

Section 1. Project Management

1.1 Title and Approvals

Assessment of Tile Drainage System Impacts to Lake Champlain and Phosphorus Loads in Tile Drainage in the Jewett Brook Watershed of St. Albans Bay and in Addison County

Quality Assurance Project Plan, Version 2.0, Amendment 1 RFA# 19005

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| Bryan Dore, Project Officer, EPA | Date |
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1.4 Project/Task Organization

Table 1 below outlines the primary project participants and their roles in the project. The scope of this QAPP Version 2.0, Amendment 1 includes monitoring and assessment of tile drainage systems and primary data collection related to the design, installation, and monitoring of experimental tile drainage treatment systems.

Stone Environmental, Inc.:

Staff members from Stone Environmental will report to the project manager for technical and administrative direction. Each staff member has responsibility for performance of assigned quality control duties in the course of accomplishing identified sub-tasks. The quality control duties include: completing the assigned task on or before schedule and in a quality manner in accordance with established procedures and documenting and ascertaining that the work performed is technically correct and meets all aspects of the QAPP.

Table 1: Roles and responsibilities

| Individual(s) assigned | Responsible for: | Authorized to: |
|----------------------------|---|---|
| Stone Environmental | | |
| David Braun | Project manager, overall study design, landowner outreach, monitoring station design, treatment system design, treatment system construction oversight, monitoring station construction oversight, monitoring program oversight, non-routine maintenance, primary contact for the Lake Champlain Basin Program. | Coordinate project operations Document and approve all major project changes Develop monitoring station designs Supervise station construction Interim/final report preparation Lead design of treatment systems Oversee construction and monitoring of treatment systems |
| Serena Matt | Management of routine field operations, data management, computations. | Repair damage/breakdown in field stations Calibrate and maintain monitoring equipment Oversee collection and handling of water samples Conduct routine operation and maintenance of field stations Perform data QA/QC and reduction Provide data reports and outputs |
| Don Meals | Statistical analysis of monitoring data and interpretation of results. | Conduct statistical data analysis Interpret project findings |
| Kim Watson, RQAP-GLP | Quality review. | Evaluate all aspects of project operations for compliance with approved QAPP Resolve QA/QC issues |
| LCBP | | |
| Matthew Vaughan | Maintain and distribute the approved QAPP. | |

1.5 Special Training Requirements/Certifications

Personnel with considerable expertise and experience in performing the project tasks will conduct all sampling and analysis for the project. If field data collection is done by subcontracted personnel at certain sites, initial training will be led by the Stone Environmental Project Manager or his designee. The Project Manager or his designee will also be responsible for continued coordination of field operations and maintenance of consistency among field sampling personnel. This consistency will be aided by the use of standard checklists and forms for sample retrieval and station maintenance (see Appendix A, Study Specific Procedure). All personnel performing the project tasks will have documented training in their respective duties and shall have read the

applicable SOPs. Stone Environmental maintains training records for all staff that document relevant training and SOP review. Laboratory analysis will occur at the Vermont Agriculture and Environmental Laboratory (VAEL) under the direction of the Laboratory Director. No additional specialized training or certifications are necessary for personnel to conduct the project tasks.

Section 2. Project Definition and Objectives

2.1 Problem Definition/Background

Subsurface drainage is an essential agronomic practice on many agricultural fields in the Lake Champlain Basin (LCB), allowing timely equipment access, reduced soil compaction, and increased crop yields in fields otherwise too wet to efficiently farm. The combined effects of drawing down the water table and providing rapid conveyance of subsurface water to an outlet can significantly change the hydrologic behavior of a field, generally reducing surface runoff by enhancing infiltration and ground water transmission. Until recently, it was widely believed that, despite hydrologic changes caused by installation of subsurface drainage, phosphorus (P) losses from agricultural lands occurred primarily via surface runoff and that very little P was lost through subsurface drainage, such that tiling a field could reasonably be expected to reduce P losses.

Recent research has revealed that subsurface drainage systems in agricultural fields can discharge significant quantities of P under a wide range of soil characteristics and management practices and should be considered in management strategies seeking to minimize nonpoint source pollution of surface waters.

In Vermont and across the LCB, little is known about the extent of tile drainage systems, and the potential impacts of tile drainage systems on water quality have not been assessed. To address this knowledge gap, the Project Team will monitor representative tile drainage systems in the Jewett Brook watershed (JBW) and Addison County, estimate P loading from these tile systems, and assess the significance of this loading to the overall P export from the JBW and similar areas of the LCB.

A promising approach to reducing P loading from agricultural tile drains is the development of media filters to remove P from tile drainage water. Experimental filters to remove P from tile drains will be developed and monitored in this study. This QAPP applies to both the primary and secondary data collection activities involved in monitoring the selected tile drains as well as the development and monitoring of two P filtration systems.

2.2 Project Objectives

The objectives of the tile drainage systems assessment are:

1. To evaluate characteristics of the Jewett Brook Watershed in Franklin County and provide detailed characterization of field areas drained by tile drainage systems selected for monitoring in Franklin County and Addison County.
2. To measure total and dissolved P concentrations and flow and calculate P loads from representative tile drainage systems in the Jewett Brook Watershed in Franklin County and additional sites in Addison County.

3. To characterize the distribution of total nitrogen and total suspended solids concentrations in drain flow from representative tile drainage systems in the Jewett Brook Watershed in Franklin County and additional sites in Addison County.
4. To design and install two P filtration systems and evaluate their performance in reducing soluble and particulate P loading from an agricultural tile drain. Analyses of soil samples collected at the site of the tile drain filters will provide data on soil texture and nutrient concentrations in the study field, which are critical reference values that will be used in comparing this test site to other fields in the Lake Champlain Basin and nationally.

Section 3. Primary Data Collection Activities for Select Tile Drain Systems

3.1 Study Location

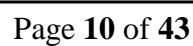
The study will be performed in two areas, the Jewett Brook Watershed (JBW) in the Town of St. Albans, Franklin County, Vermont and at several sites on farms in Addison County, Vermont. Jewett Brook flows to St. Albans Bay, a eutrophic bay of Lake Champlain (see Map 1). In 2017, monitoring stations were constructed near the outfalls of 12 tile drainage systems selected for monitoring in the JBW. Monitoring has continued at five of these sites (JBT05, JBT06, JBT07, JBT11, and JBT18) and will continue until the spring of 2019 under this QAPP Version 2.0. Monitoring commenced at five sites in Addison County upon approval of this QAPP Version 2.0 on November 21, 2018.

The proposed site for the tile drain treatment study is JBT05. JBT05 is among the sites in the Jewett Brook watershed at which monitoring has been extended. It drains a large cornfield and has been shown to discharge significant amounts of P.

3.2 Monitoring Site Selection

Through a comprehensive outreach effort to farmers and agricultural agents operating in the Jewett Brook Watershed (JBW), Stone Environmental secured agreements in 2016 with 6 of the 11 farmers believed to crop tile-drained land in the JBW to allow for monitoring of selected tile drain outlets. Taken together, 18 tile drainage systems were identified across these farmers' managed lands. Several of these tile drains are clearly not suitable for monitoring. The main reason certain tile drains were determined to be unsuitable is that they drain very small areas (<5 acres) and thus produce relatively little drainflow. Most of these tile drains were dry when visited in the summer of 2016. One other tile drain was eliminated from consideration because it was installed primarily to drain barn roof runoff via surface inlets. After excluding these unsuitable tile drains, 15 tile drains that could potentially be monitored were identified, although several of these have obvious drawbacks, including 2 with known surface inlets (standpipes and/or rock inlets). Given that the number of tile drain outlets available for monitoring was only slightly higher than the number to be monitored, no formal site selection criteria were established. Farmer cooperation and practical realities necessarily superseded efforts to intentionally represent a range of field conditions (e.g., cropping system, soil type, hydrologic soil group, soil test P, and age, layout, and depth of tile drain system) in the watershed.

In May and June 2018, meetings were held to identify farmers with tile drained land in Addison County. A total of 11 tile drain outlets were identified on three farms. Considering location,



access, drainage area, and crop, five sites were selected for monitoring in Addison County that best meet the objectives of the study.

3.3 Characterization of Tile Drained Field Areas

For the JBW sites, the best available geographic data were assembled and reviewed, including cropping patterns and soils data. The source of the soils data was the SSURGO database, maintained by USDA-NRCS. Statistics regarding cropping patterns in the watershed (acreage in permanent corn or hay production or in specific rotations) and dominant soil types and slope classes, for land with and without tile drainage, were summarized for Stone by the Vermont Agency of Agriculture, Food & Markets based on their 2015 *St. Albans Bay Watershed Cropland Inventory* (unpublished) without attribution to individual farmers or land ownership. In characterizing these fields, producer confidentiality was strictly maintained.

Detailed information was obtained for fields served by the 12 tile outlets selected for monitoring. This includes the JBT05 field, the site of the tile drain treatment study. Extent of drained area, drain spacing, tile depth, and system construction and age were defined based on information provided by the landowner, as was information on the cropping system and manure/fertilizer inputs within the drained area. Phosphorus application rates and soil test P data were assembled from nutrient management plans, where accessible, and interviews with the participating farmers and/or their technical service providers. These data are being used to analyze associations among agronomic and water quality variables and in computation of tile drain P loads in the JBW.

For the Addison County sites, soil type and slope class data will be acquired from the SSURGO database. In characterizing these fields, producer confidentiality will be strictly maintained. Detailed information will be obtained for fields served by the five tile outlets selected for monitoring. Extent of drained area, drain spacing, tile depth, and system construction and age will be defined based on information provided by the participating farmer, as will information about the cropping system and manure/fertilizer inputs. Phosphorus application rates and soil test data will be assembled from nutrient management plans, where accessible, and interviews with the participating farmers and/or their technical service providers.



Figure 1. Soil sampling locations in JBT05 study field

At the JBT05 site, soil physical and chemical properties data will be obtained through soil sample collection and analysis. Sampling will be performed in May or June of 2019. The study field will be sectioned in two portions, a lower section comprised of clay soils (mapped as Covington and Kingsbury clays) and an upland section comprised of loam soils (Massena and Georgia stony loams). A representative composite sample will be collected from each section. Soil samples from the 0–15 cm depth will be collected at nodes in a sampling grid (Figure 1) using a stainless steel soil probe. Individual soil samples will be blended in a bucket using a garden trowel. The trowel will be used to transfer approximately two cups (0.5 L) of the composited sample into a labelled polyethylene bag. The remaining soil will be discarded. Soil samples will be held under ambient conditions and transported to the Agricultural and Environmental Testing Laboratory at UVM in Burlington, VT.

Samples will be analyzed for pH and available P, K, Mg, Ca, Fe, Mn, and Zn following extraction in modified Morgan solution. Organic matter will be quantified by the loss on ignition method and reported in Walkley-Black method equivalents. Soil particle size will be analyzed by wet sieving and the hydrometer method.

3.4. Design and Installation of P Filters

Stone will design two filters to remove P from tile drain JBT05. Plans and specifications will be prepared that are suitable for construction.

The types of media used in the filters will be determined by Stone scientists in consultation with project advisors. Because no standard operating procedures exist for this task, they will be developed and documented as part of this project. At this time, we are considering several types of medias: 1) activated alumina beads blended in pea stone, 2) iron oxide pellets blended in pea

stone, 3) solid drinking water treatment residuals adhered to pea stone, and 4) a porous stone aggregate saturated with aluminum sulfate (alum) or polyaluminum chloride and dried. These candidate medias combine a fine P sorbent with a large (~1 cm) diameter, stable aggregate possessing good flow-through capacity. A fifth option to be considered is a local mineral product (a crushed shale) currently marketed as St. George Black. Any of these medias would need to be prepared in quantity for use in the P filters.

Estimated P sorption capacity, hydraulic properties, cost, and necessary preparations will be considered in reviewing media options. Bench testing of 2-3 candidate medias will be performed to evaluate their P sorption potential in model filters. An artificial P solution containing ~200-400 µg/L P will be recirculated through each media bed. This solution will be sampled daily for orthophosphate concentration using Hach PhosVer 3® (Ascorbic Acid) Method 3 and a Hach DR900 colorimeter. When the orthophosphate concentration in the influent solution falls below 200 µg/L, a known mass of P will be added using a concentrated stock solution to bring the solution concentration up to approximately 300 µg/L. The mass of P removed by the filters over the course of the bench testing will be calculated by summing the known P additions, accounting for the volume and orthophosphate concentration of the solution at the beginning and end of the experiments.

Under normal operation, the pumping rate in the model filter will be set to produce a negligible (<2 cm) difference in hydraulic head between the filter inlet and outlet. To evaluate the hydraulic conductivity of the media, the pumping rate will be increased until a substantial difference (~5 cm) in hydraulic head is seen between the inlet and the outlet. The steady-state pumping rate necessary to achieve this head difference will be measured by filling a container of known volume at the model filter outlet. This pumping rate divided by the area of the saturated cross-section of the model filter will approximate the hydraulic conductivity of the media.

After the conclusion of this evaluation, two types of media will be recommended for use in the filters. Stone will oversee construction of the P filters by a hired contractor. Materials will be assembled on site. Structures will be installed per the approved plans, at predetermined elevations. The media beds will be covered with native soil to the ground surface.

3.5 Monitoring System Design

At each of the selected tile drains and filter outlets, drainflow will be recorded continuously and flow-proportional composite water samples will be collected approximately weekly to provide total phosphorus (TP), total dissolved phosphorus (TDP), and total nitrogen (TN) concentration data representing the preceding period. Weekly discharge and weekly composite sample data will be used to compute weekly P loads; flow, concentration, and load data will be aggregated to calculate flow volume, distributions of TP, TDP, and TN concentrations, and cumulative TP and TDP loads at outflows by month and over the entire monitoring period. Field visits to retrieve and process composite water samples will be conducted per the Study Specific Procedure provided in Appendix A each week when the monitored tile drain is flowing. The sampling schedule may be influenced by weather and agronomic considerations, including collecting more frequent samples during certain farm operations such as manure or fertilizer application.

Subsequent to approval of this QAPP on November 21, 2018, sampling began at the Addison County sites. In addition to TP, TDP, and TN samples, collection of samples for total suspended solids (TSS) analysis was begun at all the monitoring stations, including the original JBW stations.

3.6 Monitoring Duration and Frequency

System operation, sample collection, and sample analysis are continuing at the five original Jewett Brook sites selected for continued monitoring. Construction of the Addison County sites was completed in October-November 2018 and monitoring commenced immediately following approval of this QAPP Version 2.0. Monitoring of the P filter outlets will commence immediately following filter construction, which is anticipated no later than June 2019. Stations will remain operational though dry periods, although samples will obviously not be collected if tile outlets cease flowing. During the winter, autosamplers will be turned off to avoid damage. However, weekly grab samples will be collected from the tile drains when discharge occurs.

Weekly retrieval, processing, and analysis of flow-proportional composite water samples will provide data representing an event mean concentration (EMC) for each constituent for the preceding period. Samples will be retrieved on the same day each week, to the maximum extent practicable.

The sampling schedule will be influenced by weather and agronomic considerations; however, the following general schedule of monitoring activities is expected:

1. Monitoring systems installation completed, and sampling initiated at Addison County sites in November 2018. System operation, sample collection, and sample analysis will continue from November 2018 to November 2019 with the exception of December 2018 – April 2019 when continuous monitoring may be suspended due to freezing conditions.
2. Monitoring continued at Jewett Brook sites JBT06, JBT07, JBT11, and JBT18 through June 2019.
3. Monitoring of site JBT05 and the two P filter outlets is currently scheduled to continue through December 2019.

3.7 Pollutants of Concern

The principal pollutant of concern is phosphorus. In addition to the potential impacts of P on immediate receiving waters, P is the primary cause of eutrophication-related impairments in Lake Champlain. Nitrogen losses are also of concern. Both N and P losses are also undesirable from an agronomic standpoint.

3.7.1 Constituents to be monitored

All water samples collected under QAPP Version 2.0 will be analyzed for TP, TDP, and TSS. Collection of TN samples will occur approximately every two weeks, at the direction of the Vermont DEC.

3.8 Sampling Procedures

This QAPP update (Version 2.0) concerns continuation of monitoring activities at five stations installed in the Jewett Brook watershed and installation, operation, and monitoring of five additional tile drain monitoring stations in Addison County, Vermont.

Monitoring and sampling methods will be consistent for the duration of the study period. Trained personnel will be responsible for satisfactory sampling operations and maintenance of monitoring stations (per the Study Specific Procedure, Appendix A), and processing of field data. Field personnel will be responsible for recording failures of sampling systems and taking corrective actions.

Table 2 summarizes the number and type of samples that are anticipated to be collected under this QAPP Version 2.0, Amendment 1. It is assumed that, on average, tile drains would flow 42 weeks per year (no discharge would be present on 10 weekly sampling visits due to dry or frozen conditions). During most weekly sampling events, it is assumed that a single set of sample splits will be processed. On one in four sampling events, it is assumed two carboys would need to be processed into two sample splits per analyte. A minimum of 10% additional QC samples are included in the sample estimates.

The estimated number of samples at all stations was calculated as:

| | | | |
|---|------|-------------|---|
| | JBW | Addison Co. | |
| | 5 | 5 | stations |
| x | 26 | 42 | weeks (assumes tile outlets are not flowing 12 weeks per year) |
| x | 1.25 | | samples per event per station (assumes a single set of splits will be taken most weeks and two sets of splits will be taken roughly one week out of four) |
| x | 1.1 | | accounts for 10% field duplicates |
| = | 179 | 289 | Total of 468 samples |

Table 2. Sample types to be collected

| Matrix | Analytical Parameters | Sample Container | Number of Samples | Sample Preservation | Hold Time (days) |
|--------|-----------------------|---|-------------------|--|------------------|
| Water | TP ¹ | Polyethylene bottle (composite) / 60-mL glass vial (aliquot for lab) | 468 | None | 28 |
| Water | TDP ¹ | Polyethylene bottle (composite) / 60-mL glass vial (aliquot for lab) | 468 | Filtered (0.45 µm) in field | 28 |
| Water | TN | Polyethylene bottle (composite) / 50-mL plastic centrifuge tube, blue cap (aliquot for lab) | 234 | Cool (<6°C), 0.1 mL H ₂ SO ₄ | 28 |
| Water | TSS | Polyethylene bottle (composite) / 1-L polyethylene bottle (aliquot for lab) | 468 | Cool (<6°C) | 7 |
| Soil | pH | Polyethylene bag | 3 | None | 180 |
| Soil | Available P | Polyethylene bag | 3 | None | 180 |
| Soil | Available K | Polyethylene bag | 3 | None | 180 |

| Matrix | Analytical Parameters | Sample Container | Number of Samples | Sample Preservation | Hold Time (days) |
|---|-----------------------|------------------|-------------------|---------------------|------------------|
| Soil | Available Mg | Polyethylene bag | 3 | None | 180 |
| Soil | Available Ca | Polyethylene bag | 3 | None | 180 |
| Soil | Available Fe | Polyethylene bag | 3 | None | 180 |
| Soil | Available Mn | Polyethylene bag | 3 | None | 180 |
| Soil | Available Zn | Polyethylene bag | 3 | None | 180 |
| Soil | Organic matter | Polyethylene bag | 3 | None | 180 |
| Soil | Particle size | Polyethylene bag | 3 | None | 180 |
| 1. VAEL employs an EPA-approved variant of standard methods wherein samples for phosphorus analysis are digested in the same glass storage vial in which they are collected. No acidification is necessary. | | | | | |

3.8.1 Water sampling instrumentation

ISCO 6712 automatic samplers will be used to collect samples of drainage water from each of the monitored tile drains and filter outlets. Sample lines will be inserted into a monitoring manhole or weir box constructed to intercept the buried tile line. Discharge monitoring is discussed in more detail in Section 3.9.

The autosamplers will be programmed to withdraw sample aliquots on a flow-proportional basis, according to the frequency of flow pulses received from the flowmeter. Flow-proportional sampling is challenging because discharge rates are highly variable and difficult to predict. If sample aliquot collection is too infrequent (e.g., in small flow events), insufficient sample volume may be collected to perform the intended analyses. If sample aliquots are collected too frequently (e.g., in an unexpectedly large flow event), the bulk sample container may not have the capacity to contain samples over the entire event, resulting in a non-representative sample. To minimize the occurrence of under-sampling and overfilling, a two-part program will be used whereby the autosampler pumps sample aliquots to two sets of containers at different intervals of accumulated discharge. Each bottle set will consist of two 10-L polyethylene carboys. The first bottle set (Set A) is intended to capture a representative sample at low flow rates and the second bottle set (Set B) is intended to capture a representative sample at high flow rates. Set B will be filled at approximately one tenth the frequency of Set A. The second bottle in each set will be filled only after the first is full, at the same frequency as the first.

Per the Study Specific Procedure (Appendix A), sampling personnel will select either Set A or Set B for analysis, but not both sets. Any sample in the bottle set not chosen will be discarded. If Set B contains sufficient sample volume (approximately 1 L is required) to perform the required analyses, Set B will be processed, and Set A discarded. If Set B does not contain sufficient sample volume, Set A will be used and any sample in Set B will be discarded.

In most events, only the first bottle in the selected bottle set will contain sample. However, if both bottles #1 and #2 in the selected set contain sample, the sample volumes will be combined in the large capacity (14-L) churn splitter used to obtain sample splits, unless doing so would exceed the capacity of the churn splitter. If greater than 14 L is collected in total in the selected bottle set, then bottles #1 and #2 will be processed independently. Split samples from both bottles will be submitted for analysis to allow calculation of total P flux.

Adjustments to the autosampler programs to increase or decrease the sampling frequency will be made either by direct connection or via remote access. Failure of the system to collect at least three sample aliquots in bottle Set A during a weekly period or exceeding the capacity of all sample bottles in Set B may result in rejection of the sample as non-representative.

3.8.2 Collection of water samples

Approximately weekly, field technicians will visit each station to process water samples according to the Study Specific Procedure included as Appendix A. If the tile line has not flowed, no sample will have been collected; this will be noted on the Sample Retrieval Form (Appendix A).

Collected water samples will be transported on ice to VAEL in Burlington, VT within the stated holding times for each analyte. Samples will be tracked using a Chain of Custody form (Appendix A) that will be completed by the sampler and will accompany all water samples delivered to VAEL. The Chain of Custody form includes sample IDs, number of containers of each sample being sent to the lab, and the analyses requested. Once the water samples are accepted by VAEL, they will be subject to the lab's internal tracking system.

3.9 Discharge Measurement

An excavation will be made to install a monitoring manhole accessing the buried tile line. Depending on the elevation of the tile drain and filter outlets relative to the water surface in the receiving ditch or stream, one of two types of flow monitoring systems will be installed within the monitoring manhole. Where submergence of the tile drain outlet is unlikely, an appropriately sized Thel-mar weir with ultrasonic level sensor will be installed in the manhole in the outlet pipe. Where the outlet is likely to become submerged during high water levels, an electromagnetic flowmeter will be installed on the inlet pipe within the manhole.

3.9.1 Discharge measurement at free-flowing outlets

The primary hydraulic device used at free-flowing (not submerged) tile outlets will be an appropriately-sized Thel-mar weir.

An ultrasonic water level sensor (ISCO 2110 Ultrasonic Flow Module) will be mounted immediately upstream of the Thel-mar weir to continuously measure stage (water level). The stated accuracy of this instrument is the greater of ± 0.00396 m or 0.00256 m per foot (0.305 m) from the calibration point. Level data will be converted to discharge rate based on the established hydraulic rating of the weir. These data will be used in calculation of discharge corresponding to each weekly sample and in calculation of pollutant export.

3.9.2 Discharge measurement at non-free-flowing outlets

To monitor flow at the tile drain outlets that are submerged or likely to become submerged at high water levels, the flowmeter will be installed on a trap section of pipe to ensure full pipe flow. A short section of pipe will be cut out and replaced with rigid pipe and fittings, forming a trap. A Krohne Waterflux 3000 electromagnetic flowmeter will be installed in the trap section, cabled to a signal converter (Krohne IFC 100) mounted above ground in an instrument enclosure. This sensor has outstanding accuracy at high flow rates (less than $\pm 0.3\%$ in a 6-inch diameter pipe at flows above 300 gallons per minute) and better accuracy at low flows than any similar pipeline flowmeter (for example, 3% in a 6-inch diameter pipe at 5 gallon per minute). The sensor is rated for full submergence and direct burial.

3.10 Precipitation Monitoring

A simple meteorological station will be used for continuous monitoring of rainfall and air temperature. Air temperature will be recorded as hourly and daily, minimum, maximum and average values throughout the study period. The temperature sensor will be housed in an appropriate solar radiation shield. A tipping bucket rain gage will be installed above the maximum crop canopy level. Every tip, marking accumulation of 0.01-in. (0.254-mm) of rainfall, will be recorded in memory with a time stamp. These precipitation data will enable evaluation of the proportion of incident rainfall expressed as tile drain flow.

3.11 Testing and Measurement Protocols

All water samples will be analyzed by the standard methods of the Vermont Agriculture and Environmental Laboratory (VAEL). These methods and relevant data quality objectives, assessment procedures, and reporting limits are described in the VAEL's Quality Systems Manual, Revision 23, dated December 18, 2015. Methods of analysis for each analyte are summarized in Table 3 and are provided in Appendix B (TP and TDP), Appendix C (TN), and Appendix D (TSS). Soil samples will be handled through the UVM Agricultural and Environmental Testing Lab and analyzed for the methods listed in Table 3.

Table 3. Analytical methods

| Sample Matrix | Analytical Parameter | Lab | Method | Reference |
|---------------|----------------------|------|---|-----------|
| Water | TP | VAEL | 4500-P H | 1 |
| Water | TDP | VAEL | 4500-P H | 1 |
| Water | TN | VAEL | 4500-N C-modified | 1 |
| Water | TSS | VAEL | 2540-D | 1 |
| Soil | pH | AETL | Potentiometric measurement of soil slurry (1:2, V:V) with dilute calcium chloride, using electronic pH meter. | 2 |
| Soil | Available aluminum | AETL | Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter. Analysis: ICP-AES. | 2 |

| Sample Matrix | Analytical Parameter | Lab | Method | Reference |
|---------------|--------------------------|------|--|-----------|
| Soil | Available boron | AETL | Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter. Analysis: ICP-AES. | 2 |
| Soil | Available calcium | AETL | Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter. Analysis: ICP-AES. | 2 |
| Soil | Available copper | AETL | Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter. Analysis: ICP-AES. | 2 |
| Soil | Available iron | AETL | Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter. Analysis: ICP-AES. | 2 |
| Soil | Available magnesium | AETL | Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter. Analysis: ICP-AES. | 2 |
| Soil | Available manganese | AETL | Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter. Analysis: ICP-AES. | 2 |
| Soil | Available phosphorus | AETL | Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter. Analysis: Molybdate blue procedure with colorimetric analysis. | 2 |
| Soil | Available potassium | AETL | Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter. Analysis: ICP-AES. | 2 |
| Soil | Available sulfur | AETL | Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter. Analysis: ICP-AES. | 2 |
| Soil | Available zinc | AETL | Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter. Analysis: ICP-AES. | 2 |
| Soil | Cation exchange capacity | AETL | CEC at pH 7 with Ammonium Acetate | 2 |
| Soil | Organic matter | AETL | Loss of weight on ignition | 2 |
| Soil | Particle size | AETL | Wet sieve and hydrometer | 3 |

References:

1. Standard Methods for the Examination of Water and Wastewater; 21st Ed. 2005.
2. Recommended Soil Testing Procedures for the Northeastern United States. 3rd Edition. Northeastern Regional Publication No. 493. Agricultural Experiment Stations of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and West Virginia. Revised July 1, 2011.
3. Gee, G.W. and J.W. Bauder. 1986. Particle-size analysis. p. 383-411. In A. Klute (ed.) Methods of Soil Analysis, Part 1. Physical and Mineralogical Methods. Agronomy Monograph No. 9 (2 ed.). American Society of Agronomy/Soil Science Society of America, Madison, WI.

3.12 Quality Assurance/ Quality Control (QA/QC)

3.12.1 Quality objectives and criteria for measurement data

The project data-quality objective is to collect, provide, maintain, analyze, display, and document valid water quantity and quality data. The monitoring information that will be collected to support project objectives will meet the quality assurance objectives outlined in this section. Data quality will be measured in terms of accuracy and precision, representativeness, comparability, completeness, and traceability.

Table 4 summarizes data quality requirements associated with the water sampling program and the accuracy and precision levels reported by the analytical laboratory for each parameter. The analytical laboratory for the water samples is VAEL, which is currently located on the University of Vermont campus in Burlington. VAEL is accredited by New Hampshire under the National Environmental Laboratory Accreditation Program (NELAP) for the specified water quality parameters. Table 4 also summarizes the data quality requirements associated with meteorological measurements, as stated by the instrument manufacturer.

Discharge measurement will document the rate and total quantity of drain flow over the course of the study. Analysis of flow-proportional water samples will provide mean concentrations of each monitored constituent. Mass of each monitored constituent will be computed from interval and total discharge volumes and constituent concentrations. To ensure data quality objectives are met, all sampling activities will be well-documented and will occur in accordance with the specifications presented in this QAPP.

For the QC samples, field duplicates will be collected of TP, TDP, TN, and TSS samples. Duplicates will be collected on a rotating basis among stations. Samples from one or two stations will be collected in duplicate on every event, such that at least 10% of the total sample load is collected in duplicate. Grab samples collected during the winter months will be collected in duplicate according to the same scheme used for the composite sample splits.

Table 4. Data quality requirements and assessments for water analyses and meteorological measurements

| Matrix | Parameter | Units | PQL ¹ | Accuracy ² | Accuracy protocol | Precision Lab/Field ³ | Precision protocol | Method Range |
|--------|---------------|-------|------------------|-------------------------------|-------------------|----------------------------------|--------------------|-------------------|
| Water | TP | µg/L | 5 µg/L | 85-115% | Spike recovery | 15/20 | Field duplicate | 5 – 200 µg/L |
| Water | TDP | µg/L | 5 µg/L | 85-115% | Spike recovery | 15/20 | Field duplicate | 5 – 200 µg/L |
| Water | TN | mg/L | 0.1 mg-N/L | 85-115% | Spike recovery | 10/20 | Field duplicate | 0.05 – 2.0 mg-N/L |
| Water | TSS | mg/L | 1 mg/L | 80-120% ⁴ | N/A | 15 ⁴ /20 | Field duplicate | 1 – 2000 mg/L |
| Air | Temperature | °C | N/A | ± 0.47°C at 25°C ⁵ | N/A | N/A | N/A | -20° to 70°C |
| Space | Precipitation | mm | N/A | ±1.0% (up to 20 mm/hr) | N/A | N/A | N/A | 0 to 12.7 cm/hr |

1. Practical Quantitation Limits (PQL) is the lower limit of quantitation (reporting).
2. Accuracy for analytical parameters is expressed as Percent Recovery of Sample Matrix Spike. Analyte Percent Recovery acceptance criteria are method specified limits or generated from historical laboratory data. Recoveries are matrix/sample dependent.
3. Laboratory Analytical Duplicate Relative Percent Difference (RPD) acceptance criteria/Field Duplicate RPD acceptance criteria.
4. Precision and accuracy for samples high in heavy sediment may be outside listed criteria, if the entire sample volume cannot be filtered and heavy particles settle quickly while decanting an aliquot of sample.
5. Stated accuracy of Onset Hobo Pendant Event and Temperature Data Logger (part UA-003-64)

Table 5 summarizes data quality requirements associated with the soil sample analysis.

Table 5. Data quality requirements for soil analyses

| Matrix | Parameter | 95% Confidence Interval ¹ |
|--|----------------|--------------------------------------|
| Soil | pH | ± 0.12 pH units |
| Soil | Organic Matter | ± 0.4 % |
| Soil | Phosphorus | ± 11 % relative error |
| Soil | Potassium | ± 7 % relative error |
| Soil | Calcium | ± 8 % relative error |
| Soil | Magnesium | ± 8 % relative error |
| Soil | Sulfur | ± 8 % relative error |
| Soil | Boron | ± 0.05 ppm |
| Soil | Copper | ± 0.10 ppm |
| Soil | Iron | ± 0.8 ppm |
| Soil | Manganese | ± 10 % relative error |
| Soil | Zinc | ± 0.3 ppm |
| Soil | Sodium | ± 4 ppm |
| 1. Soil Testing Reference Sheet, Maine Soil Testing Service, Orono, ME | | |

3.12.2 Accuracy

Accuracy is defined as a measure of how close a result is to the true value. For physical/chemical parameters, accuracy is generally assessed through the analysis of spiked samples, with results expressed as percent recovery. VAEL's Quality Systems Manual, Revision 23, provides acceptance criteria for spiked water sample results for each analyte tested. VAEL's Quality Systems Manual also describes calibration procedures, blank samples, and sample handling protocols, which provide additional information used to evaluate the accuracy of each analytical procedure.

3.12.3 Precision

Precision is defined as a measure of the reproducibility of individual measurements of the same property under a given set of conditions. Precision is generally assessed through field and laboratory duplicate analyses. In this case, duplicate analysis will be conducted on splits of field-

collected composite water samples. The most commonly used measure of precision is the relative percent difference (RPD). The formula for calculating the Relative Percent Difference is:

$$RPD = 100 * \text{Absolute Value}(X_1 - X_2) / ((X_1 + X_2) / 2)$$

where X_1 and X_2 are the two measurements being compared.

The method RPD is provided for the key analytical parameters in Table 4. Field duplicates will be prepared and delivered to the laboratory at a minimum rate of 10%.

3.12.4 Representativeness

In the context of this study, representativeness expresses the degree to which the data gathered by the project accurately and precisely represent field conditions. By continuously measuring discharge and collecting flow-proportional water samples for chemical analysis, the data gathered will accurately represent water and pollutant export under true field conditions.

Data representativeness for primary source data for this project will be accomplished through implementing standard sampling procedures and analytical methods which are appropriate for the intended data uses.

3.12.5 Comparability

Comparability expresses the confidence with which one data set can be compared to another. Comparability of the field measurements is ensured by adhering to consistent standard sampling techniques and protocols. Such consistency will be reinforced by training and supervision of field staff (see Section 1.5). Comparability of laboratory measurements is ensured through following VAEL's Quality Systems Manual, Revision 23, dated December 18, 2015, and the respective SOP for a given analyte.

3.12.6 Completeness

Completeness is a measure of the percentage of planned samples collected or the percentage of usable data points per measurement, with a usable result defined as one that meets criteria for accuracy, precision, and representativeness. Project specific completeness goals account for all aspects of sample handling, from collection through reporting. The minimum completeness objective for the key parameters measured in tile flow is determined to be 95 percent.

$$\% \text{ Completeness} = \# \text{ of Usable Points} / \text{Total \# of Data Points Collected} \times 100$$

A usable result is defined as a result that meets all criteria for accuracy, precision, and representativeness.

3.12.7 Traceability

Traceability is defined as the ability to trace the generation of each analytical result from sample collection through analysis and reporting. To accomplish this, all activities must be fully documented. Specific requirements will be met for documenting operation and maintenance of field instrumentation, sample tracking, analytical methodology including NIST traceable

standards, record-keeping, data reduction procedures, and data presentation; these requirements are described elsewhere in this document. The data quality objective for traceability with respect to all primary data analyses for all samples is 100 percent.

3.13 Quality Control Requirements

All data acquired or generated will be fully documented as to original source, quality, and history.

Field quality control sampling will consist of the following:

- At least 10% of composite water sample splits will be duplicated in the field by collecting a second aliquot from the churn splitter for delivery to the lab.
- One of two composite soil sample splits will be duplicated in the field by collecting a second aliquot from the sample bucket for delivery to the lab.
- No travel blanks will be collected because the parameters are not susceptible to cross contamination during shipment.

Data from field duplicates will be accepted if the RPD is less than or equal to 20%; in such cases, the mean of accepted field duplicates will be used to represent data from the sample involved. In cases where the RPD of field duplicates exceeds 20%, the data may be deemed unusable.

Sampling QC excursions are evaluated by the Project Manager. Field duplicate sample results are used to assess the entire sampling process, including environmental variability; therefore, the arbitrary rejection of results based on predetermined limits is not practical. The professional judgment of the Project Manager or his designee will be relied upon in evaluating results.

Rejecting sample results based on wide variability is a possibility. Notations of field duplicate excursions and blank contamination will be noted in the final report.

3.14 Instrument/Equipment Calibration and Frequency

Field analytical equipment that may be used in this project includes instruments for measuring water stage, flow rate, rainfall, and air temperature. Calibration procedures for the equipment will follow manufacturer instructions.

Instrument and equipment calibration for water analysis will be routinely carried out by VAEL under their EPA approved Quality Systems Manual, Revision 23, dated December 18, 2015.

3.15 Data Acquisition Requirements for Non-direct Measurements

Sources of supplementary data considered in this project may include weather data obtained from a local NWS cooperating station. Such data may be used to compare contemporary weather conditions against long-term averages or normals. These data will be accepted as valid if officially published by the NWS. Second, historical soil and manure test data from the farm's nutrient management plan (if available) may be reviewed to help characterize site soils and agronomic management. Soil and manure samples for this purpose are typically collected by

certified crop management consultants and analyses are performed through the UVM Agricultural and Environmental Testing Laboratory. The data reported in this manner will be accepted as valid if it is contained in a nutrient management plan recognized by the AAFM. Farm records maintained by the participating farmers will be reviewed for information regarding management of the study fields. Collection of these data by the farmer meets record keeping requirements of Vermont AAFM. Additional supplemental data sources used include published topographic data and soils mapping based on the USDA-NRCS county soil surveys.

The supplementary data will not contribute directly to project decision-making, with the exception of field agronomic practices data recorded by the participating farmer.

3.16 Data Summaries

Summary data tables will be prepared for each station using the procedures described in Section 3.18. These tables will include total discharge, mass export, and mean concentrations of all monitored constituents. Using these summary data tables, descriptive statistics (range, mean, median, standard deviation, coefficient of variation) will be calculated by station. These summary data tables and statistical summaries will be stored electronically on Stone Environmental's servers, which are backed up daily to a Unitrends backup appliance. Once per week the most recent backup will be written to a drive which is taken to a storage vault offsite.

3.17 Methods for Data Acquisition and Storage

To protect personally identifiable information (PII) in any publications or public discussions of project results, the study site will be identified by an alphanumeric code consisting of the abbreviation "JBT" (Jewett Brook Tile) or "ACT" (Addison County Tile) followed by a number between 1 and 12 (i.e., JBT01 through JBT12). Once data are reported to LCBP, they will be subject to standard measures required to protect participants' PII.

The Stone Environmental Project Manager or his designee will be responsible for organization and oversight of data generation, disbursement, processing and storage so that the data will be documented, accessible and secure for the foreseeable time period of its use. The VAEL director has the same responsibility for the laboratory data and information s/he generates.

Standard sample retrieval forms (Appendix A) will be used to document sample location, station and field conditions, date and time of collection, and personnel responsible for collection for all samples collected in the field. A Chain of Custody form (Appendix B) will be used by the laboratories to confirm sample delivery. VAEL will complete log-in sheets to document sample receipt and condition. Copies of all field sheets will be maintained in the project file at the offices of Stone Environmental.

Analytical data from VAEL will be transmitted in electronic format to the Project Manager or his designee after all internal review has been completed.

Data from the flowmeters and autosamplers will be automatically pushed to Stone Environmental's computer server every 30 minutes. These raw electronic data will be maintained

on the server for the duration of the project and will be viewable in near real-time through a web user interface. These data will be extracted into Access databases, Excel workbooks, and *R* for manipulation and preparation of data summaries.

All electronic files on Stone Environmental's servers, including raw data pushed from monitoring stations, will be backed up daily to a Unitrends backup appliance. Once per week the most recent backup will be written to a drive which is taken to a storage vault offsite. Paper and electronic files will be archived for a minimum of five years at Stone Environmental following completion of the project.

3.18 Methods of Analyses

Water level, discharge, and sample event mark data will be transmitted automatically to a computer server located at Stone Environmental's offices in Montpelier, VT.

An Access database has been created to import and process analytical data from electronic tables transmitted by VAEL, import and aggregate corresponding event discharge data from the SQL server, and calculate total discharge, constituent mean concentrations, and mass export. This data processing will be performed using a series of database queries that will accomplish the following data manipulations:

1. Analytical results of duplicate samples will be averaged
2. Analytical results will be linked to specific sampling events on a common ID (LabID)
3. The constituent mass corresponding to the collection period of each composite sample (concentration multiplied by associated discharge total) will be calculated
4. Where multiple composite samples are subsampled for analysis (for example, carboys 1 and 2), the partial event constituent masses from #3 will be summed to derive total export for the interval.

There are several common sources of inaccuracy in discharge measurement that will be attempted to minimize through selection of the most appropriate instruments and certain station design innovations. These sources of inaccuracy include submergence of the tile drain outlets, level sensor drift, and debris accumulation on weirs. Submergence of many of the outlets will be addressed by ensuring full pipe flow conditions at all times and installing an appropriate flowmeter for this condition. The Thel-mar weir will be maintained by checking the device every maintenance visit and making appropriate adjustments. In some cases, level and discharge data may warrant adjustments to account for debris or ice accumulation in monitored pipes and on weirs.

The data set used for the primary statistical analyses will include total discharge (m^3) and mean concentration (mg/L) and mass export (kg) for each monitored constituent for each sampling event for each monitored location. Data reported as less than a detection limit will be assigned a value of one-half the detection limit for purposes of data analysis but will be flagged as below detection in reported concentration data tables. All statistical analyses will be done using version

10.0 of JMP statistical software (SAS Institute). Basic descriptive statistics and exploratory data analysis will be conducted on this data set.

Section 4. Assessment and Oversight

It will be the responsibility of the Project QA Officer to ensure that project QA/QC activities, assessments, and responses are conducted according to this QAPP. The QA Officer (or designee) will have the authority to issue a stop work order upon finding a significant condition that would adversely affect the quality and usability of the data. The QA Officer will document, implement, and verify the effectiveness of corrective actions, such as an amendment to the QAPP, and take steps to ensure that everyone on the distribution list is notified.

Monitoring station readiness will be assessed through routine (minimum of twice weekly) review of flowmeter, sampler, and battery voltage data transmitted in near real-time to a server located at Stone Environmental's office. Several important and not uncommon problems may be detected remotely and quickly using these data, for example, sampler error messages, erroneous autosampling attempts, and low battery voltage. Early detection of these problem conditions will enable timely response by sampling teams to visit the monitoring station in question and correct the problem. Regular maintenance of the monitoring station and instruments will minimize the incidence of instrument malfunctions and other problems. Certain basic maintenance activities will be conducted after sampling event, to clean bulk sample containers, churn splitters, sampler lines, and flumes (if necessary) and to reset the autosampler. Site visits will be conducted for more intensive maintenance activities approximately monthly during the monitoring period. A Routine Maintenance Form will be completed during each maintenance visit (Appendix A). Deficiencies noted will be corrected by the responsible personnel. In the event that corrective action is required that is beyond the training of the maintenance personnel, a Stone Environmental project scientist with expertise in the monitoring systems will diagnose and correct the problem.

The effectiveness of monitoring will be assessed by the responsible sampling personnel at each site using data collected at the time of sample retrieval (Appendix A). Section 3.18 describes several common sources of inaccuracy in discharge measurement and how these will be addressed.

Periodically, when summary data tables are prepared for reporting purposes, the Project Manager or his designee will assess the quality of all discharge and analytical data and will be responsible for verifying/validating all sample tracking information and laboratory analysis data. Any deficiencies will be flagged with a qualifying statement in summary data tables and necessary corrective action will be taken. As part of final report preparation, the Project Manager or his designee will also review field and data management operations for the preceding year for consistency with the requirements outlined in this QAPP.

Internal assessments and response actions with regard to laboratory analysis within VAEL will occur under the terms of the lab's approved Quality Systems Manual (Revision 23). Project

investigators will examine data reports from the laboratory for problems or conditions of concern noted by analysts, based on *Sample Remark Codes*. Examples of such codes are included in Table 6.

Table 6. Sample remark codes used by VAEL

| Sample Remark Code | Description |
|---------------------------|--|
| B | Reported value is associated with a lab blank contamination. |
| BH | Reported value may be biased high. |
| BL | Reported value may be biased low. |
| E | Estimated Value |
| D | Dilution resulted in instrument concentration below PQL. |
| H | Hold time exceeded. |
| I | Matrix Interference |
| N | Not processed or processed but results not reported. |
| O | Outside calibration range, estimated value. |
| OL | Outside Limit |
| P | Preservation of sample inappropriate, value may be in error. |
| S | Surrogate recovery outside acceptance limits. |
| T | Time not provided |
| W | Sample warm on arrival, no evidence cooling has begun. |

If water quality data are suspect (e.g., flagged by the lab, duplicate RPD too high, unusual extreme concentrations), the first response will be to contact the laboratory and verify that no simple errors have been made. If questions cannot be resolved and suspect concentration data remain, the concentration data may be rejected for that constituent for the sampling event in question.

NEIWPCC may implement, at its discretion, various audits or reviews of this project to assess conformance and compliance to the quality assurance project plan in accordance with the NEIWPCC Quality Management Plan.

Quarterly reports will be submitted to LCBP and NEIWPCC, per the standard LCBP reporting process for review and approval. The LCBP Project Officer will be presented with the final project deliverables and a summary of any QA/QC actions taken before providing final approval to the report.

Any limitations and gaps in data included in the analysis will be fully disclosed within the project final report, and it will be noted that these data should be used with caution.

Section 5. Deliverables

Stone Environmental will produce a report detailing the methods and results of the watershed and drainage area characterization. The report will document cropping patterns in the JBW (acreage in permanent corn or hay production or in specific rotations) and dominant soil types and slope classes, for land with and without tile drainage, as well as providing descriptive information for the agricultural areas served by each of the tile drain systems included in the study. In addition, photo-documentation of each monitoring installation will be submitted.

Stone Environmental will also produce a succinct monitoring and assessment report summarizing the methods and results of the watershed and drainage area characterization, and the flow and water quality monitoring. The report will also include an analysis of agronomic and water quality factor associations. GIS layers used or generated to support the analyses will also be provided to LCBP, subject to confidentiality requirements of the Vermont Agency of Agriculture. Total and dissolved P concentrations and loads for each of the monitored tile drainage systems will be summarized in monthly and annual statistics. Monthly and annual summary statistics will also be presented for TN and TSS concentrations in tile drain flow.

Details related to the bench testing and evaluation of the filter media options, filter and monitoring system installation, and filter performance results will be included in the final report. Documentation of the media testing procedure development will also be included in the final report.

In addition to the task-specific deliverables described above, quarterly reports will be submitted to LCBP, per the standard LCBP reporting process for review and approval. Relevant LCBP advisory committees, notably the Technical Advisory Committee, will be presented with the final report deliverables and a summary of any QA/QC actions taken before providing final approval to the report.

Section 6. References

MAFES Analytical Laboratory. 2006. Quality Assurance Plan for MAFES Analytical Laboratory. University of Maine, Orono ME.
http://anlab.umesci.maine.edu/soillab_files/qc/anlab-qaplan.PDF (accessed April 27, 2012).

U.S. Environmental Protection Agency. 2003. A Summary of General Assessment Factors for Evaluating the Quality of Scientific and Technical Information. Washington, DC: Office of Research and Development, Science Policy Council; Report No. EPA/100/B-03/001.

Vermont Agriculture and Environmental Laboratory. 2016. Quality Systems Manual, Revision No. 23. Burlington, VT. URL:
<https://agriculture.vermont.gov/sites/ag/files/pdf/lab/VAEL%20QSM%20%20-%202016.pdf>.
(accessed November 12, 2018).

APPENDIX A:
Sampling Procedures and Routine Maintenance for Assessment of Tile Drainage Systems
in the Jewett Brook Watershed and in Addison County, Vermont

STUDY SPECIFIC PROCEDURE

Sampling Procedures and Routine Maintenance for Assessment of Tile Drainage Systems in the Jewett Brook Watershed and in Addison County, Vermont

SSP Number: 1

Date Issued: 11/14/16

Version Number: 2

Date of Revision: NA

OBJECTIVE

To facilitate collection of high-quality water samples, preventative maintenance of monitoring stations and equipment, and accurate recording of monitoring activities and data.

POLICIES

All field staff performing sampling duties for the project must read this SSP and implement the procedures written herein.

HEALTH AND SAFETY

A health and safety plan (HASP) was prepared for this project identifying possible health and safety risks involved in field activities, how these risks are to be managed, and responsibilities of project management and staff. This HASP must be read and signed by every direct employee of Stone Environmental engaged in fieldwork for this project. Contractors assisting Stone with sampling and other field activities are not similarly bound by the HASP, but should nonetheless remain alert and responsive to potential health and safety risks. Stone Environmental assumes no responsibility and will accept no liability for the health and safety of personnel who are not direct employees of Stone Environmental.

There are several common health and safety risks which demand particular attention, as follows:

Insects

Hornets, wasps, bees, and yellow jackets are common in edge-of-field settings in Vermont. These insects may build nests in the monitoring shelters. A spray can of insecticide should be available at each monitoring shelter. Personnel known to be allergic to hornet, wasp, bee, and/or yellow jacket stings should carry with them an EpiPen or similar medication as directed by their physician.

Mosquitos may carry dangerous pathogens including West Nile virus and eastern equine encephalitis. Use repellent and appropriate clothing to minimize mosquito bites.

Ticks are common in areas bordering agricultural fields. Tick populations should be reduced by mowing work areas. Long pants, tucked into socks, should be worn when possible. Skin and clothing should be checked for ticks upon leaving the field.

Plants

In addition to poison ivy and stinging nettle, personnel must avoid contact with wild parsnip, a new invasive plant in Vermont that can produce a painful and lasting burning of the skin after exposure of affected areas to sunlight. This plant occurs throughout the study area.

Severe weather

Sampling activities will often take place shortly following storm events. Under no circumstances should personnel visit monitoring stations during lightning storms. Personnel should also be alert to high wind or other conditions and avoid exposure.

Cold/heat stress

Personnel will be working under both very cold and very warm conditions in the course of the monitoring program. Standard recommendation for minimizing the risk of heat stress and hypothermia need to be observed.

FLOW PROPORTIONAL COMPOSITE SAMPLING PROCEDURES

An ISCO 6712 or 3700 autosampler will be operated to collect flow-proportional composite samples during times of the year where conditions are expected to remain above freezing. Approximately weekly, field technicians will visit each station to process the bulk composite samples into appropriate splits.

1. Record information from autosampler display (see attached Sample Retrieval Form). Note that the autosampler may display various error messages, some of which may be important, others not. If the display indicates a warning about excessive pump tubing counts, you may disregard this. If the sampler displays “No Liquid Detected”, this may indicate either that the intake was exposed to air during one or more sampling attempts or that there is a clog in the sampling line. If this warning is displayed, inspect the sampling line for a clog, kink, or ice blockage and otherwise ignore it. For all other warning messages, please contact Stone.
2. Stop the sampling program by pressing the red button to pause the program and then selecting STOP PROGRAM. In certain cases, the sampling program may have been stopped remotely by Stone. Stopping the program remotely can mitigate certain problems and potential risks, such as frozen sampling lines on cold nights.
3. Record approximate sample volumes in each carboy.

4. Select the appropriate set of carboy(s), the As (A1 and A2) or the Bs (B3 and B4). Select the appropriate carboys according to the following logic:
 - a. If the combined volume of carboys A1 and A2 is less than 14 liters, use set A.
 - b. If there is more than 14 liters in carboy A1+A2 and/or if the sampler display indicates Part A is DONE, use set B, unless carboy B3 contains less than 1 liter. If the combined volume of set A is >14 L or DONE is displayed And the volume of set B volume is <1 L, contact the Stone project manager for direction. We will need to evaluate whether the set A sample is sufficiently representative of the entire event.
 - c. If the sampler attempted to collect fewer than three aliquots into carboy A1 or the total volume collected is less than 500 mL, discard the sample. The number of aliquots attempted can be determined by viewing the sampler display. The display will indicate Part A, "2, 100 Bottle 1 after X pulses" if only one aliquot was attempted, or Part A, "3, 100 Bottle 1 after X pulses" if only two aliquots were attempted. In this example, "3" indicates that the next aliquot the sampler will attempt dispense to Bottle 1 is its third; "100" indicates that it will dispense a maximum of 100 aliquots to Bottle 1; "Bottle 1" indicates that the sampling container in use is Bottle 1, which we refer to as carboy A1; and "X pulses" indicates how many flow pulses are remaining before the sampler attempts the next aliquot.
 - d. Bottle A1 should also contain a minimum of 500 mL for sample splits to be prepared for analysis. Since the programmed aliquot volume is 100 mL, five aliquots should produce ~500 mL of sample. If five or more sample aliquots were attempted and the volume in carboy A1 is significantly less than 500 mL, then the suction line strainer was likely exposed during pumping, drawing air rather than water. This is to be expected at very low flows. You may also view the sampling report for further information about which sampling attempts were successful.
5. Fill out and affix labels to the appropriate containers. The correct container for each analyte is given in Table 1.

Table 1. Sample containers, preservation, and permissible holding times

| Analyte | Container | Preservation | Hold Time (days) |
|---------|---|--|------------------|
| TP | 60-mL glass vial | None | 28 |
| TDP | 60-mL glass vial | Filtered (0.45 µm) in field | 28 |
| TN | 50-mL plastic centrifuge tube, blue cap | Cool (<6°C), 0.1 mL H ₂ SO ₄ | 28 |
| TSS | 1-L plastic bottle | Cool (<6°C) | 7 |

The Sample ID field is a concatenation of the Site ID (JBT01, JBT02, ACT01, etc.), the collection date (mmddyy), and the carboy(s) from which sample splits are taken [A1, A2, B3, B4, A12 (if the samples from carboys A1 and A2 are added together in the churn splitter), or B34 (if the samples from B3 and B4 are added together in the churn splitter)]. See step 7 regarding the sample splitting procedure. The following examples illustrate the sample IDs syntax:

- A sample collected at JBT07 on May 2, 2017 only from carboy A1: **JBT07-050217-A1**
- A sample collected at JBT07 on September 27, 2017 by combining the contents of carboys A1 and A2 in the churn splitter: **JBT07-092717-A12**

6. Put on lab gloves
7. Pour sample from the selected carboy(s) into the churn splitter. Try to swirl the water to suspend sediment as you pour the sample into the churn splitter. NEVER combine sample from set A and set B in the churn splitter.

In many cases, only the first carboy in each set (A1 or B3) will contain sample. If the second carboy (A2 or B4) also contains sample, this can be added to the churn splitter so long as the combined volume will not exceed 14 liters, the capacity of the churn splitter. For example, if carboy A1 contains 10 liters and carboy A2 contains 2 liters, these can be composited in the churn splitter; and the resulting sample ID would be in the form: SiteID-mmddyy-A12.

If the combined volume will exceed 14 L, each carboy in the selected set should be split individually, resulting in two sets of sample splits for analysis. For example, if the set A carboys are split individually, the resulting sample IDs would be in the form SiteID-mmddyy-A1 for the carboy A1 splits and SiteID-mmddyy-A2 for the carboy A2 splits.

8. Operate the churn splitter for 5-10 seconds. With sample containers in hand, open the stopcock and let spill on the ground for 1-2 seconds to clear the line. Then prepare:
 - a. TP sample split: While operating the churn splitter, fill the glass vial up to the line.
 - b. TN sample split: While operating the churn splitter, fill a blue capped centrifuge tube to the 50 mL line.
 - c. TSS sample split: While operating the churn splitter, fill a 1-L plastic bottle half full.
 - d. Let the contents of the churn splitter settle for 1-5 minutes.

- e. TDP sample split: Sample splits for TDP analyses will be filtered in the field by dispensing sample from the churn splitter directly into a filtration apparatus containing a 45-mm Durapore® 0.45-µm acetate membrane filter. Use forceps to place a clean filter in the filter holder. Wet the filter with a spray of distilled water. Remove the plunger and attach the filter holder to the syringe. Fill a syringe with settled water from the churn splitter. Squirt approximately 10 mL onto the ground and then fill a glass vial to the 50-mL line. If the filter clogs prematurely, it may be replaced with a new filter and the process repeated.
9. Preservation. Put on safety glasses. Add 1 drop of concentrated sulfuric acid to preserve the TN sample. Place all samples on ice and store on ice or refrigerate until delivery to the laboratory. Clean up acid spills with acid neutralizing solution or copious amounts of water. To use acid neutralizing solution, shake bottle of acid neutralizing solution and cover affected area until bubbling stops.
10. Washing equipment. The standard washing procedure is for three rinses with distilled water. After each event, the churn splitter, filter holder, and carboys should be washed.
11. Reinstall carboys in the following clock positions: A1 at 6:00, A2 at 3:00, B3 at 12h, and B4 at 9:00.
12. Press the red button and select “run program” on the autosampler to ready the station for the next event. Confirm that the sampler program is running.
13. Complete the Chain of Custody form, including sample IDs, number of containers of each sample being sent to the lab, and the analyses to be performed. The Chain of Custody form must be kept with the samples, either by sticking it into the plastic sleeve taped to the underside of the cooler lid or in a ziplock bag with the samples.
14. Samples must be delivered to the laboratory within the holding times indicated in Table 1.

GRAB SAMPLING PROCEDURES

The autosampler programs will be stopped during the winter months when temperatures are expected to remain below freezing. During this period, field technicians will visit each station approximately weekly to collect grab samples if tile lines are flowing.

1. Fill out and affix labels to the appropriate containers. The correct container for each analyte is given in Table 1.
2. For grab samples, the Sample ID field is a concatenation of the Site ID (JBT01, JBT02, ACT01, etc.), the collection date (mmddyy), and the word “GRAB”. The following example illustrate the sample IDs syntax:

- A grab sample collected at JBT01 on February 2, 2017: **JBT01-020217-GRAB**

3. Grab sample collection.

- a. Put on lab gloves
- b. If the air temperature is above freezing:
 - i. Collect samples for TP, TN, and TSS analysis directly into the sample container. The preferred method is to use the autosampler to pump a sample directly into the sample container, using the manual sample mode. The autosampler pump tubing should be detached from the autosampler housing and a stream of water directed into the sample container. Set the sample volume to 200 mL and dispense the first approximately 5 pump cycles (50 mL) onto the ground, then collect sample up to the fill line on the sample container.
 - ii. Samples for TDP analysis may be dispensed directly into the filtration apparatus containing a 45-mm Durapore® 0.45-µm acetate membrane filter. Use forceps to place a clean filter in the filter holder. Wet the filter with a spray of distilled water. Remove the plunger and attach the filter holder to the syringe. Use the autosampler to pump sample into the syringe, using the manual sample mode. The autosampler pump tubing should be detached from the autosampler housing and a stream of water directed into the syringe. Set the sample volume to 200 mL and dispense the first approximately 5 pump cycles (50 mL) onto the ground, then collect approximately 60 mL of sample in the syringe. Squirt approximately 10 mL onto the ground and then fill a glass vial to the 50-mL. If the filter clogs prematurely, it may be replaced with a new filter and the process repeated.
- c. If the air temperature is below freezing:
 - i. The autosampler may be damaged by ice accumulation. If the tile line continues flowing under freezing conditions, grab samples may be withdrawn using a portable centrifugal pump inserted into the monitoring manhole. Using this pump, sample should be dispensed directly into the sample containers, dispensing the first approximately 50 mL onto the ground, then collecting sample up to the fill line on the sample containers.
 - ii. Because field filtration is not generally successful under freezing conditions, grab samples collected for TDP analysis will be filtered at VAEL. In this case, TDP samples must be brought to VAEL for processing on the day of collection.

4. Preservation. Put on safety glasses. Add 1 drop of concentrated sulfuric acid to preserve the TN sample. Place all samples on ice and store on ice or refrigerate until delivery to the laboratory. Clean up acid spills with acid neutralizing solution or copious amounts of water. To use acid neutralizing solution, shake bottle of acid neutralizing solution and cover affected area until bubbling stops.
5. The filter holder and syringe should be washed by rinsing three times with distilled water after sampling at each station.
6. Complete the Chain of Custody form, including sample IDs, number of containers of each sample being sent to the lab, and the analyses to be performed. The Chain of Custody form must be kept with the samples, either by sticking it into the plastic sleeve taped to the underside of the cooler lid or in a ziplock bag with the samples.
7. Samples must be delivered to the laboratory within the holding times indicated in Table 1.

ROUTINE MAINTENANCE

Tasks to be performed by sampler after each sampling event

1. On the Sample Retrieval Form, record the amount of rainfall collected in any manual gauges and the date and time. Record the amount of rainfall collected in the graduated cylinder to the nearest 0.01 inch then empty it. If water is present in the outer (overflow) cylinder, carefully decant this into the graduated cylinder and add this amount to the first reading. Repeat if necessary until the overflow cylinder is empty.
2. Confirm that the sampler program is running.
3. Confirm that the sampling line and pump tubing are attached.
4. Confirm that the sample carboys are installed properly.
5. Describe field/crop condition.
6. Verify that sufficient sampling supplies (bottles, filters, gloves) remain for at least two sampling events. Notify the Stone project manager if any supplies are low.

Tasks to be performed by Stone approximately monthly

1. Confirm that the sampler program is running.
2. Check the sampling line for any kinks or sags; zip-tie if necessary to maintain a consistent downward slope in the line.
3. Confirm that the sample carboys are installed properly.

4. Check the desiccant cartridges of the flowmeters and 2105ci modules and replace desiccant if necessary.
5. Restock monitoring stations with bottles, sample retrieval forms, labels, filtration supplies, gloves, and distilled water.
6. Refill or replace acid dropper bottles.
7. Cut weeds from around the shelters and flume and along the wingwalls.
8. Describe field/crop condition.

AUTHORIZATION

Written/approved by: _____ Date: _____

Dave Braun, Project Manager, Stone Environmental, Inc.

REVISION HISTORY

None

FORMS

Sample Retrieval Form

Collected by: _____

Date: _____

Weather: _____

Rainfall (if gauge is deployed) _____ in.

| | Station JBT07 | Comment |
|--|---|---------|
| Station condition | <input type="checkbox"/> OK Other _____ | |
| Field/crop condition | | |
| SAMPLE COLLECTION | | |
| Type of sample(s) collected (circle) | Composite split Grab None | |
| Sampler display | _____, _____ bottle_____ | |
| Part A status: (circle one) | 1. ACTIVE, DISABLED 2. PART A DONE 3. ACTIVE | |
| If ACTIVE and enabled, display reads: | PART A _____, _____ bottle_____ after_____ pulses | |
| Part B status: (circle one) | 1. ACTIVE, DISABLED 2. PART B DONE 3. ACTIVE | |
| If ACTIVE and enabled, display reads: | PART B _____, _____ bottle_____ after_____ pulses | |
| Time you stopped the autosampler | _____ AM or PM | |
| Carboy volume (L) | A1: A2: B3: B4: | |
| Carboys split (circle) | A1 A2 A1+A2 composite B3 B4 B3+B4 composite | |
| Sample ID assigned | JBT07 – _____ – _____ (Station) – (mmddyy) – (carboy(s)) JBT07 – _____ – _____ (Station) – (mmddyy) – (GRAB) | |
| Splits collected (circle) | TP TDP TSS TN | |
| Duplicates collected? (circle) | TP TDP TSS TN Carboy _____ | |
| RESETTING STATIONS | | |
| STOP then Re-RUN SAMPLING PROGRAM (circle) | Yes No | |
| Carboys and churn splitter triple rinsed? (circle) | Yes No NA | |
| Desiccant good? (circle) | Yes Changed | |
| Carboys installed properly? (circle) | Yes No | |
| Additional comments: | | |

Chain of Custody Form for Water Samples

Stone Project ID: 18-006

Lab Program #: 319

Stone Contact: Dave Braun, 802-272-8819, dbraun@stone-env.com

| Collection Date | Sample ID | Total # of Containers | Analyses Requested (circle those collected) | | | |
|-----------------|-----------|-----------------------|--|-----|-----|----|
| | | | TP | TDP | TSS | TN |
| | | | TP | TDP | TSS | TN |
| | | | TP | TDP | TSS | TN |
| | | | TP | TDP | TSS | TN |
| | | | TP | TDP | TSS | TN |
| | | | TP | TDP | TSS | TN |
| | | | TP | TDP | TSS | TN |
| | | | TP | TDP | TSS | TN |
| | | | TP | TDP | TSS | TN |
| | | | TP | TDP | TSS | TN |
| | | | TP | TDP | TSS | TN |
| | | | TP | TDP | TSS | TN |
| | | | TP | TDP | TSS | TN |
| | | | TP | TDP | TSS | TN |
| | | | TP | TDP | TSS | TN |
| | | | TP | TDP | TSS | TN |
| | | | TP | TDP | TSS | TN |

Sampled by: _____
print name signature

Technician: _____ Date: _____

| ACTIVITY | SITE: _____ | SITE: _____ | SITE: _____ | SITE: _____ |
|------------------------------------|---|---|---|---|
| Sampler program running | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Sampler tubing is attached | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Sample carboys installed properly | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Signal converter desiccant | <input type="checkbox"/> OK <input type="checkbox"/> Replaced <input type="checkbox"/> NA | <input type="checkbox"/> OK <input type="checkbox"/> Replaced <input type="checkbox"/> NA | <input type="checkbox"/> OK <input type="checkbox"/> Replaced <input type="checkbox"/> NA | <input type="checkbox"/> OK <input type="checkbox"/> Replaced <input type="checkbox"/> NA |
| 2105ci module desiccant | <input type="checkbox"/> OK <input type="checkbox"/> Replaced <input type="checkbox"/> NA | <input type="checkbox"/> OK <input type="checkbox"/> Replaced <input type="checkbox"/> NA | <input type="checkbox"/> OK <input type="checkbox"/> Replaced <input type="checkbox"/> NA | <input type="checkbox"/> OK <input type="checkbox"/> Replaced <input type="checkbox"/> NA |
| Restock sampling supplies | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Restock forms and labels if needed | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Mow weeds | <input type="checkbox"/> <input type="checkbox"/> NA | <input type="checkbox"/> <input type="checkbox"/> NA | <input type="checkbox"/> <input type="checkbox"/> NA | <input type="checkbox"/> <input type="checkbox"/> NA |
| Field Condition: | | | | |
| Comments: | | | | |

APPENDIX B (attached):
Determination of Phosphorus by Flow Injection Analysis 24 8 1-2015
(Acid Persulfate Digestion Method)

**APPENDIX C (attached):
Standard Operating Procedure for Total Nitrogen 24 7 1-2015
(Persulfate Digestion Method)**

APPENDIX D (attached):
Standard Operating Procedure (SOP) for Total Suspended Solids (TSS) 14 11 03-2015