out in the coastal monitoring section (Section 9), a majority of the monitoring that takes place in coastal regions is supported through funding supplied by NHDES to various partners, federal dollars granted to the BEACH program, and state and federal (PPG) funds to support a portion of the shellfish program. A current emphasis on more intensive monitoring in the Great Bay estuary and the Piscataqua River indicate that additional support through staffing, equipment, and laboratory analysis would be greatly beneficial. However, due to past litigation and ongoing negotiations with several municipalities with respect to the permitting requirements for their wastewater treatment facilities, defining the specific monitoring activities for this area has been on a year-to-year basis. In total, NHDES contributes approximately $75,000 annually to these activities, but expects that costs will increase as research uncovers additional confounding factors that affect conditions in Great Bay and require additional monitoring. Ultimately, it is likely that NHDES's contribution towards these efforts could exceed $150,000/year.

15.3 Wetlands Monitoring

The specific needs to cover wetlands monitoring development is covered in Section 10. In summary, the immediate needs include sufficient resources to continue the development of the indicators and indices necessary to assess the overall condition of this waterbody type. Once a fully mature program is developed, long-term funding will be required to shift efforts toward an operational mode that works in concert with the monitoring efforts in the other freshwater waterbody types.

15.4 Instream Flow

For over a decade NHDES has worked to develop and implement an instream flow program. The Lamprey and Souhegan Rives served as pilot efforts to identify and describe the flows necessary to protect the aquatic community during different periods of the year. Through this process it has become apparent that a means of evaluating the effects of water management are appropriate and necessary for assessing the types of management actions taken. The natural variability in biological populations, the fact that management measures are only rarely applied, and other non-flow factors make assessing the effects of instream flow management a study in long-term trends. Ideally, adequate monitoring would be conducted before the start of management to establish baseline conditions. Monitoring would then be continued to track changing biological and recreational conditions and to inform adaptive management decisions.

Long-term monitoring strategies for the Program are under development and will build upon existing trend monitoring activities. Elements of a monitoring plan are likely to be focused around fish collections and surveys of riparian plant communities to answer whether flow conditions are affecting biological integrity. Five-year monitoring cycles are recommended. Assessments of chemical or physical parameters such as specific conductance and temperature would provide clues to a cause if changes were observed.

Planning for implementation of a comprehensive monitoring plan is greatly complicated by the uncertain of availability of staff. Each field season, NHDES already collects thousands of data points to fulfill its current obligations as outlined in this strategy. Additional field work to assess fish communities and riparian habitat will require significant staff time above the present capacity. In order to fully assess the long-term ecological effects of the Instream Flow Program, additional resources for monitoring will be needed. At a minimum this would entail an additional full time aquatic biologist, 2-3 interns to assist in completing field work, and the necessary additional equipment to complete biological surveys. NHDES estimates this would cost $200,000 annually.

15.5 Information Technology

Data management and reporting are key elements to an effective monitoring program. EPA requires that data collected using federal funds granted to the states be transferred and included in its national database, STORET/WQX within a specified timeframe (e.g., every two years). The data must also be included in a state's evaluation of water quality conditions and reported to EPA biennially in its 305(b)/303(d) integrated report.

NHDES currently uses its EMD as the primary independent data storage and retrieval platform. The EMD is also used to transfer data directly to STORET/WQX. However, meeting EPA's two year deadline can be challenging, especially for new or non-standard data elements, as is the case with some types of biological data. NHDES' current situation for management of the EMD is limited to minimal staff that either work part-time or split their full-time job responsibilities amongst other programs. In sum, 1.5 full-time staff equivalents (FTEs) are dedicated to the management and future development of the EMD. Given the limited resources available, NHDES believes it is doing an excellent job of managing its data, making it available to the public via its OneStop data retrieval site, and transferring data to EPA's national repository. NHDES is committed to continuing these efforts as funding allows.

Moving forward, NHDES recognizes a need for assistance via EPA contractors or funding sources in order to further develop its EMD in order to fully accept non-standard data records and enhance its ability to upload data the STORET/WQX. However, NHDES feels these efforts will require a significant sum of funds (>$500,000) to finalize development efforts and a commitment of additional funds annually over the long term for maintenance of it data management systems. NHDES will explore the potential of applying for EPA Exchange Network Grant Funds in the future once it has fully defined its data management and transfer needs.

REFERENCES

Daley, M. L., J. D. Potter, and W. H. McDowell. 2009. Salinization of urbanizing New Hampshire streams and groundwater: effects of road salt and hydrologic variability. Journal of the North American Benthological Society, Vol. 28, 4:929–940.

Deacon, J.R., S.A. Soule, and T.E. Smith, T.E., 2005, Effects of urbanization on stream quality at selected sites in the Seacoast region in New Hampshire, 2001-03: U.S. Geological Survey Scientific Investigations Report 2005-5103, 18 p.

Driscol, C.T., G.B. Lawrence, A.J. Bulger, T.J. Butler, C.S. Cronan, C. Eagar, K.F. Lambert, G.E. Likens, J.L. Stoddard, and K.C. Weathers. 2001. Acidic deposition in the northeastern United States: Sources, inputs, ecosystem effects, and management strategies. Bioscience, Vol. 51 12:180-198.

EPA. 2003. Elements of a state water monitoring and assessment program. EPA-841-B-03-003. U.S. Environmental Protection Agency, Washington, D.C.

EPA. 2006. Wadeable streams assessment. EPA-B-06-002. U.S. Environmental Protection Agency, Washington, D.C.

EPA. 2010. Acid Rain Program 2009 Progress Reports. *EPA*. Environmental Protection Agency, Dec. 2010. Web. 27 Jan. 2014. <http://www.epa.gov/airmarkets/progress/ARP09.html>.

Isaak, D. J., C. C. Muhlfeld, A. S. Todd, R. Al-chokhachy, J. Roberts, J. L. Kershner, K. D. Fausch, S. W. Hostetler. 2012. The past as a prelude to the future for understanding 21st-century climate effects on Rocky Mountain trout. Fisheries, Vol. 37 12:542-556.

Isaak, D. J. and B. E. Rieman. 2012. Stream isotherm shifts from climate change and implications for distributions of ectothermic organisms. Global Change Biology, Vol. 19 3:742-751.

NHB. 2013. Comparison of alternative wetland assessment methods at numerous sites in New Hampshire. New Hampshire Natural Heritage Bureau. Concord, NH.

NHDES. 2005. State of New Hampshire water monitoring strategy. R-WD-05-27. New Hampshire Department of Environmental Services, Concord, NH.

NHDES. 2004. Air pollution transport and how it affects New Hampshire. R-ARD 04-1. New Hampshire Department of Environmental Services, Concord, NH.

NHDES. 2008a. Quality of New Hampshire Lakes and Ponds: A layman's guide. NHDES-WSPCD-92-1. New Hampshire Department of Environmental Services. Concord, NH.

NHDES. 2008b. Summary and results of Level 1 landscape level wetlands assessment. From Ted Walsh, Water Quality Specialist, To: Paul Currier, Administrator, Watershed Management Bureau, Gregg Comstock, Supervisor, Water Quality Planning Section, Ken Edwardson, water quality Assessment Program. (Attached as Appendix 36 in 2008 305(b) /303(d) report). September 16. Concord, NH.

http://des.nh.gov/organization/divisions/water/wmb/swqa/2008/documents/appendix_36_l1_wet.pdf.

NHDES. 2010. Creation of the 2010 State-wide wetland base Map. Memo from Matt Wood, Water Quality Specialist to Ken Edwardson, Water Quality Assessment Program Coordinator. Watershed Management Bureau. Concord, NH.

NHDES. 2011a. Transitional water fish assemblage index of biotic integrity for New Hampshire wadeable streams. R-WD-11-6. New Hampshire Department of Environmental Services, Concord, NH.

NHDES. 2011b. 2011 – 2017 New Hampshire wetland program plan. New Hampshire Department of Environmental Services, Concord, NH. http://des.nh.gov/organization/divisions/water/wetlands/documents/epa-plan-2011-17.pdf

NHDES. 2012. 2012 Section 305(b) and 303(d) consolidated assessment and listing methodology. R-WD-12-2. New Hampshire Department of Environmental Services, Concord, NH.

NHDES. 2013a. Draft Exotic Aquatic Species Program Report 2009 - 2012. New Hampshire Department of Environmental Services, Concord, NH.

NHDES. 2013b. New Hampshire's wetlands monitoring strategy. R-WD-13-15. New Hampshire Department of Environmental Services, Concord, NH.

NHDES. 2015. Quality management plan. R-CO-06-3. New Hampshire Department of Environmental Services, Concord, NH.

Nichols, W. F. and D. Faber-Langendoen. 2012. *Level 2.5 Ecological Integrity Assessment Manual: Wetland Systems*. New Hampshire Natural Heritage Bureau & NatureServe, Concord, NH.

PREP. 2013. State of our estuaries 2013. Piscataqua Regional Estuaries Partnership, Durham, NH.

Staudinger, M. D., N. B. Grimm, A. Staudt, S. L. Carter, F. S. Chapin III, P. Kareiva, M. Ruckelshaus, B. A. Stein. 2012. Impacts of Climate Change on Biodiversity, Ecosystems, and Ecosystem Services: Technical Input to the 2013 National Climate Assessment. Cooperative Report to the 2013 National Climate Assessment. 296 p.

Sundquist. 2010. Population growth and land use change in the granite state. Society for the Protection of New Hampshire Forests, Concord, NH.

Trowbridge, P. R., J. S. Kahl, D. Sassan, D. L. Heath, and E. M. Walsh. 2010. Relating road salt to exceedances of the water quality standard for chloride in New Hampshire streams. Environmental Science and Technology, Vol. 44, 13:4903-4909.

Appendix A. NHDES surface water monitoring summary sampling and reporting schedule for probability-based, trend, and synoptic monitoring efforts, 2013 - 2024. Grey boxes are reporting years.

Reporting Summary by Year												
Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Reports					Rivers and Streams Probability Survey Report	Rivers and Streams Trend Report	Lakes and Ponds Trend Report		Lakes and Ponds Probability Survey Report	Rivers and Streams Trend Report	Lakes and Ponds Trend Report	Rivers, Streams, Lakes, Ponds Synoptic Report
Design component: Probability Monitoring												
Waterbody Type: Rivers and Streams												
Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Cycle	1	1	1	1	2	2	2	2	2	3	3	3
Sampling	x	x	x	x (if needed)		x	x				x	x
Reporting					x (cycle 1)							
Waterbody Type: Lakes and Pond												
Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Cycle	1	1	1	1	2	2	2	2	2	3	3	3
Sampling					x	x	x	x (if needed)		x		
Reporting									x (cycle 2)			
Design component: Trend Monitoring												
Waterbody Type: Rivers and Streams												
Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Cycle	1	1	1	1	2	2	2	2	2	3	3	3
Sampling	x	x	x	x	x	x	x	x	x	x	x	x
Reporting						x (cycle 1)				x (cycle 2)		
Waterbody Type: Lakes and Ponds												
Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Cycle	1	1	1	1	2	2	2	2	2	3	3	3
Sampling	x	x	x	x	x	x	x	x	x	x	x	x
Reporting							x (cycle 1)				x (cycle 2)	
Design component: Synoptic Monitoring												
Waterbody Type: Rivers, Streams, Lakes, Ponds												
Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Cycle	1	1	1	1	1	1	1	1	1	1	2	2
Sampling	x	x	x	x	x	x	x	x	x	x	x	x
Reporting												x (cycle 1)

Appendix B. Rivers and stream sampling locations included in the NHDES trend monitoring network.

Station ID	River	Town	Waterbody ID	HUC8	HUC8 Name	Elevation (ft)	Latitude	Longitude	Drainage Area (sq. mi.)	Wadeable/ Non-wadeable	Size Category	% developed	Development Category
01-AND	Androscoggin River	GILEAD	MERIV400020103-06	01040002	Lower Androscoggin	674	44.3973	-70.9884	1,536	Non-wadeable	large	1.6%	low
02-ASH	Ashuelot River	HINSDALE	NHRIV802010403-20	01080201	Middle Connecticut	202	42.7861	-72.4865	421	Wadeable	large	6.4%	high
01-CNT	Connecticut River	NORTHFIELD	MARIV802010501-05	01080201	Middle Connecticut	173	42.6836	-72.4714	6721	Non-wadeable	large	5.7%	moderate
01K-HOB	Hodgson Brook	PORTSMOUTH	NHRIV600031001-04	01060003	Piscataqua-Salmon Falls	21	43.0693	-70.7785	4	Wadeable	small	81.4%	high
01-MER	Merrimack River	TYNGSBOROUGH	MARIV700061206-24	01070006	Merrimack River	92	42.6760	-71.4213	4,060	Non-wadeable	large	10.1%	high
01-MSC	Mascoma River	LEBANON	NHRIV801060106-20	01080106	Black-Ottauquechee	358	43.6338	-72.3174	195	Wadeable	large	5.4%	moderate
01-SAC	Saco River	FRYEBURG	MERIV600020305-02	01060002	Saco	391	44.0169	-70.9899	425	Non-wadeable	large	4.2%	moderate
01-SGR	Sugar River	CLAREMONT	NHRIV801060407-16	01080106	Black-Ottauquechee	298	43.3983	-72.3939	272	Wadeable	large	7.1%	high
01T-SOP	South Branch Piscataquog R	NEW BOSTON	NHRIV700060606-05	01070006	Merrimack River	392	42.9823	-71.6826	56	Wadeable	medium	6.0%	moderate
01-TYB	Tully Brook	RICHMOND	NHRIV802020203-05	01080202	Miller	940	42.7365	-72.2322	5	Wadeable	small	3.4%	moderate
01X-OTB	Otter Brook	ROXBURY	NHRIV802010201-19	01080201	Middle Connecticut	826	42.9713	-72.2162	41	Wadeable	medium	4.7%	moderate
02-BBO	Bear Brook	ALLENSTOWN	NHRIV700060503-16	01070006	Merrimack River	369	43.1452	-71.3552	10	Wadeable	small	4.3%	moderate
02-CLD	Cold River	WALPOLE	NHRIV801070203-09	01080107	West	396	43.1321	-72.3904	83	Wadeable	large	4.6%	moderate
02-CTC	Contoocook River	BOSCAWEN	NHIMP700030507-07	01070003	Contoocook	271	43.2849	-71.5966	763	Non-wadeable	large	5.9%	moderate
02E-NSR	North Branch Sugar River	CROYDON	NHRIV801060404-11	01080106	Black-Ottauquechee	826	43.4154	-72.1804	68	Wadeable	medium	6.1%	high
02-ISG	Isinglass River	ROCHESTER	NHRIV600030607-10	01060003	Piscataqua-Salmon Falls	113	43.2334	-70.9554	74	Non-wadeable	medium	7.7%	high
02-ISR	Israel River	LANCASTER	NHRIV801010806-09	01080101	Upper Connecticut	865	44.4879	-71.5696	133	Wadeable	large	2.9%	low
02-SHG	Souhegan River	MERRIMACK	NHRIV700060906-18	01070006	Merrimack River	95	42.8606	-71.4930	169	Wadeable	large	12.1%	high
03-AMM	Ammonoosuc River	BATH	NHRIV801030506-10	01080103	Waits	466	44.1548	-71.9819	396	Wadeable	large	4.9%	moderate
03-JWT	Jewett Brook	LACONIA	NHRIV700020201-16	01070002	Winnipesauke e River	512	43.5317	-71.4631	5	Wadeable	small	27.3%	high
04-SBB	Stratford Bog Brook	STRATFORD	NHRIV801010602-02	01080101	Upper Connecticut	1530	44.6817	-71.4958	17	Wadeable	small	0.0%	low
05-NWL	Newell Brook	DUMMER	NHRIV400010602-10	01040001	Upper Androscoggin	1276	44.6863	-71.2254	7	Wadeable	small	0.0%	low
05-SMS	Simms Stream	COLUMBIA	NHRIV801010403-02	01080101	Upper Connecticut	1263	44.8492	-71.4931	28	Wadeable	medium	1.2%	low
06-SBR	South Branch Baker River	WENTWORTH	NHRIV700010304-12	01070001	Pemigewasset	793	43.8187	-71.9305	31	Wadeable	medium	1.6%	low
07-BLM	Bellamy River	MADBURY	NHRIV600030903-08	01060003	Piscataqua-Salmon Falls	93	43.1744	-70.9178	23	Wadeable	medium	9.5%	high
07-FLT	Flints Brook	HOLLIS	NHRIV700040402-03	01070004	Nashua	178	42.7266	-71.5562	5	Wadeable	small	15.2%	high
07T-ISG	Isinglass River	BARRINGTON	NHRIV600030607-01	01060003	Piscataqua-Salmon Falls	235	43.2388	-71.0766	58	Wadeable	medium	5.6%	moderate
08-MER	Merrimack River	MANCHESTER	NHRIV700060803-14-02	01070006	Merrimack River	110	42.9360	-71.4565	3,086	Non-wadeable	large	7.0%	high
09-OYS	Oyster River	LEE	NHRIV600030902-04	01060003	Piscataqua-Salmon Falls	69	43.1483	-70.9657	12	Wadeable	small	11.2%	high
06-EBS	East Branch Saco River	JACKSON	NHRIV600020301-01	01060002	Saco	1701	44.1219	-71.1303	34	Wadeable	small	0.3%	low
14-ISR	Israel River	JEFFERSON	NHRIV801010806-06	01080101	Upper Connecticut	1052	44.4119	-71.4978	71	Wadeable	medium	2.7%	low
15-EXT	Exeter River	BRENTWOOD	NHRIV600030803-05	01060003	Piscataqua-Salmon Falls	65	42.9847	-71.0384	63	Wadeable	medium	10.2%	high
18-CCH	Cocheco River	ROCHESTER	NHIMP600030607-02	01060003	Piscataqua-Salmon Falls	160	43.2743	-70.9772	80	Non-wadeable	large	14.0%	high
22-AMM	Ammonoosuc River	BETHLEHEM	NHRIV801030403-01	01080103	Waits	1183	44.2716	-71.6316	88	Wadeable	large	4.0%	moderate
23-PMI	Pemigewasset River	WOODSTOCK	NHRIV700010203-01	01070001	Pemigewasset	704	44.0221	-71.6820	181	Non-wadeable	large	2.4%	low
27-MER	Merrimack River	CONCORD	NHRIV700060302-24	01070006	Merrimack River	240	43.2710	-71.5645	2,359	Non-wadeable	large	5.3%	moderate
58-CNT	Connecticut River	LANCASTER	NHRIV801010902-03	01080101	Upper Connecticut	815	44.4961	-71.5944	1,243	Non-wadeable	large	5.4%	moderate
02-GNB	Grant Brook	LYME	NHRIV801040204-02	01080104	Upper Connecticut-Mascoma	489	43.8075	-72.1636	13	Wadeable	small	2.1%	low
01T-MKB	Mink Brook	HANOVER	NHRIV801040401-05	01080104	Upper Connecticut-Mascoma	502	43.6928	-72.2748	17	Wadeable	medium	6.4%	high
10-WNR	Warner River	BRADFORD	NHRIV700030302-12	01070003	Contoocook	610	43.2675	-71.9188	58	Wadeable	medium	4.4%	moderate

Appendix C. Lakes and ponds included in the NHDES trend monitoring network.

Waterbody	Town	HUC 8	HUC 8 Name	Year Span	Total Years	Waterbody ID	Trophic Class	Year of Trophic Class	% developed	Development Category
Armington Lake	Piermont	1080104	Upper Connecticut River - Mascoma River	1990-2012	23	NHLAK801040201-01	Oligo	2007	2.0	low
Ashuelot Pond	Washington	1080201	Middle Connecticut River	1989-2012	24	NHLAK802010101-01	Meso	2004	3.1	moderate
Ayers Lake	Barrington	1060003	Piscataqua River - Salmon Falls River	1987-2012	26	NHLAK600030607-01	Oligo	1995	7.1	high
Baxter Lake	Farmington	1060003	Piscataqua River - Salmon Falls River	1999-2012	14	NHLAK600030602-01	Meso	1995	3.5	moderate
Bearcamp Pond	Sandwich	1060002	Saco River	1991-2012	22	NHLAK600020601-01-01	Meso	1998	0.9	low
Beaver Lake	Derry	1070006	Merrimack River	1993-2012	20	NHLAK700061203-02-01	Meso	1999	20.6	high
Blaisdell Lake	Sutton	1070003	Contoocook River	1986-2012	27	NHLAK700030302-02	Meso	2005	7.7	high
Broad Bay	Ossipee	1060002	Saco River	1990-2012	23	NHLAK600020804-01-03	Oligo	2003	3.9	moderate
Captains Pond	Salem	1070006	Merrimack River	2001-2012	12	NHLAK700061102-03-01	Meso	2002	33.8	high
Chalk Pond	Newbury	1080106	Black River - Ottauquechee River	1986-2012	27	NHLAK801060402-03	Meso	2006	3.7	moderate
Chestnut Pond	Epsom	1070006	Merrimack River	2002-2012	11	NHLAK700060502-03	Meso	2006	4.1	moderate
Clement Pond	Hopkinton	1070003	Contoocook River	1991-2012	22	NHLAK700030505-01	Meso	1990	3.4	moderate
Clough Pond	Loudon	1070006	Merrimack River	2002-2012	11	NHLAK700060202-03-01	Meso	2002	3.5	moderate
Contoocook Lake	Jaffrey	1070003	Contoocook River	1994-2012	19	NHLAK700030101-03-01	Meso	2006	5.8	moderate
Crescent Lake	Acworth	1080107	West River	1990-2012	23	NHLAK801070201-01	Meso	1992	4.1	moderate
Crystal Lake	Gilmanton	1070006	Merrimack River	1989-2012	24	NHLAK700060401-02-01	Oligo	2003	1.4	low
Deering Lake	Deering	1070006	Merrimack River	1987-2012	26	NHLAK700060601-01	Oligo	1997	5.0	moderate
Dorrs Pond	Manchester	1070006	Merrimack River	2000-2012	13	NHLAK700060802-01	Meso	1997	76.0	high
Eastman Pond	Grantham	1080106	Black River - Ottauquechee River	1987-2012	26	NHLAK801060401-06	Meso	1999	9.7	high
Forest Lake	Winchester	1080201	Middle Connecticut River	1991-2012	22	NHLAK802010401-01-01	Eutro	2005	2.4	low
Gilmore Pond	Jaffrey	1070003	Contoocook River	1990-2012	23	NHLAK700030101-05	Oligo	2006	6.4	high
Granite Lake	Stoddard	1080201	Middle Connecticut River	1989-2012	24	NHLAK802010201-05	Oligo	2006	7.4	high
Great Pond, North	Kingston	1070006	Merrimack River	1995-2012	18	NHLAK700061403-06-01	Meso	2004	13.4	high
Halfmoon Lake	Barnstead	1070006	Merrimack River	1989-2012	24	NHLAK700060402-03	Meso	1992	7.2	high
Halfmoon Pond	Washington	1070003	Contoocook River	1992-2012	21	NHLAK700030201-02	Meso	2001	1.6	low
Harvey Lake	Northwood	1070006	Merrimack River	1995-2012	18	NHLAK700060502-05	Eutro	2006	14.1	high
Highland Lake	Andover	1070001	Pemigewasset River	1987-2012	26	NHLAK700010804-01-01	Meso	1994	3.6	moderate
Highland Lake, North	Stoddard	1070003	Contoocook River	2001-2012	12	NHLAK700030201-03	Meso	2007	3.2	moderate
Island Pond	Stoddard	1070003	Contoocook River	1988-2012	25	NHLAK700030202-02-01	Meso	2004	3.3	moderate
Island Pond, Big	Derry	1070006	Merrimack River	1990-2012	23	NHLAK700061101-01-01	Eutro	2002	19.7	high
Jenness Pond	Northwood	1070006	Merrimack River	1994-2012	19	NHLAK700060502-06	Meso	1991	6.2	high
Kezar Lake	North Sutton	1070003	Contoocook River	1988-2012	25	NHLAK700030303-03-01	Meso	2003	13.6	high
Kolelemook Lake	Springfield	1080106	Black River - Ottauquechee River	1987-2012	26	NHLAK801060401-08-01	Oligo	1996	4.6	moderate
Lake Skatuatakee	Harrisville	1070003	Contoocook River	1989-2012	24	NHLAK700030103-08	Meso	2006	2.5	low
Lake Sunapee, Stn 200	Sunapee	1080106	Black River - Ottauquechee River	1990-2012	23	NHLAK801060402-05-01	Oligo	2006	7.7	high
Lake Waukewan, Mayo Stn	Meredith	1070002	Winnipesaukee River	1993-2012	20	NHLAK700020108-02-01	Oligo	1994	5.0	moderate
Lake Winnisquam, Pot Island	Laconia	1070002	Winnipesaukee River	1987-2012	26	NHLAK700020201-05-01	Oligo	2007	7.4	high
Laurel Lake	Fitzwilliam	1080202	Miller River	1989-2012	24	NHLAK802020202-02-01	Oligo	2006	5.4	moderate
Leavitt Bay	Ossipee	1060002	Saco River	1990-2012	23	NHLAK600020804-01-02	Oligo	2003	4.0	moderate
Lees Pond	Moultonborough	1070002	Winnipesaukee River	1991-2012	22	NHLAK700020103-05	Meso	1992	3.5	moderate
Little Lake Sunapee	New London	1080106	Black River - Ottauquechee River	1999-2012	14	NHLAK801060402-04-01	Oligo	2008	4.5	moderate
Loon Lake	Plymouth	1070001	Pemigewasset River	1989-2012	24	NHLAK700010307-01	Meso	1999	1.6	low
Loon Pond	Gilmanton	1070006	Merrimack River	1996-2012	17	NHLAK700060201-01-01	Meso	1996	3.8	moderate

Waterbody	Town	HUC 8	HUC 8 Name	Year Span	Total Years	Waterbody ID	Trophic Class	Year of Trophic Class	% developed	Development Category
Mascoma Lake, Stn. 1	Enfield	1080106	Black River - Ottauquechee River	1991-2012	22	NHLAK801060105-04-01	Oligo	2008	3.1	moderate
Massasecum Lake	Bradford	1070003	Contoocook River	1986-2012	27	NHLAK700030302-04-01	Meso	2005	3.9	moderate
Messer Pond	New London	1070003	Contoocook River	1996-2012	17	NHLAK700030303-04	Meso	1996	12.3	high
Millen Pond	Washington	1080201	Middle Connecticut River	1995-2012	18	NHLAK802010101-06-01	Oligo	1997	6.1	high
Mountainview Lake	Sunapee	1080106	Black River - Ottauquechee River	1985-2012	28	NHLAK801060402-11	Oligo	1992	9.4	high
New Pond	Canterbury	1070006	Merrimack River	2002-2012	11	NHLAK700060201-03	Meso	1997	1.8	low
Northwood Lake	Northwood	1070006	Merrimack River	1998-2012	15	NHLAK700060502-08-01	Meso	2000	8.1	high
Nubanusit Lake	Nelson	1070003	Contoocook River	1991-2012	22	NHLAK700030103-07	Oligo	2003	0.7	low
Nutts Pond	Manchester	1070006	Merrimack River	2000-2012	13	NHLAK700060803-01	Meso	1995	94.7	high
Otter Pond	Sunapee	1080106	Black River - Ottauquechee River	1986-2012	27	NHLAK801060402-12-01	Meso	2008	7.4	high
Partridge Lake	Littleton	1080103	Waits River	1989-2012	24	NHLAK801030502-03	Meso	2006	4.4	moderate
Pawtuckaway Lake, North Stn	Nottingham	1060003	Piscataqua River - Salmon Falls River	1988-2012	25	NHLAK600030704-02-01	Meso	1998	4.4	moderate
Pea Porridge Ponds (Big)	Madison	1060002	Saco River	1995-2012	18	NHLAK600020303-05	Oligo	2001	5.5	moderate
Pea Porridge Ponds (Middle)	Madison	1060002	Saco River	1995-2012	18	NHLAK600020303-06	Meso	2001	6.4	high
Pearly Pond	Rindge	1080202	Miller River	1992-2012	21	NHLAK802020103-08	Eutro	2004	6.1	high
Perkins Pond	Sunapee	1080106	Black River - Ottauquechee River	1987-2012	26	NHLAK801060405-03	Meso	2003	7.4	high
Pine Island Pond	Manchester	1070006	Merrimack River	2000-2012	13	NHLAK700060703-04	Eutro	1997	22.1	high
Pleasant Lake	New London	1070003	Contoocook River	1997-2012	16	NHLAK700030402-02-01	Oligo	1993	2.9	low
Pleasant Lake	Deerfield	1070006	Merrimack River	1989-2012	24	NHLAK700060502-09-01	Oligo	1996	6.5	high
Pleasant Pond	Francestown	1070006	Merrimack River	2000-2012	13	NHLAK700060604-01	Meso	2004	3.9	moderate
Province Lake	Effingham	1060002	Saco River	1991-2012	22	NHLAK600020902-01	Meso	2006	8.2	high
Rand Pond	Goshen	1080106	Black River - Ottauquechee River	1994-2012	19	NHLAK801060403-04-01	Oligo	1994	6.9	high
Robinson Pond	Hudson	1070006	Merrimack River	2000-2012	13	NHLAK700061203-06-01	Meso	1998	18.8	high
Rockybound Pond	Croydon	1080106	Black River - Ottauquechee River	1990-2012	23	NHLAK801060404-01	Meso	2006	2.3	low
Rust Pond	Wolfeboro	1070002	Winnipesaukee River	1988-2012	25	NHLAK700020101-07-01	Oligo	2000	5.7	moderate
Sand Pond	Marlow	1080201	Middle Connecticut River	2000-2012	13	NHLAK802010101-08	Oligo	2008	3.8	moderate
Sebbins Pond	Bedford	1070006	Merrimack River	1987-2012	26	NHLAK700060804-02	Meso	1999	48.5	high
Silver Lake	Harrisville	1080201	Middle Connecticut River	1991-2012	22	NHLAK802010202-09	Oligo	1998	2.9	low
Spofford Lake	Chesterfield	1080107	West River	1990-2012	23	NHLAK801070503-01-01	Oligo	1995	9.0	high
Stevens Pond	Manchester	1070006	Merrimack River	2000-2012	13	NHLAK700060803-02	Eutro	1997	88.2	high
Stinson Lake	Rumney	1070001	Pemigewasset River	1988-2012	25	NHLAK700010306-01	Oligo	2002	1.3	low
Stocker Pond	Grantham	1080106	Black River - Ottauquechee River	1988-2012	25	NHLAK801060401-02	Meso	2001	12.0	high
Swanzey Lake	Swanzey	1080201	Middle Connecticut River	1990-2012	23	NHLAK802010302-01-01	Meso	2005	3.8	moderate
Tarleton Lake	Piermont	1080104	Upper Connecticut River - Mascoma River	2002-2012	11	NHLAK801040201-03	Oligo	1992	1.5	low
Thorndike Pond	Jaffrey	1070003	Contoocook River	1990-2012	23	NHLAK700030102-01-01	Oligo	1998	3.2	moderate
Todd Lake	Newbury	1070003	Contoocook River	1987-2012	26	NHLAK700030301-02	Meso	1991	3.9	moderate
Tom Pond	Warner	1070003	Contoocook River	1987-2012	26	NHLAK700030304-05	Meso	2006	9.4	high
Webster Lake	Franklin	1070001	Pemigewasset River	1986-2012	27	NHLAK700010804-02-01	Oligo	1992	3.5	moderate
White Oak Pond	Holderness	1070001	Pemigewasset River	1989-2012	24	NHLAK700010501-05	Meso	1990	1.7	low
Winnepocket Lake	Webster	1070003	Contoocook River	1995-2012	18	NHLAK700030304-08	Oligo	1998	1.9	low

Appendix D. Beaches included in the NHDES lake and pond trend monitoring network.

Beach Name	Waterbody ID	Waterbody Name	Town	Sample Total	Advisory Total (days)
AHERN STATE PARK	NHLAK700020201-05-05	LAKE WINNISQUAM - AHERN STATE PARK	LACONIA	175	5
ANGLE POND GROVE	NHLAK700061403-01-02	ANGLE POND - ANGLE POND GROVE BEACH	SANDOWN	59	19
BABOOSIC LAKE PARK TB	NHLAK700060905-01-02	BABOOSIC LAKE - TOWN BEACH	AMHERST	87	25
BEARCAMP POND TB	NHLAK600020601-01-02	BEARCAMP POND - TOWN BEACH	SANDWICH	66	5
BEARDS BROOK TB	NHRIV700030204-15-02	BEARDS BROOK - TOWN BEACH	HILLSBOROUGH	88	0
BEAVER LAKE GALLIEN'S BEACH	NHLAK700061203-02-02	BEAVER LAKE - GALLIEN'S BEACH	DERRY	104	10
BOW LAKE BENNETT BRIDGE TB	NHLAK600030604-01-04	BOW LAKE - BENNETT BRIDGE BEACH	NORTHWOOD	67	11
BOW LAKE MARY WALDRON TB	NHLAK600030604-01-03	BOW LAKE - MARY WALDRON BEACH	NORTHWOOD	89	8
BOW LAKE TB	NHLAK600030604-01-02	BOW LAKE - TOWN BEACH	STRAFFORD	88	0
BURNS POND PB	NHLAK801030101-01-02	BURNS POND - PUBLIC BEACH	WHITEFIELD	63	10
CAMPER BEACH ON BEAVER POND AT BEAR BROOK STATE PARK	NHIMP600030702-01-02	BEAVER POND - BEAVER POND BEACH	ALLENSTOWN	69	0
CANAAN STREET LAKE TB	NHLAK801060101-01-02	CANAAN STREET LAKE - TOWN BEACH	CANAAN	79	0
CHESHAM BEACH	NHLAK802010202-07-02	RUSSEL RESERVOIR - CHESHAM BEACH	HARRISVILLE	65	0
CHOCURUA LAKE PB	NHLAK600020604-01-04	LAKE CHOCORUA - PUBLIC BEACH	TAMWORTH	92	0
CHOCURUA LAKE TB	NHLAK600020604-01-03	LAKE CHOCORUA - TOWN BEACH	TAMWORTH	92	6
CLARK POND FB ARGUE REC AREA	NHIMP700060501-03-02	CLARKS POND - TOWN BEACH	PITTSFIELD	87	0
CLOUGH SP	NHLAK700060602-01-02	EVERETT LAKE - CLOUGH STATE PARK BEACH	WEARE	68	9
COBBETTS POND TB	NHLAK700061204-01-03	COBBETTS POND - TOWN BEACH	WINDHAM	71	0
COLD RIVER POT HOLE TB	NHRIV600020602-04-02	COLD RIVER - POT HOLE TOWN BEACH	SANDWICH	56	137
CONWAY LAKE TB	NHLAK600020304-01-02	CONWAY LAKE - TOWN BEACH	CONWAY	81	13
CORCORANS POND TB	NHIMP700010401-01-02	SNOWS BROOK - CORCORAN POND TOWN BEACH	WATERVILLE VALLEY	64	0
COUNTRY POND TB	NHLAK700061403-03-02	COUNTRY POND - TOWN BEACH	NEWTON	67	0
CRYSTAL LAKE TB	NHLAK700060703-02-02	CRYSTAL LAKE-TOWN BEACH	MANCHESTER	249	0
CRYSTAL LAKE TB	NHLAK700060401-02-02	CRYSTAL LAKE-TOWN BEACH	GILMANTON	110	9
CRYSTAL LAKE TB	NHLAK600020304-02-02	CRYSTAL LAKE-TOWN BEACH	EATON	84	2
CUNNINGHAM POND TB	NHLAK700030104-02-02	CUNNINGHAM POND - TOWN BEACH	PETERBOROUGH	60	25
DARRAH POND BEACH	NHLAK700061002-01-02	DARRAH POND - TOWN BEACH	LITCHFIELD	66	6
DAY-USE BEACH ON CATAMOUNT POND AT BEAR BROOK SP	NHLAK700060503-02-02	CATAMOUNT POND - BEAR BROOK STATE PARK BEACH	ALLENSTOWN	162	0
DUNCAN LAKE TB	NHLAK600020703-01-02	DUNCAN LAKE - TOWN BEACH	OSSIPEE	57	0
ECHO LAKE SP	NHLAK600020302-01-02	ECHO LAKE - STATE PARK BEACH	CONWAY	96	11
ELLACOYA SP	NHLAK700020110-02-12	LAKE WINNIPESAUKEE - ELACOYA STATE PARK BEACH	GILFORD	166	4
ELM BROOK PARK	NHIMP700030503-01-02	ELM BROOK - ELM BROOK PARK BEACH	HOPKINTON	437	11
FOREST LAKE SP	NHLAK801030101-02-02	FOREST LAKE - FOREST LAKE STATE PARK	DALTON	73	0
FOREST LAKE TB	NHLAK802010401-01-02	FOREST LAKE - TOWN BEACH	WINCHESTER	58	3
FRANCONIA SP	NHLAK801030302-01-02	ECHO LAKE - FRANCONIA STATE PARK BEACH	FRANCONIA	103	13
FRENCH POND BEACH	NHLAK700030504-02-02	FRENCH POND - PUBLIC ACCESS	HENNIKER	61	0
GREGG LAKE TB	NHLAK700030108-02-02	GREGG LAKE - TOWN BEACH	ANTRIM	97	1
HARRISVILLE LAKE TB	NHLAK700030103-05-02	HARRISVILLE LAKE - SUNSET TOWN BEACH	HARRISVILLE	56	25
HAUNTED LAKE TB	NHLAK700060605-04-02	HAUNTED LAKE - TOWN BEACH	FRANCESTOWN	58	1
HERMIT LAKE TB	NHLAK700010802-03-02	HERMIT LAKE - TOWN BEACH	SANBORNTON	81	0
HIGHLAND LAKE TB	NHLAK700010804-01-02	HIGHLAND LAKE - TOWN BEACH	ANDOVER	58	19
HOOD POND TB	NHLAK700061203-03-02	HOODS POND - TOWN BEACH	DERRY	99	53
HORACE LAKE CHASE PARK TB	NHLAK700060601-05-02	WEARE RESERVOIR - CHASE PARK TOWN BEACH	WEARE	85	0
INDIAN POND TB	NHLAK801040205-01-02	INDIAN POND - TOWN BEACH	ORFORD	63	5
ISLAND POND CHASE'S GROVE	NHLAK700061101-01-02	ISLAND POND - CHASE'S GROVE	DERRY	75	43

Beach Name	Waterbody ID	Waterbody Name	Town	Sample Total	Advisory Total (days)
ISLAND POND PB	NHLAK700030202-02-02	ISLAND POND - PUBLIC BEACH	STODDARD	59	12
ISLAND POND SANBORN SHORE ACRES	NHLAK700061101-01-03	ISLAND POND - SANBORN SHORE ACRES	HAMPSTEAD	57	2
KILTON POND HUFF BEACH	NHLAK700010701-02-02	KILTON POND - HUFF BEACH	GRAFTON	58	0
KIMBALL POND TB	NHIMP700030507-01-02	KIMBALL POND - KIMBALL POND TOWN BEACH	HOPKINTON	58	6
KINGSTON SP	NHLAK700061403-06-02	GREAT POND - KINGSTON STATE PARK BEACH	KINGSTON	104	2
KOLELEMOOK LAKE TB	NHLAK801060401-08-02	KOLEMOOK LAKE - TOWN BEACH	SPRINGFIELD	66	4
LAKE CONTOOCOOK TB	NHLAK700030101-03-02	CONTOOCOOK LAKE - TOWN BEACH	JAFFREY	101	0
LAKE NATICOOK WASSERMAN PARK	NHLAK700061002-04-02	NATICOOK LAKE - WASSERMAN PARK BEACH	MERRIMACK	125	0
LAKE POTANIPO TB	NHLAK700040401-02-02	LAKE POTANIPO - TOWN BEACH	BROOKLINE	62	9
LAKE SUNAPEE BLODGETTS LANDING	NHLAK801060402-05-04	SUNAPEE LAKE - BLODGETT'S LANDING BEACH	NEWBURY	40	0
LAKE SUNAPEE DEPOT BEACH	NHLAK801060402-05-06	SUNAPEE LAKE - DEPOT BEACH	NEWBURY	64	48
LAKE SUNAPEE GEORGES MILL TB	NHLAK801060402-05-02	SUNAPEE LAKE - GEORGES MILL TOWN BEACH	SUNAPEE	60	3
LAKE TARLETON STATE PARK	NHLAK801040201-03-03	LAKE TARLETON - LAKE TARLETON STATE PARK BEACH	PIERMONT	52	0
LAKE WENTWORTH ALBEE BEACH	NHLAK700020101-05-02	LAKE WENTWORTH - ALBEE BEACH	WOLFEBORO	128	17
LAKE WENTWORTH SP	NHLAK700020101-05-03	LAKE WENTWORTH - WENTWORTH STATE PARK BEACH	WOLFEBORO	125	0
LAKE WINNIPESAUKEE ALTON BAY TB	NHLAK700020110-02-10	LAKE WINNIPESAUKEE - ALTON BAY TOWN BEACH	ALTON	97	1
LAKE WINNIPESAUKEE BREWSTER BEACH	NHLAK700020110-02-09	LAKE WINNIPESAUKEE - BREWSTER BEACH	WOLFEBORO	115	0
LAKE WINNIPESAUKEE CARRY BEACH	NHLAK700020110-02-08	LAKE WINNIPESAUKEE - CARRY BEACH	WOLFEBORO	100	4
LAKE WINNIPESAUKEE ENDICOTT PARK	NHLAK700020110-02-14	LAKE WINNIPESAUKEE - ENDICOTT PARK WEIRS BEACH	LACONIA	245	1
LAKE WINNIPESAUKEE LEAVITT PARK	NHLAK700020110-02-15	LAKE WINNIPESAUKEE - LEAVITT PARK BEACH	MEREDITH	89	4
LAKE WINNIPESAUKEE PB	NHLAK700020110-02-07	LAKE WINNIPESAUKEE - PUBLIC BEACH	TUFTONBORO	105	8
LAKE WINNIPESAUKEE PUBLIC DOCK TB	NHLAK700020110-02-11	LAKE WINNIPESAUKEE - PUBLIC DOCK TOWN BEACH	ALTON	90	12
LAKE WINNIPESAUKEE STATES LANDING TB	NHLAK700020110-02-17	LAKE WINNIPESAUKEE - STATES LANDING TOWN BEACH	MOULTONBOROUGH	61	4
LAKE WINNIPESAUKEE TB	NHLAK700020110-02-13	LAKE WINNIPESAUKEE - GILFORD TOWN BEACH	GILFORD	126	8
LAKE WINNIPESAUKEE TB	NHLAK700020110-02-16	LAKE WINNIPESAUKEE - TOWN BEACH (CENTER HARBOR)	CENTER HARBOR	56	0
LAKE WINNIPESAUKEE TB	NHLAK700020110-02-05	LAKE WINNIPESAUKEE - MOULTONBOROUGH TOWN BEACH	MOULTONBOROUGH	65	8
LAKE WINNIPESAUKEE WAWBEEK CONDO ASSOC BEACH	NHLAK700020110-02-37	LAKE WINNIPESAUKEE - WAWBEEK CONDO ASSOC BEACH	TUFTONBORO	49	7
LAKE WINNISQUAM BARTLETT TB	NHLAK700020201-05-03	LAKE WINNISQUAM - BARTLETTS BEACH	LACONIA	221	7
LAKE WINNISQUAM TB	NHLAK700020201-05-02	LAKE WINNISQUAM - TOWN BEACH	SANBORNTON	66	20
LAUREL LAKE TB	NHLAK802020202-02-02	LAUREL LAKE - TOWN BEACH	FITZWILLIAM	62	8
LITTLE SQUAM LAKE TB	NHLAK700010502-01-02	LITTLE SQUAM LAKE - TOWN BEACH	ASHLAND	134	9
LITTLE SUNAPEE LAKE BUCKLIN TB	NHLAK801060402-04-02	LITTLE SUNAPEE LAKE - BUCKLIN TOWN BEACH	NEW LONDON	110	0
LONG POND TB	NHLAK700061205-02-02	LONG POND - TOWN BEACH	PELHAM	96	59
LOVELL POND TB	NHLAK600030401-01-02	LOVELL POND - TOWN BEACH	WAKEFIELD	69	1
MACDOWELL RESERVOIR BEACH	NHLAK700030103-06-02	MACDOWELL RESERVOIR - MACDOWELL RESERVOIR BEACH	PETERBOROUGH	457	8
MASCOMA LAKE DARTMOUTH COLLEGE YACHT CLUB	NHLAK801060105-04-04	MASCOMA LAKE - DARTMOUTH COLLEGE BEACH	ENFIELD	48	0
MASCOMA LAKE SHAKOMA TB	NHLAK801060105-04-02	MASCOMA LAKE - SHAKOMA BEACH	ENFIELD	58	3
MASSASECUM CASINO	NHLAK700030302-04-02	LAKE MASSASECUM - MASSASECUM CASINO BEACH	BRADFORD	87	33
MASSASECUM LAKE FRENCH'S PARK TB	NHLAK700030302-04-03	LAKE MASSASECUM - FRENCH'S PARK TOWN BEACH	BRADFORD	100	0
MELENDY POND TB	NHLAK700040401-01-02	MELENDY POND - TOWN BEACH	BROOKLINE	61	0
MELVIN VILLAGE TOWN PIER	NHLAK700020110-02-04	LAKE WINNIPESAUKEE - MELVIN VILLAGE LAKE TOWN PIER BEACH	TUFTONBORO	68	2
MILL POND BEACH	NHIMP600020702-01-02	DAN HOLE RIVER - MILL POND TOWN BEACH	OSSIPEE	64	97
MILL POND TB	NHIMP700030204-05-02	BEARDS BROOK - MILL POND TOWN BEACH	WASHINGTON	119	2
MILLEN POND TB	NHLAK802010101-06-02	MILLEN POND - TOWN BEACH	WASHINGTON	101	7
MILTON POND REC AREA	NHLAK600030404-01-03	MILTON THREE PONDS - MILTON POND REC AREA BEACH	MILTON	123	12
MIRROR LAKE BEACH	NHLAK700020106-02-02	MIRROR LAKE - MIRROR LAKE BEACH	TUFTONBORO	65	0
MOORES POND ASSOCIATION BEACH	NHLAK600020604-03-03	MOORES POND - ASSOCIATION BEACH	TAMWORTH	61	1

Beach Name	Waterbody ID	Waterbody Name	Town	Sample Total	Advisory Total (days)
MOORES POND SKI AND BEACH	NHLAK600020604-03-02	MOORES POND - MOORES POND SKI AND BEACH	TAMWORTH	175	7
MOOSE BROOK SP	NHIMP400020101-02-02	MOOSE BROOK - MOOSE BROOK STATE PARK BEACH	GORHAM	81	6
MOOSE BROOK TP	NHIMP400020101-01-02	MOOSE BROOK - TOWN POOL-RAVINE BEACH	RANDOLPH	56	0
NEWFOUND LAKE CUMMINGS BEACH	NHLAK700010603-02-04	NEWFOUND LAKE - CUMMINGS BEACH	BRISTOL	91	4
NEWFOUND LAKE HEBRON TOWN BEACH	NHLAK700010603-02-14	NEWFOUND LAKE - HEBRON TOWN BEACH	HEBRON	70	2
NEWFOUND LAKE-AVERY-CROUSE BEACH	NHLAK700010603-02-02	NEWFOUND LAKE - TOWN BEACH	BRISTOL	87	2
NORTHWOOD LAKE TB	NHLAK700060502-08-02	NORTHWOOD LAKE - TOWN BEACH	NORTHWOOD	183	2
NORTHWOOD LAKE-LYNN GROVE ASSOC	NHLAK700060502-08-04	NORTHWOOD LAKE - LYNN GROVE ASSOCIATION BEACH	NORTHWOOD	60	13
NORWAY POND TB	NHLAK700030107-02-02	NORWAY POND - TOWN BEACH	HANCOCK	64	14
OPECHEE BAY BOND BEACH	NHLAK700020201-06-02	OPECHEE BAY - BOND BEACH	LACONIA	83	102
OPECHEE BAY OPECHEE PARK COVE	NHLAK700020201-06-04	OPECHEE BAY - OPECHEE PARK COVE BEACH	LACONIA	174	8
OPECHEE BAY OPECHEE POINT	NHLAK700020201-06-03	OPECHEE BAY - OPECHEE POINT BEACH	LACONIA	128	27
OTTER BROOK PARK	NHLAK802010201-06-02	OTTER BROOK LAKE - OTTER BROOK PK BEACH	KEENE	464	3
OTTER LK GREENFIELD SP-CAMPING BCH	NHLAK700030105-02-05	OTTER LAKE - GREENFIELD SP CAMPING BEACH	GREENFIELD	107	4
OTTER LK GREENFIELD SP-MIDDLE BCH	NHLAK700030105-02-04	OTTER LAKE - GREENFIELD SP MIDDLE BEACH	GREENFIELD	121	11
OTTER LK GREENFIELD SP-PICNIC BCH	NHLAK700030105-02-03	OTTER LAKE - GREENFIELD SP PICNIC BEACH	GREENFIELD	126	14
PAWTUCKAWAY LAKE TB	NHLAK600030704-02-03	PAWTUCKAWAY LAKE - TOWN BEACH	NOTTINGHAM	62	3
PAWTUCKAWAY SP	NHLAK600030704-02-02	PAWTUCKAWAY LAKE - PAWTUCKAWAY STATE PARK BEACH	NOTTINGHAM	307	4
PEABODY RIVER LIBBY TOWN POOL	NHLAK400020102-01	PEABODY RIVER - LIBBY TOWN POOL	GORHAM	92	0
PHILLIPS POND SEELEY TB	NHLAK600030802-03-02	PHILLIPS POND - SEELEY TOWN BEACH	SANDOWN	72	0
PIERCE LAKE MANAHAN PARK	NHLAK700030202-03-02	JACKMAN RESERVOIR - MANAHAN PARK TOWN BEACH	HILLSBOROUGH	112	111
PLEASANT LAKE ELKINS BEACH	NHLAK700030402-02-02	PLEASANT LAKE - ELKINS BEACH	NEW LONDON	114	2
PLEASANT LAKE TB	NHLAK700060601-03-02	PLEASANT LAKE - PUBLIC ACCESS BEACH	HENNIKER	62	5
PLEASANT LAKE VEASEY PARK	NHLAK700060502-09-02	PLEASANT LAKE - VEASEY PARK BEACH	DEERFIELD	75	9
POST POND CHASE TB	NHLAK801040203-01-02	POST POND - CHASE TOWN BEACH	LYME	70	146
RAINBOW LAKE KAREN-GENA BEACH ASSOC	NHLAK700061203-05-02	RAINBOW LAKE - KAREN-GENA BEACH	DERRY	31	25
RAND POND PUBLIC WAY	NHLAK801060403-04-02	RAND POND - PUBLIC WAY BEACH	GOSHEN	63	9
ROBINSON POND TB	NHLAK700061203-06-02	ROBINSON POND - TOWN BEACH	HUDSON	223	11
SACO RIVER DAVIS PARK REC AREA	NHRIV600020304-01-02	SACO RIVER - DAVIS PARK REC AREA BEACH	CONWAY	56	29
SACO RIVER FIRST BRIDGE REC AREA	NHRIV600020302-02-02	SACO RIVER - FIRST BRIDGE REC AREA BEACH	CONWAY	57	26
SANDY BEACH CAMPGROUND	NHLAK700030505-04-01	ROLF POND - SANDY BEACH CAMPGROUND BEACH	HOPKINTON	70	3
SILVER LAKE FOOT OF THE LAKE BEACH	NHLAK600020801-06-03	SILVER LAKE - FOOT OF THE LAKE BEACH	MADISON	61	110
SILVER LAKE KENNETT PARK BEACH	NHLAK600020801-06-05	SILVER LAKE - KENNETT PARK BEACH	MADISON	40	13
SILVER LAKE MONUMENT BEACH	NHLAK600020801-06-02	SILVER LAKE - MONUMENT BEACH	MADISON	60	0
SILVER LAKE NICHOLS BEACH	NHLAK600020801-06-04	SILVER LAKE - NICHOLS BEACH	MADISON	58	28
SILVER LAKE RESERVOIR	NHIMP700030304-04-02	SILVER BROOK - SILVER LAKE RESERVOIR BEACH	WARNER	69	4
SILVER LAKE SP	NHLAK700061001-02-02	SILVER LAKE - STATE PARK BEACH	HOLLIS	111	5
SONDOGARDY POND GLINES PARK	NHLAK700060101-02-02	SONDOGARDY POND - GLINES PARK BEACH	NORTHFIELD	225	2
SOUTH POND REC AREA	NHLAK801010707-04-02	SOUTH POND - REC AREA BEACH	STARK	90	9
SPOFFORD LAKE N SHORE RD TB	NHLAK801070503-01-03	SPOFFORD LAKE - N SHORE RD TOWN BEACH	CHESTERFIELD	71	16
SPOFFORD LAKE WARES GROVE TB	NHLAK801070503-01-04	SPOFFORD LAKE - WARES GROVE TOWN BEACH	CHESTERFIELD	93	4
SQUAM LAKE LIVERMORE BEACH	NHLAK700010501-04-02	SQUAM LAKE - LIVERMORE BEACH	HOLDERNESS	52	67
SQUAM LAKE TB	NHLAK700010501-04-03	SQUAM LAKE-TOWN BEACH	SANDWICH	55	2
STONE POND TB	NHLAK802010303-05-02	STONE POND - TOWN BEACH	MARLBOROUGH	62	9
STONY BROOK GOSS PARK TB	NHRIV700060903-16-02	STONY BROOK - TOWN BEACH (GOSS PARK)	WILTON	86	0
STORRS POND ADULT BEACH	NHLAK801040402-02-03	STORRS POND - ADULT BEACH	HANOVER	65	0
STORRS POND REC AREA	NHLAK801040402-02-02	STORRS POND - RECREATION AREA BEACH	HANOVER	75	0

Beach Name	Waterbody ID	Waterbody Name	Town	Sample Total	Advisory Total (days)
SUNAPEE LAKE DEWEY TB	NHLAK801060402-05-03	SUNAPEE LAKE - DEWEY (TOWN) BEACH	SUNAPEE	98	13
SUNAPEE SP	NHLAK801060402-05-05	SUNAPEE LAKE - SUNAPEE STATE PARK BEACH	NEWBURY	109	0
SUNCOOK LAKE TB	NHLAK700060402-10-04	UPPER SUNCOOK LAKE - TOWN BEACH	BARNSTEAD	57	17
SUNSET LAKE SUNSET PARK	NHLAK700061101-03-03	SUNSET LAKE - SUNSET PARK BEACH	HAMPSTEAD	92	19
SUNSET LAKE TB	NHLAK700030105-03-02	SUNSET LAKE - TOWN BEACH	GREENFIELD	61	14
SUNSET LAKE TB	NHLAK700061101-03-02	WASH POND - TOWN BEACH	HAMPSTEAD	176	0
SURRY MTN REC	NHLAK802010104-02-02	SURRY MOUNTAIN RESERVOIR - REC AREA BEACH	SURRY	406	0
SWANZEY LAKE RICHARDSON PARK TB	NHLAK802010302-01-02	SWANZEY LAKE - RICHARDSON PARK TOWN BEACH	SWANZEY	109	0
TANNERY POND BEACH	NHLAK700030402-03-02	TANNERY POND - BEACH	WILMOT	66	0
THORNDIKE POND TB	NHLAK700030102-01-02	THORNDIKE POND - TOWN BEACH	JAFFREY	59	0
TUTTLE BROOK TWIN MTN REC AREA	NHRIV801030402-07-02	TUTTLE BROOK - TWIN MTN REC AREA BEACH	CARROLL	70	0
VILLAGE POND SAND DAM TB	NHIMP802010303-04-02	VILLAGE POND DAM - SAND DAM VILLAGE POND TOWN BEACH	TROY	143	21
WADLEIGH SP	NHLAK700030303-03-02	KEZAR LAKE - WADLEIGH STATE PARK BEACH	SUTTON	91	0
WAUKEWAN LAKE TB	NHLAK700020108-02-03	LAKE WAUKEWAN - TOWN BEACH	MEREDITH	81	5
WEBSTER LAKE GRIFFIN TB	NHLAK700010804-02-02	WEBSTER LAKE - GRIFFIN TOWN BEACH	FRANKLIN	345	21
WEBSTER LAKE LAGACE TB	NHLAK700010804-02-03	WEBSTER LAKE - LEGACE TOWN BEACH	FRANKLIN	326	3
WELLINGTON SP	NHLAK700010603-02-05	NEWFOUND LAKE - WELLINGTON STATE PARK BEACH	BRISTOL	100	2
WHITE LAKE SP	NHLAK600020605-02-02	WHITE LAKE - STATE PARK BEACH	TAMWORTH	96	6
WHITTEMORE POND TB	NHLAK700030108-01-02	WHITTEMORE LAKE - TOWN BEACH	BENNINGTON	58	2
WINNISQUAM LAKE TB	NHLAK700020201-05-04	LAKE WINNISQUAM - BELMONT TOWN BEACH	BELMONT	99	15
ZEPHYR LAKE TB	NHLAK700030105-01-02	ZEPHYR LAKE - TOWN BEACH	GREENFIELD	67	4

Appendix E. Synoptic rotational watershed sampling design based on New Hampshire 10-digit hydrologic unit codes (HUC 10s) and suggested year designated for sampling of at least one lake/pond and one river/stream segment. Schedule corresponds to Figure 5 and is based on sampling 8 - 10 HUC 10s within a given year.

HUC 10	HUC 10 Name	Year									
		1	2	3	4	5	6	7	8	9	10
104000102	Umbagog Lake Drainage					x					
104000103	Aziscohos Lake Drainage			x							
104000104	Magalloway River					x					
104000105	Clear Stream							x			
104000106	Middle Androscoggin River									x	
104000201	Gorham-Shelburne Tributaries		X								
104000202	Androscoggin River (2) at Rumford Point				x						
106000201	Upper Saco River	x									
106000202	Swift River			x							
106000203	Conway Tributaries					x					
106000204	Saco River-Lovewell Pond							x			
106000206	Bearcamp River									x	
106000207	Pine River										x
106000208	Ossipee Lake Drainage				x						
106000209	Ossipee River						x				
106000210	Little Ossipee River								x		
106000305	Salmon Falls River		X								
106000306	Cocheco River				x						
106000307	Lamprey River					x					
106000308	Exeter River								x		
106000309	Great Bay Drainage										x
106000310	Coastal Drainage							x			
107000101	East Branch Pemigewasset River	x									
107000102	Upper Pemigewasset River			x							
107000103	Baker River					x					
107000104	Middle Pemigewasset River							x			
107000105	Squam River									x	
107000106	Newfound River									x	
107000107	Smith River				x						
107000108	Lower Pemigewasset River						x				
107000201	Lake Winnipesaukee Drainage	x									
107000202	Winnipesaukee River			x							
107000301	Upper Contoocook River							x			
107000302	North Branch				x						
107000303	Lower Contoocook River						x				
107000304	Warner River								x		
107000305	Blackwater River										x
107000306	Lower Contoocook River	x									
107000403	Squannacook River									x	
107000404	Nashua River-Squannacook River to mouth				x						
107000601	Upper Merrimack River	x									
107000602	Soucook River			x							
107000603	Concord Tributaries					x					
107000604	Upper Suncook River							x			
107000605	Suncook River									x	
107000606	Piscataquog River		X								
107000607	Cohas Brook										x

HUC 10	HUC 10 Name	Year									
		1	2	3	4	5	6	7	8	9	10
107000608	Manchester Tributaries						x				
107000609	Souhegan River								x		
107000610	Litchfield-Hudson Tributaries										x
107000611	Spickett River							x			
107000612	Merrimack River-Nashua River to Shawsheen River								x		
107000614	Merrimack River-Shawsheen River to mouth					x					
108010101	Connecticut Lakes Drainage	x									
108010102	Headwater Tributaries			x							
108010103	Mohawk River-Stewartstown Tributaries					x					
108010104	Connecticut River-Mohawk River to Nulhegan River							x			
108010106	Connecticut River-Nulhegan River to Upper Ammonoosuc River									x	
108010107	Upper Ammonoosuc River		X								
108010108	Israel River				x						
108010109	Connecticut River-Upper Ammonoosuc River to Johns River						x				
108010301	Johns River		X								
108010302	Connecticut River-Johns River to Ammonoosuc River				x						
108010303	Gale River						x				
108010304	Ammonoosuc River								x		
108010305	Lower Ammonoosuc River										x
108010307	Connecticut River-Ammonoosuc River to Waits River	x									
108010402	Connecticut River-Waits River to Hewes Brook									x	
108010404	Connecticut River-Ompompanoosuc River to White River			x							
108010601	Mascoma River		X								
108010603	Connecticut River-White River to Sugar River										x
108010604	Sugar River						x				
108010607	Connecticut River-Sugar River to Bellows Falls								x		
108010702	Cold River		X								
108010705	Connecticut River-Bellows Falls to Vernon Dam				x						
108020101	Upper Ashuelot River		X								
108020102	The Branch				x						
108020103	Middle Ashuelot River						x				
108020104	Lower Ashuelot River								x		
108020105	Connecticut River-Vernon Dam to Deerfield River										x
108020201	Upper Millers River	x									
108020202	Lower Millers River			x							
	Count of Stations / Year	8	8	8	10	8	8	8	8	8	8