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Sampling and Analysis Plan

Silver Lake Water Quality Monitoring

Halifax, Plympton, Pembroke and Kingston, Massachusetts



PREPARED FOR

Central Plymouth County Water District Commission
c/o Frank Basler, County Administrator
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July 24, 2021





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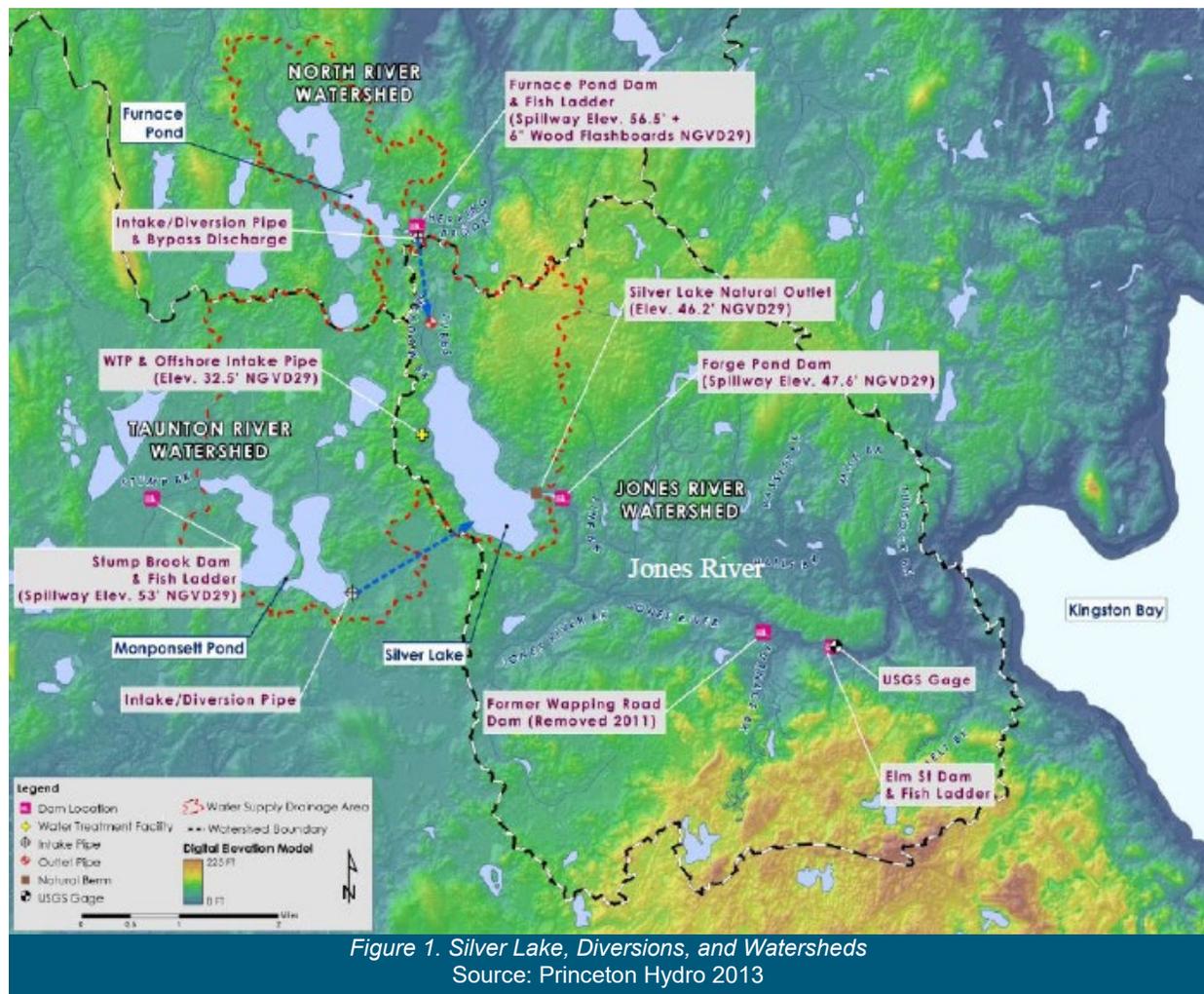




INTRODUCTION AND PROJECT DESCRIPTION

ESS Group, Inc. (ESS) has developed this Sampling and Analysis Plan (SAP) to provide the Central Plymouth County Water District Commission (CPCWDC) with a detailed description of the technical approach and schedule for executing the Silver Lake Water Quality Monitoring Project (the Project).

Silver Lake is a designated Class A waterbody and Outstanding Resource Water (ORW) located in the towns of Halifax, Plympton, Pembroke, and Kingston, Massachusetts. In addition to serving as the primary source water reservoir for the City of Brockton and connected drinking distribution systems, Silver Lake constitutes the headwater source of the Jones River (Figure 1).



Concerns have arisen regarding potential water quality impacts to Silver Lake from watershed sources and water diversions. Silver Lake is now proposed for listing in the Draft 2018/2020 Integrated List of Waters by the Massachusetts Department of Environmental Protection (MassDEP). The proposed impairments include Fish Passage Barrier, Flow Regime Modification, and Dissolved Oxygen. The Dissolved Oxygen impairment, if finalized, would require a TMDL.



The overall goals of this Project are as follows:

1. Collect water quality data to help inform community management decisions to address water quality and quantity issues in Silver Lake and connected water bodies; and
2. Develop a baseline understanding of current water quality and continue to develop solutions-oriented relationships with the City of Brockton's Water Division and the public.

To support these goals, ESS will collect and analyze detailed water quality, physical, hydrologic, and biological data.

PROJECT DESIGN

The Project is designed to improve the understanding of key water quality drivers in Silver Lake. This Project approach has been designed with the following questions, issues, and data gaps in mind.

- Publicly available water quality data for Silver Lake appears limited mainly to assessments completed in 2004 (ESS) and in 2008-2009 (JRWA; Chase et al., 2013). More recent data are needed to address the current condition of the lake.
- Diversion of water from East Monponsett Pond by the City of Brockton's public water supply system may increase the external loading of phosphorus to Silver Lake. Over time, this could result in Silver Lake's water quality trending toward a state of more frequent and intense harmful algal blooms.
- In addition to the above, watershed loading to Silver Lake from stormwater runoff, septic systems, agricultural runoff, and other sources may contribute to degradation of water quality.

Components of the Project design are described in the following sections.

Sampling Domain

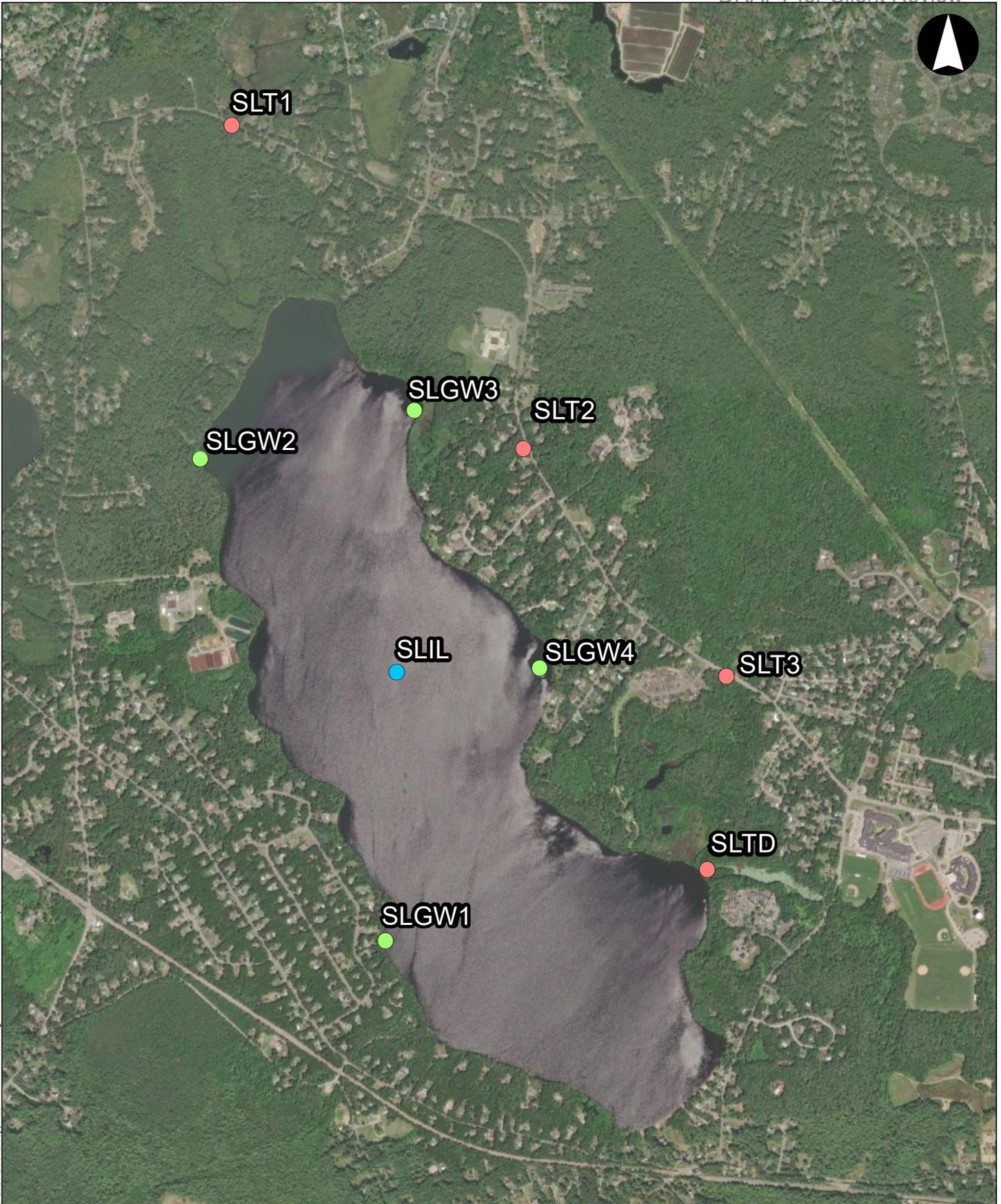
The Project will include collection of data from Silver Lake, its natural tributaries, shallow groundwater, and water diversion sources. The anticipated primary sampling locations are shown in Figure 2 and described in Table A.

East Monponsett and Furnace Ponds are publicly accessible and do not require prior arrangement for sampling. Access to Silver Lake will be through the Silver Lake Water Treatment Plant, which is operated on behalf of the City of Brockton by Veolia North America. ESS will coordinate gate access directly with the plant operator prior to each visit to Silver Lake.

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Silver Lake Water Quality Monitoring Project

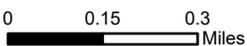
Halifax, Plympton, Pembroke, and Kingston, MA

Legend

- Groundwater Sample Location
- In-Lake Sample Location
- Tributary/Outlet Sample Location

Proposed Silver Lake Water Quality Sample Locations

Figure 2



Source: 1) Esri, World Imagery, 2021

Sample Locations are approximate and subject to change based on field observations

**Table A. Anticipated Sampling Locations**

Water Body	Site ID	Description	Type
Silver Lake	SLIL	Deep hole	In-lake
Silver Lake	SLGW1	Southwestern shoreline	Groundwater
Silver Lake	SLGW1	Northwestern shoreline	Groundwater
Silver Lake	SLGW3	Northeastern shoreline	Groundwater
Silver Lake	SLGW4	Eastern shoreline	Groundwater
Tubbs Meadow Brook	SLT1	Tubbs Meadow Brook between Route 27 and Silver Lake	Tributary
Little Brook	SLT2	Little Brook between Route 27 and Silver Lake	Tributary
Mirage Brook	SLT3	Mirage Brook between Route 27 and Silver Lake	Tributary
Jones River	SLTD	Outlet from Silver Lake	Outlet
Furnace Pond/Diversion	FPD	Furnace Pond diversion to Tubbs Meadow Brook	In-lake/Diversion
East Monponsett Pond/Diversion	MPD	East Monponsett Pond diversion to Silver Lake	In-lake/Diversion

Sampling Design

The Project sampling design consists of the following principal elements:

1. Bathymetry, Aquatic Plant, and Benthic Surveys
2. In-Lake Water Column & Quality Sampling
3. Upstream and Downstream Monitoring
4. Groundwater Assessment

Each of these are described in the following sections.

Bathymetry, Aquatic Plant, and Benthic Surveys

Bathymetric, aquatic plant, and benthic surveys of Silver Lake will be completed and used to create detailed maps of water depth, plant growth, and area of the lake impacted by anoxia. Survey timing is anticipated for August 2021.





Bathymetry. Bathymetry will be measured using an echosounder in deep, open waters and a calibrated sounding line in shallower waters where plant growth is dense. Given the wet antecedent conditions in June and July, Silver Lake is currently near capacity. Therefore, the planned survey timing is likely to provide adequate water depth to complete the bathymetric mapping.

Lake bathymetry will be tied to a vertical control and used to create a contour map of the lake.

The bathymetry survey will include at least 350 survey locations. The locations will be distributed using a gridded survey approach (Figure 3). This method is similar to point-intercept survey methods, in that it uses a pre-determined sampling interval to ensure adequate coverage of the entire water body. The primary difference is that, whereas point-intercept survey methods require navigation to a specific point (i.e., the intersection of each grid line), the gridded survey only requires navigation to each cell. This ensures adequate coverage of survey data throughout the lake while providing field crews with flexibility select the exact location and number of points within each cell based on observed field conditions.

The field data and geographic coordinates for each data point will be recorded using a Differential Global Positioning System (DGPS) capable of sub-meter horizontal accuracy in the NAD83 Massachusetts State Plane Coordinate system.

Aquatic Plants. Aquatic plant growth will be assessed at each survey location using one or more of the following tools: a color underwater video camera, macrophyte pole- and/or throw-rakes, and direct observation from the boat. Aquatic plants will be field identified. Specimens that cannot be readily field-identified to genus/species level will be collected and identification under a high-powered dissecting microscope.

The planned timing provides ideal conditions for mapping rooted plants, which will be at their seasonal peak of growth.

Aquatic plant data collected will include community composition, vegetative cover (percent of bottom) and biomass/volume (measure of vegetative growth in the water column). Supplemental data on substrate type (muck, sand, etc.) will also be collected.

Data collected from the aquatic plant survey will be used to generate maps of plant cover and biovolume for the lake. Additionally, a field guide to the aquatic plants of Silver Lake as a resource for future monitoring efforts.

The aquatic plant surveys will include at least 350 survey locations. As with the bathymetry survey, the plant survey locations will be distributed using a gridded survey approach.

The field data and geographic coordinates for each data point will be recorded using a Differential Global Positioning System (DGPS) capable of sub-meter horizontal accuracy in the NAD83 Massachusetts State Plane Coordinate system.

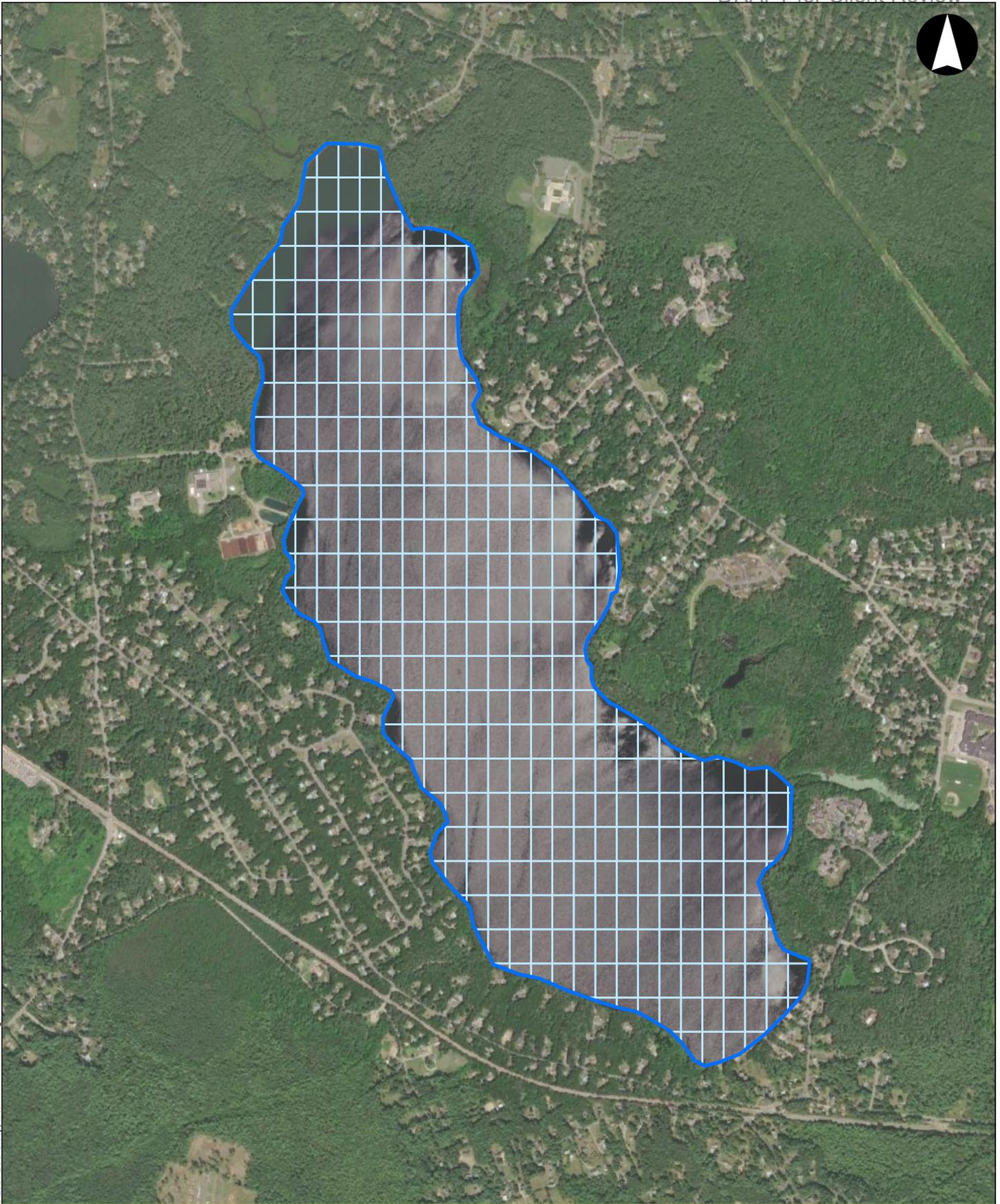




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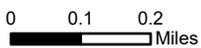
Silver Lake Water Quality Monitoring Project

Halifax, Plympton, Pembroke, and Kingston, MA

Legend

-  Silver Lake Boundary
-  Mapping Grid
Approximately 360 Cells

Proposed Silver Lake Mapping Grid



Source: 1) Esri, World Imagery, 2021

Figure 3



Macroinvertebrates. Due to their relatively long lifespan (months to years), benthic macroinvertebrates are one of the most useful organisms for inferring longer term water quality conditions in surface waters.

Benthic macroinvertebrate samples will be collected along a transect perpendicular to the long axis of the lake, allowing the collection of samples from both shallow and deep environments within the lake. A total of seven samples will be collected, each from a different depth (approximately 5 ft, 15 ft, 25 ft, 35 ft, 45 ft, 55 ft, and 65 ft).

Depending on the conditions observed in the lake and depth of water at the sampling location, ESS will use a grab sampler (e.g., Ekman grab), clam rake, or dip net to collect macroinvertebrate samples. The total area sampled will be noted for each location so that the data can be used to quantify densities of each organism. Samples will be field-preserved in 75% ethanol.

Macroinvertebrates will be sorted from each sediment sample, then identified and enumerated by a Society for Freshwater Science (SFS) certified taxonomist under a high-power dissecting and/or compound microscope. The target level for macroinvertebrate identification will be genus/species for most organisms. This will allow for the mapping of the area of the lake affected by seasonal stressors, such as anoxia (i.e., areas lacking dissolved oxygen).

The geographic coordinates for each data point will be recorded using a Differential Global Positioning System (DGPS) capable of sub-meter horizontal accuracy in the NAD83 Massachusetts State Plane Coordinate system.

In-Lake Water Column & Quality Sampling

In-lake sampling of water quality will be used to establish the current baseline conditions in Silver Lake. Survey timing is anticipated to begin in August 2021 and extend through April 2022, exclusive of months when ice cover is present (currently anticipated to be January and February).

To ensure acquisition of the most useful and complete dataset over a short period of time, the in-lake monitoring program will include both continuous data logging and collection of discrete water quality samples as part of the field program.

Continuous Data Logging. The continuous data logging portion of the field program will include deployment of two monitoring arrays at the deepest location in the lake (currently anticipated to be approximately 75 feet deep when water level is at normal pool elevation). The data logger array will be used to detect differences in key parameters (water level, temperature, and chlorophyll – a surrogate for algal growth) over time and through the vertical water column. One array will be located within 5 meters (16 feet) of the lake surface and the second array will be located within 16 feet of the sediment-water interface. The chlorophyll a datalogger will only be included in the shallow monitoring array. The surface datalogger array will be allowed to move up and down with changes in water level so that it remains at the same relative depth while the bottom datalogger will maintained at a fixed location to effectively track changes in water level.

Loggers will be programmed to collect readings at hourly intervals. Data will be downloaded during each site visit. See Appendix A for more information on logger installation and operation.

Discrete Water Quality Sampling. To complement and supplement the continuous data logging program, multiple rounds of discrete in-lake water quality samples will be collected from September 2021 through April 2022, exclusive of January and February 2022, for a total of six sampling events.





During these events, samples will be collected from the same in-lake location as the datalogger array. Additionally, water quality profiles will be measured in situ within the water column. See Appendix A for more information on sampling methods and Table B for the distribution of in-lake sampling effort.

Water quality samples will be sent to the laboratory for analysis of the following:

- Total Phosphorus
- Soluble Phosphorus
- Total Nitrogen (nitrite-N+nitrate-N and Total Kjeldahl N)
- Alkalinity
- Chlorophyll a
- Phytoplankton Enumeration and ID

Additionally, the following parameters will be field measured:

- pH
- Secchi Disk Transparency
- Apparent Color
- Turbidity
- Water Temperature (full vertical profile at 1 m increments)
- Specific Conductance (full vertical profile at 1 m increments)
- Dissolved Oxygen (full vertical profile at 1 m increments)

Table B. Surface Water Quality Analytes and Parameters to Be Monitored in Silver Lake

Analyte/Parameter	Sampling Position(s) at SLIL	Number of Visits	Number of Samples per Visit	Total Number of Samples
Total Phosphorus	Surface, Mid-depth, Bottom	6	3	18
Soluble Phosphorus	Surface, Mid-depth, Bottom	6	3	18
Total Nitrogen	Surface, Mid-depth, Bottom	6	3	18
Alkalinity	Surface, Mid-depth, Bottom	6	3	18
Chlorophyll a	Surface	6	1	6
Algal ID and Enumeration	Surface	6	1	6
<i>E. coli</i>	Surface	4	1	4
Cyanotoxins	Surface	2	1	2
pH	Surface, Mid-depth, Bottom	6	3	18
Secchi Disk Transparency	Surface	6	1	6
Apparent Color	Surface, Mid-depth, Bottom	6	3	18
Turbidity	Surface, Mid-depth, Bottom	6	3	18
Water Temperature*	Every meter	6	22	132
Specific Conductance*	Every meter	6	22	132
Dissolved Oxygen*	Every meter	6	22	132

*Number of samples is estimated. Actual number will be determined by field conditions (i.e., water depth).



Since there is concern regarding documented impairments in East Monponsett Pond and Furnace Pond and the potential for these to impact Silver Lake through inter-basin water transfer, surface samples will also be collected from these diversions concurrent with a subset of the in-lake sampling events at Silver Lake. The timing of these sampling events will be targeted during periods of active diversion, as conditions allow. See Table C for the distribution of sampling effort.

Table C. Surface Water Quality Analytes and Parameters to Be Monitored from Diversions (East Monponsett and Furnace Ponds)

Analyte/Parameter	Number of Visits	Number of Samples per Visit	Total Number of Samples
Total Phosphorus	3	2	6
Soluble Phosphorus	3	2	6
Total Nitrogen	3	2	6
Alkalinity	3	2	6
Chlorophyll a	3	2	6
Algal ID and Enumeration	3	2	6
<i>E. coli</i>	3	2	6
Cyanotoxins	2	2	4
pH	3	2	6
Secchi Disk Transparency	3	2	6
Apparent Color	3	2	6
Turbidity	3	2	6
Water Temperature	3	2	6
Specific Conductance	3	2	6
Dissolved Oxygen	3	2	6

Upstream and Downstream Monitoring

Upstream and downstream monitoring will be used to improve understanding of the hydrologic and nutrient budgets for Silver Lake. Survey timing is anticipated to begin in September 2021 and extend through April 2022, inclusive of the winter months.

To ensure acquisition of the most useful and complete dataset over a short period of time, the upstream and downstream monitoring field program will include continuous data logging, direct measurement of discharge, and collection of discrete water quality samples.

Continuous Data Logging. The continuous data logging portion of the field program will include deployment of four water level loggers, including one each at Tubbs Meadow Brook, Little Brook and Mirage Brook (tributary inlets) and one downstream (outlet to Forge Pond). Additionally, since the water level loggers will be sealed (unvented), a fifth pressure logger will be deployed in a discreet location to allow for continuous atmospheric pressure correction. The deployed loggers will also continuously monitor temperature over the course of the study.]



Water level loggers will be programmed to collect readings at hourly intervals. Data will be downloaded during each site visit. See Appendix A for more information on logger installation and operation.

Discrete Water Quality and Discharge Sampling. To complement and supplement the continuous data logging program, monthly rounds of discrete upstream and downstream water quality and discharge measurement will be completed from September 2021 through April 2022, for a total of eight sampling events. At least one of the rounds will be collected during wet weather conditions to capture the impact of stormwater runoff.

See Appendix A for more information on sampling methods.

Water quality samples will be sent to the laboratory for analysis of the following:

- Total Phosphorus (low detect)
- Soluble Phosphorus (low detect)
- Total Nitrogen (includes nitrite-N+nitrate-N and TKN)

Additionally, the following parameters will be field measured:

- Stream Discharge
- pH
- Apparent Color
- Turbidity
- Specific Conductance
- Temperature
- Dissolved Oxygen

The discharge measurements collected in each stream monitoring location will be used to develop stage-discharge rating curves. These curves will, in turn, be used to convert logger water levels into a continuous discharge record for the period of study. This will also allow for the estimation of surface water contaminant loads from surface tributaries into Silver Lake and out of the lake into downstream waters.

Groundwater Assessment

Groundwater seepage sampling will be used to assess the influence of groundwater inflows on water quality in Silver Lake. Survey timing is anticipated for April 2022.

Direct groundwater seepage can sometimes be a major source of pollutants to surface water bodies, including densely developed shorelines. Measuring the quantity and quality of these groundwater inputs can be important for understanding why the system is no longer meeting its water quality goals. A seepage survey measures the quantity and quality of groundwater entering the lake along the immediate shorelines where groundwater in seepage is highest and typically the most influenced by human behaviors and activities.





To measure the seepage rate, eight seepage meters will be deployed along four key shoreline segments of Silver Lake, including two at the upper end and two closer to the dam and outlet. Two of these shoreline segments will be located downgradient of nearby developed areas and two will be located adjacent to natural or less-developed areas. Two meters will be deployed along each shoreline segment to adequately capture the local variability in groundwater movement.

On the same day, shallow porewater samples will be collected from each of the four shoreline segments using a littoral interstitial porewater (LIP) sampler, which is essentially a mini-well that extracts groundwater from sediments for water quality testing. Samples will be measured in the field for temperature, pH, and specific conductance and compared to surface water quality measurements to ensure that groundwater is being obtained by the LIP sampler. A total of four composite groundwater quality samples will be collected in Silver Lake; one from each shoreline segment.

See Appendix A for more information on sampling methods.

Laboratory analysis will be conducted for the following at each shoreline sampling segment:

- Soluble Phosphorus
- Ammonia
- Nitrate-Nitrogen

ESS anticipates completing the seepage sampling program in spring of 2022 to capture seasonal high water-table conditions.

Quality Assurance

A Quality Assurance Project Plan (QAPP) will be prepared under separate cover and submitted to EPA Region 1 for review and comment. The purpose of the QAPP is to ensure that the data collected under this SAP meet the required data quality objectives.

PROJECT SCHEDULE

The overall Project schedule is currently anticipated to extend from July 2021 to June 2022. A detailed Project schedule showing the timing of planned sampling events and deliverables is provided in Figure 4. Task 4 presents the specific schedule for sampling and analysis components included in this SAP.





CPCWDC – Silver Lake Water Quality Monitoring –Sampling and Analysis Plan
 July 24, 2021

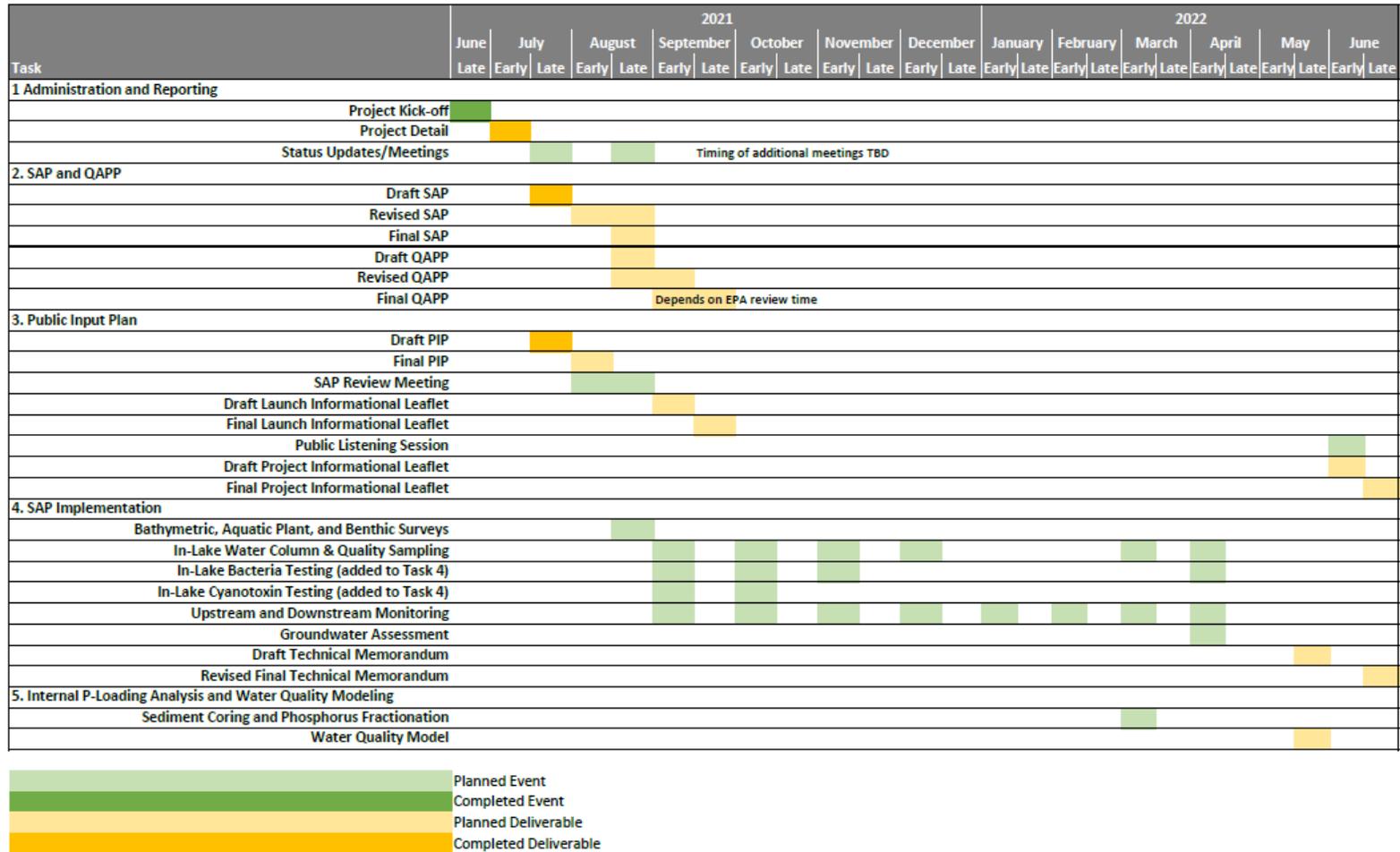


Figure 4. Detailed Project Schedule for Silver Lake Water Quality Monitoring Project
 Current through July 24, 2021

Appendix A

Field SOPs





GUIDELINES FOR MEASUREMENT OF SPECIFIC CONDUCTANCE

1.0 INTRODUCTION

1.1 Purpose and Applicability

These Standard Operating Guidelines (SOG) provide basic instructions for routine calibration and operation of a variety of specific conductance meters. This SOG document also addresses estimation of total dissolved solids (TDS) and salinity by direct measurement of specific conductance (specific methods and capabilities for these parameters are outlined in the manufacturer's individual instrument manuals). This SOG is designed to be consistent with EPA Method 120.1 and Standard Method 2510 B which address specific conductance measurements of drinking, surface, and saline waters, domestic and industrial wastes, and acid rain.

1.2 Quality Assurance Planning Considerations

The end use of the data will determine the quality assurance requirements that are necessary to produce data of acceptable quality. These quality assurance requirements will be defined in the site-specific workplan or Quality Assurance Project Plan (QAPP) (hereafter referred to as the project plan) or laboratory Quality Assurance Manual (QAM) and may include duplicate or replicate measurements or confirmatory analyses.

2.0 RESPONSIBILITIES

- The project manager is responsible for ensuring that project-specific requirements are communicated to the project team and for providing the materials, resources, and guidance necessary to perform the measurements in accordance with this SOG and the project plan.
- The analyst is responsible for verifying that the specific conductance meter is in proper operating condition prior to use and for implementing the calibration and measurement procedures in accordance with this SOG and the project plan.

3.0 REQUIRED MATERIALS

The following materials are necessary for this procedure:

- Specific conductance meter
- Specific conductance meter manufacturer's instruction manual
- Deionized water
- Conductivity standard at concentration that approximates anticipated range of sample concentrations
- Lint-free tissues
- Calibration sheets or logbook
- Laboratory or field data sheets or logbooks

4.0 METHODS

4.1 Sample Handling, Preservation, and General Measurement Procedures

- Specific conductance measurements should be taken in situ or soon after sample collection since temperature changes, precipitation reactions, and absorption of carbon from the air can affect the specific conductance. If specific conductance measurements cannot be taken immediately (within 24 hours), samples should be filtered through a 0.45 μm filter, stored at 4°C and analyzed within 28 days.
- Report results as specific conductance, $\mu\text{mhos/cm}$ or $\mu\text{S/cm}$ at 25°C.



Handheld YSI 2030 meter, red arrow showing where the specific conductance is measured



- Secondary standards may be purchased as a solution from commercial vendors. These standards should not be used after their expiration dates as provided by the manufacturer. An expiration date of one year from date of purchase should be used if the expiration date is worn or missing.

4.2. Calibration and Measurement Procedures

- The specific conductance meter must be calibrated (or the calibration checked) before any analyses are performed.
- Set up the instrument according to the manufacturer's instructions.
- Rinse the probe with deionized water prior to use. If necessary, dry with a lint-free tissue or cloth.
- Follow the manufacturer's recommendations for appropriate calibration receptacle and depth of immersion.
- Record the stabilized specific conductance reading of the standard and the temperature. Enter the calibration mode (according to manufacturer's instructions) and change the value on the primary display to match the value of the calibration standard. The meter may be adjusted to $\pm 20\%$ from the default setting. If the measurement differs by more than $\pm 20\%$, the probe should be cleaned, serviced, or replaced as needed.
- An additional check may be performed, if required by the project plan, by placing the probe into an additional standard. This standard should be from a different source than the standard used for the initial calibration. This standard should read within 5% of the true value.
- Verify the calibration at least once a month or whenever the instrument has been moved from freshwater to saltwater environments or vice versa. Recalibrate or service the instrument, as needed, if the check value is not within 15% of the true (calibration standard) value.



Use of YSI handheld device and probe

4.3. Troubleshooting Information

If there are any performance problems with any of the specific conductance meters which result in inability to achieve the acceptance criteria presented in Section 5.0 or the project-specific acceptance criteria, consult the appropriate section of the meter instruction manual for troubleshooting procedures. If the problem persists, consult the manufacturer's customer service department immediately for further guidance.

4.4. Maintenance

- Instrument maintenance should be performed according to the procedures and frequencies required by the manufacturer.
- The probe must be stored and maintained according to the manufacturer's instructions.

5.0 QUALITY CONTROL

- The meter must be calibrated (or the calibration checked) before sampling, and will not be used for sample determinations of specific conductance unless the initial check standard value is within 5% of the true value.



- Duplicate measurements of a single sample will be performed at the frequency specified in the project plan. In the absence of project-specific criteria, duplicate measurements should agree within 10%.

6.0 DOCUMENTATION

- Meter calibration, temperature check, and maintenance information will be recorded in a calibration log. Specific conductance data may be recorded on the appropriate laboratory or field data sheets or logbooks.
- Calibration documentation should be maintained in a thorough and consistent manner. At a minimum, the following information should be recorded:
 - Date and time of calibration
 - Person performing the measurement
 - Instrument identification number/model
 - Expiration dates and batch numbers for all standards
 - Reading for standard before and after meter adjustment
 - Readings for all continuing calibration checks
 - Temperature of standards (corrected for any difference with reference thermometer)
 - Comments
- Documentation for recorded data must include a minimum of the following:
 - Date and time of analysis
 - Person performing the measurement
 - Sample identification/station location
 - Temperature (corrected for any difference with reference thermometer) and conductance of sample (including units and duplicate measurements).
 - Comments

7.0 TRAINING/QUALIFICATIONS

To properly perform specific conductance measurements, the analyst must be familiar with the calibration and measurement techniques stated in this SOG. The analyst must also be experienced in the operation of the meter.

Certain state certification programs require that specific conductance measurements be taken in the field by, or in the presence of, personnel that are qualified under the certification program.



GUIDELINES FOR MEASUREMENT OF DISSOLVED OXYGEN

1.0 INTRODUCTION

1.1 Purpose and Applicability

These Standard Operating Guidelines (SOG) provide basic instructions for routine measurement of dissolved oxygen using a polarographic sensor-equipped dissolved oxygen meter with a digital read-out (e.g., YSI Pro2030 Dissolved Oxygen, Conductivity, Salinity Instrument). Measurements are made in accordance with methods that address dissolved oxygen measurement of drinking, surface, and saline waters, and domestic and industrial wastes.

1.2 Quality Assurance Planning Considerations

The end use of the data will determine the quality assurance requirements that are necessary to produce data of acceptable quality. These quality assurance requirements will be defined in the site-specific workplan or Quality Assurance Project Plan (QAPP) (hereafter referred to as the project plan) or laboratory Quality Assurance Manual (QAM) and may include duplicate or replicate measurements or confirmatory measurements.

2.0 RESPONSIBILITIES

- The project manager is responsible for ensuring that project-specific requirements are communicated to the project team and for providing the materials, resources, and guidance necessary to perform the measurements in accordance with this SOG and the project plan.
- The analyst is responsible for verifying that the dissolved oxygen measuring device is in proper operating condition prior to use and for implementing the calibration and measurement procedures in accordance with this SOG and the project plan.

3.0 REQUIRED MATERIALS

The following materials are necessary for this procedure:

- Dissolved oxygen meter with digital read-out device
- Manufacturer's instruction manual for the instrument
- Manufacturer's recommended operating solution and replacement membranes or caps
- Laboratory or field data sheets or logbooks

4.0 METHODS

4.1 Sample Handling, Preservation, and General Measurement Procedures

To achieve accurate dissolved oxygen measurements, samples should be analyzed in situ. Measurements in flowing waters should be made in relatively turbulent free areas. Measurements in standing waters may require gentle probe agitation to create water movement around the probe (check instrument manual to confirm).

4.2. Calibration and Measurement Procedures

To accurately calibrate some dissolved oxygen meters, it may be necessary to know the altitude of the region in which you are located and the approximate salinity of the water you will be analyzing. Fresh water has a salinity of approximately zero. Seawater has an approximate salinity of 35 practical salinity units



Handheld YSI 2030 meter, Red arrow showing where the dissolved oxygen is measured



(psu). If uncertain, measure salinity first with an appropriate device. The instructions below are applicable to the YSI Model 55; for other instruments, consult the instruction manual.

- Ensure that the sponge inside the instrument's calibration chamber is wet then insert the probe into the chamber. Turn the instrument on and wait for readings to stabilize (as long as 15 minutes, depending on the model).
- To calibrate, enter the calibration menu by pressing and releasing both the up and down arrow keys at the same time. Enter the altitude (in hundreds of feet) at the prompt by using the arrow keys to increase or decrease the altitude (example: 12 = 1,200 feet). Press enter when correct altitude is shown.
- The meter should display CAL in the lower left of the display with the calibration value in the lower right of the display and the current D.O. reading (before calibration) should be on the main display. Once the D.O. reading is stable, press ENTER. Enter the salinity at the prompt by using the arrow keys. Press ENTER when finished and the instrument will return to normal operation.
- Calibration should be performed at a temperature within $\pm 10^{\circ}\text{C}$ of the sample temperature. Recalibrate every 15 samples and whenever the unit is turned on.
- If calibration is out of range, erratic readings occur, bubbles appear, or if the membrane becomes damaged, wrinkled, or fouled refill the membrane solution and/or replace the membrane, per the manufacturer's manual.
- Avoid contact with environments containing substances that may attack the probe materials (e.g. acids, caustics, and strong solvents).



Use of YSI handheld device and probe

4.3. Troubleshooting Information

If there are any performance problems with the dissolved oxygen-measuring device, consult the appropriate section of the instruction manual for the checkout and self-test procedures. If the problem persists, consult the manufacturer's customer service department immediately for further instructions.

4.4. Maintenance

Instrument maintenance for meter-type dissolved oxygen measuring devices should be performed according to the procedures and frequencies required by the manufacturer. Rinsing the probe with distilled or deionized water and preventing exposure of the membrane to drying is typically all that is required on a day-to-day basis.

5.0 QUALITY CONTROL

Duplicate measurements of a single sample should be performed at the frequency specified in the project plan. In the absence of project-specific criteria, duplicate measurements should agree within ± 0.2 mg/L.

6.0 DOCUMENTATION

All dissolved oxygen meter calibration, checks, and maintenance information will be recorded in a calibration logbook. Dissolved oxygen data may be recorded on the appropriate field data sheets or field books.



- Calibration documentation must be maintained in a thorough and consistent manner. At a minimum, the following information must be recorded:
 - Date and time of calibration
 - Person performing the measurement
 - Instrument identification number/model
 - Readings for all continuing calibration checks
 - Comments
- Documentation for recorded data must include a minimum of the following:
 - Date and time of analysis
 - Person performing the measurement
 - Sample identification/station location
 - Dissolved oxygen, both in mg/L and percent saturation and temperature of sample (including units and duplicate measurements)
 - Comments

7.0 TRAINING/QUALIFICATIONS

To properly perform dissolved oxygen measurements, the analyst must be familiar with the calibration and measurement techniques stated in this SOG. The analyst must also be experienced in the operation of the meter.

Certain state certification programs require that dissolved oxygen measurements in the field be taken by, or in the presence of, personnel that are qualified under the certification program.



GUIDELINES FOR MEASUREMENT OF PH

1.0 INTRODUCTION

1.1 Purpose and Applicability

These Standard Operating Guidelines (SOG) provide basic instructions for routine calibration and operation of a variety of pH field pens. Although these meters may measure additional parameters (e.g., temperature, specific conductance, etc.), this SOG addresses pH measurement only (other capabilities are outlined in the appropriate SOG and manufacturer's individual instrument manuals). This SOG is designed specifically for the measurement of pH in accordance with EPA Method 150.1 and Standard Method 4500-H B which address electrometric pH measurements of drinking, surface, and saline waters, domestic and industrial wastes, and acid rain.

1.2 Quality Assurance Planning Considerations

The end use of the data will determine the quality assurance requirements that are necessary to produce data of acceptable quality. These quality assurance requirements will be defined in the site-specific workplan or Quality Assurance Project Plan (QAPP) (hereafter referred to as the project plan) or laboratory Quality Assurance Manual (QAM) and may include duplicate or replicate measurements or confirmatory analyses.

2.0 RESPONSIBILITIES

- The project manager is responsible for ensuring that project-specific requirements are communicated to the project team and for providing the materials, resources, and guidance necessary to perform the measurements in accordance with this SOG and the project plan.
- The analyst is responsible for verifying that the pH meter is in proper operating condition prior to use and for implementing the calibration and measurement procedures in accordance with this SOG and the project plan.

3.0 REQUIRED MATERIALS

The following materials are necessary for this procedure:

- pH meter
- pH meter manufacturer's instruction manual
- Deionized or distilled water
- 4.0, 7.0, and 10.0 buffer solutions
- Lint-free tissues
- Mild detergent
- Manufacturer's recommended storage solution
- Manufacturer's recommended cleaning solution
- Field data sheet or logbook
- Calibration sheet or logbook



4.0 METHODS

4.1 Sample Handling, Preservation, and General Measurement Procedures

- To achieve accurate pH measurements, samples should be analyzed immediately in the field, or as soon as possible after collection. Sample should be measured *in situ* or collected in plastic or glass containers.
- As temperature can affect the pH measurements obtained, both the pH and the temperature of the sample must be recorded, unless the meter is capable of automatic temperature correction (ATC).
- Primary standard buffer salts available from NIST can be purchased and are necessary for situations where extreme accuracy is required. Secondary standard buffers may be purchased as a solution from commercial vendors and are recommended for routine use. Buffers should not be used after their expiration dates as provided by the manufacturer. An expiration date of one year should be used if the manufacturer does not supply an expiration date or if the buffers are prepared from pH powder pillows, etc.
- Keep the probe elevated off the bottom to avoid disturbing sediments. Allow readings to fully stabilize before recording the pH measurement. This may take several minutes, especially if the pH is drastically different from the last reading or the bulb has been allowed to dry out between readings.
- Rinse the electrode with deionized or distilled water between samples and wipe gently, if needed, with a lint-free tissue. If a more thorough cleaning is required, use a mild detergent (e.g., dish soap) or the manufacturer's recommended cleaning solution.
- Store the probe in the manufacturer's recommended storage solution or, if this is not available, tap water. Do not use distilled or deionized water for storage purposes.



4.2. Calibration and Measurement Procedures

- The pH meter should be checked weekly before any analyses are performed. Otherwise, the meter should be checked or calibrated at the frequency specified in the project plan.
- Calibration should include a minimum of one point but ideally, a two point calibration that brackets the expected pH of the samples to be measured is desirable. Calibration measurements should be recorded in the calibration logbook.
- Choose either 7.0 and 10.0 (high range) or 4.0 and 7.0 (low range) buffers, whichever will bracket the expected sample range. Pour each buffer into a clean glass beaker. The volume should be sufficient to fully submerge the pH bulb and thermistor. If the pH is being measured in a laboratory, place the beaker on the magnetic stirrer and place the stirring bar in the beaker. Measure and record the temperatures of the buffers using a calibrated thermometer or automatic temperature compensation (ATC).
- Follow the manufacturer's calibration instructions.
- Once calibration is complete, discard the buffer and rinse the beaker (and stirring bar, if used) thoroughly with distilled or deionized water.



- An additional check may be performed, if required by the project plan, by placing the electrode into an additional buffer solution. This buffer should be from a different source than the buffers used for the initial calibration. This buffer should read within ± 0.2 pH units of the buffer's true pH value.
- Recalibrate the instrument if any of the following apply:
 - the check value varies more than 0.2 pH units from the true value
 - the expected pH of the sampled water body is outside the current calibration range
 - readings are erratic or do not stabilize
 - the instrument has just been cleaned or otherwise disturbed for maintenance

4.3. Troubleshooting Information

If there are any instrument performance problems that result in the inability to achieve the acceptance criteria presented in Section 5.0, consult the appropriate section of the meter instruction manual for troubleshooting procedures. If the problem persists, consult the manufacturer's customer service department immediately for further guidance.

4.4. Maintenance

- Instrument maintenance should be performed according to the procedures and frequencies required by the manufacturer.
- The electrode should be stored and maintained according to the manufacturer's instructions.

5.0 QUALITY CONTROL

- Duplicate measurements of a single sample will be performed at the frequency specified in the project plan. In the absence of project-specific criteria, duplicate measurements should agree within ± 0.2 pH units.

6.0 DOCUMENTATION

- All pH meter calibration, temperature check, and maintenance information will be recorded in a calibration logbook.
- pH data may be recorded on the appropriate laboratory or field data sheets or logbooks.
- Calibration documentation must be maintained in a thorough and consistent manner. At a minimum, the following information must be recorded:
 - Date and time of calibration
 - Person performing the measurement
 - Instrument identification number/model
 - Expiration dates and batch numbers for all buffer solutions
 - Reading for pH 7.0 buffer before and after meter adjustment
 - Reading for pH 4.0 or 10.0 buffer before and after meter adjustment
 - Readings for all continuing calibration checks
 - Temperature of buffers (corrected for any difference with reference thermometer), including units
 - Comments



- Documentation for recorded data must include a minimum of the following:
 - Date and time of analysis
 - Person performing the measurement
 - Sample identification/station location
 - Temperature and pH of sample (including units and duplicate measurements)
 - Comments

7.0 TRAINING/QUALIFICATIONS

To properly perform pH measurements, the analyst must be familiar with the calibration and measurement techniques stated in this SOG. The analyst must also be experienced in the operation of the meter.



GUIDELINES FOR MEASURING STREAMFLOW

1.0 INTRODUCTION

These guidelines provide instructions for the field measurement of flow rate in bodies of running water.

Descriptions of two field techniques are provided.

The first, called the time of travel method, is simple and does not require expensive or specialized equipment. This is most appropriate for rapid streamflow assessments where order of magnitude accuracy is acceptable or water depth is too low for the accurate measurement using a velocity meter.

The second method requires the use of a current meter, which is the preferred method where discharge measurements are being used to develop at-a-station rating curves and water depth is sufficient for measurement.

Additionally, these guidelines provide This method of calculating streamflow involves determining the cross-sectional area of the stream and measuring the average time it takes for a neutrally buoyant object to travel a known distance.

2.0 REQUIRED MATERIALS

The following materials are necessary for the measuring streamflow:

- Measuring stick to measure stream depth (folding stick is recommended)
- Flexible tape measure (longer than the width of the stream)
- Field data sheet, logbook, or tablet with electronic data sheet

If using a velocity meter, the following additional materials are also required:

- Swoffer Model 2100 current velocity meter (or similar)
- Calibrated wading rod

If using the time of travel method, the following additional materials are also required.

- A neutrally buoyant float
- Stopwatch (built-in app on most smartphones)
- Net (to catch the float)



3.0 METHODS

3.1 Choosing a Cross Section

- Select an appropriate stream cross section. The location selected should be straight (no bends), and free of obstructions. Unobstructed runs are ideal.
- Identify the left and right banks of the stream. When working in streams, left and right are relative to the mean flow direction. Therefore, the left bank will be to one's left when facing downstream but to one's right when facing upstream.
- To assure consistency of measurements and allow for easier comparison of data across time, flow should be measured at the same cross section of the stream during all visits. Include descriptions of site landmarks in field notes, and/or take photos of measurement locations. If site conditions allow, install permanent cross section markers, such as stakes or rebar.
- If a staff gauge is present near the stream measurement location, record the staff gauge depth during each visit.



Measuring stream depth using a folding yard stick.

3.2. Divide the Channel into Subsections

- Establish a transect by stretching the measuring tape across the stream, perpendicular to the channel axis. Secure each end of the tape to the stream banks so that the tape is taut.
- Take a minimum of four photographs, including one each facing upstream, the left bank, downstream, and the right bank.
- Starting with the left edge of water, measure width and stream depth at no less than three locations (stations) within the stream channel. This is the minimum number of stations and most streams will require more than three measurements to accurately calculate discharge.
- The area between each vertical station represents a channel subsection.

3.3. Measuring Velocity

3.3.1 Time-of-Travel Method

- To measure travel time, time how long it takes for a neutrally buoyant object (a float) to travel a known distance. Suitable objects should float, but sit very low in the water to minimize influence from wind, and can be untethered or tethered (methods adapted from EPA, 2012a described below).



- Suitable floats include:
 - citrus fruits or pieces of citrus peel
 - small sponge rubber balls
 - cheese puffs
 - small sticks or bits of vegetation
- Always face upstream when taking velocity measurements. Stand far enough downstream that stream velocity is not affected in the location being measured.
- Surface velocity is generally greater than depth-averaged velocity, so a correction factor (0.8 for rocky-bottom streams, 0.9 for muddy-bottom streams) is applied to float travel times (see Section 3.3, EPA 2012b)
- Untethered floats should be biodegradable, or a second person equipped with a net should be stationed downstream of the sampling reach to retrieve the float(s).
- Hold the measuring stick above the water surface, perpendicular to the cross section. Release the untethered float somewhat upstream of the end of the measuring stick to allow the float to reach full flow velocity. Using a stopwatch, time how long it takes for the float to travel a known distance (3 ft is recommended for most streams but longer distances may be appropriate where velocity is high). Repeat this process three times to obtain an average time to travel at one station before proceeding to the next station.

3.3.2 Depth-Averaged Current Meter Method

- Set the current meter to average measurements over at least a three second period. Longer periods may be used if appropriate to conditions.
- Always face upstream when taking velocity measurements. Stand far enough downstream that stream velocity is not affected in the location being measured.
- Carefully place the wading rod in the flow until the base is firmly on the stream bottom.
- Orient the current meter perpendicular to the cross section transect.
- Ensure that the wading rod is straight up and down (not angled).
- Hold the wading rod steady while adjusting the calibrated height of current meter to match the measured depth. This will allow collection of measurements that are reflective of depth-averaged velocity.
- Once at least three seconds have passed, view the reading from the current meter. Allow at least three readings to occur before recording. This will prevent erroneous data due to averaging of measurements from the set up process.



3.4. Calculating Flow

- The following equation is used to calculate flow using the time-of-travel method):

$$Q = (ACL)/T$$

- Q = stream discharge
- A = cross sectional area
- L = distance traveled by the float
- C = correction factor (0.8 for rough streambeds, 0.9 for smooth streambeds)
- T = average time of travel (seconds)

The following equation is used to calculate flow using the depth-averaged current meter method:

$$Q = AV$$

- Q = stream discharge
- A = cross sectional area
- V = velocity at 60% depth

4.0 DOCUMENTATION

Record streamflow data on field sheets, field notebooks, or electronic tablets. Any unanticipated site-specific information, which requires deviation from the above guidelines should also be recorded. In addition to recording the required discharge data, field notes for streamflow measurement should include a minimum of the following:

- Name or initials of person conducting the measurement
- Discharge measurement method used
- Site ID or name
- Date and time of streamflow measurement
- Environmental conditions (wind, temperature, etc.)
- Other relevant observations about site conditions
- Photographic evidence of streamflow and site conditions is also useful for verification of relative stream stage and flow from different visits, as well as any environmental factors that may have influenced data collection.

5.0 REFERENCES

EPA, 2012a. Water: Monitoring and Assessment. 5.1 Stream Flow. United States Environmental Protection Agency. Office of Water. EPA 841-B-97-003. Accessed January 27, 2020 at <https://archive.epa.gov/water/archive/web/html/vms51.html>



EPA, 2012b. SEDS Operating Procedure, Hydrologic Studies. Effective Date November 1, 2012. United States Environmental Protection Agency. Office of Water. SEDSPROC-501-R3. Accessed January 27, 2020 at <https://www.epa.gov/sites/production/files/2015-06/documents/Hydrological-Studies.pdf>



GUIDELINES FOR COLLECTION OF SURFACE WATER SAMPLES

1.0 INTRODUCTION

These guidelines provide basic instructions for the routine acquisition of surface water from lakes, ponds, and streams. The methods outlined below are intended to (1) standardize water sample collection methods; (2) ensure that samples delivered to the laboratory represent field conditions as accurately as possible; (3) assure proper documentation of sample collection; and (4) minimize cross contamination between sampling sites.

2.0 REQUIRED MATERIALS

The following materials are necessary for the acquisition of surface water samples:

- Nitrile gloves
- Labeled sample bottles provided by contracted laboratory (appropriately sanitized and containing the necessary preservative for desired analyses, see Table 1.0 for examples)
- Field data sheets or logbooks, including list of sites or locations to be sampled, and pencil
- Cooler with ice packs for sample storage
- Integrated depth sampler (if collecting algae sample)
- Secchi disk (if collecting algae samples)
- Laboratory Chain of Custody

Table 1.0 Example Container Types, Preservative Requirements, and Hold Times for Water Quality Samples.

Analysis	Bottle Type	Preservative	Hold Time
Total Phosphorus	plastic	H ₂ SO ₄	28 days
Dissolved Phosphorus	plastic	As Is	analyze immediately*
Total Suspended Solids (TSS)	plastic	As Is	7 days
Nitrate/Nitrite	plastic	As Is	48 hrs
Total Kjeldahl Nitrogen (TKN)	plastic	H ₂ SO ₄	28 days
Metals - Total	plastic	HNO ₃	6 months**
Metals - Dissolved	plastic	As Is	6 months**
Algae	opaque plastic	Lugol's iodine	>1 year
Chlorophyll-a	opaque plastic	As Is	analyze immediately
Bacteria	sterile plastic	As Is	6 hrs

* = 24 hrs with field filtration, ** = 28 days for mercury



3.0 METHODS

3.1 General Sampling Instructions

- Testing methods, sample containers, preservation techniques, and sample volumes should be selected in consultation with the laboratory to ensure that samples obtained will provide the desired results.
- Hold times vary considerably between different analytes and must be taken into consideration when planning field sampling efforts and lab courier pickups to assure the validity of analytical results.
- Field filtration of certain samples (dissolved phosphorus) is recommended. The laboratory can supply syringes and filters for use in the field.
- In general, surface water samples should be collected via direct grab methods.
- Sample collection should precede the measurement of physical field parameters (including pH, apparent color, turbidity, conductivity, and dissolved oxygen) in order to minimize the risk of sediment disturbance and/or sample contamination.
- Clean rubber gloves should be worn at each sampling location. When sampling multiple sites on the same day, gloves may be rinsed in the immediate area of the waterbody to be sampled (downstream at flowing sites).
- Approximately 1-inch of air space should be left when filling sample bottles (except for dissolved oxygen, alkalinity, and BOD samples), so that bottles may be shaken (if needed) before analyses (EPA, 1997; Simpson 1991).
- Sample containers with preservatives should not be used to collect water samples. If using containers with preservatives, a pre-cleaned container of similar type (an as is bottle) should be used to collect and subsequently transfer the sample to the preserved container.
- Ensure that all sample bottles are correctly and completely labeled before storage. Sample bottles should be stored in a cooler with ice packs (it is best to avoid ice, as meltwater could potentially contaminate samples) or in a refrigerator until they are submitted to a lab courier.



Using a pre-cleaned (as is) bottle to fill a sample bottle containing preservative.



3.1.1. Lake and Pond Sampling

- Grab samples from lakes and ponds should be collected at approximately 8 to 12 inches beneath the water surface or mid-way between the surface and the bottom if the waterbody is shallow (EPA 1997). Samples should not be collected in close proximity to the lake shoreline or submerged obstacles.
- To collect water samples, hold an as is bottle near the base, remove the lid, and plunge it into the water with the opening facing downward. Invert the bottle and allow it to fill before bringing it to the surface. Decant sufficient water from the bottle to allow for the required headspace and replace the cover, or carefully pour the contents into a bottle containing preservative. Repeat the above process to refill the as is bottle as many times as necessary.

Algae Samples

- Algae samples should be stored in opaque bottles with a small amount of Lugol's iodine for preservative (~1-2 drops in a 250 mL bottle). Algal taxonomy labs can provide opaque plastic bottles, but standard plastic as is bottles covered in aluminum foil can also be used.
- Algae samples should be collected using an integrated depth sampler. An integrated depth sampler consists of a length of tubing (~1in diameter, at least 2 m long) with a weight attached to one end. Sample collection procedures using the depth sampler should proceed as follows (procedure adapted from EPA 2012):



Integrated depth sampler for collection of algae samples.

- Determine the euphotic zone:
 - Lower the secchi disk over the shaded side of the boat until it disappears. Lower the disk a bit further, then slowly raise the disk until it reappears. Record the reappearance depth. The euphotic zone is calculated by multiplying the reappearance depth by 2.
- Holding onto the non-weighted end of the sampler, lower the tube into the water column. Rinse the sampler by submerging it three times.
- Lower the sampler so that it is submerged to the depth of the euphotic zone, or fully submerged if the euphotic zone is deeper than the length of the sampler. Cover the opening at the non-weighted end with a gloved thumb.



- Lift the sampler completely out of the water and cover the opening at the weighted end with a gloved thumb (both ends should be covered). Repeatedly lift each end of the sampler to mix the water sample within the tube.
- Fill the algae sample bottle with the required volume of water from the sampler (the bottle will contain Lugol's solution as preservative so be careful not to over-fill).
- Unlike samples for most other analytes, preserved algae samples can be stored at room temperature before submission to a lab.

3.1.2. Stream Sampling

- Samples should be collected from the center of small streams (i.e., 10-20 feet wide with a maximum depth of less than 2 feet), and at a location where water depth is 2-3 feet in larger streams.
- Always approach a sampling location from downstream, traveling so as to minimize the disturbance of bottom sediments and upstream waters.
- Stand downstream of the desired sampling location, hold the sample bottle near its base and plunge it below the water surface with the opening (mouth) downward. The opening of sample bottles should always be directed away from the sampler in an upstream direction.
- To inform investigations about nutrient inputs, stream flow should be measured whenever water quality samples are collected (see Guidelines for Measuring Stream Flow)

4.0 DOCUMENTATION

Report surface water field data on sheets or in notebooks. Any unanticipated site-specific information, which requires deviation from the above guidelines, should be recorded. Field notes for surface water sampling should include a minimum of the following:

- Name or initials of person collecting the samples
- Sample identification/station location
- Date and time of sample collection
- Environmental conditions (e.g. wind, weather)
- Other comments or observations about water quality and site conditions (e.g. visible algae bloom, dead fish nearby, sample has noticeable odor or color, etc.)

Photographic evidence of any notable conditions is also desirable.

5.0 REFERENCES

EPA, 2012. 2012 National Lakes Assessment Field Operations Manual. Version 1.0, May 15, 2012. United States Environmental Protection Agency. Office of Water. EPA-841-B-11-003. Accessed January 22, 2020 at https://www.epa.gov/sites/production/files/2013-11/documents/nla2012_fieldoperationsmanual_120517_final_combinedqrg.pdf



GUIDELINES FOR MEASURING GROUNDWATER SEEPAGE QUANTITY AND QUALITY

1.0 INTRODUCTION

These Standard Operating Guidelines (SOG) provide basic instructions for the routine measurement of groundwater seepage quality and quantity. These standard methods describe the proper installation of seepage meters and the operation of Littoral Interstitial Porewater (LIP) samplers.

2.0 REQUIRED MATERIALS

The following materials are necessary for the seepage meter installation procedure:

- Seepage meters of known diameter
- Plastic tubing with one hole stopper
- Seepage bags with one hole stoppers and plastic clamps
- 250 mL graduated cylinder
- Field book or data sheets

The following materials are necessary for the collection of groundwater samples for analysis:

- Hand pump
- 2-1 L filter flasks with stoppers and tubing
- Littoral Interstitial Porewater (LIP) sampler
- Sample bottles with labels

3.0 METHODS

3.1 Seepage Meter Installation

- Initially, representative segments of the shoreline, where seepage meters will be positioned, are selected based on topography and housing density. Such segments may also be assigned to shoreline locations based on specific project objectives.
- ESS personnel shall estimate seepage quantity by installing two seepage meters per defined shoreline segment and measuring the change in volume in the attached seepage bag over time. Change in volume multiplied by a conversion factor relating the allotted seepage time (i.e., fraction of the day for which the seepage meter was running) and then adjusting to unit area (square meter), yields the liters of in-seepage (positive value) or out-seepage (negative value) per square meter per day.
- Seepage meters shall be firmly embedded in the substrate to depth of greater than 4 inches. Inserting seepage meters to this preferred depth will ensure that volumetric changes observed in the attached seepage bags are truly representative of groundwater flows and will increase the likelihood that seepage meters will not be disrupted by strong currents or wave action.
- At each designated shoreline location (segments pre-determined by project plan), one seepage meter should be placed at a relatively shallow depth and one at a deeper depth in order to capture ground water flows that may be occurring in different strata.
- Seepage meters must be allowed to equilibrate for a minimum of 5 minutes before the system is “closed” by the attachment of the seepage bags.



- The seepage bag should be filled with an appropriate pre-measured volume of water. In most instances 250 mL will be appropriate. The pre-determined volume of water is necessary since this volume is compared to the volume obtained after sufficient time has elapsed to quantify the change in volume (either positive or negative).
- Seepage bags are to be secured in place with as little disturbance of the seepage meter as possible. The best approach is to slowly twist the seepage bag's rubber stopper into the hole of the seepage meter.
- Prior to use, seepage bags must be air dried in order to ensure that all residual water is removed from bags and therefore will not confound the change in volume measurements. Additionally, each bag and associated stopper must be visually inspected and air pressure tested prior to each use to ensure that no leakage can occur.

3.2. Groundwater Sampling Using Littoral Interstitial Porewater Sampler

- Groundwater seepage quality can be collected through sampling with a Littoral Interstitial Porewater (LIP) sampler. A hand pump, attached to a 250 ml HDPE plastic flask, creates a low-pressure vacuum causing water to flow from the LIP sampler into the attached plastic flask. To avoid accidental contact of the extracted water with the hand pump, a second plastic flask should be connected in-line using additional tubing.
- Porewater should be extracted from a minimum of three locations in each segment and composited using equal volumes from each location.
- Samples collected may be tested in the field for parameters such as, temperature, conductivity, and pH, and/or transferred into labeled bottles and sent to a laboratory for the other analyses.

4.0 DOCUMENTATION

Record data on field sheets, field notebooks, or electronic tablets. Any unanticipated site-specific information, which requires deviation from the above guidelines should also be recorded. Documentation should include a minimum of the following:

- Name or initials of person conducting the measurement
- Date
- Site ID or name
- Size of seepage meter (diameter)
- Time of seepage meter installation
- Time of seepage meter retrieval
- Volume of water added to seepage meter bag at installation
- Volume of water remaining in seepage meter bag at retrieval
- Results of in-lake and extracted groundwater field parameter measurements (temperature, pH, and specific conductance at a minimum)
- Environmental conditions (wind, temperature, etc.) and other relevant observations about site conditions
- Photographic evidence of conditions



GUIDELINES FOR THE MEASUREMENT OF TURBIDITY

1.0 INTRODUCTION

1.1 Purpose and Applicability

These Standard Operating Guidelines (SOG) provide basic instructions for routine measurement of turbidity using a nephelometric turbidity meter with a digital read-out device (e.g., LaMotte 2020we Turbidimeter). Measurements are made in accordance with EPA Method 180.1 that addresses nephelometric turbidity measurement of drinking, surface, and saline waters, and domestic and industrial wastes.

1.2 Quality Assurance Planning Considerations

The end use of the data will determine the quality assurance requirements that are necessary to produce data of acceptable quality. These quality assurance requirements will be defined in the site-specific workplan or Quality Assurance Project Plan (QAPP) (hereafter referred to as the project plan) or laboratory Quality Assurance Manual (QAM) and may include duplicate or replicate measurements or confirmatory measurements.

2.0 RESPONSIBILITIES

- The analyst is responsible for verifying that the turbidity measuring device is in proper operating condition prior to use and for implementing the calibration and measurement procedures in accordance with this SOG and the project plan.
- The project manager is responsible for ensuring that project-specific requirements are communicated to the project team and for providing the materials, resources, and guidance necessary to perform the measurements in accordance with this SOG and the project plan.

3.0 REQUIRED MATERIALS

The following materials are necessary for this procedure:

- Turbidity meter with digital read-out device
- Manufacturer's instruction manual for the instrument
- Turbidity tubes/cuvettes
- Mild detergent
- Lint-free cloth
- Distilled water
- Nephelometric Turbidity Unit (NTU) calibration standards
- Laboratory or field data sheets or logbooks



Example of a sample cuvette

4.0 METHODS

4.1 Sample Handling, Preservation, and General Measurement Procedures

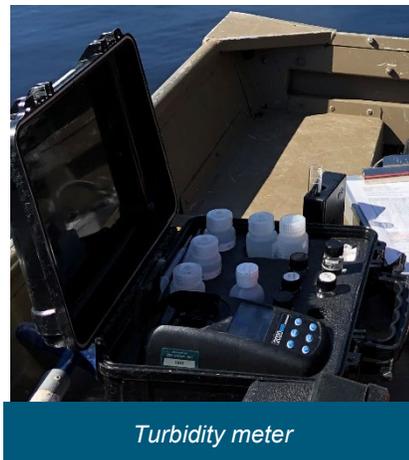
To achieve accurate turbidity measurements, samples should be analyzed immediately upon collection (preferably within 15 minutes). Samples should be collected in glass or plastic containers.

4.2. Calibration and Measurement Procedures

- Select a turbidity standard in the range of the samples to be tested (typically 0.00 NTU, 1.00 NTU or 10.0 NTU) or as recommended by the manufacturer. Fill a turbidity tube or cuvette with the standard, cap, and wipe the tube with the clean lint-free cloth.



- Place the sample into the turbidity meter such that the indexing arrow or line on the turbidity tube is aligned with the indexing arrow or notch on the meter face. Close the lid and press the “READ” button. If the displayed value is not the same as the value of the standard (within 10%), continue with the calibration procedure.
- Follow the calibration procedures outlined by the manufacturer’s manual.
- Verify the calibration every 15 samples and at the end of the day. Recalibrate the instrument if the check value varies more than 10% from the true value.
- Rinse cuvettes with deionized or distilled water and wiped gently with a lint-free tissue between sample analysis.
- Recalibrate the instrument with the appropriate NTU standard if the standard is not of the same order of magnitude as the samples being tested.
- The meter must be re-calibrated following any maintenance activities and prior to the next use.
- Record the turbidity reading to the nearest 0.01 NTU for measurements less than 11 NTU and to the nearest 0.1 for measurements greater than 11 NTU but less than 110 NTU. For values greater than 110 NTU record to the nearest 1 NTU.



Turbidity meter

4.3. Troubleshooting Information

If there are any performance problems with any of the meter-type turbidity measuring devices, consult the appropriate section of the meter instruction manual for the checkout and self-test procedures. If the problem persists, consult the manufacturer's customer service department immediately for further instructions.

4.4. Maintenance

Instrument maintenance for meter-type turbidity measuring devices should be performed according to the procedures and frequencies required by the manufacturer.

5.0 QUALITY CONTROL

The turbidity measuring tubes will, at a minimum, be checked against NTU calibration standards at the frequency stated in Section 4.2. This verification procedure will be performed in accordance with the manufacturer’s manual.

Duplicate measurements of a single sample will be performed at the frequency required in the project plan. In the absence of project-specific criteria, duplicate measurements should agree within + 5% for readings below 10 NTU and + 10% for readings above 100 NTU.

6.0 DOCUMENTATION

All turbidity meter calibration, checks, and maintenance information will be recorded on the daily calibration sheet or logbook. Turbidity data may be recorded on the appropriate laboratory or field data sheets or logbooks.

Calibration documentation must be maintained in a thorough and consistent manner. At a minimum, the following information must be recorded:



- Date and time of calibration
- Person performing the measurement
- Instrument identification number/model
- Expiration dates and batch numbers for all standard solutions
- Reading for each standard before and after meter adjustment
- Readings for all continuing calibration checks
- Comments

Documentation for recorded data must include a minimum of the following:

- Date and time of analysis
- Person performing the measurement
- Sample identification/station location
- Turbidity of sample (including units and any duplicate measurements)
- Comments

7.0 TRAINING/QUALIFICATIONS

To properly perform turbidity measurements, the analyst must be familiar with the calibration and measurement techniques stated in this SOG. The analyst must also be experienced in the operation of the meter.



GUIDELINES FOR USE OF WATER LEVEL DATALOGGERS IN SURFACE WATER

1.0 INTRODUCTION

These guidelines provide basic instructions for programming, deploying and downloading data from electronic dataloggers which are used for long-term water level monitoring and monitoring of other water quality parameters (e.g., temperature, conductivity). The methods outlined below are intended to (1) standardize datalogger monitoring of water levels; (2) ensure that data collected represent field conditions as accurately as possible; (3) provide guidance for the secure transfer and storage of data; and (4) assure proper field measurements and documentation.

2.0 REQUIRED MATERIALS

The following materials are necessary:

- Datalogger or Barologger
- Rebar, metal fence post or similar
- Sledgehammer or post driver
- Computer, laptop or tablet
- Communications device
- Datalogger software
- PVC housing and hose clamps
- Braided nylon twine or wire
- Water level monitoring device (electronic water level meter, plunker, etc.)
- Tools

3.0 PROGRAMMING THE DATALOGGER

The following general procedure is followed to edit the datalogger information and program the datalogger to collect readings. Always refer to the manufacturer's instructions for datalogger programming, deployment and data downloading and correction instructions.

If the datalogger is unvented, a second datalogger or Barologger will also need to be deployed to collect barometric pressure readings to support the barometric pressure correction of the data downloaded from the unvented datalogger.

- Connect the datalogger or Barologger to the computer, laptop or tablet using the supplied communications device.
- Select the appropriate COM or USB port for the communications device.
- Open the logger programming or launching page to allow for entering the logger details and programming the device for frequency of readings.
- Check the datalogger battery life and available memory to verify that it is acceptable for the intended use. This information can also be used to determine the frequency of data downloads that will be necessary.
- Rename the datalogger using the Site location.



- Program the datalogger to collect readings for the selected parameters at the specified interval.
 - The additional datalogger or Barologger should be programmed to collect readings at the same interval.
- Disconnect the datalogger from the communications device using the software program to disengage or remove from the communications device.

4.0 DEPLOYING THE DATALOGGER

The following general procedure should be used to deploy the datalogger for collection of readings.

- An appropriate location for the installation of the datalogger should be selected within a deep portion of the water body to allow for fluctuations in the water level.
 - An additional datalogger or Barologger should be mounted in the air in an inconspicuous location such as a tree or attached to a building.
- In surface water, the datalogger should be deployed within a PVC housing, if possible, to help to dampen any fluctuations (e.g., wave action or turbulence) in the surface water surface.
- The PVC housing should be secured using hose clamps to a mounting post (typically either rebar, metal fence post or similar) that can be driven into the substrate beneath the water body.
- Prior to deployment, collect a depth to water measurement from the top of the mounting post (rebar, metal fence post or similar) and an approximate depth to the bottom of the PVC housing.
- Deploy the datalogger by placing inside the PVC housing, attaching either braided nylon twine or wire to the datalogger, and threading through the top of the PVC cap to allow for retrieval of the datalogger without disturbing the position of the PVC housing.

5.0 DOWNLOADING DATA

The following general procedure should be followed when downloading the data.

- Soon after deployment (typically within two weeks, or as soon as possible given project constraints), a verification download should be performed to verify that the datalogger was programmed correctly and is collecting data at the appropriate interval.
- Subsequent downloads can be scheduled as necessary taking into consideration the frequency of readings and the available memory and battery life of the datalogger.
- Prior to removing the datalogger to download the data, collect a depth to water measurement from the top of the mounting post or other acceptable measuring point.
- Remove the datalogger and connect to the communications device.
- Connect the communications device to the computer, laptop or tablet and open the software.
- Navigate to the data download page and proceed with downloading the collected data.



- Certain datalogger software packages will require that the datalogging process be stopped and the datalogger will have to be reprogrammed prior to redeployment.
- If the datalogger is unvented, correct the downloaded data using the program supplied by the Vendor using the data collected from the additional datalogger or Barologger.

6.0 STREAMFLOW MEASUREMENTS

In order to convert the hydraulic head (pressure) measurements from the datalogger to streamflow, a series of streamflow measurements needs to be collected at varying stream stages or flow stages to support the development of a rating curve.

REFER TO THE GUIDELINES FOR MEASURING STREAMFLOW SOP FOR DETAILS ON THE COLLECTION OF STREAMFLOW MEASUREMENTS AND DEVELOPMENT OF A RATING CURVE.

7.0 DOCUMENTATION

Maintain field notes for the datalogger deployment and data download events including the collected field measurements that will be used to QC the data collected by the datalogger and convert the collected measurements to elevation, if applicable.

Photodocumentation of the datalogger deployment and setup should also be maintained as well as any observations during the field visits.

8.0 REFERENCES

Select references to Vendors that supply dataloggers are provided below.

Solinst, Levellogger Series Software User Guide, <https://www.solinst.com/products/dataloggers-and-telemetry/3001-levellogger-series/operating-instructions/user-guide/3001-user-guide.php>

In-Situ, Rugged Troll 100 and 200 and Rugged Troll BaroTroll Instruments, https://in-situ.com/pub/media/support/documents/Rugged_TROLL_Manual.pdf

Onset, HOBO U20L Water Level Logger (U20L-0x) User's Manual, https://www.onsetcomp.com/support/manuals/u20l_17153/