

SITE SPECIFIC PROJECT PLAN FOR:
PARTRIDGE LAKE WATERSHED-BASED RESTORATION PLAN PHASE 1
NHDES Project # CS-330129-07

Under the New Hampshire Department of Environmental Services
New Hampshire Nonpoint Source Management Program QAPP
August 27, 2020
RFA# 20097

October 21, 2020

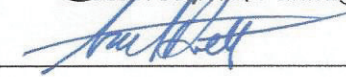
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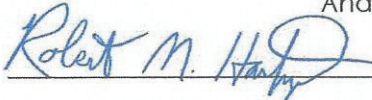
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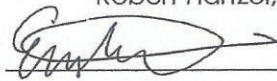
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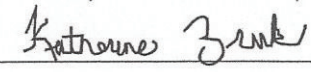
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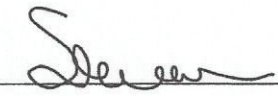
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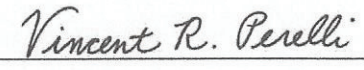
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1-DISTRIBUTION LIST

Table 1 lists people who will receive copies of the approved Site Specific Project Plan (SSPP) for "Partridge Lake Watershed-Based Restoration Plan Phase II" under the *New Hampshire Nonpoint Source Management Program Quality Assurance Program Plan* dated August 27, 2020.

Table 1. SSPP Distribution List

PLPOA = Partridge Lake Property Owners Association. CEI = Comprehensive Environmental, Inc. USEPANE = United States Environmental Protection Agency, Region 1, New England. NHDES = New Hampshire Department of Environmental Services. Littleton – Town of Littleton, New Hampshire.

Name	Project Role	Organization	Phone/E-mail
John Schultz	Project Manager	PLPOA	603-259-6108 jschultz@phmeco.com
Andrew Dorsett	Manager and Fiscal Agent	Littleton	603-444-3996 adorsett@townoflittleton.org
Bob Hartzel	Task Order Manager	CEI	508-281-5201 rhartzel@ceiengineers.com
Emily DiFranco	Field Lead / QA Coordinator	CEI	603-365-4300 edifranco@ceiengineers.com
Dave Roman	Pollutant Load Reduction Lead	CEI	508-281-5176 droman@ceiengineers.com
Josephine Hatton	GIS Lead	CEI	800-725-2550 jhatton@ceiengineers.com
Katie Zink	CWSRF Project Manager	NHDES	603-271-8475 katherine.e.zink@des.nh.gov
Stephen Landry	NPS Program QA Coordinator	NHDES	603-271-2969 stephen.c.landry@des.nh.gov
Vincent Perelli	QA Manager	NHDES	603-271-8989 vincent.r.perelli@des.nh.gov
Erik Beck	Project Manager	USEPANE	617-918-1606 beck.erik@epa.gov

2-PROJECT ORGANIZATION

Figure 1 outlines the organizational structure of project personnel. Table 2 identifies their specific roles and responsibilities. John Schultz, Project Manager, will oversee and communicate project progress to the New Hampshire Department of Environmental Services (NHDES), partners, and stakeholders, with help from the Partridge Lake Property Owners Association (PLPOA) and the Town of Littleton. The PLPOA and Town of Littleton will also be responsible for documenting and notifying NHDES, partners, and stakeholders of any changes made to the project.

Principal data users include the PLPOA, Comprehensive Environmental, Inc. (CEI), the Town of Littleton, and NHDES, who will use the data to assist in the development of a watershed-based restoration plan for Partridge Lake. Project personnel will present the data to the Partridge Lake Watershed Advisory Committee (PLWAC), who will be the principal decision makers. The PLWAC will be comprised of representatives from the PLPOA, CEI, the Town of Littleton, New Hampshire Fish and Game, NHDES, the New Hampshire Department of Transportation (NHDOT), and watershed landowners.

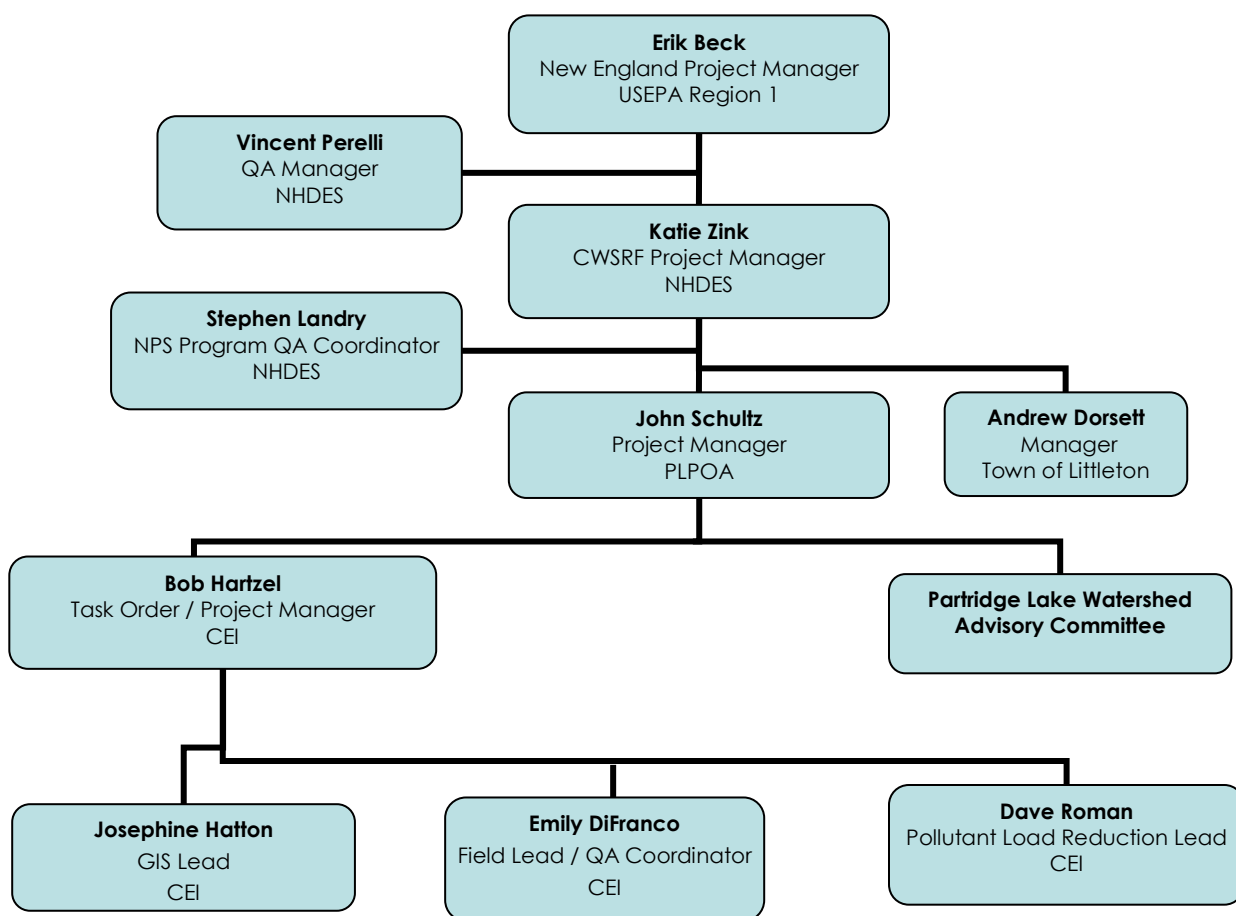


Figure 1. Project Organizational Chart. PLPOA = Partridge Lake Property Owners Association. CEI = Comprehensive Environmental, Inc. NHDES = New Hampshire Department of Environmental Services. USEPA – United States Environmental Protection Agency, Region 1 New England. CWSRF = Clean Water State Revolving Fund. NPS = Nonpoint Source Management Program.

Table 2. Personnel roles and responsibilities of key project personnel

Town of Littleton	Andrew Dorsett is the Town Manager for Littleton, New Hampshire and the recipient of the Clean Water State Revolving Fund (CWSRF) Stormwater Planning Loan to develop the watershed-based restoration plan for Partridge Lake. Mr. Dorsett will review all project deliverables to ensure contract adherence, approve payment requests, and process disbursements between the Town of Littleton, NHDES, and CEI.
PLPOA	John Schultz is the President of the Partridge Lake Property Owners Association (PLPOA) and serves as a co-lead for the project alongside the Town of Littleton. Mr. Schultz and the PLPOA are the primary recipients of the completed watershed restoration plan and Mr. Schultz will assist with review of project deliverables developed by contractors to ensure contract adherence.
PLWAC	Members of the Partridge Lake Watershed Advisory Committee (PLWAC) will be derived from various state, municipal, and local entities and collaborate with the project team identified in this table during all facets of watershed restoration plan development. The PLWAC will provide technical input, field assistance, review draft documents, and participate in key decision-making milestones during the contract period.
NHDES	Steve Landry (NHDES) is the Nonpoint Source (NPS) Management Program Coordinator and Quality Assurance Program Coordinator for NPS projects. He is responsible for reviewing Site Specific Project Plans (SSPPs) and Quality Assurance Project Plans (QAPPs). In addition, Mr. Landry will serve as a co-leader for NHDES on the project and review project deliverables.
	Katie Zink (NHDES) is the Clean Water State Revolving Fund (CWSRF) Project Manager for NHDES on this Stormwater Planning project. Ms. Zink will assist the Town of Littleton with contract management requirements relative to CWSRF and review project deliverables developed by contractors to ensure technical quality and contract adherence.
	Vincent Perelli (NHDES) is the agency's Quality Assurance Manager, and will be responsible for reviewing and approving this Site Specific Project Plan (SSPP). Mr. Perelli will consult on any SSPP amendments requested during the contract period but remain independent from the project.
CEI	Bob Hartzel (CEI) is the Task Order/Project Manager, and is responsible for overall management of the contract team, including overseeing CEI staff and subcontractor staff and coordinating with the Town of Littleton and the PLWAC.
	Emily DiFranco (CEI) is the Field Lead and the Quality Assurance Coordinator. She will prepare and conduct the field assessments, prepare the SSPP, and perform monitoring of quality control (QC) activities to determine conformance with quality assurance and quality control requirements.
	Dave Roman (CEI) is the Pollutant Load Reduction Analysis Lead and will develop analysis input data sets, perform the analysis, and prepare project deliverables. Mr. Roman will implement the QA/QC program related to load reduction analysis tasks.
	Josephine Hatton (CEI) is the GIS Lead and will develop all watershed-specific maps.

USEPANE	Erik Beck (USEPANE) is Project Manager for the New Hampshire Nonpoint Source Management Program and he oversees and approves work plans and projects funded through Section 319 and 604(b) of the Clean Water Act. Since this project funding is derived from a Clean Water State Revolving Fund (CWSRF) Loan awarded to the Town of Littleton, Mr. Beck will remain independent from the project.
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3-SITE INFORMATION

Partridge Lake is a 99-acre lake located in Littleton, New Hampshire (Figure 2). The lake is currently on the 303(d) List of Impaired Waters for New Hampshire for failing to support the designated uses of Aquatic Life Integrity and Primary Contact Recreation (swimming) due to low dissolved oxygen (DO) and elevated concentrations of Cyanobacteria hepatotoxic microcystins. Low DO in lakes is often indicative of enhanced nutrient loading from nonpoint source (NPS) pollution in stormwater runoff and internal loading from the lake itself. Nutrients stimulate plant and algae growth in the lake, which in turn consume oxygen during decomposition, depleting the system of oxygen for aquatic life. The limiting nutrient in Partridge Lake is phosphorus, and in addition to contributing to the oxygen depletion and subsequent internal loading of nutrients from lake sediments that feed the anoxia during the summer months, the elevated phosphorus concentrations also fuel the Cyanobacteria blooms in Partridge Lake.

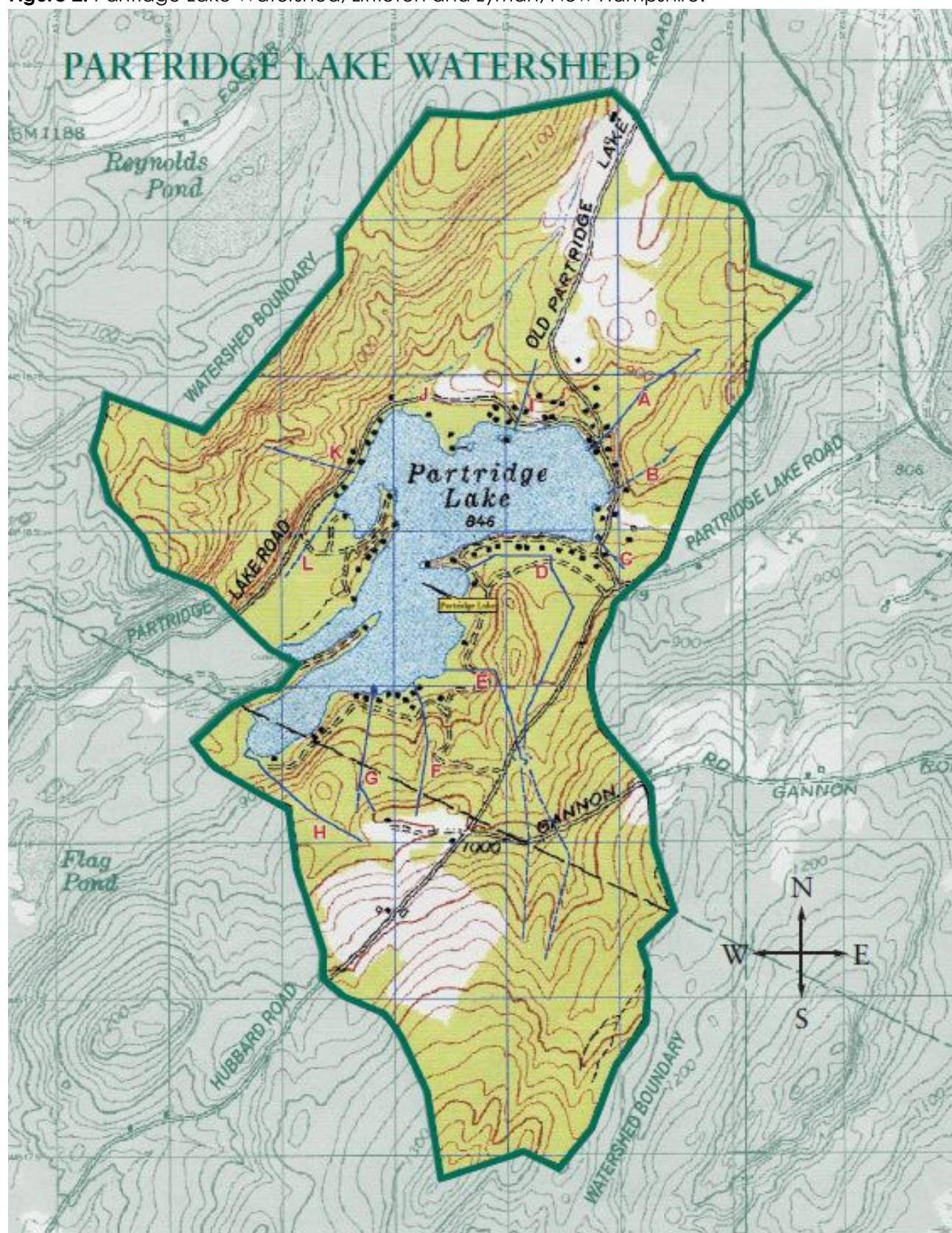
Because some forms of Cyanobacteria are toxic to people as well as animals, the blooms have resulted in swimming advisories being issued several years in a row to protect the public and residents that live along the shoreline of Partridge Lake. A watershed-based plan for Partridge Lake was completed in 2008 with several of the watershed management recommendations and best management practices implemented by the Partridge Lake Property Owners Association over the past twelve years to address pollutant/nutrient loading reaching the lake via stormwater runoff from the watershed. Based upon lake quality testing and results associated with the PLPOA participation in the New Hampshire Volunteer Lake Assessment Program (NHVLAP), the declining trends in transparency, dissolved oxygen, chlorophyll-a, hypolimnetic phosphorus concentrations, and recurring Cyanobacteria blooms point to a significant source of nutrient loading from within Partridge Lake itself that likely exceeds all external/watershed sources by a significant order of magnitude. It is therefore likely that in order to reduce or eliminate the occurrence of toxic algal blooms, sources of phosphorus reaching the lake will need to be identified and controlled from both the watershed and from within the lake itself.

This project will generate a watershed-based restoration plan for Partridge Lake that serves as an update/revision to the 2008 Partridge Lake Watershed Based Plan (Gomez and Sullivan 2008), and build upon the findings and recommendations contained in that document, draw from the information provided in the Partridge Lake and Watershed Diagnostic Study (NHDES 2005), the ongoing data collection efforts of the PLPOA through their participation in NHVLAP, and establish new, in-lake water quality goals designed to halt and/or reverse the decreasing lake quality trends, and provide a thorough understanding of the internal contributions of phosphorus to the lake and the possible management actions available to address them.

The challenge is to reduce current and/or prevent future nutrient loading to Partridge Lake to avoid a further decline in lake quality and trophic status. The watershed restoration plan will focus on the Dissolved Oxygen and Cyanobacteria impairments, determine the magnitude of external and internal phosphorus loading, and identify specific strategies for reducing excess phosphorus input to the lake.

CEI has been contracted by the Town of Littleton to provide support, leadership, and guidance in developing the watershed-based restoration plan for Partridge Lake. The specific project objectives are as follows:

1. Perform data review and assimilative capacity development for Partridge Lake by gathering all available water quality data and determine if acceptable for use in analysis of assimilative capacity;
2. Establish water quality goals for Partridge Lake by working with project partners to establish a process for determining the in-lake water quality goal for phosphorus;
3. Confirm phosphorus loading sources, including internal load for Partridge Lake using the Lake Loading Response Model (LLRM) to determine existing and potential, future conditions for Partridge Lake relative to eutrophication;
4. Estimate pollutant load reductions and actions needed in order to achieve water quality goals under various modeling scenarios;
5. Compile and evaluate work completed to date in the previous watershed-based plan for Partridge Lake and ongoing efforts by the PLPOA to help inform development of an updated education/outreach strategy; and
6. Publish the Partridge Lake Watershed Restoration Plan

Figure 2. Partridge Lake Watershed, Littleton and Lyman, New Hampshire.

4-Project Rationale

The Partridge Lake Watershed-based Restoration Plan project represents part of an ongoing strategy designed to restore and then protect the quality and integrity of Partridge Lake. The strategy represents a long-term commitment of lake and watershed study, management, and implementation of recommended actions through collaborative efforts among the PLPOA, the Town of Littleton, NHDES, and consultants with expertise in lake and watershed management.

Partridge Lake does not support the designated uses of Aquatic Life Integrity due to insufficient dissolved oxygen concentrations nor does it support Primary Contact Recreation (swimming) due to excessive concentrations of Chlorophyll-a and Cyanobacteria in the lake. Partridge Lake (NHLAK801030502-03) appears in the 2018 305(b)/303(d) Assessment failing to meet the aforementioned designated uses and is in the 2020-2024 New Hampshire Nonpoint Source Management Program Plan as ranking 118th for Lake and Impoundment Recovery Potential (currently set as medium priority).

The existing impairments are likely caused by NPS pollution in stormwater runoff, aging or failing septic systems, and significant contributions from internal loading of phosphorus from lake sediments. All of these sources are recognized within the New Hampshire Nonpoint Source Management Program Plan with stormwater ranked as the number one contributor of NPS pollution to surface waters in New Hampshire. Development of a watershed restoration plan for Partridge Lake will assist the PLPOA and their project partners in focusing their efforts to identify those watershed-based nutrient sources, and to quantify the potentially significant internal loading component of the nutrient budget for Partridge Lake and better understand the watershed and in-lake sources of pollutants that have led to the impairments. These efforts will then inform the development of revised nutrient budgets, pollution source allocations, conceptual best management practice (BMP) recommendations, and cost/benefit analyses for both watershed and in-lake treatments to achieve the established water quality goals for Partridge Lake.

5-PROJECT APPROACH/STUDY DESIGN

Previous analysis and study of Partridge Lake and the watershed indicate that the morphology and hydrology of the Partridge Lake watershed makes it highly sensitive to development and therefore plays a significant role in impacting the overall water quality of the lake, emphasizing the importance of management planning in this watershed. The *Partridge Lake and Watershed Diagnostic Study* (NHDES 2005) and the *Partridge Lake Watershed Based Plan* (Gomez and Sullivan 2008) both provided in-depth lake and watershed analyses and modeling, in-lake study, and a suite of watershed management recommendations designed to improve the quality of Partridge Lake by reducing phosphorus and eliminating cyanobacteria. Several phases of watershed BMP implementation has taken place over the past twelve years in the watershed, and trends in lake quality parameters appear to be relatively stable. However, the recurrence of cyanobacteria blooms within Partridge Lake remains a priority concern for stakeholders and the risks to public health that toxic algal blooms pose. The outcomes of previous studies and the evidence provided from ongoing in-lake testing by volunteers from the PLPOA to document water quality trends need to be revisited, evaluated, and considered as part of a renewed effort to identify and quantify phosphorus sources originating from the watershed and from within Partridge Lake itself.

The scope of work for this next phase of watershed management and lake restoration begins with the development of a second U.S. Environmental Protection Agency (EPA) compliant nine-key-element Partridge Lake Watershed-based Restoration Plan that addresses the impairments in the lake by confirming the impacts from existing sources of pollutants identified in previous planning efforts, documenting the existence and severity of other pollutant sources (internal loading) and the actions and costs necessary to restore lake quality and achieve the goals set forth in the new watershed-based restoration plan.

The objectives to be accomplished by CEI for development of the restoration plan include: 1) data review and assimilative capacity development; 2) establish water quality goals; 3) confirm phosphorus loading sources, including internal load; 4) estimate pollutant load reductions and actions needed to achieve the water quality goals for Partridge Lake; 5) develop an information and education strategy that includes a social media plan; and 6) publish the Partridge Lake Watershed Restoration Plan.

This stakeholder-driven process will assist the PLWAC in understanding how existing land use, shoreline development, future watershed development, and phosphorus contributions from internal loading impacts lake quality and why development of an updated watershed-based restoration plan for Partridge Lake is a necessary task for successful lake quality management planning, implementation, and restoration.

To ensure successful development of the restoration plan, the Town of Littleton has contracted with Comprehensive Environmental Inc. (CEI) to perform the watershed assessment, pollutant load and in-lake modeling analyses, identification of mitigation actions, estimation of pollution reductions necessary for restoring the water quality of Partridge Lake, and publication of the final watershed restoration plan.

Completion of the following tasks will occur:

- **Evaluate existing water quality data for completeness and validity in the Partridge Lake watershed from all available sources.** The NHDES Environmental Monitoring Database (EMD) data portal will be used to access data that has been pre-screened and quality checked by NHDES. The datasets include information from NHDES lake trophic surveys and data from the New Hampshire Volunteer Lake Assessment Program (NHVLAP). Water quality data will be used to assess current water quality conditions, determine the assimilative capacity, and assist the PLWAC in setting a water quality goal for phosphorus. Details on the sources of water quality data and method for determining the assimilative capacity and water quality goal are provided in Sections 6 and 7.
- **Determine the historical and current total phosphorus and chlorophyll-a levels for Partridge Lake**
- **Determine the assimilative capacity of Partridge Lake for phosphorus and prepare a summary of water quality criteria.** This will include an examination of resulting chlorophyll-a and dissolved oxygen as it relates to existing impairments.
- **Work with project partners (PLWAC) to establish a process for determining the Partridge Lake water quality goals for phosphorus.** As part of this process, CEI will provide written guidance on additional data collection that may be helpful in closing data gaps and providing a more refined understanding of nutrient dynamics related to internal

phosphorus loading. Based on initial discussions with project partners, CEI anticipates that additional data collection could include targeted sampling efforts beginning at ice-out and continuing through development of thermal stratification, and sediment sampling for analysis of sediment phosphorus concentrations. CEI will determine the historic and current median total phosphorus (TP), chlorophyll-*a*, dissolved oxygen (DO) levels, and associated trends. The data for each parameter will be presented in graphs and described in a technical memorandum, including a discussion of significant data gaps or recommended future monitoring protocols that would improve statistical confidence in the data.

- **Facilitate a project kickoff meeting (virtual) to discuss information generated in the previous task with the PLWAC and reach consensus on a water quality goal for TP in Partridge Lake.** It is anticipated that CEI will develop draft water quality goals that are “conservatively protective” based on regulatory standards, NHDES trophic class ranges for relevant parameters, and the goals of the PLWAC (e.g., eliminate toxic algal blooms, address internal TP loading to the lake, etc.) as further identified during the goal-setting process.
- **Estimate in-lake phosphorus concentration and associated chlorophyll-*a* concentration, Secchi transparency, and probability of algal blooms using the Lakes Loading Response Model (LLRM).** This task will also include a summary of loading estimates by type: waterfowl, septic, land use, atmospheric deposition, and internal load of TP. Estimates will be obtained from the completed LLRM model.
- **Complete a watershed build-out analysis, based on data provided by the Town of Littleton, the Regional Planning Commission, and the PLPOA.** Projected future land uses, population and number of developed parcels will be used in the analysis to estimate potential future phosphorus loads and increases from existing conditions. The results will be used to estimate the level of impact future development may have on Partridge Lake. This analysis will help to inform and prioritize recommendations to address these estimated future impacts.
- **Run modeling scenarios to estimate phosphorus loading to Partridge Lake under various conceptual and potential future conditions, including natural background (i.e., undeveloped watershed), current conditions (based on available data), and build-out under current zoning.** CEI will calculate the estimated pollutant load reductions needed to meet water quality goals under each scenario.
- **Determine phosphorus load reductions needed in order to achieve water quality goals under various modeling scenarios.** The various land use/buildout scenarios will be incorporated into LLRM to determine the phosphorus load reductions needed to meet water quality targets.
- **Review and revise (as necessary) best management practice (BMP) recommendations from the 2008 Partridge Lake Watershed-based Plan.** CEI proposes to identify new locations needing BMPs, and recommend new technologies to achieve pollutant load reductions sufficient to achieve goals. Prior to field investigations to identify potential BMP locations, CEI will work with the PLWAC to identify and prioritize potential BMP locations in the Partridge Lake watershed. CEI will identify potential target areas

through a desktop analysis, review of existing data furnished by the Town of Littleton, review of previous watershed studies, and review of information from published sources such as New Hampshire's GRANIT GIS clearinghouse. Following the desktop analysis and preliminary data collection, CEI will conduct a 1-day field assessment of priority areas. This effort will include use of a checklist that documents sources of NPS pollution including, but not limited to: 1) roadside runoff to tributaries; 2) direct runoff to surface waters; 3) runoff from development; 4) conversion of seasonal to year-round residences; 5) use of fertilizers; 6) excavation and other land disturbing activities; 7) erosion from poorly-buffered properties; 8) runoff from parking lots and other impervious areas adjacent to tributaries. The watershed field assessment will preferably be conducted during a period of active runoff-producing rainfall, to facilitate identification of potential BMP locations and types, and gauge feasibility. During field assessment, CEI will assess identified locations for space constraints, potential accessibility issues, presence of mature vegetation that may cause conflicts (e.g., tree roots), potential utility conflicts, site-specific drainage patterns, and other factors that may cause issues during design, construction, or long-term maintenance. It is anticipated that the watershed field assessment will result in identification of up to 15 implementation sites for BMPs. CEI will provide site photos, a map showing the location of each BMP site, and a summary table including key information for all potential sites, including general range of BMP size, estimated cost, treated phosphorus load, and limitations which can be used for prioritization.

- **Prepare BMP design concepts for each recommended management measure generated during field assessments.** The design concepts will include site photos, a narrative description of the NPS management measure, estimated costs, estimated pollutant removal, design information, and suggested maintenance (Appendix B). The design concept will also include a typical cross section/detail from existing resources source materials such as those found in the USEPA Clean Water Toolbox or state agency materials developed with funding support from NHDES, USEPA, and other government agencies.
- **Perform analysis of in-lake treatment options.** CEI will prepare an alternatives analysis for in-lake treatment options relative to phosphorus inactivation/sequestration/filtration etc. that includes cost estimates needed to achieve water quality goals. This alternatives analysis will include the following:
 - CEI will conduct a comprehensive literature review to ensure that the alternatives analysis includes a robust and up-to-date analysis of past and recently conducted projects involving lake phosphorus inactivation, sequestration, and filtration. This will include data and information from regional, national, and international projects from a variety of sources, including peer-reviewed journals such as the Lake and Reservoir Management Journal, Limnology, Limnological Review, Journal of Limnology, Limnology and Oceanography, International Journal of Limnology, and other sources.
 - For projects where information from peer-reviewed journals (or similar publications) is not available, CEI will also compile data and information as available from project reports, including information, on water quality, project

costs, longevity of effectiveness, logistical constraints, maintenance considerations, etc.

- Based on the data and literature review, CEI will prepare an alternatives analysis technical memorandum that will be provided to the PLWAC as a stand-alone document for review and comment. CEI will prepare a final version of this memorandum to incorporate review comments, and the memorandum will then be incorporated as a section of the draft/final Watershed Restoration Plan.
- **Estimate pollutant load reduction estimates.** CEI will estimate pollutant load reduction attributed to each site-specific, watershed-based BMP and in-lake treatment methods as described in previous tasks. Using the list of potential watershed and in-lake BMPs developed in previous tasks, CEI will develop a prioritized matrix of actions, including estimated costs, pollutant removal efficiency, social factors, relevant, regulatory authorities, and parties anticipated to complete the work. Prioritizations of recommended actions will be based on a cost/benefit analysis where the low-cost/high-benefit actions will earn the highest rank.
- **Develop information and education strategy.** CEI will compile and evaluate work completed in the previous watershed-based plan for Partridge Lake to help inform development of an updated education/outreach plan. CEI will work with the PLWAC on all aspects of the strategy development with the intent of generating a deliverable that will be an education/outreach and social media plan that runs concurrently with development of the Watershed Restoration Plan and throughout the 10-year implementation period.
- **Publish the Partridge Lake Watershed Restoration Plan.** CEI will compile work completed in above tasks into a draft Partridge Lake Watershed Restoration Plan (WRP) and distribute to project partners for review and comment. CEI will incorporate comments from project partners on the draft WRP, make revisions, and prepare for a final project meeting to present the draft WRP to the public. CEI will participate in the public meeting to present the draft WRP, incorporate public comments into the draft, and develop the final WRP. CEI will submit the final WRP to the PLWAC. The final WRP will be a USEPA-compliant (a-i) watershed-based plan that incorporates watershed and in-lake nutrient sources and management, implementation, and restoration measures, costs, and resources to control them linked to the water quality goals set for Partridge Lake.

6-HISTORICAL DATA INFORMATION

Data exist for the “deep spot” sampling location, the tributaries contributing flow to Partridge Lake, and the outlet from 1979 to present. Data is available through the NHDES Lake Information Mapper

<https://nhdes.maps.arcgis.com/apps/webappviewer/index.html?id=1f45dc20877b4b959239b8a4a60ef540> and presented in Lake Trophic Survey Reports (1979, 1992, and 2006), NHVLAP reports (2019 and 2020), the Partridge Lake Diagnostic Feasibility Study (2005), the Partridge Lake Watershed-based Plan (2008), and the Total Maximum Daily Load Report for Mercury (2007). The Lake Information Mapper application also contains ice-out data from 1997 to 2019 for Partridge Lake that will aid CEI and the PLWAC in targeting ice-out sampling and dissolved oxygen/phosphorus profile development under fully mixed conditions in the lake.

Water quality data are currently collected by volunteers participating in NHVLAP. Water samples are transported to the NHDES Limnology Center where QA/QC protocols are followed for processing and analysis according to the NHVLAP Programmatic QAPP. The data are accepted and entered into the EMD managed by NHDES.

7-ESTABLISHING WATER QUALITY GOALS

Pollution threats to Partridge Lake quality include stormwater runoff, development, recreation, septic systems, erosion, internal phosphorus loading, and land-use practices. The goal of this project is to protect surface waters in the watershed from these threats by developing a Watershed-based Restoration Plan that will establish in-lake and watershed load reduction goals for phosphorus.

A water quality goal for total phosphorus (TP) will be established for Partridge Lake by the PLWAC through an interactive process facilitated by CEI. This will be based on the results of the water quality analysis conducted by CEI. The data will be divided into two categories – “historical” data greater than 10 years old, and “recent” data collected within the last 10 years. The seasonal (May 24-September 15) median for the deep spot will be determined for both TP and chlorophyll-a (Chl-a) using all data.

The assimilative capacity of a waterbody describes the amount of pollutant that can be added to that waterbody without exceeding water quality thresholds. For New Hampshire lakes, the water quality threshold for phosphorus is based on the lake's trophic status. The NHDES has determined that the trophic status of Partridge Lake is categorized as mesotrophic (NHDES, EMD). For mesotrophic lakes, the water quality nutrient threshold for phosphorus is 12 µg/L (<https://www.des.nh.gov/organization/divisions/water/wmb/swqa/2018/documents/r-wd-19-04.pdf>).

Three types of lake assimilative capacity will be calculated for total phosphorus: total assimilative capacity, reserve assimilative capacity, and remaining assimilative capacity. This information is then used to determine water quality goals and actions necessary to achieve those goals. The assimilative capacity analysis is conducted in accordance with the Standard Operating Procedure for Assimilative Capacity Analysis for New Hampshire Waters (Appendix B in the *Guidance for Developing Watershed-based Plans in New Hampshire for Nonpoint Source Management Program Watershed Assistance Grants, Water Quality Protection Grants, and Clean Water State Revolving Fund Stormwater Planning Loans*, April 2, 2020) included in the *New Hampshire Department of Environmental Services Nonpoint Source Management Program Quality Assurance Program Plan – RFA#20097* (August 27, 2020).

In determining assimilative capacity, NHDES recommends 10% of the State threshold to be kept in reserve; therefore, phosphorus levels should remain below 10.8 µg/L to be in the Tier 2 High Quality Water category for a mesotrophic lake.

Assimilative Capacity (AC) for Total Phosphorus (TP)

- Total AC = (Water Quality Standard or 12 µg/L TP) – (Best Possible WQ or 0 µg/L TP) = 12 µg/L TP
- Reserve assimilative capacity = Total AC – (0.10 x Total AC) = 10.8 µg/L TP
- Remaining assimilative capacity = 10.8 µg/L – Recent Median TP

Once the water quality data analysis and assimilative capacity calculations have been completed and reviewed by NHDES, the CEI project team will determine the pollutant load reductions needed to meet water quality thresholds or other goals as determined by the PLWAC.

8-LOADING MODELS

A. Watershed Phosphorus Loading

The most current version of the Lake Loading Response Model (also called SHEDMOD or ENSR-LRM) will be used to assess current nutrient loads from the watershed. This model was developed by AECOM for use in New England and modified for New Hampshire lakes by incorporating New Hampshire land use, TP export coefficients, and adding septic system loading to the model (AECOM, 2009). This model provides the best fit for the Partridge Lake watershed and has been used extensively for numerous lake TMDLs and watershed-based plan development projects in New Hampshire. A recently completed (and NHDES-approved) LLRM model version and the LLRM User Guide contained in the *Total Maximum Daily Load for Robinson Pond, Hudson, NH* (AECOM and NHDES, 2011) will serve as the primary documentation on the model.

Data needed for input to the LLRM includes water quality monitoring data (TP, Chl-a, and transparency); physical characteristics, such as lake surface area, volume, and flushing rate; tributary monitoring data, including discharge; corrected land use data; sub-watershed land area delineations; precipitation data; and septic system data. CEI will develop a septic system database in support of this component of LLRM data gathering, and the database will be provided as a Microsoft Excel spreadsheet with instructions for updating as future watershed development occurs. Weather data will be downloaded from the National Oceanic and Atmospheric Association (NOAA) National Centers for Environmental Information (NCEI). Tributary discharge data will be used, where available, from USGS gauging stations in the area. Sub-watershed land area will be delineated using the most current data possible. In the absence of data that meet project standards for completeness and validity, LLRM default values will be used, pending approval by the PLWAC.

Geographical Information Systems (GIS) data will be obtained by CEI to assist with the land-use assessment and to delineate land use area by land use type (in acres) for input to the LLRM. GIS land use data are available from the State of New Hampshire GIS website (GRANIT). The New Hampshire Land Cover Assessment 2001 (or NHLC01) consists of the most recent and detailed classification of land cover in New Hampshire based on satellite images acquired between 1990 and 1999, with further revisions in 2001 (GRANIT). There is also a National Land Cover Dataset (NLCD) from 2016 that is more recent and will be integrated into the assessment tool for this effort. These data will be used for the land-use loading analysis as described below in the section titled *Future Loading Model/Build-Out Analysis*. GIS land-use coverages will be ground-truthed by CEI based on field observations, stakeholder input, and publicly-available, recent aerial photography to ensure the best coverages for input to the model.

David Roman of CEI will run the model. He has expertise in using watershed loading models for over ten years, and has successfully applied results from LLRM and BATHTUB models in support of developing many watershed plans. NHDES will provide technical assistance and review of modeling methods and results. David will make edits to the model based on feedback from NHDES and the PLWAC.

B. In-Lake Total Phosphorus Concentrations

Results of the watershed TP modeling will be input to a series of empirical models that provide predictions of in-lake TP concentrations, Chl-*a* concentrations, algal bloom frequency, and water clarity. Also referred to as TP retention modeling, the model estimates in-lake TP concentrations based on physical and chemical lake characteristics, including lake volume, mean depth, watershed area, flushing rate, and estimated watershed TP loading. Because of the imperfect nature of any model to predict processes within natural systems, the model will compare six different in-lake TP models. The average of the six empirical models will be used as the predicted TP value for Partridge Lake with some exceptions (it may be determined that one of the models is most representative, or a model could be eliminated as inapplicable, which will be documented both in the model spreadsheet and in all applicable reports). The predicted in-lake TP concentration will be compared to actual in-lake water quality data (discussed above). Additional predictions (Chl-*a*, water clarity, and algal bloom probability) will be determined based on the median in-lake TP concentration.

C. Future Loading Model/Buildout Analysis

CEI will receive buildout analysis data from the Town of Littleton to analyze the effects of predicted future watershed development on the water quality of Partridge Lake. The buildout analysis uses GIS-based zoning data and CommunityViz® software to estimate future development within the watershed. The analysis will combine projected population estimates, current zoning restrictions, and a host of additional development constraints (e.g., conservation lands, steep slopes, wetlands, existing buildings, soils with development suitability, unbuildable parcels, etc.) to determine the extent of buildable area in the watershed. Future TP loading will be estimated under full or partial buildout (depending on the timeline of full buildout) and an assessment of the potential effects of future development as it relates to water quality goals will be determined.

D. Septic Systems

CEI will review previous septic system survey data generated by the PLPOA and documented in the 2008 Partridge Lake Watershed Management Plan. Data contained within these survey results will assist with populating the nutrient loading cells within the LLRM when determining contributing sources of phosphorus to the lake. CEI will provide options for additional methods to detect failing septic systems, provide options for septic system programs that could be implemented in the Partridge Lake watershed, conduct a regulatory review of local and state ordinances in regards to septic systems, and develop a septic system database focused upon septic systems along the lake shore. The database will incorporate information such as location, age, and maintenance history of individual septic systems from previous septic surveys and from available town and state records. The database will be provided as a Microsoft Excel spreadsheet.

E. Watershed Survey

Following desktop analysis and preliminary data collection, CEI will conduct a 1-day field assessment of priority pollutant loading and BMP areas throughout the watershed. This effort will include use of checklist (Appendix A) that documents sources of NPS pollution including, but not limited to: roadside runoff to tributaries; direct runoff to surface waters; runoff from development; conversion of season to year-round residences; use of fertilizers; excavation and other land

disturbance activities; erosion from poorly-buffered properties; and runoff from impervious areas adjacent to tributaries and/or the shoreline of Partridge Lake. In addition to providing a summary of each location, site photos, and potential BMP types for pollutant source areas identified, CEI will also provide maps for each location and a summary table for each potential BMP site that contains the general range of BMP size, estimated cost, treated TP load, and limitations to implementation that can be used for prioritization.

F. Pollutant Load Reduction Estimates

The Massachusetts Department of Environmental Protection's (MassDEP) Watershed Based Plans Tool (WBPT) will be used to calculate load reduction estimates for areas of the watershed that are shown to contribute substantial amounts of phosphorus to Partridge Lake. The WBPT is an established empirical model that estimates nutrient or pollutant export amount from watershed sites based on drainage area, precipitation patterns, land use, and known concentrations of pollutants.

Load reduction estimates will be calculated by David Roman of CEI and reviewed by Bob Hartzel of CEI for completeness and rationality. Data will be evaluated using the best professional judgment of qualified staff and comparisons to load reduction estimates generated from similar watershed analyses in New Hampshire. A final review will be completed by Matt Lundstedt, CEI Engineering Technical Lead.

The PLWAC will identify and prioritize areas of the watershed to install pollutant runoff controls using BMPs based on the results of the load reduction estimate analysis. CEI will estimate load reductions and cost estimates for the identified BMPs. Potential sizing, costs, and pollutant load reductions will be calculated for each recommended structural BMP by using the WBPT. Required inputs include: BMP type, design storm size, drainage area, and land use. Outputs include: anticipated BMP footprint based on a typical cross section; estimated construction cost; and estimated load reduction for Total Suspended Solids (TSS), Total Phosphorus (TP), and Total Nitrogen (TN). Outputs from the WBPT have been previously reviewed and approved by USEPA Region 1.

The WBPT has been configured for a subset of common structural BMPs. Output parameters for BMPs not currently included in the WBPT were calculated by CEI as feasible based on published information and professional judgement. CEI included these work products and supplements to the WBPT in the USEPA-approved *QAPP for Field Assessments and Analysis in support of Bantam Lake Watershed Based Plan Appendix* (2020). Specific methods for this BMP pollutant loading estimate analysis are as follows:

- **Delineate drainage area and determine land use information:** Where applicable, the drainage area to proposed BMP features will be delineated by CEI staff using one-foot contours obtained from existing site surveys, field survey, aerial imagery, and best professional judgement. The land use/cover type within each delineated drainage area will be estimated based on data from the National Land Cover Database (NLCD).
- **Perform sizing:** A general design objective is to size each BMP to treat and potentially infiltrate the water quality volume (WQV) to the maximum extent practicable. The WQV is the minimum amount of stormwater runoff from a rainfall event that should be captured and treated to remove the majority of stormwater pollutants on an average annual basis. The WQV is defined by CEI as the volume of runoff generated by the first

one-inch of rainfall. However, each proposed BMP should be designed to get the most treatment that is practical given the size and constraints of each site. Applicable BMPs (e.g., bioretention cells) were sized using the MassDEP WBPT based on a one-inch design storm.

- **Estimate costs:** The construction costs for each potential structural BMP will be estimated by CEI using output from the MassDEP WBPT, then adjusted based on best professional judgement relative to overall site size and complexity (i.e., inflated upwards for conservatism). BMPs not supported by the MassDEP WBPT will be estimated using inflation adjusted unit pricing from past projects in the region. Once construction costs are calculated, engineering and design costs will be calculated at 30-percent of the estimated construction cost. Engineering and design costs represent approximate costs for engineering design and analysis, survey, design drawing preparation, and permitting. The 30-percent estimate may vary on a site-specific basis. An overall capital cost for each structural BMP will then be estimated by summing estimated construction and engineering costs. A contingency factor of roughly 20-percent will be applied to provide a cost estimate range. Cost estimates will not include engineering services related to building and construction quality assurance.
- **Calculate potential pollutant load reductions:** Pollutant loading estimates associated with applicable structural BMPs will be calculated based on the MassDEP WBPT. Structural BMPs not supported by the MassDEP WBPT (e.g., bank stabilization) will be calculated based upon the USEPA Region 5 Spreadsheet Model for Estimating Load Reductions included in the *New Hampshire Department of Environmental Services Nonpoint Source Management Program QAPP- RFA#20097* (2020).

BMPs will be prioritized based on specific load reduction estimates to identify the top priority BMPs. CEI will provide recommendations for a post-BMP monitoring program to confirm that the desired BMPs are achieving the desired pollutant removal. These estimates will guide future implementation efforts in the watershed to help reduce phosphorus levels in Partridge Lake. Any observations, trends, conclusions, and limitations in the data will be documented by CEI in the final report and reported to PLWAC.

9-QUALITY OBJECTIVES AND CRITERIA

The QA process for this project consists of using data of acceptable quality, data analysis procedures, modeling methodology and tools, administrative procedures, and technical reviews. Project quality objectives and criteria for data will be addressed by: (1) evaluating the quality of the data used, and (2) assessing the results of the model application.

Measurement Data Acceptance Criteria

Model setup, calibration, validation, and application for this project will be accomplished using secondary data from qualified sources, including governmental agencies. Data of known and documented quality are essential components of the success of the water quality modeling analysis to be conducted under this project because the model will generate data to be used to support the in-lake water quality goal-setting and decision-making process. Table 2 summarizes the acceptance criteria for secondary data that will be used in the setup and calibration of the model.

The organizations generating the secondary data that may be used in this project typically apply their own review and verification procedures to evaluate a dataset's integrity and conformance to QA/QC requirements. The quality of the data will be judged using information in source documents, from websites of origin, or directly from the authors. If the quality of the data can be adequately determined, the data will be used. If it is determined that no quality requirements exist or can be established for a dataset that must be used for this task, a case-by-case basis determination will be made regarding the use of the data. Data of unknown quality will not be used if the use of such data is believed to have a significant or disproportionate impact on the model and project results.

Secondary data will be assembled, reviewed, and formatted in an Excel spreadsheet format ready for input into the LLRM by the CEI team. Data that are outside of typical ranges for a given parameter will be flagged for exclusion during model setup, calibration, and validation. Flagged data will only be excluded if they are determined to be erroneous (e.g., pH >14).

Table 3. Data Acceptance Criteria for Secondary Data

Quality Criterion	Description
Reasonableness	Datasets will be reviewed to identify anomalous values that may represent data entry or analytical errors. Such values will not be used without clarification from the agency providing the data.
Completeness	Datasets will be reviewed to determine the extent of gaps in space and time. It is likely that some data gaps will be evident. These gaps and the methods used to fill the gaps will be discussed in project deliverables.
Comparability	Datasets from different sources will be compared by checking the methods used to collect the data and that the units of reporting are standardized.
Representativeness	Datasets will be evaluated to ensure that the reported variable and its spatial and temporal resolution are appropriate for the project. For example, datasets must be able to be reasonably aggregated (or disaggregated) to represent conditions in the model and must be representative of conditions during the simulation periods. The goal is for data and information to reflect present day conditions. Where possible, data from the past 10 years will be used.
Relevance	Data specific to the study site will be used. If needed, regional data and information that most closely represent the study site will be used.
Reliability	Sources of data and information will be considered reliable if they meet at least one of the following acceptance criteria: <ul style="list-style-type: none"> • The information or data are from a peer-reviewed, government, industry-specified source. • The source is published. • The author is engaged in a relevant field such that competent knowledge is expected (i.e., the author writes for an industry trade association publication versus a general newspaper). • The information was presented in a technical conference where it is subject to review by other industry experts. • The information or data are from a lake association/watershed group, deemed credible by NHDES. • Sources of data that use unknown collection and data review procedures are considered less reliable, and will be used only if necessary to fill data gaps and following discussion with and approval by NHDES.

EPA's *Guidance for Quality Assurance Project Plans for Modeling* (EPA QA/G-5M) discusses the importance of using performance criteria as the basis by which judgments are made on whether the model results are adequate to support the decisions required to address the study objectives. A "weight of evidence" approach that embodies the following principles will be adopted for LLRM and other model calibration in this project (Donigian 2002):

Given that models are approximations of natural systems; exact duplication of observed data is not a performance criterion. The model calibration process will measure, through comparability goals, the ability of the model to simulate observed data.

No single procedure or statistic is widely accepted as measuring, nor capable of establishing, acceptable model performance. Thus, both quantitative (error statistics) and qualitative (graphical) comparisons of observed data and model results will be used to provide sufficient evidence to weight the decision of model acceptance or rejection.

All model and observed data comparisons must recognize, either qualitatively or quantitatively, the inherent errors and uncertainty in both the model and the measurements of the observed data sets.

10-QUALITY CONTROL

Quality control checks will be performed by CEI Task Manager, Bob Hartzel to ensure that information collected for the project is accurately entered in spreadsheets. QA/QC checks will be conducted on all spreadsheets for inconsistencies. If errors are identified, CEI Task Manager, Bob Hartzel, will review the input values and correct the error to ensure that no incorrect information is used in any model calculation. In addition, CEI Task Manager, Bob Hartzel, will review all model inputs, calculations, and outputs for QA/QC. All QA/QC issues identified will be properly documented, along with the appropriate steps taken to resolve the issues, in the final LLRM report and in the spreadsheet model log documentation tab.

11-FINAL PRODUCTS AND REPORTING/SCHEDULE

The following objectives will be completed by CEI and report and/delivered to the Town of Littleton and the PLWAC by the Project Task Manager, Bob Hartzel, during the project period:

- Site Specific Project Plan for the Partridge Lake Watershed Restoration Plan – **November 2020**
- **NHVLAP sampling – November 2020 through August 2021**
- Data review and assimilative capacity development for Partridge Lake – **December 2020**
- Establish water quality goals for Partridge Lake – **February 2021**
- Confirm phosphorus loading sources, including internal load – **May 2021**
- Estimate pollutant load reductions and actions needed – **August 2021**
- Information and education strategy /social medial plan – **September 2021**
- Partridge Lake Watershed Restoration Plan – **November 2021**

APPENDIX A

Watershed Assessment Field Data Form (page 1)

Watershed / Subwatershed Name: _____ Field Crew: _____

Site # _____ Date: _____ Site Ownership (if known): _____

Weather Conditions: _____ Rain in last 48 hours (approx. total) _____

Location (town, road name, house#, intersection) _____

GPS Coordinates: _____ Photos Taken? _____

General Site Description:

Land

State Road

Municipal Road

Private Road

Trail/Path

Use/Activity:

Driveway

Residential

Commercial

Municipal/Public

circle

one

Boat Access

Agriculture

Construction Site

Other: _____

Description of Problems/Improvement Opportunities: circle ALL that apply

Problem Type	Description (circle)	Notes/Description of Problem	Approx. Size (length x width)
Surface Erosion	<i>Slight</i> <i>Moderate</i> <i>Severe</i>		
Road Shoulder Erosion	<i>Slight</i> <i>Moderate</i> <i>Severe</i>		
Soil	<i>Bare</i> <i>Uncovered Pile</i> <i>Winter Sand</i>		
Culvert	<i>Unstable Inlet/Outlet</i> <i>Clogged</i> <i>Crushed/Broken</i> <i>Undersized</i>		
Ditch	<i>Slight Erosion</i> <i>Moderate Erosion</i> <i>Severe Erosion</i> <i>Bank Failure</i> <i>Undersized</i>		
Parking Lot	<i>Drains Directly to Waterbody</i> <i>Evidence of Concentrated Flow</i>		
Shoreline	<i>Undercut</i> <i>Lack of Shoreline Vegetation</i> <i>Erosion</i> <i>Unstable Access</i>		
Agriculture	<i>Livestock Access to Waterbody</i> <i>Tilled Eroding Fields</i> <i>Manure Washing Off-Site</i> <i>Inadequate Buffer</i>		

Watershed Assessment Field Data Form (page 2)

Other (e.g., area to improve stormwater treatment)			
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Recommended BMP(s): circle ALL that apply:

*Vegetated Filter Strip**Bioretention**Detention Basin**Retention Basin**Infiltration Basin**Infiltration Trench**Gravel Wetland**Sand Filter**Grassed Swale**Other:* _____*Subsurface Structure**Deep Sump Catch Basin**Leaching Catch Basin**Hydrodynamic Separator**Establish Buffer**Enhance Buffer**Add New Surface Material**Bank Armoring**Bank Stabilization**Divert Runoff**Armor Inlet/Outlet (Culvert)**Replace Culvert**Enlarge Culvert**Plunge Pool**Conservation Tillage**Crop Nutrient Management**Livestock Access Limitation**Pet Waste Station*

Description of Recommendation(s):

Potential Site Constraints: circle ALL that apply

*Limited Space**Utilities**Private Property**Crosses Property Lines**Permitting Issues (e.g., wetlands)**Steep Slope**Difficult Access**May Interfere with Snow Plowing**Other:* _____

Sketch of Site / Potential BMP(s):

APPENDIX B

Example Conceptual BMP Design (Page 1 of 2)

Site 1: Boat Launch

Location: 123 Smith Street

Source Type: Boat Launch/Parking Lot

Owner: Town of Townington

Priority: High

Site Description

The Boat Launch and parking lot are located on Palmer Road. The parking lot is relatively flat and unpaved and drains as surface runoff down the boat launch into the Lake. The Boat Ramp is cracked and is in poor condition. There are no known underground utilities or site access constraints at this site. Underlying soils are Sandy Loam (Hydrologic Soil Group B) and are expected to provide effective infiltration.



Existing Boat Launch Parking Area.



Existing Boat Launch

Proposed Improvements

1. Install appx. 60' by 30' bioretention cell in existing grassed area to east of boat ramp with curb inlet to capture sediment / debris from upgradient gravel parking lot. Install riprap overflow to discharge to Bantam Lake.
2. Replace paved boat ramp with articulated block ramp (appx. 30' wide by 30' long). Install trench drain at the top of boat launch ramp (approximately 46' wide) and direct flow to east of ramp to bioretention cell.

See **Figures Below** for for an overview of proposed improvements, including a typical design detail for a bioretention cell.

Estimated Costs: \$78,000 - \$117,000

Estimated Nutrient Load Reduction:

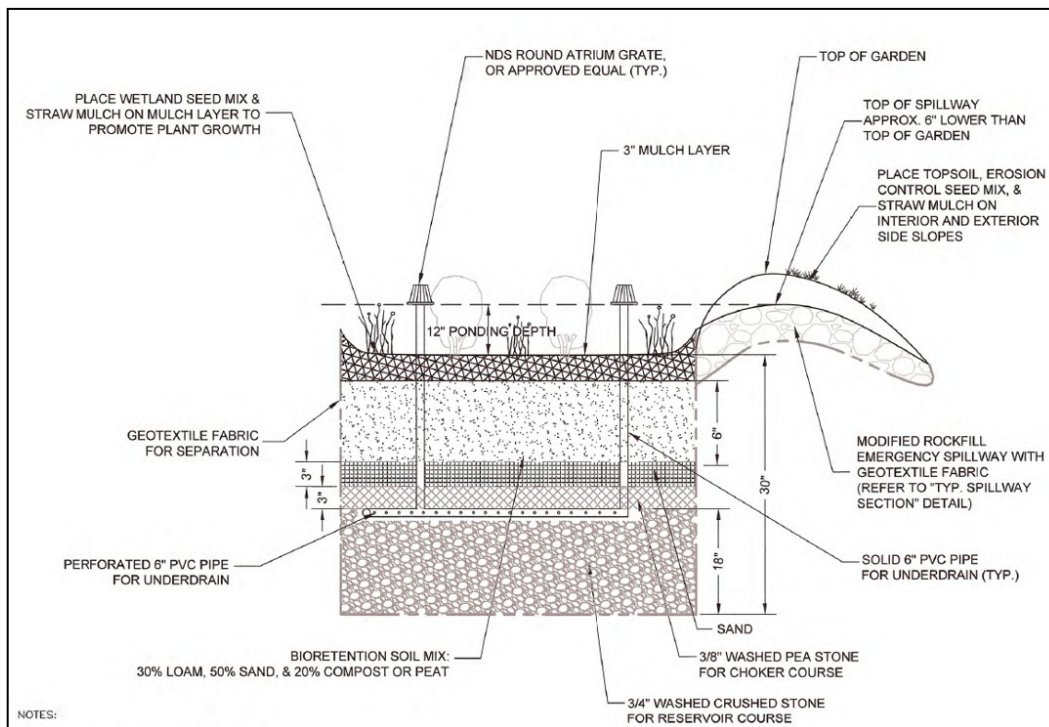
- Total Suspended Solids: 0.4 ton/yr
- Total Phosphorus: 2.1 lb/yr
- Total Nitrogen: 12.2 lb/yr

Anticipated Permits: Municipal Inland Wetland Permit, 401 Water Quality Cert.

Example Conceptual BMP Design (Page 2 of 2)



Proposed Parking Lot and Boat Launch Improvements.



Typical Bioretention Cell Cross Section with Underdrain and Overflow