**Sampling & Analysis Plan**

2024 Targeted Assessment monitoring

Lakes

in

Western Massachusetts

(Watershed Cohort B2)

CN#: 601.0

March 2024



Massachusetts Department of Environmental Protection

Division of Watershed Management

Watershed Planning Program

8 New Bond Street

Worcester, MA

***NOTE: This draft sampling plan provides detail re: sampling locations, frequencies, analytes, etc. and is intended to augment WPP’s multi-year programmatic QAPP approved by EPA for 2020 through 2024. The contents mirror selected elements of WPP’s programmatic QAPP (i.e.,QA-R5 EPA Guidance). See the QAPP for relevant information not provided in this SAP.***

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#### Project Organization

The Massachusetts Department of Environmental Protection (MassDEP), Division of Watershed Management (DWM), Watershed Planning Program (WPP) gathers background information, formulates sampling plans and carries out monitoring and assessment activities on rivers, lakes and coastal waters pursuant to the requirements of the Clean Water Act (CWA). Massachusetts’ water monitoring programs include both deterministic (targeted) and probabilistic (random) sampling networks and encompass both rotating watershed monitoring cycles as well as non-rotating, priority-driven schedules (see *A Strategy for Monitoring and Assessing the Quality of Massachusetts’ Waters to Support Multiple Water Resource Management Objectives 2016 – 2025* at <https://www.mass.gov/doc/water-quality-monitoring-strategy-2016-2025/download>) (MassDEP 2018).

Targeted monitoring networks are a component of the Massachusetts’ water monitoring strategy and are used to achieve a wide range of objectives. The types of monitoring objectives that can be addressed with targeted monitoring include water resource assessment, source identification, stressor identification, trend analysis, TMDL development, water quality criteria/biocriteria development and 303(d) list development. Targeted monitoring networks have typically been implemented on rotating watershed schedules in conjunction with the other components of the monitoring strategy. This Sampling and Analysis Plan (SAP) provides details pertaining to the Targeted Assessment Monitoring (TAM) project planned by the WPP for lakes in western Massachusetts in 2024. Specific descriptions of WPP staff roles and responsibilities for this monitoring project are detailed in Table 1. In addition, the WPP fulltime monitoring program staff will be augmented by the hiring of five (5) seasonal employees from May through September to ensure that enough personnel are available to carry out field surveys and selected laboratory analyses, as planned.

| **Table 1.** Project Roles and Responsibilities related to monitoring and data use | |
| --- | --- |
| **Project Personnel** | **Responsibility** |
| Project Coordinators  -James Meek (Site Allotment 5) | Responsible for lake reconnaissance, obtaining landowner access permission, defining logistics for efficient monitoring and generation of useable data at assigned sites using the procedures contained in the TAM Field Operations Manual for lakes and WPP SOPs. |
| Water quality survey crews  -James Meek (lead)  -Therese Beaudoin (lead)  -Pete Mitchell (lead)  -Dan Davis (lead)  -Steve Bittner (lead)  -WPP staff and seasonal employees | Responsible for the collection of samples and data at assigned lakes using the sample collection techniques and probe use procedures contained in the TAM Field Operations Manual for lakes and WPP SOPs. |
| Macrophyte survey crews  -James Meek (lead)  -Therese Beaudoin (lead)  -Pete Mitchell (lead)  -Dan Davis (lead)  -Steve Bittner (lead)  -WPP staff and seasonal employees | Responsible for documenting macrophyte surface cover, biovolume and species composition using techniques and procedures contained in the TAM Field Operations Manual for lakes and WPP SOPs. |
| Littoral macroinvertebrate survey crews  -James Meek (lead)  -Dan Davis (lead)  -Pete Mitchell (lead)  -Therese Beaudoin (lead)  - Steve Bittner (lead)  -WPP staff and seasonal employees | Responsible for littoral macroinvertebrate and aquatic habitat survey data collection using procedures contained in the TAM Field Operations Manual for lakes and WPP SOPs. |
| Fish tissue survey crews  -Dan Davis (lead)  -Pete Mitchell (lead)  -WPP staff and seasonal employees | Responsible for conducting accurate, precise fish tissue sampling using electrofishing or netting techniques contained in the TAM Field Operations Manual for lakes and WPP SOPs. |
| WPP Laboratory (algal)  -Joan Beskenis (lead)  -Sue Flint (backup)  -WPP staff and seasonal employees | Responsible for the analysis of chlorophyll samples using techniques and procedures contained in WPP SOPs. |
| WPP Laboratory (turbidity)  -Sue Flint (lead)  -Shervon De Leon (backup)  -WPP staff and seasonal employees | Responsible for the analysis of turbidity samples using techniques and procedures contained in WPP SOPs. |

For each field monitoring survey event, the staff member serving as the survey crew leader (at a minimum) will have met the following qualifications:

• Familiarity with this SAP and all applicable SOPs for that survey

• Completion of a multiprobe sampling/grab sampling/QC training segment

• Prior field experience with survey equipment and with similar monitoring surveys

• Be physically able to access the sites, carry equipment and samples, and perform the sampling.

Survey crew leaders will be accompanied by one or more additional crew members for each survey, depending on the kind of sampling to be undertaken (e.g., water, macroinvertebrates, fish, etc.). All field survey crew personnel and WES/WPP lab personnel will be trained in the proper application of standard operating procedures (SOPs). Field training may range from formal WPP training sessions to field instructions provided by a trained and experienced WPP survey crew leader. WPP lab training (e.g., chlorophyll *a*, turbidity) will be provided to selected WPP staff and seasonal employees, who will run the analyses. All WPP training activities will be documented using signature sheets. The WPP lab will perform the *E. coli* analyses on water samples collected as part of this project.

Dr. Oscar Pancorbo, Director of MassDEP’s Wall Experiment Station (WES), and/or his designees, will coordinate with the WPP regarding sample delivery, analyses, and reporting. WES has been selected to perform total phosphorus, total nitrogen, chloride, total alkalinity, total hardness, dissolved organic carbon (DOC), and fish tissue contaminants (Hg, As, Cd, and Se). If WES is unable to perform any analyses due to resource constraints, the samples will be sent to Alpha Analytical (WES backup laboratory) for analyses. If necessary, WES will coordinate with Alpha Analytical and/or their designee regarding sample delivery, analyses, reporting, and invoice payment.

The project manager at Contractor X (contractor for phytoplankton taxonomy will be determined at a later date) and Cole Ecological and/or their designees will coordinate with the WPP regarding sample delivery, analyses, and reporting. The phytoplankton taxonomy contractor has been selected to perform phytoplankton taxonomic identification on samples collected as part of this project. Cole Ecological has been selected to perform macroinvertebrate taxonomic identification on samples collected as part of this project.

#### Project Definition and Background

Deterministic (i.e., targeted) monitoring networks are used for identifying individual waters for assessment and listing in accordance with sections 305(b) and 303(d) of the CWA. Massachusetts’ water monitoring strategy (MassDEP 2018) highlights the value of deterministic (i.e., targeted) monitoring for confirming causes and identifying sources of impairment or, alternatively, demonstrating that previously impaired waters are now supporting their beneficial uses. The WPP has prioritized the Millers, Deerfield, and Westfield watersheds in western Massachusetts (B2) for TAM in 2024, year three of a new seven-year recurring river basin schedule (see Appendix A). The WPP has developed a general approach for prioritizing waters to be monitored that focuses on strengthening the categorization of waters (i.e., assessment units or AUs) included on Massachusetts’ integrated CWA section 305(b)/303(d) report (IR) (MassDEP 2021). Highest priority will be given to gathering data and information on AUs currently listed as impaired that may not be and, therefore, could be delisted, as well as on AUs that are not currently identified as impaired but there is some evidence to suggest that they are impaired and should be listed as such (see Sampling Process Design below). A total of 6 lakes located throughout Cohort B2, had been prioritized and scheduled for monitoring in 2024.

The goal of the 2024 monitoring effort is to collect enough water quality and biomonitoring data to assess the aquatic life, fish consumption, recreational and aesthetic use support status of the AUs represented by the lakes. The WPP proposes to gather the following kinds of environmental data and information at each site in fulfillment of this goal:

* Discrete vertical profile (dissolved oxygen, temperature, pH, conductivity)
* Continuous vertical profile (dissolved oxygen, temperature)
* Secchi disk transparency
* Nutrients (total phosphorus, total nitrogen)
* Water chemistry (alkalinity, hardness, turbidity, chloride, dissolved organic carbon)
* Chlorophyll a
* Pathogens (*E. coli*)
* Phytoplankton community
* Littoral macroinvertebrate community
* Fish tissue (Hg, As, Cd, and Se)
* Macrophytes (percent cover, biovolume, exotics)
* Aesthetics observations
* Human disturbance observations
* Bathymetry

#### Project Description

**Overview of Targeted Assessment Monitoring in 2024**

##### Index Site - Water Quality (Chemical, Biological and Physical)

Water quality [discrete vertical profile (DO, temperature, pH, conductivity), nutrients, chlorophyll a, phytoplankton, alkalinity, hardness, turbidity, chloride, dissolved organic carbon] samples will be collected approximately once a month between July and September (3 sampling events) at the index site of each lake using techniques described in the TAM Field Operations Manual for lakes and WPP standard operating procedures (SOP). The index site is located at the maximum depth point in each lake. Samples will be field preserved, as appropriate, and delivered to the Senator William Wall Experiment Station in Lawrence (WES) for nutrient (total nitrogen, total phosphorus), chloride, alkalinity, and hardness analyses, the WPP lab in Worcester for chlorophyll and turbidity analyses, and Contractor X for phytoplankton taxonomy, enumeration and biovolume. Alpha Analytical in Westborough will serve as a backup laboratory for WES and any analyses that cannot be performed by WES due to resource constraints will be sent to Alpha Analytical. A minimum of one duplicate and one blank sample per analyte will be tested for QC biweekly (@ approx.10% of the samples). In total, approximately 720 samples will be analyzed for the listed indicators.

Onset multiprobe (dissolved oxygen and temperature) and Tidbits (temperature) will be deployed on a long-term continuous basis from June through September at all lakes using techniques described in the Regional Monitoring Network (RMN) protocols (Stamp 2020) and the TAM Field Operations Manual for lakes. The probes will be deployed vertically on a stringer with a buoy at the top and anchor at the bottom to provide data on thermal stratification and dissolved oxygen changes over time. Two Onset multiprobes will be deployed on the stringer near the surface and near the bottom with Tidbits every 0.5 or 1 meter (depending on overall depth and equipment availability) between the Onset multiprobes. At deployment and prior to retrieval of multiprobes, as well as at various times during the deployment, QC readings will be taken using a separate meter as specified in WPP’s unattended probe SOPs. After retrieval of deployed multiprobes, post-deployment calibration and QC checks on the data will be performed.

##### Shoreline Site - Water Quality (Bacteriological)

Water quality (*E. coli*) samples will be collected at the designated shoreline site for each lake using techniques described in the TAM Field Operations Manual for lakes. The shoreline site is located at a bathing beach if one exists, or a shoreline point where the lake is easily accessible by the public (e.g., adjacent road or culvert) for recreation. *E. coli* sampling will be performed on six occasions within a 90-day window between June 1 and September 30 (Primary Contact Recreation Season). Samples will be field preserved, as appropriate, and delivered to the WPP laboratory in Worcester, MA for *E. coli* analyses. A minimum of one duplicate and one blank sample per analyte will be tested for QC for each sampling week (@ approx.10% of the samples).

##### Macrophyte Community and Bathymetry

The aquatic macrophyte community (biovolume and species composition) and bathymetry will be surveyed once during the summer in each lake using protocols described in the TAM Field Operations Manual for lakes. Bathymetric mapping will be conducted in May using BioBase. The biovolume of aquatic macrophytes will be estimated in each lakes using BioBase mapping and/or a Visual Macrophyte Percent Biovolume Map on the macrophyte field sheet. BioBase is cloud-based software that automates processing of depth finder sonar log files to make aquatic vegetation and bathymetric maps (Navico 2015). If visual observations clearly indicate (i.e., very low biovolume or very high biovolume) that aquatic macrophyte biovolume is or is not a stressor to recreational uses, only a Visual Macrophyte Percent Biovolume Map will be completed for the lake (i.e., no BioBase mapping). Macrophyte species composition will be estimated by identifying macrophyte species from periodic spatially diverse rake drags within each lake until no new species are identified by the survey crew with the goal of producing a dominant species list. Any macrophyte species that cannot be identified by the survey crew will be delivered to the WPP biological lab in Worcester for identification.

##### Littoral Macroinvertebrate Community

The littoral macroinvertebrate community will be sampled at all lakes on one occasion during late summer or early fall, using protocols developed for the 2012 National Lake Assessments (NLA) (USEPA 2011) and incorporated into the TAM Field Operations Manual for Lakes. These organisms can integrate environmental conditions (chemical – including nutrients and toxics; and physical – including shoreline alteration and water level fluctuations) over a long period of time and are an excellent measure of the water body’s health. Specimens will be placed into 2L Nalgene jars, preserved with denatured 95% ethanol and transported to the WPP lab for storage. Cole Ecological will process (i.e., subsample) the macroinvertebrate samples and complete the necessary taxonomic identifications. In addition, habitat evaluations will be completed at all lakes sampled for littoral macroinvertebrates.

##### Fish Tissue

Fish tissue samples will be collected at all lakes on one occasion during late spring/early summer using a variety of techniques (electroshocking, gill nets, etc.) described in the TAM Field Operations Manual for lakes. Composite samples of filets from three individuals of edible and legal size from a species will be collected for 3 – 5 target species and analyzed by WES in Lawrence for select metals (mercury, arsenic, cadmium, and selenium).

#### Sampling Process Design

The 2024 sampling process is designed to collect water quality and biomonitoring data to support the assessment of selected lakes in western Massachusetts. Both AUs and waters without AUs were selected for monitoring according to the prioritization scheme for targeted assessment monitoring outlined in the description of the WPP’s new Seven-year Flexible Watershed Monitoring Schedule (Appendix A). Methods for identifying candidate lakes were developed for four of the priority categories and applied to lakes in Cohort B2 to create a master list of potential sites. Brief descriptions of the lake selection processes follow.

Priority Category 1 (High):This priority category focuses on the identification of waters on the Integrated List of Waters (IR) with causes of impairment (Cat 4c and 5) that could be removed either because there is evidence of restoration, or their original listing was in error. Only a small subset of the remaining lakes was added to the list of candidate waters to be monitored and assessed in 2024 due to resource limitations.

Priority Categories 2 (High) and 3 (Medium):These priority categories are focused at identifying existing AUs (priority category 2) supporting all or some uses, existing AUs with no uses assessed (priority category 3), and/or other waters that are not yet defined as AUs (priority category 3) that are suspected of having impairment causes not included the IR. Candidate lakes for these priority categories were identified by evaluating human disturbance in the local catchment and watershed using LakeCat metrics and selecting lakes with high levels of human disturbance (Hill, et.al. 2018).  Any of the lakes that are already impaired AUs (IR Category 5) in the most recent IR, likely be impaired in the next cycle IR, or was sampled between 2011 and 2023, were eliminated from the priority category 2 and 3 candidate list (MassDEP 2021).  The remaining lakes on the candidate list were evaluated in GIS using aerial photography and other coverages to eliminate those with limited access and sample feasibility issues (e.g. tidal, wetland, run-of-river impoundment, borderline lake/wetland etc.). Only a small subset of the remaining lakes was added to the list of candidate waters to be monitored and assessed in 2024 due to resource limitations.

Priority Category 4 (Medium): Some AUs are listed in the IR as impaired solely for a bioassessment cause (e.g., “benthic macroinvertebrates”, “fish bioassessments”, “lack of a cold-water assemblage”, “combined biota/habitat bioassessments”). These priority category 4 waters are candidates for the process of stressor identification which will help identify underlying causes of biological impairment and define appropriate measures (TMDL, habitat restoration, etc.) for their restoration. No lake AUs are impaired solely for a bioassessment cause so this priority category was not used for lakes.

Priority Category 5 (Medium): This priority category is focused on AUs that may be cold water fisheries (CWF), but available data and information are insufficient for designating them as such in the water quality standards. Criteria for designating a lake as a CWF does not currently exist so this priority category was not used for lakes.

Priority Category 6 (Medium): This priority category is focused on identifying existing AUs with no uses assessed and/or other waters that are not yet defined as AUs that are suspected of supporting one or more designated uses and are not currently in Category 1 or 2 of the IR. Candidate lakes for this priority category were identified by evaluating human disturbance in the local catchment and watershed using LakeCat metrics and selecting lakes with low levels of human disturbance (Hill, et.al. 2018). The remaining lakes on the candidate list were evaluated in GIS using aerial photography and other coverages to eliminate those with limited access and sample feasibility issues (e.g., tidal, wetland, run-of-river impoundment, borderline lake/wetland etc.). Only a small subset of the remaining lakes was added to the list of candidate waters to be monitored and assessed in 2024 due to resource limitations.

A final master list containing 18 TAM candidate priority monitoring lakes was created by combining the results of the individual selection processes carried out for the different priority categories. The TAM allotment of lakes was assigned to an individual WPP monitoring coordinators who are responsible for lake reconnaissance, adding or replacing lakes to fill out a survey group (if necessary), obtaining landowner access permission, defining logistics for efficient monitoring, and generation of useable data at assigned lakes using the procedures contained in WPP SOPs. Based on the desktop and field reconnaissance information and logistical/resource considerations, a final list of 6 lakes (3 groups of 2 lakes) was developed for monitoring in 2024 (Table 2). Lake locations and monitoring sites are detailed and illustrated in Table 2 and Figure 1. The project and monitoring schedules are outlined in Table 3.

| **Table 2.** Watershed Cohort B2 2024 TAM lakes and monitoring locations | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Site ID1** | **Site Type2** | **Unique ID** | **Assessment Unit (AU)** | **Waterbody Name** | **Watershed** | **Site Group** | **Description** | **Latitude** | **Longitude** |
| [TAM-015](http://maps.google.com/maps?q=loc:42.563715,-72.01791) | Index | W3358 | MA35034 | Kendall Pond | Millers | 13 | [index site, Gardner] | 42.56372 | -72.01791 |
| [TAM-016](http://maps.google.com/maps?q=loc:42.577619,-71.969651) | Index | W3360 | MA35021 | Dunn Pond | Millers | 13 | [index site, Gardner] | 42.57762 | -71.96965 |
| [TAM-018](http://maps.google.com/maps?q=loc:42.655943,-72.347617) | Index | W3364 | MA35048 | Moores Pond | Millers | 14 | [index site, Warwick] | 42.65594 | -72.34762 |
| [TAM-019](http://maps.google.com/maps?q=loc:42.676963,-72.281015) | Index | W3366 | MA35074 | Sheomet Lake | Millers | 14 | [index site, Warwick] | 42.67696 | -72.28102 |
| [TAM-017](http://maps.google.com/maps?q=loc:42.529926,-72.799705) | Index | W3362 | MA33001 | Ashfield Pond | Deerfield | 15 | [index site, Ashfield] | 42.52993 | -72.79971 |
| [TAM-021](http://maps.google.com/maps?q=loc:42.293364669,-73.066527741) | Index | W3422 | MA32015 | Center Pond | Westfield | 15 | [index site, Becket] | 42.29336 | -73.06653 |
| [TAM-015S](http://maps.google.com/maps?q=loc:42.562372225,-72.020242268) | Shore | W3359 | MA35034 | Kendall Pond | Millers | I | [pond access, southwestern lobe of pond, Gardner] | 42.56237 | -72.02024 |
| [TAM-016S](http://maps.google.com/maps?q=loc:42.57937538,-71.971328592) | Shore | W3361 | MA35021 | Dunn Pond | Millers | I | [beach, northeastern edge of pond, Gardner] | 42.57938 | -71.97133 |
| [TAM-017S](http://maps.google.com/maps?q=loc:42.529174176,-72.798212377) | Shore | W3363 | MA33001 | Ashfield Pond | Deerfield | I | [beach, southeastern edge of pond, Ashfield] | 42.52917 | -72.79821 |
| [TAM-018S](http://maps.google.com/maps?q=loc:42.654384,-72.348947) | Shore | W3365 | MA35048 | Moores Pond | Millers | I | [beach, southwestern edge of pond, Warwick] | 42.65438 | -72.34895 |
| [TAM-019S](http://maps.google.com/maps?q=loc:42.677187524,-72.27989855) | Shore | W3367 | MA35074 | Sheomet Lake | Millers | I | [beach, southeastern edge of pond, Warwick] | 42.67719 | -72.27990 |
| [TAM-021S](http://maps.google.com/maps?q=loc:42.29510831,-73.063913687) | Shore | W3420 | MA32015 | Center Pond | Westfield | I | [beach, southeastern edge of pond, off western end of Mecum Way, Becket] | 42.29511 | -73.06391 |
| 1 – Google Maps hyperlink is the estimated index site or shoreline site depending on site type.  2 – Index = index site - located at the maximum depth point in the lake. Shore = shoreline site - located at a bathing beach, if one exists, or a shoreline point where the lake is easily accessible by the public. | | | | | | | | | |

Map

Description automatically generated

**Figure 1.** Watershed Cohort B2 2024 TAM Lakes

| **Table 3.** Project Schedule for 2024 targeted assessment monitoring at lakes | | | |
| --- | --- | --- | --- |
| **Activity** | **Approx. Date of Initiation** | **Approx. Date of Completion** | **Deliverable** |
| Coordination, staff meetings, reconnaissance, river/stream sampling plan development, site selection, etc. | Jan 2024 | Apr 2024 | Draft sampling plan; meeting notes, etc. |
| Draft sampling plan review and approval | Mar 2024 | Apr 2024 | Internal WPP concurrence on sampling plan |
| Fish tissue and bathymetry surveys  (1 visit) | May 2024 | Jun 2024 | Field data; lab samples to WES |
| Vertical profile probes deploy/retrieval | Jun 2024 | Oct 2024 | Continuous DO/temperature data |
| Water quality sampling surveys  (3 visits) (*Index Site)* | Jul 2024 | Sep 2024 | Field data; lab samples to WES, WPP, EPA and/or contract lab(s) |
| Water quality sampling surveys  (6 visits) (*Shoreline Site)* | Jun 2024 | Sep 2024 | Field data; lab samples to WES, WPP, EPA and/or contract lab(s) |
| Benthic/Habitat sampling surveys  (1 visit) | Jul 2024 | Sep 2024 | Field data; benthic samples to contractor |
| Macrophyte surveys (1 visit) | Jul 2024 | Sep 2024 | Field data |
| Data QA/QC review and validation | Jan 2025 | Jun 2025 | 2024 Data Validation Report |
| Data review, analysis, and preliminary reporting | Jun 2025 | Mar 2026 | Final data analysis |

#### Non-Direct Measurements

Table 4 presents a brief list of relevant external data sources that may be used in coordinating monitoring efforts or the interpretation of monitoring data. For example, stage data from the USGS could be used to determine if water levels are appropriate for certain types of sampling or rain data from NCEI could be used to determine if a sampling event occurred during wet or dry weather.

**Table 4.** External data sources used for the 2024 targeted assessment monitoring.

|  |  |
| --- | --- |
| **Organization** | **Data** |
| United States Geological Survey (USGS)  <https://www.usgs.gov/centers/new-england-water/> | Continuously stream stage and discharge measurements at gage stations within the project extent. |
| National Centers for Environmental Information (NCEI)  <https://www.ncdc.noaa.gov/> | Daily precipitation and temperature data weather stations within the project extent. |
| The Weather Underground  <http://www.wunderground.com/> | Daily precipitation and temperature data weather stations within the southwestern basin group. |

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#### Appendix A – Seven-year Flexible Watershed Monitoring Schedule

**Introduction**

Most elements of the MassDEP’s existing surface water monitoring program are administered by personnel of the Division of Watershed Management’s Watershed Planning Program (DWM-WPP). Current and proposed surface water monitoring program elements are presented in *A Strategy for Monitoring and Assessing the Quality of Massachusetts’ Waters to Support Multiple Water Resource Management Objectives 2016 - 2025* (the Monitoring Strategy). The ultimate goal embodied in the Monitoring Strategy is to implement a comprehensive monitoring program that serves all water quality management needs and addresses all water body types. As such, the monitoring program is designed to provide data and information from streams, rivers, lakes, reservoirs, estuaries, coastal areas and wetlands to support the five major objectives listed below.

1. Assess the status or condition of Massachusetts’ waters
2. Develop, implement and evaluate pollution control strategies
3. Develop policies and standards and identify emerging issues
4. Measure the effectiveness of water quality management programs
5. Maintain reserve monitoring capacity to respond to unforeseen data needs

Major themes inherent in both the MassDEP’s water management programs and the monitoring elements that support them are 1) the focus on the watershed as the fundamental planning unit for water quality management, 2) the assessment of biological communities, such as aquatic macroinvertebrates and fish, as the most reliable indicators of water quality conditions and ecosystem health, 3) the application of new technology and streamlined systems for data processing and analysis to support monitoring and assessment activities, and 4) the formation and reliance on partnerships and collaboration to meet water quality goals. Massachusetts’ existing and proposed water monitoring programs include both deterministic (targeted) and probabilistic (random) sampling networks and encompass both rotating watershed monitoring cycles as well as non-rotating, priority-driven schedules.

Probabilistic sampling designs provide statistically valid estimates of the use support status of 100% of the waters in a target population (e.g., shallow streams, deep rivers, lakes, etc.) with data and information collected from a random sample of those waters. Beginning in 2011 MassDEP carried out a five-year probabilistic survey of shallow streams and applied a similar sampling design to lakes and ponds from 2016 – 2018. A random sampling design for Massachusetts’ coastal waters is currently in development.

While probabilistically derived sampling networks determine, at larger scales (e.g., statewide), the percentage of stream miles or lake acres that are meeting water quality standards, they are not as useful for assessing the use-support status of individual water bodies or assessment units (AU) or for identifying individual impaired waters for listing pursuant to § 303(d) of the Clean Water Act (CWA). The Monitoring Strategy calls for the use of targeted monitoring designs to confirm causes and identify sources of impairment or to demonstrate that previously impaired waters are now supporting their beneficial uses and can be removed from the 303(d) list of impaired waters. Furthermore, monitoring data from targeted waters are needed to develop, implement and measure the effectiveness of control strategies, such as TMDLs, watershed-based plans, National Pollutant Discharge Elimination System (NPDES) wastewater discharge permits and best management practices (BMP). These program elements and the monitoring networks needed to support them are depicted in Figure 1.

**Rotating Watershed Water Quality Management**

Watershed protection is the dominant theme of many state water quality management programs, and the EPA has endorsed this approach by providing financial and technical support for watershed-based water quality management activities. In 1993 the MassDEP placed the 27 major watersheds and coastal drainage areas (loosely termed “basins”) in Massachusetts on a rotating five-year schedule to synchronize monitoring, assessment and other components of its watershed management program. The goal was to allocate one year to each of five water management steps or phases (i.e., Year 1 – planning; Year 2 – monitoring; Year 3 – assessment; Year 4 – implementation of control strategies; and Year 5 – effectiveness evaluation), after which the process would begin again.

The completion of all the steps in the watershed management process within a five-year timeframe proved to be impracticable. The practice of watershed management is inherently complex, resource-intensive and time-consuming and project demand often outpaces available funding and other resources. Therefore, while MassDEP’s water management program continues to progress in a stepwise fashion to restore impaired waters and protect waters that meet water quality standards, in practice these steps are typically not completed within a five-year timeframe as originally conceived. Furthermore, the watersheds were originally grouped to balance workloads associated with permitting and other related administrative tasks rather than equalizing the number of river miles or lake acres among the five groups for monitoring and assessment purposes. To facilitate monitoring, the “basins” were regrouped in 2010 on a regional basis to take advantage of potential benefits to monitoring survey logistics of more closely aligned watersheds, and to more equitably distribute Massachusetts’ total river miles among the five groups. To date, despite this new arrangement, targeted assessment monitoring in these watershed groups has been precluded by priority-driven monitoring schedules and a general lack of resources.

**Flexible Seven-Year Basin Rotation for Monitoring**

The use of the watershed, or river basin, as a fundamental planning unit for water quality management was a guiding principle in the development of the Monitoring Strategy, and it remains a goal of the DWM-WPP to resume monitoring and assessment activities on a rotating watershed schedule. However, the need exists to maintain enough flexibility within that schedule to perform additional monitoring to meet other water management program needs. To that end, the DWM-WPP is establishing a sequential schedule that provides the opportunity for monitoring to be carried out in each watershed at least once every seven years yet allows for monitoring resources to be disproportionately applied in each watershed to fulfill specific water resource management objectives. Massachusetts’ 27 major watersheds and coastal drainage areas have been arranged by geography (and hydrology) into four major groups, or cohorts (A-D), each consisting of from three to ten “basins”. In turn, each major cohort is subdivided into one or two minor cohorts, each of which represents one year of the seven-year monitoring schedule (Figures 2 and 3).

Basic assessment monitoring will be performed in each minor cohort for one year and will be consecutive within major cohorts (e.g. A2 will always follow A1). However, the extended time allotted to the major cohorts (two years for all but three basins) allows for the basic schedule to be adapted to fulfill specific data needs. As such, the level of effort applied to monitoring within each major cohort, will not necessarily be evenly distributed through the minor cohorts or among individual basins, but will vary depending on priorities and objectives. Therefore, targeted monitoring may be focused anywhere within the major cohort and, if necessary, extend through all or a portion of the time allotted to that cohort. A few examples are presented below to illustrate how the above design provides the flexibility to meet a number of monitoring objectives while maintaining an overall rotating watershed structure.

Absent the need for site- or project-specific data, the overall monitoring goal will default to basic assessment and monitoring each year will be designed in accordance with the prioritization scheme presented in the following section. In Cohort A, the Concord, Merrimack, Nashua and Shawsheen watersheds (A1) would be monitored in Year 1 followed by the Ipswich, Parker, and Charles watersheds, and North Coastal and Boston Harbor coastal drainage systems (A2) in Year 2. WPP monitoring resources could be applied disproportionately, if, for example, the Merrimack and Charles watersheds received higher priority for whatever reason, in which case they might be monitored for both years in Cohort A.

Alternatively, sampling at selected locations could be performed for up to two years in larger-order rivers if pollutant loading information is needed to support TMDL development or NPDES permit development, while rotating through smaller-order rivers in the corresponding minor cohorts. If intensive surveys were needed to support model development in a particular watershed, they could also be carried out in multiple years within the major cohort. Finally, depending upon circumstances, monitoring resources might be more efficiently applied by performing stream sampling in both minor cohorts (A1 and A2) in the first year followed by lake sampling in the second year.

The proposed rotating basin structure not only provides flexibility to prioritize and apportion monitoring resources, but also presents multiple options for managing various monitoring program elements. For example, the delegation of monitoring projects to WPP monitoring personnel can be place-based (e.g., monitoring coordinator is assigned a basin for managing any monitoring activities in that basin), expertise-driven (e.g., one coordinator manages all fish sampling to be carried out in a given year, or resource-driven (e.g., one coordinator manages lake monitoring, while others coordinate stream sampling, etc.). In any case, projects will be assigned in accordance with the monitoring priorities established for the major cohort and may extend up to two years in most cohorts.

**Prioritizing Waters for Targeted Assessment Monitoring**

| **Priority** | **Priority Order** | **General Category** | **Category Descriptions1** |
| --- | --- | --- | --- |
| High | 1 | Delisting | Assessment units currently listed in Categories 4c or 5 where there are indications it should not be listed for at least one impairment cause (indications can be environmental improvement or listing/assessment methodology changes or errors). |
| High | 2 | Listing | Assessment units NOT listed in Categories 4c or 5 where there are indications it should be listed for at least one impairment cause (indications can be environmental degradation or listing/assessment methodology changes or errors). |
| Medium | 3 | Unassessed (suspect impairment) | Assessment units listed in Category 3 or waters without an assessment unit where there are indications it could listed in Categories 4c or 5 for at least one impairment cause (i.e. unassessed waters suspected to be impaired). |
| Medium | 4 | Stressor Identification | Assessment units listed in Category 5 for a non-pollutant (i.e. Fishes Bioassessment, Aquatic Macroinvertebrate Bioassessment) with no stressor impairment causes. |
| Medium | 5 | CWF Determination | Assessment units or waters without an assessment unit thought to be an undesignated or under documented coldwater fishery (CWF). |
| Low | 6 | Unassessed (suspect support) | Assessment units listed in Category 3 or waters without an assessment where there are indications it could listed in Category 1 or 2 (i.e. unassessed waters likely to support uses). |
| Low | 7 | Priority NPDES | Assessment units or most sensitive receiving waters with a prioritized NPDES permit development (i.e. situations where a reassessment of the targeted assessment unit would be of value). |
| Low | 8 | TMDL Effectiveness | Assessment units currently listed in Category 4a where the TMDL was potentially successful in removing the use impairment or the original listing of the impairment cause was potentially in error. |
| Low | 9 | Priority TMDL | Assessment units in Category 5 prioritized for TMDL development (i.e. situations where a reassessment of the listed assessment unit would be of value). |

1 – Assessment units placed in prioritization categories based on available information (indications) from multiple sources (monitoring data, landscape data, pollution control measures, assessment methodologies, etc.). Annual basin selection will be consistent with rotating basin schedule. Monitoring parameters will generally include all typical default analytes (e.g., bacteria, nutrients, chloride, probes) unless an indicator specific project is identified.

**Figure 1.** Monitoring Networks for Multiple Water Management Objectives



**Figure 2**. DWM-WPP Seven-Year Basin Rotation for Water Resource Monitoring

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  | **NHD Water Resource Estimations** | | | | | **Assessment Units** | |
| **NAME** | **Major Cohort** | **Total Years in Cohort** | **Minor Cohort** | **Perennial River Miles** | **River Miles per Year** | **Lakes > 5 Acres** | **Lake Acreage** | **Lakes per Year** | **River Segments (Total Length Miles)** | **Lake Segments (Total Area Acres)** |
| Concord (SuAsCo) | A | 2  (2021-2022) | A1 | 529 | 1324 | 134 | 7186 | 367 | 53 (187) | 61 (6572) |
| Merrimack | A1 | 344 | 93 | 5071 | 39 (140) | 29 (3515) |
| Nashua | A1 | 664 | 126 | 10344 | 79 (273) | 69 (9524) |
| Shawsheen | A1 | 98 | 12 | 408 | 21 (65) | 14 (406) |
| Ipswich | A2 | 157 | 68 | 2992 | 22 (97) | 39 (1922) |
| North Coastal | A2 | 116 | 64 | 2698 | 22 (41) | 42 (2006) |
| Parker | A2 | 81 | 24 | 588 | 7 (28) | 12 (290) |
| Charles | A2 | 384 | 113 | 3726 | 45 (178) | 50 (2824) |
| Boston Harbor | A2 | 274 | 100 | 4352 | 60 (166) | 50 (2982) |
| Connecticut | B | 2  (2023-2024) | B1 | 999 | 1722 | 96 | 3358 | 233 | 63 (345) | 46 (2460) |
| Chicopee | B1 | 907 | 168 | 31113 | 51 (259) | 74 (29797) |
| Millers | B2 | 435 | 97 | 4762 | 30 (134) | 64 (3846) |
| Westfield | B2 | 630 | 85 | 4295 | 63 (320) | 33 (3648) |
| Deerfield | B2 | 474 | 21 | 788 | 130 (366) | 22 (561) |
| Ten Mile | C | 2  (2025-2026) | C1 | 92 | 1322 | 21 | 937 | 611 | 10 (35) | 12 (595) |
| Taunton | C1 | 746 | 223 | 13697 | 49 (222) | 87 (10901) |
| Narragansett Bay | C1 | 178 | 29 | 4552 | 20 (65) | 6 (3769) |
| Blackstone | C1 | 334 | 148 | 6509 | 48 (168) | 100 (5177) |
| Quinebaug | C1 | 210 | 56 | 2451 | 28 (86) | 25 (1980) |
| French | C1 | 97 | 56 | 3603 | 18 (39) | 43 (3420) |
| Buzzards Bay | C2 | 479 | 210 | 6546 | 25 (79) | 72 (4983) |
| South Coastal | C2 | 244 | 131 | 4925 | 22 (58) | 75 (4214) |
| Cape Cod | C2 | 177 | 280 | 11567 | 16 (33) | 68 (5706) |
| Islands | C2 | 86 | 69 | 5738 | 6 (12) | 5 (106) |
| Housatonic | D | 1  (2027) | D1 | 547 | 952 | 117 | 5982 | 194 | 35 (219) | 33 (4284) |
| Hudson | D1 | 229 | 13 | 759 | 26 (109) | 8 (716) |
| Farmington | D1 | 175 | 64 | 3907 | 40 (108) | 18 (2135) |
|  |  |  | **Totals** | 9687 |  | 2618 | 152852 |  | 1028 (3830) | 1157 (118338) |

**Figure 3.** DWM-WPP Seven-Year Basin Rotation for Water Resource Monitoring

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