# AGRICULTURAL PRACTICE MONITORING AND EVALUATION

## FINAL REPORT

**Stone Project ID 112540-W**
**July 31, 2015**

*Monitoring station at the inlet of the water and sediment control basin (WAS1) during a December 2014 rain-on-snow event*


**Prepared for:**
Vermont Agency of Agriculture, Food & Markets
Laura DiPietro and Michael Middleman
116 State St.
Montpelier, VT 05620
Tel. / 802.828.1289
E-Mail / laura.dipietro@state.vt.us

**Prepared by:**
Dave Braun, Don Meals, Julie Moore, and Allison Jerram
Stone Environmental, Inc.
535 Stone Cutters Way
Montpelier, VT 05602
Tel. / 802.229.4541
E-Mail / jmoore@stone-env.com


STONE ENVIRONMENTAL INC

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# 1. INTRODUCTION

Lake Champlain continues to suffer the effects of excessive phosphorus (P) loading from sources in the Lake Champlain Basin (LCB). It is estimated that more than 90% of the lake's current annual P load is derived from nonpoint sources (VTANR 2008). Nonpoint source P lost from agricultural land is a significant component of the lake's annual P load (Troy et al. 2007). Although federal and state programs, as well as landowners, have made unprecedented investments implementing best management practices (BMPs) to address transport of P, sediment, and other pollutants from agricultural operations in the LCB, these efforts have not yet yielded desired water quality results.

Vermont farmers are facing increasing pressure to reduce their contributions to water pollution in Lake Champlain. In 2011, the U.S. EPA withdrew their 2002 approval of the Vermont portion of the Lake Champlain total maximum daily load (TMDL) for P. Recently modeling efforts undertaken by EPA have estimated that almost 40% of the annual phosphorus load delivered to Lake Champlain is attributable to agriculture and that the vast majority of the agricultural load is attributable to hay and cropland (USEPA 2013). Vermont farmers have shown strong interest in implementing BMPs such as conservation tillage, manure and nutrient management, and cover crops over the past decades. Although many producers attribute significant agronomic and water quality benefits to these management practices, the effectiveness of many of these practices in reducing P and sediment losses from agricultural land is not well documented. Only a limited number of studies exist from sites with similar climate and landscape settings to Vermont. In addition, many reported studies are plot-scale with simulated rainfall; such results may not apply directly to the field or watershed scales.

This study addresses an urgent need to evaluate and document the effectiveness of conservation practices in the Lake Champlain Basin. This project was designed to meet the stated purpose of USDA-NRCS Conservation Practice Standard 799 – Monitoring and Evaluation, which is to *sample and measure water quality parameters to evaluate conservation system and practice performance*. Although the 799 Standard has since been discontinued by NRCS, this monitoring program continues subject to its guidelines. More information about NRCS Conservation Practice Standards can be found at: www.nrcs.usda.gov/technical/Standards/nhcp.html. The principal hypothesis being tested is that application of these conservation practices will significantly reduce runoff losses of nutrients and sediment from agricultural fields in corn and hay production. The agricultural practices being evaluated are:

- Soil aeration on hayland (VT NRCS Practice Standard 633) prior to manure application;
- Reduced tillage (VT NRCS Practice Standard 329) with manure injection and cover cropping on corn land;
- Cover cropping (VT NRCS Practice Standard 340) on corn land; and
- A water and sediment control basin (WASCoB) (VT NRCS Practice Standard 638) treating runoff from corn land.

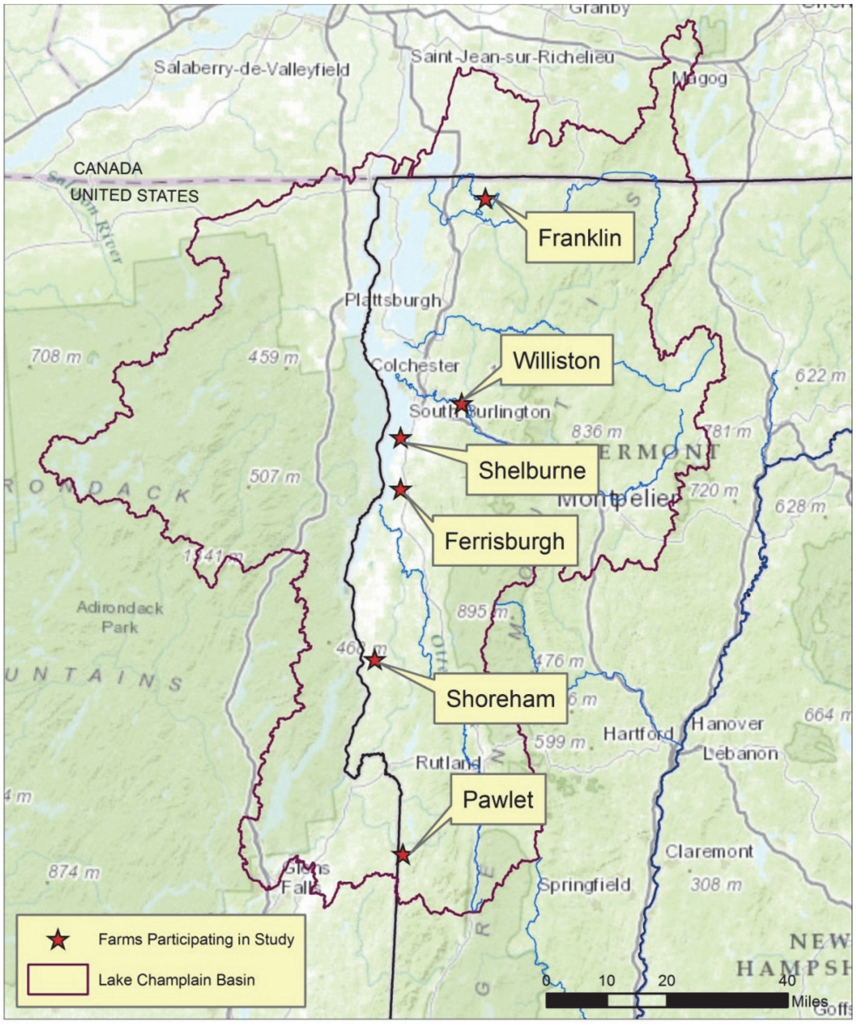



*Figure 1. Locations of participating farms*

These practices are being evaluated on field/watershed sites at working farms in the Vermont-portion of the Lake Champlain Basin. Locations of the monitored farms are shown in Figure 1. By agreement with site landowners, exact site locations will not be publicly disclosed. Sites are referred to by town name.

The project employs a paired-watershed design in order to document the effects of these conservation practices on runoff losses of nutrients and sediments at the field scale. The paired-watershed design includes two (or more) fields or watersheds—a control and a treatment—and two time periods—calibration and treatment. The watersheds need not be identical, but should be generally similar in size, slope, location, precipitation received, soils, and land cover (Hewlett 1971). The control watershed accounts for year-to-year climate variations and the management practices remain consistent during the entire study. The treatment watershed undergoes a change in management (e.g., soil aeration or cover cropping) at some point during the study. The basis of the paired-watershed approach is that there is a quantifiable relationship (i.e., a linear regression model) between paired data from the watersheds (calibration) and that this relationship is valid until a change is made in one of the watersheds (treatment). At that time, a new relationship will exist. The difference between the calibration and treatment relationships is used to evaluate and quantify the effect of treatment.

The primary datasets that are being used to assess the strength of the calibration and treatment period relationships and effects of treatment are:

- Total event discharge;
- Event mean concentrations of total phosphorus (TP), total dissolved phosphorus (TDP), total nitrogen (TN), total dissolved nitrogen (TDN), total suspended solids (TSS), and chloride; and

- Event mass export of TP, TDP, TN, TDN, TSS, and chloride.

Monitoring data of secondary importance include: precipitation, air temperature, runoff specific conductance, and runoff temperature.

This final report prepared for the Vermont Agency of Agriculture, Food, and Markets (VAAFM) summarizes agronomic, event discharge, and water quality data collected for the paired watershed sites through December, 2014. Weather data are summarized through June, 2015. Statistical analyses of the paired watershed data and evaluation of conservation practice effectiveness are not presented in this report and will not be performed until the 2015 monitoring season is over. These analyses and findings will be summarized in a 2016 report to the Lake Champlain Basin Program.

On July 8, 2015, monitoring at the WASCoB site (stations WAS1 and WAS2) was discontinued. These stations have now been decommissioned. Because monitoring of the WASCoB has ended, statistical analyses of the WASCoB data are presented in this final report.

## 2. GOALS AND OBJECTIVES

The goal of the project is to quantify the treatment effect of specific conservation practices—cover cropping, reduced tillage with manure injection, soil aeration, and water and sediment control basins—in reducing runoff losses of nutrients, with particular emphasis on phosphorus, and sediment from agricultural fields in corn and hay production.

Specific project objectives include:

- Developing accurate estimates of pollutant reductions attributable to different conservation practices in Vermont-specific climate and landscape settings;
- Collecting scientifically sound data on BMP performance in support of TMDLs and other pollution-reduction programs;
- Analyzing data in a manner that can inform incentive program structure to ensure the most effective practices are emphasized; and
- Identifying potential modifications to BMPs that may improve performance.

# 3. DESCRIPTION OF STUDY SITES

Six working dairy farms in the Vermont portion of the Lake Champlain Basin contracted with NRCS, committing to participation in the project. The general locations of the participating farms are shown in Figure 1. Summary data for each study watershed are presented in Table 1 and descriptions and maps are presented in Appendix A. The maps depict the monitoring station location, field topography, the drainage area boundary, soil mapping units (SSURGO), and the extent of wingwalls.

*Table 1. Soil and slope descriptions of study watersheds*

| Watershed | Area (acres) | Area (ha) | Mean slope (%) | Aspect | Soil Type | Hydrologic Soil Group |
|---|---|---|---|---|---|---|
| FER1 | 4.5 | 1.8 | 3.2 | SE | Covington silty clay, Cv: 54.6% | D |
| | | | | | Vergennes clay, VeE: 9.4% | D |
| | | | | | Vergennes clay, VeB: 36% | D |
| FER2 | 7.2 | 2.9 | 2.1 | W | Vergennes clay, VeB: 55.7% | D |
| | | | | | Covington silty clay, Cv: 44.8% | D |
| FRA1 | 15.6 | 6.3 | 3.9 | W | Munson silt loam, MuC: 11% | D |
| | | | | | Scantic silt loam, ScA: 19.4% | D |
| | | | | | Belgrade silt loam, BeC: 14.8% | B |
| | | | | | Georgia stony loam, GeB: 20.7% | C |
| | | | | | St. Albans silty loam, SaB: 7.9% | B |
| | | | | | Massena stony loam, MeA: 26.1% | C |
| FRA2 | 13.4 | 5.4 | 3.7 | W | Munson silt loam, MuC: 3.8% | D |
| | | | | | Scantic silt loam, ScA: 23.8% | D |
| | | | | | Belgrade silt loam, BeC: 6.4% | B |
| | | | | | Georgia stony loam, GeB: 4.9% | C |
| | | | | | St. Albans silty loam, SaB: 3.1% | B |
| | | | | | Massena stony loam, MeA: 8.8% | C |
| | | | | | Munson silt loam, MuB: 41% | D |
| | | | | | Lordstown-Rock outcrop complex, LrC: 7.9% | C |
| PAW1 | 6.0 | 2.4 | 4.5 | SW | Bomoseen and Pittstown soils, 148B: 62.9% | C |
| | | | | | Taconic-Macomber complex, 43C: 4.3% | D |
| | | | | | Bomoseen and Pittstown soils, 148C: 33.5% | C |
| PAW2 | 3.1 | 1.3 | 11.6 | SE | Taconic-Hubbardton-Macomber complex, 12F: 0.7% | D |
| | | | | | Raynham silt loam, 26A: 34.3% | C |
| | | | | | Macomber-Dutchess complex, 52B: 24.4% | C |
| | | | | | Bomoseen and Pittstown soils, 148C: 40.6% | C |
| SHE1 | 6.8 | 2.7 | 2.7 | SW | Covington silty clay, Cv: 89.4% | D |
| | | | | | Palatine silt loam, PaD: 1.4% | C |
| | | | | | Palatine silt loam, PaC: 9.4% | C |
| SHE2 | 5.8 | 2.3 | 3.0 | S | Vergennes clay, VeB: 100% | D |
| SHO1 | 5.9 | 2.4 | 3.8 | W | Vergennes clay, VgB: 100% | D |
| SHO2 | 2.4 | 1.0 | 6.9 | SW | Vergennes clay, VgB: 100% | D |

| Watershed | Area (acres) | Area (ha) | Mean slope (%) | Aspect | Soil Type | Hydrologic Soil Group |
|---|---|---|---|---|---|---|
| WAS1 | 22.1 | 8.9 | 0.5 | E | Raynham silt loam, RaB: 59%<br>Binghamville silt loam, Bg: 41% | C<br>C |
| WAS2 | 22.7 | 9.2 | 0.5 | E | Raynham silt loam, RaB: 60%<br>Binghamville silt loam, Bg: 40% | C<br>C |
| WIL1 | 4.3 | 1.7 | 0.12 | S | Limerick silt loam, Le: 85.9%<br>Hadley very fine sandy loam, Hf: 7%<br>Winooski very fine sandy loam, Wo: 7% | C<br>B<br>B |
| WIL2 | 2.0 | 0.81 | 0.06 | N | Limerick silt loam, Le: 34.6%<br>Winooski very fine sandy loam, Wo: 65.3% | C<br>B |

# 4. METHODS

A Quality Assurance Project Plan (QAPP) was prepared and approved by the Lake Champlain Basin Program and U.S. EPA in June 2012, prior to commencement of the field work and data acquisition aspects of the project. Following the fall 2012 monitoring period, the QAPP was revised to account for changes in staffing, instrumentation, and monitoring and sample handling procedures. Version 2.0 of the QAPP was distributed for signature on July 9, 2013 and it remains in effect. Version 2.0 of the QAPP is included as Appendix B.

## 4.1. Soil Characterization

Soil characterization sampling and analyses were conducted in the fall of 2012. A probe was used to collect soil cores throughout each watershed to 10 cm depth in hay fields and to 20 cm in corn fields (Figure 2). Cores were composited and blended in a plastic bucket using a trowel. Subsamples were transferred to polyethylene bags and analyzed for pH (1:2, V:V, in dilute calcium chloride) and available P, K, Mg, Ca, Fe, Mn, and Zn following extraction in modified Morgan solution, and for organic matter, cation exchange capacity, and soil particle sizes. Organic matter was quantified by the loss on ignition method. Soil particle size was analyzed by wet sieving and the hydrometer method. The sampling procedure is further described in the Soil Sampling Procedure O&R, included as Appendix C.

Soil samples were delivered to the University of Vermont Agricultural and Environmental Testing Laboratory (AETL) and were analyzed by AETL and the University of Maine Analytical Laboratory and Maine Soil Testing Lab. Sample splits were also shipped to the USDA ARS Grassland Soil and Water Research Laboratory in Temple, Texas for analysis of soil health indicators.

*Figure 2. Soil probe used to collect composite soil samples*

## 4.2. Agronomic Data Collection

Annually, data on agronomic and field management activities including tillage (date, method); manure, nutrient, and agrichemical applications (date, method, rate); planting (date, method, variety); and harvest (date, method, yield) were collected for each study field directly from the participating farmers. These data were collected on an agronomic information form prepared for each farm and/or by interviewing participating farmers. The forms used to collect these data are included as Appendix D (for corn sites) and Appendix E (for hay sites). Information on field management from the participating farmers was supplemented by direct observation by sampling personnel, and by time-lapse photography from repeatable photo points at each monitoring site. The agronomic practice data forms sent to each participating farmer were "seeded" with information available from Stone's review of the time-lapse camera photographs. For example, we were able to indicate the dates hay cuts were made.

Face-to-face meetings were held with all participating farmers in March–April of 2014 and 2015 to review management plans for the study watersheds for the coming season, focusing on implementation of planned treatments.

Cover crop and residue percent cover measurements were performed at the three corn sites (FRA, PAW, and WIL) in October–November, 2013. In 2014, these measurements were made at the FRA and PAW sites before corn was planted and at all three corn sites in late fall. In 2015, measurements were made at all three corn sites prior to tillage and planting and will be repeated in the late fall.

The procedure used to quantify the percent cover of cover crop and residue is detailed in Appendix F. Between 10 and 20 randomized locations were surveyed in each study watershed on each survey date using a gridded quadrat with 64 measuring points (Figure 3).

*Figure 3. Quadrat used in cover crop percent cover measurements*

## 4.3. Monitoring Station Construction

The primary hydraulic device used at each runoff monitoring station is an H-flume of an appropriate size for the study watershed. H-flume sizes (1.5, 2.0, or 2.5-ft) were selected using professional judgement, considering the results of rainfall-runoff modeling. HydroCAD models were constructed to predict peak flow rates for design storms of varying magnitude (1-, 2-, 10-, and 25-year recurrence intervals), using the watershed areas and soil and topographic data.

The flume at each station is bolted to a plywood trough (the "flume approach channel"), which creates a laminar flow stream entering the flume. The flume approach channel is mounted to a manifold made from a sheet of ¾-inch plywood, which is partially buried such that the entrance is nearly level with the ground. The discharge end of the flume is suspended by chains from a scaffold. Tensioners on the chains are adjusted to precisely level the flume. Plywood wingwalls were installed, as needed, to direct flow into the flume.

An ultrasonic water level sensor (ISCO 2110 Ultrasonic Flow Module) was installed in each flume to continuously measure stage (water level). The 2110 Ultrasonic Flow Module converts level data to flow rate based on the established hydraulic properties of the flume. These flow data are used to generate runoff event hydrographs and to calculate pollutant transport rates.

Each monitoring station includes an ISCO 6712 autosampler. The autosampler draws water through an intake screen and suction line secured in a splash pan mounted below the flume outlet (Figure 5). The splash pan ensures that the sample is well mixed and that the intake is submerged even at relatively low flow rates, when an intake mounted in the flume would draw air.

The autosampler was programmed to pump runoff water on a flow proportional basis into bulk (10 L) sample containers. To minimize the occurrence of under-sampling and overfilling, a two-part program was developed whereby the autosampler pumps sample to two sets of containers at different intervals of accumulated flow. The first set of bottles is intended to capture a representative runoff sample from small to medium sized events and a second set of bottles is intended to capture the medium to large events. The second set fills at approximately $1/10^{th}$ to $1/20^{th}$ the frequency of the first set. If the capacity of the first set of bottles is exceeded, the sample will be rejected and the second set of bottles will be used instead. Using this sampling program, runoff events varying in magnitude by more than a factor of 100 can be representatively and automatically sampled. The initial sampler pacing setting were defined using output from HydroCAD models developed for each study watershed. These initial sampler pacing settings were refined using the runoff flow rates and volumes measured during the first months of operation. In addition, sampler pacing settings may be adjusted in advance of major predicted storms, with the intent of representatively sampling every runoff-producing storm.

The flowmeter and autosampler at each station are cabled to an ISCO 2105-Ci Interface Module with an integral IP modem. The 2105-Ci modules allow two-way communication with the monitoring stations. The modules were programmed to push hydrologic and sampling data every 30 minutes to a computer server maintained by Stone. This technology eliminates the need to download the flowmeters and autosamplers and provides for near-real time, secure data storage. Data pushed to the server are viewable in graphical formats on a customized web site. The ability to view station status and monitoring data in near-real time, on any computer with internet access, enhanced the quality of data collection by enabling sampling personnel to better time field visits, shortly after runoff events end or when they are nearing completion. It has also enabled earlier detection of instrument malfunctions. The 2105-Ci units were programmed to send text messages to sampling personnel to alert them that a runoff event is in progress, which improves staff response time. Finally, the capability of starting, stopping, and resetting autosamplers and reprogramming instruments remotely has improved sampling operations, especially when back to back storm events occur and during freezing conditions. This has been particularly useful in adjusting sampler flow pacing based on weather forecasts.

Each station is powered by a Kyocera KD135GX 135-Watt solar panel and two 6-volt deep cycle marine batteries connected in series. The autosampler, ultrasonic level module, interface module, solar power charge controller, batteries, samples bottles, and churn splitter are housed in a secure instrument shelter. Photographs of field monitoring station components are presented in Figure 5 and Figure 5.

*Figure 5. H-flume, splash pan, and siphon sampler array*

*Figure 5. Instrument shelter with autosampler and carboys*

To measure water temperature and conductivity of the runoff stream, a HOBO® U24-001 Conductivity Data Logger is installed in the splash pan in the runoff channel below the flume. These data are downloaded onsite using a waterproof shuttle device.

### 4.4. Meteorological Monitoring

A simple meteorological station was installed at each participating farm for the continuous monitoring of rainfall and air temperature. An Onset HOBO® RG3 tipping bucket rain gage was calibrated and installed. Every tip marks the accumulation of 0.01 inches (0.254 mm) of rainfall and is recorded in memory with a time stamp. Continuous precipitation monitoring is supplemented by a manual rain gage located at each site as a backup. An air temperature sensor is housed in a solar radiation shield. Raw precipitation data are post-processed to calculate monthly totals and the total for each runoff event. Air temperature data are processed to calculate daily and monthly minimum, maximum, and average values.

Calibration of the tipping bucket rain gages was checked in the field each spring (April–May) and the gages were recalibrated as necessary. Meteorological data were downloaded approximately monthly during routine site maintenance. In 2014, there were significant data gaps at two of the six weather stations, resulting from recurrent instrument malfunctions. Data gaps in the temperature and precipitation data are identified in Table 24 through Table 29 (see table footnotes).

### 4.5. Routine Maintenance

Field staff visited each monitoring stations at least monthly during the monitoring season to perform routine maintenance, download instruments, and restock supplies. These maintenance activities are listed on the *Monthly Maintenance Checklist* included in the QAPP, Version 2.0. Data transmitted from the stations were checked approximately bi-weekly to verify that data communications were successful, the voltage of the main batteries was good, and recorded level data were near zero during dry periods.

## 4.6. Runoff Event Sampling

Stations were visited as soon as possible after the end of a monitored event. Runoff samples were processed in accordance with the QAPP, Version 2.0 (Appendix B). Event data were recorded on the *Sample Retrieval/Routine Maintenance by Sampler Form*, which is included in the QAPP. Following collection, samples were refrigerated or stored on ice and arrangements were made for their transport to the Department of Environmental Conservation laboratory within seven days of collection.

After start up in the fall of 2012, the monitoring stations were essentially dormant from February 1 to March 12, 2013, but were quickly brought on-line in order to capture a significant runoff event resulting from a rain-on-snow beginning on March 12. The stations were operated continuously from mid-March through December 6, 2013. Following the mid-March event, there was a period of nearly two months of dry weather and low activity at all stations. There were no runoff events at the Williston, Shoreham, Franklin, and WASCoB sites during this period, while the Shelburne, Ferrisburgh, and Pawlet sites recorded between two and four events. A significant change in the weather pattern occurred in mid-May, and the period from late-May through early - July was characterized by record-breaking rainfall totals, saturated soil conditions, and large runoff events. Although it was wet throughout Vermont during this period, the more intense rainfall events were concentrated in Chittenden County and areas to the south. Precipitation totals during the remainder of the summer and the fall were generally close to or below long-term normals and few runoff events occurred. The last sampled runoff event in 2013 was on December 6, 2013.

The winter of 2013-2014 was characterized by ice in the fields and flumes, deep frost penetration, and late snowfalls. Spring conditions were late to arrive. Stations were operated through icy conditions in April by remote control of the autosamplers. The first sampled runoff event of 2014 began on April 1 at Ferrisburgh. At the Franklin, Shoreham, and Williston sites there were no paired runoff events over an 8-month period between mid-April and the major “Christmas Event”, which occurred from December 24 – 26, 2014 at most stations. The period without a runoff event was almost as long at the Ferrisburgh site, May 6 – December 24, 2014. No runoff was recorded at either Shelburne station from June 26 to December 16, 2014. Only the Pawlet site appeared to run off more frequently, although sampling there was discontinued until late October due to misapplication of the cover crop treatment.

Operating autosamplers remotely during rain storms and thaws in the winter months was somewhat more successful in the winter of 2014-2015 than in 2013-2014. During the winter of 2013-2014, many of the flumes filled with ice in December and flow measurement during runoff events in December and January were generally badly affected by ice. Monitoring of the large “Christmas event” in 2014, which produced runoff at 13 of the 14 stations (all stations except WIL1), was made possible by remote autosampler operation, as was an event in mid-January 2015 at the Ferrisburgh site. Several events were successfully monitored in March and April 2015 through remote autosampler operation.

Spring was especially late in 2015. Deep frost penetration again resulted in heaving of soil, flumes, and wingwalls, which contributed to bypass flow beneath the flumes at several stations, compromising certain spring events. The first major runoff event in 2015 at six of the seven sites was a snowmelt event starting on March 10th. Samples from the Williston and Ferrisburgh sites were submitted for analysis. The flow data for both Ferrisburgh stations were invalid due to bypass flow beneath the flumes; however, sampling was sufficiently representative that analytical data for this event will be used. In April, paired events were successfully monitored only at PAW and SHO. There were no paired events in May at any sites. Rainfall totals in April and May were generally near or below normal across the sites. June, however, was a very wet month, with multiple runoff events recorded at every station except WIL1.

The number of paired sampling events for each station through June 2015 is presented in Table 2, below. Because so few paired runoff events occurred in 2014, there are insufficient treatment period data to proceed with statistical analyses of the paired watershed sites.

*Table 2. Number of paired events with valid data at both stations, through July 1, 2015*

| | **Calibration Period** | | **Treatment Period** | |
|---|---|---|---|---|
| **Station** | **Number of Paired Flow Events**[1] | **Number of Paired Chemistry Events** | **Number of Paired Flow Events**[1] | **Number of Paired Chemistry Events** |
| FER | 23 (4)[2] | 20 (4)[2] | 13 | 12 |
| FRA | 14 | 9 | 9 | 7 |
| PAW | 40 | 28 | 10 | 8 |
| SHE | 27 (3)[2] | 20 | 11 | 11 |
| SHO | 13 (2)[2] | 8 (2)[2] | 7 | 6 |
| WIL | 18 | 15 | 4 | 2 |
| WAS | 18 | 18 | NA | NA |

*[1] Includes only events with measureable runoff and valid data at both stations in a pair*
*[2] Numbers in parentheses are the 2014 events added to the calibration period dataset. These events are included in the tabulated event numbers but are not included in the calibration period statistics presented in Section 7.*

In several cases, adjustments were made to raw flow data to account for sediment or ice accumulation in flumes. These adjustments were made in Excel by fitting a power trendline to a portion of the hydrograph spanning the period of suspect data. In most cases, there is an obvious drop in measured flow when the sediment or ice was cleared from the flume

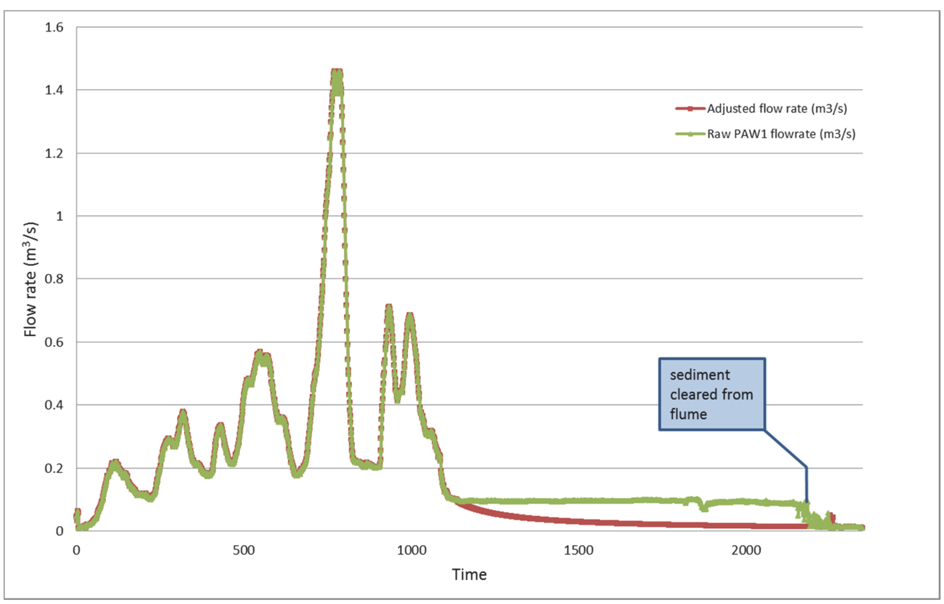



*Figure 6. Uncorrected and adjusted flow rate at PAW1 station*

by field staff. A trendline was fit to the "good" data points immediately prior to the period of suspected sediment- or ice-affected flow and to the points immediately after sediment or ice was cleared from the flume. Figure 6 shows one instance where the raw flow data were adjusted to account for sediment in the flume. Stations and events with adjusted flow data in 2013 were as follows:

- FER2, Event 1 (March 12-14, 2013)
- FER1, Event 7 (June 11-12, 2013)
- FER2, Event 21 (November 27-28, 2013)
- PAW1, Event 1 (March 12-13, 2013)
- PAW1, Event 10 (June 2-4, 2013)
- PAW1, Event 14 (June 24-27, 2013)
- PAW1, Event 15 (June 27-30, 2013)
- PAW1, Event 17 (July 5-7, 2013)
- PAW1, Event 19 (July 10-11, 2013)

For FER1, Event 7 (June 11-12, 2013), an adjustment was made to account for a minor leak beneath the wingwall. The bypass flow resulting from this leak was estimated as the additional flow occurring immediately after the leak was temporarily plugged by field staff. This flow was added to the measured flow over the declining limb of the hydrograph.

In 2014, flow data adjustments to correct for ice in the flume were made for the following stations and events. Several other events where flow was indicated were too badly affected by ice to make reasonable corrections.

- FER1, Event 1 (April 1-3, 2014)
- FER2, Event 1 (April 1-4, 2014)
- FER2, Event 4 (April 15-16, 2014)
- FER1, Event 8 (January 19, 2015)
- FER2, Event 8 (January 19, 2015)
- FRA1, Event 3 (March 30, 2014)
- PAW1, Event 5 (December 3-4, 2014)
- PAW1, Event 6 (December 22-27, 2014)
- SHO1, Event 1 (April 4-7, 2014)
- SHO2, Event 1 (April 4-6, 2014)

Adjustments will also need to be made for certain spring 2015 events.

### 4.6.1. Problems encountered at monitoring stations in 2013

Considering the scale of the monitoring program, there were relatively few technical problems encountered in 2013. There were essentially no problems with the power supply systems, ultrasonic flow meters, autosamplers, tipping bucket rain gages, or air temperature sensors. Any problems with the telemetry systems were minor and were rectified without any loss of data. The most significant problem experienced in 2013 was flow that bypassed five different station flumes during very large events, either by undermining or flowing around the wingwall. These and other less critical problems, along with the remedial measures implemented, are described below.

- Significant erosion and undermining ("blow-outs") occurred along the wingwalls at the FER1, FER2, and PAW1 stations during three different, very large events in the spring of 2013. These blow-outs resulted in the loss of data from the event (i.e., we don't know how much water passed under the wingwall) and required significant, unanticipated repairs. In each case, soil surrounding the eroded section was excavated and a thick layer of bentonite chips was placed along the base of the wall on both sides, followed by backfill to the surface with tamped native soil. Each repair held successfully during the multiple rain events that followed. These blow-outs resulted in exclusion of the following events from statistical analysis:
  - FER2, Event 6: Discharge and analytical data excluded
  - PAW1, Event 10 (June 2-4, 2013): Discharge and analytical data excluded
- On July 11, 2013, there was a very large event (Event 15) at SHO1 and SHO2, with peak flows substantially higher than any seen previously at these sites. Time-lapse photographs showed the ponded level behind the SHO1 flume reaching the end of the wingwall. Comparing total runoff volume for SHO1 and SHO2 across all events demonstrated that the July 11 event was an outlier, with relatively less flow at SHO1 than would be expected given the total flow at SHO2. On October 8, we surveyed the flumes and the ends of the wingwalls at SHO1 and SHO2 and found that the ground surface elevations at the ends of the wingwalls were not high enough and bypass flow could occur at both stations. The problem was more significant at SHO1 than at SHO2. We believe that substantial bypass flow occurred around the SHO1 wingwall and minor bypass flow occurred around the SHO2 wingwall during the July 11 event. We do not believe bypass flow occurred during any other events. The problem at SHO1 likely resulted from a combination of settling/compaction of the soil berms that were created during station construction and extended beyond the plywood wingwalls and installation of the flume too high on the wingwall. Therefore, in late October, Stone staff reinstalled the SHO1 flume several inches lower and built up the soil berms adjacent to the wingwalls at both stations. Flow and analytical data from the July 11 event were excluded from statistical analysis.
- On the April 17, 2013, the pressure transducer was reinstalled at site WAS2 to measure water level. The pressure transducer began transmitting erroneous readings almost immediately. A borrowed unit was installed on April 19, 2013 and the faulty unit was sent in for repair. The repaired unit was reinstalled on May 22, 2013. These reinstallations necessitated multiple level adjustments. For the period April 19 through May 2, the necessary level adjustment cannot be determined with confidence. Since there were no events during this period, these data have simply been eliminated.
- The conductivity sensor/logger installed at SHE2 malfunctioned (it stopped recording data) in July and again in August. We determined that it needed to be returned to the manufacturer for service. The repaired unit was reinstalled at SHE2 on October 11, 2013.
- The conductivity sensor/logger installed at WAS2 malfunctioned (it stopped recording data) after October 18, 2013. During a field visit on November 21, 2013, we determined that it needed to be returned to the manufacturer for service. The unit was repaired and was reinstalled in the spring of 2014.

### 4.6.2. Problems encountered at monitoring stations in 2014

There were relatively few technical problems encountered in 2014 considering the scale of the monitoring program. There were essentially no problems with the power supply systems, flow meters, and autosamplers. However, the deep frost penetration in the winter of 2013-2014 and the late spring created several monitoring challenges early in the 2014 growing season. The most significant problem experienced in 2014 was flow that bypassed the flumes at several stations during very large events. These and other problems, along with the repairs implemented, are described below.

- The deep frost resulted in major heaving of the flume supports and wingwalls at some stations. A great deal of effort was expended leveling and re-leveling flumes, leveling and supporting shelters, and re-setting posts as the frost melted.
- In the spring of 2014, there was significant erosion and undermining ("blow-outs") at the FRA1, FRA2, and PAW1 stations that resulted in bypass flow under the wingwalls. These blow-outs required significant, unanticipated repairs. In each case, soil surrounding the eroded section was excavated and a thick layer of bentonite chips was placed along the base of the wall on both sides, followed by backfill to the surface with tamped native soil. The PAW1 site required extensive repairs, but there was no loss of data because monitoring had been suspended due to the misapplication of cover crop seed. At Franklin, these blow-outs resulted in exclusion of the following events from statistical analysis:
    - FRA2, Event 5 (April 1, 2014): Not sampled. Discharge data to be excluded.
    - FRA1, Event 8 (April 15, 2014): Discharge and loading data to be excluded. Analytical data are considered valid because sampled flow and bypassed flow are unlikely to differ in quality.
    - FRA2, Event 8 (April 15, 2014): Discharge and loading data to be excluded. Analytical data are considered valid because sampled flow and bypassed flow are unlikely to differ in quality.
- Bypass flow also occurred at the SHE1 station when a small gully cut through the soil berm adjacent to the wingwall. This gully was backfilled with compacted native soil on April 25, 2014. There was no loss of data because monitoring had been suspended until the SHE1 field was aerated, following the first hay cut.
- At the Ferrisburgh site, minor bypass flow was observed at both FER1 and FER2 on December 26, 2014, during Event 7. At FER1, a small sinkhole formed over the buried tile line, likely as a result of an earlier tile blowout. This hole was deemed insignificant and the monitoring data are believed to be valid. At FER2, there was a larger leak. The reported FER2 data are considered provisional; we are evaluating whether reasonable adjustments may be made in these data. If not, this event will be excluded.
- Ice, submergence of the WASCoB outlet, and erosion of the WASCoB spillway impacted flow measurement and sampling at the WAS2 site in April, 2014. On May 8, 2014, sand bags were

installed along the spillway to approximate the former elevation of the spillway crest. WAS2 data collected in 2014 prior to this repair are suspect.

- At the WASCoB inlet station, minor bypass flow was reported during Event 2 (April 15-17, 2014). This bypass flow was assumed to be insignificant relative to the magnitude of the event.
- The tipping bucket installed at Pawlet malfunctioned and failed to record data between March 13 and April 27, 2014. A similar malfunction occurred between July 9 and September 15, 2014 in the tipping bucket installed at Shoreham. The two-month outage in Shoreham occurred because a technician incorrectly diagnosed the problem during maintenance in August, believing it was corrected. Both units were successfully repaired in the field and reinstalled.
- The tipping bucket at Shelburne was not properly launched and did not record data between June 7 and July 8, 2014.
- The conductivity sensor/logger installed at the FRA1 station was not properly launched and did not record data between July 15 and August 14, 2014.
- The time lapse camera at FRA1 stopped working on March 16$^{th}$ and was replaced on May 8, 2014. The time lapse camera at FRA2 stopped working on September 8$^{th}$ and was replaced on December 19, 2014.

#### 4.6.3. Problems encountered at monitoring stations in 2015 (through June)

Deep frost penetration again resulted in heaving of soil, flumes, and wingwalls, which contributed to bypass flow beneath the flumes at several stations, compromising certain spring events. Frost heaving, both of the ground surface under the flume and of the posts supporting the flume and flume approaches, was most evident at the FRA, PAW, and WAS1 sites. Additionally, three flowmeters critically malfunctioned at the start of the monitoring period and needed to be returned to the manufacturer for repair. These and other problems, along with the repairs implemented, are described below.

- An ice jam at the SHO1 flume approach resulted in considerable bypass flow around the end of the wingwall during a thaw event in a late March.
- Significant bypass flow occurred beneath the flumes over the winter and snowmelt period at both PAW stations, both FRA stations, FER2, and WAS1. Eliminating the bypass flow channels at these stations required considerable excavation, filling, and compaction. Minor bypass flow at WIL2 was also addressed.
- Significant bypass flow occurred at FER1 in May when runoff found a new route into the underlying tile drain.

Beyond the weather-related challenges, operation of the stations through June saw four instrument failures that prevented runoff monitoring at the SHE and WIL sites for significant periods, as follows:

- The 2105-Ci module at WIL1 failed in March. This module was successfully reset and reprogrammed with no significant loss of data.

- The 2110 ultrasonic flowmeters at SHE1, WIL1, and WIL2 all malfunctioned in the same few week period and all required costly and time-consuming repair by the manufacturer. As a result, the sampling programs were suspended and flow data are missing for the following periods:
  - SHE1: March 10–June 10.
  - WIL1: March 24–April 6
  - WIL2: March 31–April 6th.
- After repair of the SHE1 flowmeter, this flowmeter and the meter from SHE2 were moved to the Williston stations to minimize downtime there, while the WIL1 and WIL2 flowmeters were being repaired. Monitoring at WIL was prioritized over SHE because there are fewer treatment period event data for WIL. As a result flow data are also missing for SHE2 from April 7–June 10.
- The time-lapse camera at WIL malfunctioned and did not record images during the month of June. It was replaced in early July.
- The tipping bucket datalogger at Shoreham recorded invalid temperature data in May. This was determined to result from a communications error between the logger and the data shuttle and the problem was resolved for data collected after May. Precipitation data were not affected.

### 4.7. Water and Sediment Control Basin (WASCoB) Monitoring

Monitoring of the WASCoB began in May 2013 and stopped on July 8, 2015. Even under the best circumstances, the WASCoB is a difficult structure in which to accurately monitor flow. There are two outlets—a standpipe with multiple orifices and a spillway—and both are insensitive, meaning that significant changes in outflow rate produce only a small change in stage. For example, the stage-discharge rating we developed for the WASCoB illustrates that when the water level rises above the top orifice of the standpipe and again when the spillway is overtopped, a modest1-cm increase in stage corresponds with a 30 percent increase in flow rate. Therefore, relatively small errors in stage measurement due to sensor drift or movement or small waves on the pond may translate to large errors when computing flow rates based on a stage-discharge relationship.

*Figure 7. Water and sediment control basin, Franklin, Vermont*

Monitoring conditions at the WASCoB were often less than ideal. The standpipe has a tendency to freeze up, restricting outflow. This standpipe discharges to a shallow channel with very little slope. This channel gradually filled in with sediment and vegetation during the monitoring period, which created backwater conditions in the standpipe. Several attempts were made to keep the channel clear through hand digging, but the improvements in flow were short-lived. On at least one occasion, in the spring of 2014, the road ditch downstream from the outlet channel flooded due to a blockage and the WASCoB was entirely submerged. During this same event, the WASCoB spillway was eroded approximately 10 cm. Whether due to ice on the WASCoB or in the standpipe or outlet channel, erosion of the spillway, or backwater conditions due to the outlet channel filling in, the relationship between stage and discharge for this structure was less constant than expected.

WASCoB discharge data calculated for 2013 were post-processed by substituting a complex (5-part) rating curve for the preliminary rating taken from the HydroCAD model upon which the WASCoB hydraulic design was based. This refined rating was developed from three sources of information: 1) the HydroCAD model; 2) survey of the WASCoB outlet structures and orifices; and 3) paired pond stage and outlet flow measurements made using an auxiliary area-velocity flowmeter from May 23 - 28, 2013. Stage data were also adjusted in 2013 to account for minor sensor drift. From May 22 through December 15, 2013, a correction of -0.0067 m was applied to all stage readings. This stage correction factor was derived from elevation surveys conducted on three occasions in 2013, to check the accuracy of stage readings made with the pressure transducer relative to the WASCoB outlet structures. The resulting continuous discharge dataset for 2013 reflected both the stage correction and the refined stage-discharge rating.

For 2014, the WAS2 flowmeter was reprogrammed using the refined stage-discharge rating to calculate discharge from measured level. This change was made on March 31, 2014. In early April, 2014, the WASCoB outlet became surcharged by water from the road ditch along Browns Corner Road. When the water receded, we noted significant erosion (~10 cm drop in elevation) of the WASCoB spillway. This erosion temporarily invalidated the refined rating curve developed for the WASCoB outlet. On May 8, 2014, sand bags were installed along the spillway to approximate the former elevation of the spillway crest. Due to the effects of ice on the WASCoB, surcharging of the outlet structures, and erosion of the spillway, computed flow data for the WAS2 station are invalid for the winter and spring months through May 8, 2014.

To minimize the risk of damaging the ISCO 720 pressure transducer installed at the WAS2 station, a 730 bubbler flow module was substituted for the pressure transducer before the pond froze in 2014. The pressure transducer was reinstalled on April 9, 2015 and the measured water level was adjusted based on surveyed elevations. No problems were noted at the WASCoB between April 9 and July 8, 2015 when monitoring was discontinued,

### 4.8. Runoff Sample Analysis

Analysis of all field runoff samples is being conducted by the VT DEC laboratory, currently located at the University of Vermont. All water samples are analyzed in accordance with the standard methods of the VT DEC Laboratory. These methods and relevant data quality objectives, assessment procedures, and reporting limits are described in the laboratory's Quality Assurance Plan, Revision 20, dated January 2012 (VT DEC 2012).

## 4.9. Sediment Sampling and Analysis

Per the QAPP (Version 2.0), sediment samples are collected when the total sediment volume cleared from the flume and approach channel after an event is greater than one liter. Sediment is shoveled from the flume/approach into a 5-gallon polyethylene bucket, incremented with 1-L marks. After recording the collected sediment volume, the sediment is homogenized and a subsample is collected into an 8-ounce (237 mL) plastic jar. Remaining sediment is discarded downstream of the monitoring station. The jar is transferred under chain of custody to the University of Vermont's Agricultural and Environmental Testing Laboratory for bulk density and total phosphorus analysis. The bulk density is multiplied by the measured sediment volume in the flume/approach to estimate the sediment mass and the total phosphorus concentration is multiplied by the sediment mass to estimate the phosphorus mass deposited in the flume/approach channel.

In 2013, significant amounts (>1 L) of sediment were deposited during certain events in flumes at three stations: WAS1 and both Pawlet stations. In 2014, there were no sampled runoff events which deposited significant sediment in the flume and approach. The change from 2013 is largely attributable to the fact that the Pawlet stations were not monitored through the spring and summer of 2014, due to misapplication of the cover crop practice. The Pawlet stations accounted for all but two of the sediment samples collected in 2013.

## 4.10. Data Analysis Methods

All project data are archived in original form (digital downloads, laboratory reports) and organized in databases and Excel spreadsheets. Transcribed data are checked for errors between original sources and files used for reporting and analysis. Data analyses are conducted primarily on $\log_{10}$-transformed data to satisfy the assumptions of parametric statistics. All statistical analyses are conducted using JMP statistical software, version 10 (SAS Institute 2012).

This final report includes results of statistical analyses of calibration period runoff data collected through December 2013. These results were also presented in the Year 1 Annual Report. Recognizing that the treatment period dataset for all sites is sparse and that monitoring is ongoing in 2015, further statistical analyses of the paired watershed data will not be performed until the 2015 monitoring season is over. Analyses of these data and evaluation of conservation practice effectiveness will be presented in a 2016 report to the Lake Champlain Basin Program.

On July 8, 2015, monitoring at the WASCoB site (stations WAS1 and WAS2) was discontinued. These stations have now been decommissioned. Because monitoring of the WASCoB has ended, statistical analyses of the WASCoB data are presented in this final report.

# 5. AGRONOMIC DATA

## 5.1. Soil Characterization

Results of soil physical and chemical analyses of composite soil samples are presented in Table 3 through Table 5.

*Table 3. Selected characteristics of composite soil samples from the study watersheds*

| Site | pH (water) | OM (%) | Sand (%) | Silt (%) | Clay (%) | USDA Texture | Avail. P (mg/kg) | K (mg/kg) | Mg (mg/kg) | Al (mg/kg) | Ca (mg/kg) | Zn (mg/kg) | S (mg/kg) | Mn (mg/kg) | B (mg/kg) | Cu (mg/kg) | Fe (mg/kg) | Na (mg/kg) | CEC (meq per 100g) | Ca (%) | K (%) | Mg (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FER 1 | 6.3 | 3.5 | 8.4 | 52.9 | 38.7 | Silty cl. loam | 2.3 | 119 | 417 | 42 | 1896 | 0.7 | 16 | 13.9 | 0.1 | 0.55 | 11.1 | 63 | 13.3 | 71.5 | 2.3 | 26.2 |
| FER 2 | 6.4 | 3.1 | 10.1 | 57.8 | 32.1 | Silty cl. loam | 5.4 | 125 | 338 | 34 | 1820 | 0.7 | 19 | 14.5 | 0.2 | 0.65 | 10.8 | 65 | 12.2 | 74.4 | 2.6 | 23 |
| FRA 1 Corn | 7 | 4.3 | 28.5 | 52.8 | 18.7 | Silt loam | 10.5 | 98 | 174 | 22 | 2857 | 0.7 | 25 | 14.4 | 0.4 | 0.3 | 4.1 | 33 | 16 | 89.4 | 1.6 | 9.1 |
| FRA 1 Hay | 6.7 | 3.7 | 12.2 | 66.3 | 21.5 | Silt loam | 8.6 | 81 | 200 | 25 | 2287 | 0.5 | 19 | 14.7 | 0.3 | 0.2 | 5 | 23 | 13.3 | 85.9 | 1.6 | 12.5 |
| FRA 2 Corn | 7 | 3.9 | 21.4 | 57.5 | 21.2 | Silt loam | 9.6 | 92 | 165 | 28 | 2450 | 0.5 | 21 | 10.8 | 0.3 | 0.2 | 4.8 | 28 | 13.9 | 88.4 | 1.7 | 9.9 |
| FRA 2 Hay | 6.7 | 3.9 | 13.7 | 65.5 | 20.8 | Silt loam | 10.2 | 92 | 200 | 25 | 2278 | 0.5 | 18 | 12 | 0.25 | 0.25 | 4.8 | 23 | 13.3 | 85.7 | 1.8 | 12.5 |
| PAW 1 | 7.9 | 3.6 | 35.0 | 49.6 | 15.3 | Silt loam | 8.3 | 79 | 112 | 19 | 3540 | 0.5 | 21 | 13.9 | 0.25 | 0.35 | 2.2 | 17 | 18.8 | 94 | 1.1 | 5 |
| PAW 2 | 5.8 | 3.2 | 25.2 | 60.5 | 14.3 | Silt loam | 1.3 | 25 | 55 | 61 | 813 | 0.5 | 19 | 24.5 | 0.05 | 0.25 | 6.5 | 16 | 4.6 | 64.1 | 1 | 7.2 |
| SHE 1 | 7.3 | 4 | 43.9 | 25.5 | 30.7 | Clay loam | 8.4 | 89 | 187 | 12 | 3652 | 0.5 | 16 | 17.4 | 0.45 | 0.2 | 2.5 | 37 | 20 | 91.1 | 1.1 | 7.8 |
| SHE 2 | 7 | 5.1 | 11.9 | 49.7 | 38.3 | Silty cl. loam | 4.3 | 168 | 493 | 17 | 3304 | 0.7 | 20 | 9.6 | 0.35 | 0.2 | 4.7 | 64 | 21.1 | 78.4 | 2 | 19.5 |
| SHO 1 | 6.1 | 4.7 | 7.6 | 26.5 | 66.0 | Clay | 1.4 | 195 | 498 | 59 | 2530 | 0.9 | 12 | 13.7 | 0.25 | 0.3 | 16.6 | 52 | 17.3 | 68.8 | 2.7 | 22.6 |
| SHO 2 | 5.7 | 3.2 | 10.7 | 29.8 | 59.5 | Clay | 1.1 | 148 | 442 | 69 | 2147 | 1 | 9 | 14.6 | 0.15 | 0.35 | 18.4 | 40 | 14.8 | 63 | 2.2 | 21.6 |
| SHO 2-D | 5.8 | 3.5 | 11.5 | 29.0 | 59.5 | Clay | 1.1 | 140 | 442 | 65 | 1960 | 1 | 9 | 15.8 | 0.15 | 0.3 | 17.4 | 36 | 13.8 | 62.2 | 2.3 | 23.4 |
| WAS | 6.9 | 3.1 | 13.8 | 64.4 | 21.8 | Silt loam | 4.7 | 74 | 165 | 36 | 1669 | 0.3 | 14 | 9.3 | 0.15 | 0.2 | 6.4 | 27 | 9.9 | 84.2 | 1.9 | 13.9 |
| WIL 1 | 7.1 | 4.9 | 27.4 | 60.7 | 11.9 | Silt loam | 22.5 | 173 | 107 | 31 | 1959 | 0.9 | 12 | 4.2 | 0.3 | 0.45 | 3.9 | 19 | 11.1 | 88 | 4 | 8 |
| WIL 1-D | 7.2 | 5.1 | 20.8 | 66.6 | 12.6 | Silt loam | 23.4 | 159 | 109 | 33 | 2013 | 1 | 12 | 4.4 | 0.35 | 0.45 | 4.5 | 20 | 11.4 | 88.4 | 3.6 | 8 |
| WIL 2 | 7.3 | 3.6 | 31.3 | 55.9 | 12.8 | Silt loam | 43.5 | 148 | 121 | 15 | 2293 | 1.2 | 11 | 6.1 | 0.4 | 0.5 | 3.9 | 19 | 12.9 | 89.2 | 3 | 7.8 |

*Table 4. Soil nutrient content in study watersheds, USDA ARS analyses*

| Site | Total P (lbs/ac) | Inorganic P (lbs/ac) | Organic P (lbs/ac) | Total N (lbs/ac) | Inorganic N (lbs/ac) | Organic N (lbs/ac) |
|---|---|---|---|---|---|---|
| FER1 | 61.64 | 39.67 | 21.97 | 218.61 | 167.78 | 50.83 |
| FER2 | 118.68 | 95.30 | 23.38 | 221.19 | 159.97 | 61.22 |
| FRA1-corn | 133.17 | 120.90 | 12.27 | 219.21 | 157.92 | 61.29 |
| FRA1-hay | 114.08 | 105.78 | 8.30 | 125.20 | 83.41 | 41.79 |
| FRA2-corn | 135.70 | 123.84 | 11.86 | 194.63 | 142.66 | 51.97 |
| FRA2-hay | 136.16 | 128.17 | 7.99 | 158.94 | 104.35 | 54.59 |
| PAW1 | 68.31 | 59.09 | 9.22 | 189.49 | 149.99 | 39.51 |
| PAW2 | 19.16 | 12.25 | 6.91 | 126.21 | 95.09 | 31.12 |
| SHE1 | 89.70 | 67.04 | 22.66 | 197.66 | 130.33 | 67.32 |
| SHE2 | 74.75 | 47.74 | 27.01 | 223.95 | 157.40 | 66.55 |
| SHO1 | 37.49 | 13.42 | 24.07 | 111.94 | 23.93 | 88.01 |
| SHO1-D | 39.10 | 13.90 | 25.20 | 108.89 | 21.27 | 87.62 |
| SHO2 | 36.80 | 16.16 | 20.64 | 85.89 | 26.58 | 59.40 |
| WAS | 89.01 | 80.99 | 8.02 | 113.41 | 78.59 | 34.82 |
| WIL1 | 239.20 | 220.96 | 18.24 | 188.44 | 139.50 | 48.94 |
| WIL2 | 292.10 | 282.35 | 9.75 | 135.98 | 106.22 | 29.76 |

*Table 5. Soil health indicators in study watersheds, USDA ARS analyses*

| Site | Solvita 1-day CO2-C (ppm) | Organic C (ppm) | Organic N (ppm) | Organic C:N |
|---|---|---|---|---|
| FER1 | 44.20 | 265.98 | 25.42 | 10.47 |
| FER2 | 37.08 | 255.44 | 30.61 | 8.34 |
| FRA1-corn | 39.79 | 287.04 | 30.65 | 9.37 |
| FRA1-hay | 37.08 | 195.91 | 20.90 | 9.38 |
| FRA2-corn | 33.10 | 270.00 | 25.99 | 10.39 |
| FRA2-hay | 33.10 | 241.24 | 27.29 | 8.84 |
| PAW1 | 29.00 | 155.13 | 19.75 | 7.85 |
| PAW2 | 29.00 | 118.23 | 15.56 | 7.60 |
| SHE1 | 44.20 | 317.19 | 33.66 | 9.42 |
| SHE2 | 38.43 | 349.43 | 33.28 | 10.50 |
| SHO1 | 60.93 | 437.15 | 44.01 | 9.93 |
| SHO1-D | 56.75 | 437.16 | 43.81 | 10.80 |
| SHO2 | 49.58 | 276.24 | 29.70 | 9.30 |
| WAS | 31.05 | 153.42 | 17.41 | 8.81 |
| WIL1 | 26.96 | 172.62 | 24.47 | 7.05 |
| WIL2 | 25.93 | 98.71 | 14.88 | 6.63 |

## 5.2. Study Field Practices

Field management activities were recorded for each field/watershed for the 2012, 2013, and 2014 growing seasons, based on direct field observations, images collected using time lapse cameras, and information provided by participating farmers. These data are presented in Table 6 through Table 23.

### 5.2.1. Ferrisburgh site

The FER1 and FER2 study watersheds were in corn production in 2011. In April 2012, the fields were harrowed and seeded for hay production. Table 6 presents the 2012 field management information. No manure or fertilizer was applied in 2012.

*Table 6. Management activities in the Ferrisburgh study watersheds (FER1 and FER2) in 2012*

| Date | Activity |
|---|---|
| 04/12/12 | Fields harrowed. |
| 04/16/12 | Fields seeded in red clover with a cover of peas/oats. |
| 07/04/12 | First cut. Estimated yield: 1.5 T/acre. |
| 09/01/12 | Second cut. Estimated yield: 1 T/acre. |
| 09/??/12 | FER2 was reseeded with red clover using an interseeder. |

Table 7 summarizes field management activities at the Ferrisburgh site in 2013. The farmer at the Ferrisburgh site did not apply any manure following the first three hay cuts in 2013. In October, manure was applied to FER2 but not to FER1. Several calls were placed to the farmer to ascertain his ability to correct this “unpaired” manure application. The farmer was unable to apply manure again until early December, at which time manure was applied to both fields, although less (4 loads) was apparently applied to FER2.

*Table 7. Management activities in the Ferrisburgh study watersheds (FER1 and FER2) in 2013*

| Date | Activity |
|---|---|
| 04/28/13 | The entire FER1 field was interseeded. The FER2 field was interseeded in certain spots (“touched up”). Seeding rates and equipment are unknown. |
| 06/18/13 | First cut of hay at FER1. Yield was 2.8 tons/acre. |
| 06/19/13 | First cut of hay at FER2. Yield was 2.8 tons/acre. |
| 07/24/13 | Second cut of hay at FER1 and FER2. Yields were 2.7 tons/acre and 2.8 tons/acre, respectively. |
| 08/24/13 | Third cut of hay at FER1. Yield was 3 tons/acre. |
| 08/25/13 | Third cut of hay at FER2. Yield was 3 tons/acre. |
| 09/19/13 | Fourth cut hay at FER1 and FER2. Yields on both fields were 3 tons/acre. |
| 10/11/13 | Wood ash was broadcast at a rate of 2 tons/acre on both fields. |
| 10/17/13, 10/18/13 | On FER2, manure was broadcast at 5000 gal./acre using a traveling reel and gun. Manure was from the home farm pit and was not agitated prior to spreading or incorporated afterwards. |
| 12/05/13 | On FER1, manure was broadcast at 4000 gal./acre using a tank spreader. Manure was from the home farm pit and was agitated for ½-day prior to spreading. It was not incorporated. |
| 12/06/13 | On FER2, manure was broadcast at 4000 gal./acre using a tank spreader. A portion of the field was not spread due to wetness (only four loads were applied). Manure was from the home farm pit and was agitated for ½-day prior to spreading. It was not incorporated. |

Table 8 summarizes field management activities at the Ferrisburgh site in 2014, based only on field observations and interpretation of time lapse camera imagery. The first aeration of the treatment watershed

(FER2) occurred on June 12, 2014 following the first hay cut. Manure was applied on both watersheds after FER2 was aerated.

*Table 8. Management activities in the Ferrisburgh study watersheds (FER1 and FER2) in 2014*

| Date | Activity |
|---|---|
| 6/6/14 – 6/8/14 | First hay cut and collected on FER1. |
| 6/9/14 – 6/10/14 | First hay cut and collected on FER2. |
| 6/12/14 | Field aerated and manure spread on FER2. Manure also spread on FER1. |
| 7/9/14 – 7/10/14 | Second hay cut and collected on FER1 and FER2. |
| 8/17/14 – 8/18/14 | Third hay cut and collected on FER2. |
| 8/18/14 – 8/19/14 | Third hay cut and collected on FER1. |
| 10/11/14 – 10/14/14 | Fourth hay cut and collected on FER2. |
| 10/12/14 – 10/15/14 | Fourth hay cut and collected on FER1. |
| 10/20/14 | Wood ash, bedding, or similar material applied on FER1 and FER2. |

There was no aeration or manure application following the first hay cut in 2015, contrary to the agreed upon management. Following second cut, manure was spread on both watersheds in the July 23-28 timeframe, following aeration of FER2.

### 5.2.2. Franklin site

The Franklin study watersheds are adjoining drainage areas within a large strip cropped field. Corn and hay are planted in alternating strips on contour. In 2012 the strips were switched; grass was planted in the corn strips and corn was planted into the hay strips after first cut. Management activities in 2012 are listed in Table 9.

*Table 9. Management activities in the Franklin study watersheds (FRA1 and FRA2) in 2012*

| Date | Activity |
|---|---|
| 04/05/12 | Spring nitrogen (38-0-0) was broadcast on grass strips (that were later planted to corn, on 06/01/12) at 100 lbs/acres. |
| 05/28/12 | Spring manure application, via low nozzle using a Houle 6300 gallon spreader at the following rates: #2-6 loads, #17-7 loads, #3-7 loads, #4-7 loads. Manure was taken from Pit 1 and well-agitated prior to spreading. Hay strips were aerated prior to manure application. Manure was tested and found to be 6.7% dry matter. |
| 06/01/12 | Corn was zone-till planted into the hay strips, at a depth of 2” in rows 30” on center and at a rate of 33,000/acre. Fields #2, #3, and #4 were planted with Mycogen TMF2Q493; Field #17 was planted with TMF2Q493 and Pioneer P0125HRw/1250. |
| 06/01/12 | Corn starter (7-21-7 Mg 1) was applied via the zone till planter at 55 lbs/acre; some fields did not get any corn starter due to malfunction of zone-till planter/operator error. |
| 06/07/12 | Pre-emerge pesticide application on corn strips; Lumax 1.5 qts/acre; Showdown 1 qt/acre; and Rifle 8 oz/acre. |
| 06/18/12 | Post-emerge pesticide application on corn strips for army worms; Tombstone 2.8 oz/acre. |
| 07/04/12 | Corn topdress (30-0-20) was broadcast at 225 lbs/acre. |
| 07/09/12 | Herbicide application for grass control on corn strips; Glystar plus 4 oz/acre. |
| 10/07/12 | Corn chopped for silage; yield ~15 T/acre; no residue. |
| 10/26/12 | Fall manure application, via low nozzle using a Houle 6300 gallon spreader at the following rates: #2—8 loads; #17—10 loads; #3—9 loads; #4—12 loads. Manure was taken from Pit 1 and well-agitated prior to spreading. Manure was tested and found to be 6.7% dry matter. Manure was immediately incorporate via chisel plow. |

Table 10 summarizes field management activities at the Franklin site in 2013. The first application of the conservation practice (manure injection/reduced tillage) during fall 2013 was successful. Figure 8, from the time lapse camera, shows the manure injector in operation.

*Table 10. Management activities in the Franklin study watersheds (FRA1 and FRA2) in 2013*

| Date | Activity |
|---|---|
| 05/06/13 | Spring tillage using disc harrows and grubbers. |
| 05/08/13 | Corn was planted into strips in rows 30-inches on center at a rate of 33,000 seeds per acre. The corn variety used was Mycogen TMF2L538. |
| 05/08/13 | Corn starter fertilizer (19-19-19) applied via subsurface band at a rate of 150 lbs/acre. |
| 05/09/13 | Pre-emergent pesticide (Lumax EZ 2.7 qts/acre) surface sprayed on corn strips. |
| 06/03/13 | Hay strips cut and harvested. |
| 07/05/13 | Corn fertilizer (46-0-0) was top dressed at a rate of 369 lbs/acre. |
| 09/17/13 | On FRA1, winter rye cover crop spread via helicopter at a rate of 120 lbs/acre. Stand quality approximately 30%. |
| 10/02/13 | Corn chopped for silage. Estimated yield of 23 tons/acre. Percent residue unknown. |
| 10/09/13 | Hay strips cut and harvested. |
| 10/11/13 | On FRA1, manure injected using a Jamesway 4500 gallon spreader at a rate of 6,729 gal./acre. Manure was taken from Pit 1 and well-agitated prior to spreading. Manure was tested and found to contain 4.8% dry matter. |
| 10/10/13, 10/11/13 | On FRA2, manure applied via low nozzle using a Houle 6300 gallon spreader at a rate of 5,040 gal./acre. Manure was taken from Pit 1 and well-agitated prior to spreading. Manure was tested and found to contain 4.8% dry matter. Manure was immediately incorporated with an International chisel plow. |
| 10/15/13 | Manure surface applied on hay strips. |


*Figure 8. Manure injection at FRA1 on October 11, 2013*

Manure injection/reduced tillage on FRA1 and chisel plowing of FRA2 produced very different field surface conditions. Figure 10 and Figure 9 illustrate these different surface conditions in the fall of 2013. Chisel plowing at FRA2 created furrows perpendicular to the slope and voids between soil clods. These furrows and voids provided substantial depression storage within the FRA2 watershed, which was largely absent on the smoother surface of the FRA1 watershed.

*Figure 9. Surface condition of FRA2 watershed following manure application and chisel plowing*

*Figure 10. Surface condition of FRA1 field area following manure injection*

Figure 11 shows the approximate boundary between the FRA1 (foreground) and FRA2 (background) watersheds in fall of 2013. Note the apparent soil sealing and wheel tracks present in the FRA1 watershed. We suspect the differences in soil surface condition increased the runoff potential of the FRA1 watershed relative to the FRA2 watershed during fall 2013.

Table 11 summarizes field management activities at the Franklin site in 2014.

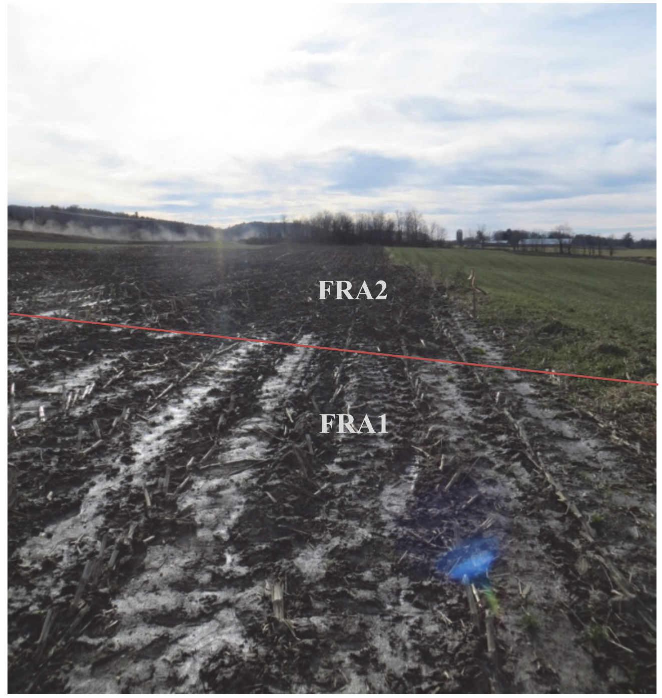



*Figure 11. Boundary between FRA1 and FRA2 watersheds*

*Table 11. Management activities in the Franklin study watersheds (FRA1 and FRA2) in 2014*

| Date | Activity |
|---|---|
| 5/18/14 | On FRA1 corn strips vertical tillage was applied using the unit available through UVM Extension; the corn strips on FRA2 were chisel plowed. |
| 5/20/14 | On both FRA1 and FRA2, corn was planted into the strips in rows 30-inches on center at a rate of 33,000 seeds per acre. The corn variety used was Mycogen TMF2L538RZCRL. |
| 5/20/14 | On both FRA1 and FRA2, corn fertilizer (9-24-16 with 1.8 Mag) was applied in a subsurface band at 200 lb./acre. |
| 5/21/14 | Pesticides (Lumax EZ at 2.5 qt./acre and Cropsmart at 0.75 qt./acre) were applied on corn strips as a pre-emergent, surface spray. |
| 6/01/14 | Hay strips were cut and harvested. |
| 7/05/14 | Corn fertilizer (39.75-0-0) was applied as a top dress at a rate of 286 lb./acre. |
| 7/05/14 | The FRA1 field was interseeded with summer rye at a rate of 30 lb./acre. |
| 9/30/14 | Corn was chopped for silage. Estimated yield of 25 tons/acre. Approximately 5% residue cover left on field. |
| 10/10/14 | Manure was surface spread on hay strips on both FRA1 and FRA2. |
| 10/10/14 | The FRA2 field was subsoiled using Brillion subsoilers. |
| 10/11/14 | On FRA1, manure was injected using a Jamesway 4600 manure injector at a rate of 9,000 gal./acre. Manure was taken from the Fiske pit and was well-agitated prior to injection. Manure was not tested for percent dry matter. |
| 10/12/14 | On FRA2, manure was applied via a low nozzle spreader using a Houle 6300 gallon spreader at a rate of 7890 gal./acre. Manure was taken from the Fiske pit and was well-agitated prior to spreading. Manure was not tested for percent dry matter. Manure was incorporated with a subsoiler. |
| 10/14/14 | Due to poor establishment of the interseeded summer rye, winter wheat was drilled on FRA1 only. |

Figure 12. Surface condition of FRA1 field area in the spring of 2014

The differing field surface conditions present in the fall of 2013 after manure injection/reduced tillage on FRA1 and chisel plowing of FRA2 persisted in the spring of 2014. Figure 12 and Figure 13 illustrate the differing surface conditions present into the spring of 2014. Following vertical tillage on FRA1 and conventional tillage on FRA2 on May 18, 2014, the surface condition of the fields appeared more comparable.

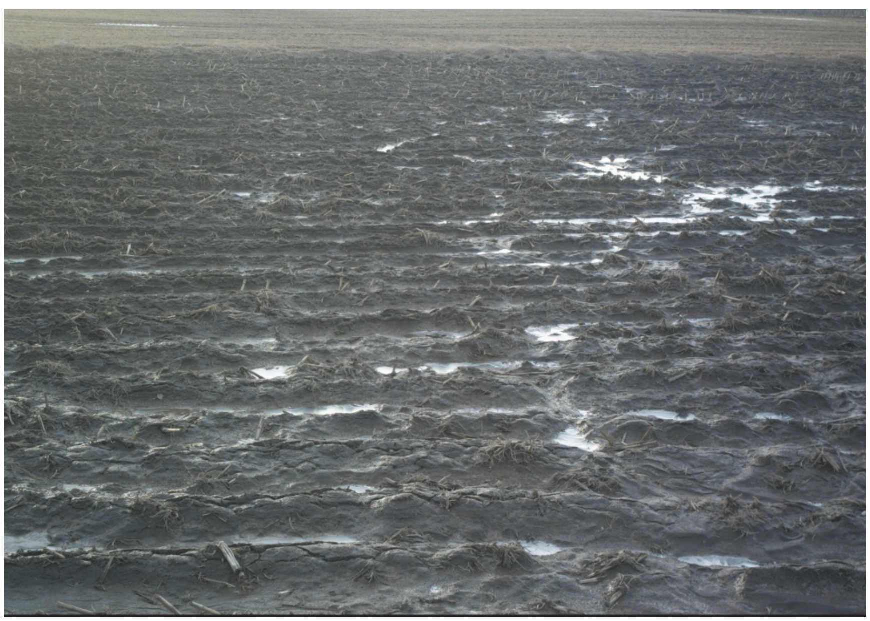


Figure 13. Surface condition of FRA2 field area in the spring of 2014


*Figure 14. Manure injection at FRA1 on October 11, 2014*

The second application of the conservation practice (manure injection/reduced tillage) during fall 2014 was successful. Figure 14 from the time lapse camera shows the manure injector in operation.

### 5.2.3. Pawlet site

The Pawlet study watersheds have been in continuous corn production of many years. Management activities in the Pawlet study watersheds in 2012 are listed Table 12. No fall manure application or tillage was performed.

*Table 12. Management activities in the Pawlet study watersheds (PAW1 and PAW2) in 2012*

| Date | Activity |
|---|---|
| 5/12/12 | Spring manure application, via high nozzle, at a rate of 4,000 gallons per acre. Manure was incorporated via chisel plow. |
| 5/29/12 | Corn was planted in rows 30" on center at a rate of 32,000/acre; seed variety was 35A34. |
| | Fertilizer (30-10-20) was applied, 200 lbs/acre. |
| 9/27/12 | All corn chopped (based on time-lapse camera photos); yield 18-22 T/acre; no residue. |

Management activities in the Pawlet study watersheds in 2013 are listed Table 13. Manure was applied to both fields in early May (Figure 15) and incorporated by chisel plow a day later. No manure was applied in the fall. The participating farmer commented that in 2013 both the corn yield and the soil erosion on the study fields were the "worst he has ever seen".


*Figure 15. Manure application on the PAW2 field area, May 6, 2013*

*Table 13. Management activities in the Pawlet study watersheds (PAW1 and PAW2) in 2013*

| Date | Activity |
|---|---|
| 5/2/13 | On PAW1, manure applied via a high nozzle tanker at a rate of 4500 gallons/ acre. Manure was taken from a well agitated pit. The manure contained 7% dry matter. |
| 5/3/13 | Manure incorporated on PAW1 by chisel plow; spring tillage by harrow connected to a Case IH 8930 tractor. |
| 5/6/13 | On PAW2, manure applied via a high nozzle tanker at a rate of 4500 gallons/ acre. Manure was taken from a well agitated pit. The manure contained 7% dry matter. |
| 5/7/13 | Manure incorporated on PAW2 by chisel plow; spring tillage by harrow connected to a Case IH 8930 tractor. |
| 5/8/13 | Corn was planted in rows 30-inches on center at a rate of 32,000 seeds per acre; seed variety was 95-day Pioneer. Fertilizer (27-9-18) was applied through the planter at 225 lbs/acre. |
| 5/9/13 | Herbicide applied by spraying at a rate of 3 quarts/acre. Herbicide used was Lexar-EZ (EPA# 100-1414). |
| 9/27/13 | PAW2 corn harvested for silage; yield 7 tons/acre; farmer reported 60% weed cover. |
| 10/1/13 | PAW1 corn harvested for silage; yield 7 tons/acre; farmer reported 60% weed cover. |
| 10/15/13 | Winter wheat seed broadcast for cover crop spread at 100 lbs/acre on both fields; stand quality was poor. |

Several large runoff events in the spring of 2013 caused substantial soil erosion of the PAW1 field. Figure 16 shows rill erosion upslope of the PAW1 station on June 5, 2013. A thick layer of sediment was deposited both immediately upslope of the PAW1 flume (Figure 17) and at the lower end of the field, smothering young corn plants.

Figure 16. Erosion and sediment deposition upslope of the PAW1 station, June 5, 2013

In November 2013, the producer at the Pawlet site communicated that he had broadcast winter wheat seed as a cover crop on October 15th to both PAW1 and PAW2; this action represented a major departure from the agreed-on plan to apply cover crop to PAW1 (the treatment watershed) only. The cover crop was seeded at the very end of the date range that cover cropping is considered viable in Vermont. Based on cover crop density measurements made in November 2013 and April 2014 (see Section 5.3), the catch was very poor (0-2% cover).

Figure 17. Sediment deposition immediately upslope of the PAW1 station, June 5, 2013

Because both watersheds were mistakenly seeded and because there was essentially no cover crop establishment on either watershed, paired runoff events occurring between mid-October and December 2013 were included with the calibration period data for purposes of statistical analysis.

Various remedies were considered to establish the intended field treatment in the spring of 2014. We considered reseeding the PAW1 watershed and/or applying herbicide to the PAW2 watershed early in the spring, but the lateness of the spring precluded these measures. Due to the misapplication of the treatment, monitoring of the Pawlet stations was suspended for the spring and summer of 2014. This decision was made because project leaders concluded that additional pre-treatment monitoring would be unlikely to improve the already strong statistical relationships between the paired watersheds.

Table 14 presents a summary of agronomic data at the Pawlet site in 2014. Manure was spread and corn was planted on the PAW1 field in mid-May and on the PAW2 field in late June (Figure 18). Wetness delayed planting of the PAW2 field. In the interim, winter wheat mistakenly seeded on PAW2 after corn harvest in

2013 continued to grow in areas where it had successfully established. The participating farmer reported a fair yield from PAW1 and a poor yield from PAW2 in 2014. No manure was applied to either field in the fall.

*Table 14. Management activities in the Pawlet study watersheds (PAW1 and PAW2) in 2014*

| Date | Activity |
|---|---|
| 5/13/14 | The PAW1 field was tilled to a depth of 4 inches with a 20-foot disc harrow. |
| 5/13/14 | On PAW1, manure was spread with a high nozzle tank spreader at a rate of 4,500 gal./acre. Manure was taken from the home farm pit and was well-agitated prior to spreading. It was incorporated with a plow and harrow. Manure was not tested for percent dry matter. |
| 5/16/14 | On PAW1, corn was planted in rows 30-inches on center at a rate of 32,000 seeds per acre. The corn variety used was 105-day silage corn. |
| 5/16/14 | On PAW1, corn fertilizer (27.2-9.1-18.1) was surface applied next to the row at a rate of 220.9 lb./acre. |
| 5/17/14 | On PAW1, pesticide (Lexar at 3 qt./acre) was applied as a surface spray. |
| 6/22/14 | The PAW2 field was tilled to a depth of 4 inches with a 20-foot disc harrow. |
| 6/22/14 | On PAW2, manure was spread with a high nozzle tank spreader at a rate of 4,500 gal./acre. Manure was taken from the home farm pit and was well-agitated prior to spreading. It was incorporated with a plow and harrow. Manure was not tested for percent dry matter. |
| 6/23/14 | On PAW2, corn was planted in rows 30-inches on center at a rate of 32,000 seeds per acre. The corn variety used was 105 day silage corn. |
| 6/23/14 | On PAW2, corn fertilizer (27.2-9.1-18.1) was surface applied next to the row at a rate of 220.9 lb./acre. |
| 6/23/14 | On PAW2, pesticide (Lexar 3 at qt./acre) was applied as a surface spray. |
| 9/20/14 | On PAW1, corn was chopped for silage. The estimated yield was 18.5 tons/acre. Approximately 18-inch stubble was left on field. |
| 9/23/14 | On PAW1 only, winter rye seed was top dressed. |
| 9/24/14 | On PAW2, corn was chopped for silage. The estimated yield was 4 tons/acre. Approximately 16-inch stubble was left on field. |


*Figure 18. Corn being planted in the PAW2 field, June 23, 2014*

Following corn harvest in 2014, winter rye seed was broadcast on the PAW1 watershed only on September 23, 2014. Cover crop surveys in October and November indicated the establishment was fair (9-10 % cover). Treatment phase monitoring therefore commenced in the fall of 2014 after establishment of the cover crop on PAW1.

### 5.2.4. Shelburne site

The SHE1 and SHE2 fields have been in hay production for many years. The SHE2 field (also known as the "Lodge" field) consists of old sod, primarily orchard grass, fescue, canary grass, and clover. No crop was harvested from SHE2 in 2011 due to wet conditions. The southern portion of the SHE1 field (also known as the "Duck Pond" field) consists of old sod, primarily orchard grass, brome grass, fescue, canary grass, and clover, whereas the northern portion of the field was seeded with timothy and clover in the spring of 2009.

Management activities in the Shelburne study watersheds in 2012 are listed in Table 15.

*Table 15. Management activities in the Shelburne study watersheds (SHE1 and SHE2) in 2012*

| Date | Activity |
|---|---|
| 6/5/12 | First hay cut on SHE2. Baled 6/11 (56 round bales @ 700#). Total yield 4215 lbs hay/acre, 4004 lbs dm/acre. |
| 6/9/12 | First hay cut on SHE1. Baled 6/12 (580 small square bales @ 35#, 75 round bales @ 700#. Remainder was rained on, not baled until 6/16 (49 round bales @ 700#). Total yield 4377 lbs hay/acre, 3939 lbs dm/acre. |
| 7/19/12 | Second hay cut on SHE2. Baled 7/20 (14 wrapped bales, 1350# @ 47% dm). Total yield 2032 lbs silage/acre, 955 lbs dm/acre. |
| 7/24/12 | Second hay cut on SHE1. Baled on 7/25 (53 wrapped bales, 1350# @ 47% dm). Total yield 2908 lbs silage/acre, 1367 lbs dm/acre. |
| 9/3-4/12 | Manure application on SHE1 with 7,300 gallon Houle manure tankers (by John Whitney Custom Farm Work) at a rate of 5,561 gallons/acre. Manure analysis report available. |
| 9/4/12 | Manure application on SHE2 with 7,300 gallon Houle manure tankers (by John Whitney Custom Farm Work) at a rate of 6,193 gallons/acre. Manure analysis report available. |
| 12/4/12 | Sheep pen installed at SHE2. |
| 12/7-14/12 | 95 sheep were grazed at SHE2 during this time period, rotated between 3-5 paddocks. Sheep were moved out of SHE2 the morning of 12/14. |

The Shelburne study fields remained wet for much of the spring and summer of 2013, which limited opportunities to cut hay and spread manure. Two hay cuts were made in 2013 and each field received one highly diluted (0.6 % dry matter) manure application. Agronomic data for the Shelburne study fields in 2013 are presented in Table 16.

*Table 16. Management activities in the Shelburne study watersheds (SHE1 and SHE2) in 2013*

| Date | Activity |
|---|---|
| 7/13/13 | First hay cut at both SHE1 and SHE2. Baled 7/16/13. SHE1 yield was 2.12 ton dry matter/acre. SHE2 yield was 2.45 ton dry matter/acre. |
| 8/2/13 | Liquid manure applied with Houle 7300 gallon tankers (by John Whitney Custom Farm Work) at a rate of 7300 gallons/acre. Manure was from a poorly agitated and very wet pit. Manure was composed of 0.6% dry matter. Manure was not incorporated. |
| 9/3/13 | Second hay cut at SHE1. Baled on 9/6/13. Yield was 0.74 ton dry matter/acre. |
| 9/4/13 | Second hay cut at SHE2. Baled on 9/6/13. Yield was 0.64 ton dry matter/acre. |

Table 17 summarizes field management activities at the Shelburne site in 2014. The first and only aeration of the treatment watershed (SHE1) in 2014 occurred on June 10, 2014 following the first hay cut. Manure was applied on both watersheds after SHE1 was aerated. No aeration was performed prior to the second manure application, October 21, 2014. Manure from different sources was applied to the study watersheds on both application dates. For the first application, spreading rates were higher for SHE2 than SHE1 to compensate for the more dilute manure applied.

*Table 17. Management activities in the Shelburne study watersheds (SHE1 and SHE2) in 2014*

| Date | Activity |
|---|---|
| 6/8/14 | First hay cut at both SHE1 and SHE2. Hay was baled in round bales. SHE1 yield was 2,380 lb. dry matter/acre. SHE2 yield was 2,310 lb. dry matter/acre. |
| 6/10/14 | The SHE1 field was aerated and manure applied to both SHE1 and SHE2. 3,456 gallons/acre was applied on SHE1 and 6,400 gallons/acre was applied on SHE2. The manure applied on SHE1 had an estimated dry matter content of 12.9% and P content of 2.4 lb./wet ton (as $P_2O_5$). The first 21,600 gallons (38% of the manure volume) applied on SHE2 was from the same source, with an estimated dry matter content of 12.9% and P content of 2.4 lb./wet ton (as $P_2O_5$) and the remaining 36,000 gallons (62% of the manure volume) was from a different, more diluted source, with an estimated dry matter content of 1.8% and P content of 0.5 lb./wet ton (as $P_2O_5$). |
| 7/17/14 | Second hay cut at SHE1 and SHE2. Hay was baled in round bales. SHE1 yield was 1,254 lb. dry matter/acre. SHE2 yield was 1,804 lb. dry matter/acre. |
| 8/27/14 | Third cut at SHE1. Hay was baled in round bales. SHE1 yield was 644 lb. dry matter/acre. |
| 9/4/14 | Third cut at SHE2. Hay was baled in round bales. SHE2 yield was 1,928 lb. dry matter/acre. |
| 10/21/14 | Second manure application to SHE1 and SHE2. No aeration prior to manure application because the SHE1 field was too soft. 4,320 gallons/acre with an estimated dry matter content of 1.8% and P content of 0.5 lb./wet ton (as $P_2O_5$) was applied to SHE1. 4,800 gallons/acre with an estimated dry matter content of 4.9% and P content of 1.3 lb./wet ton (as $P_2O_5$) was applied to SHE2. |

Due to wet field conditions, no aeration or manure application occurred following the first hay cut in 2015, contrary to the agreed upon management. Following second cut, the SHE1 field was aerated on July 27-28, 2015. Manure was spread on SHE1 on July 29 and on SHE2 on July 30.

### 5.2.5. Shoreham site

The Shoreham site was historically an orchard. The SHO2 study field was seeded for hay production in 2006 and the SHO1 field was seeded in 2009. Both fields consist of the following plant species (in decreasing order): alfalfa, reed canary grass, fescue, and timothy. Field management activities in 2012 are summarized in Table 18

*Table 18. Management activities in the Shoreham study watersheds (SHO1 and SHO2) in 2012*

| Date | Activity |
|---|---|
| Late March 2012 | Coated urea fertilizer broadcast at a rate of 150 lb/acre. |
| 5/18/12 | First hay cut. Loaded 5/19/12. Estimated yield 3 tons/acre. |
| 7/2/12 | Manure application with 4300 gallon Houle manure tank at a rate of 5,000 gallons/acre. Manure source was Home pit #1, pit was agitated very well. Manure was thick from lack of rain. |
| 7/4/12 | Second hay cut. Loaded 7/6/12. Estimated yield 20 small square bales/acre. |
| 8/21/12 | Third hay cut. Loaded 8/22/12. Estimated yield 2 tons/acre. |
| 11/20/12 | Fourth hay cut. Loaded 11/21/12. Estimated yield 1.5 tons/acre. |

In 2013, there were four hay cuts and two manure applications to the Shoreham study fields (Table 19).

*Table 19. Management activities in the Shoreham study watersheds (SHO1 and SHO2) in 2013*

| Date | Activity |
|---|---|
| 4/15/13 | Dry fertilizer broadcasted on both SHO1 and SHO2 at a rate of 150 lbs/acre (46-0-0 urea with coating). |
| 5/18/13 | First hay cut on both SHO1 and SHO2. Loaded 5/20/13. Estimated yield of 3.5 ton/acre as fed. |
| 7/12/13 | Second hay cut on both SHO1 and SHO2. Loaded 7/13/13. Estimated yield of 3 ton/acre as fed. |
| 7/20/13 | Manure applied on both SHO1 and SHO2 with a Peterbilt towing a Diller 4,500 gallon tank at a rate of 4,500 gallons/acre. Manure sourced from Home Pit 1, which was very well agitated prior to application. Manure was not incorporated. |
| 8/16/13 | Third hay cut on both SHO1 and SHO2. Loaded on 8/17/13. Estimated yield of 1.5 ton/acre as fed. |
| 9/29/13 | Fourth hay cut on both SHO1 and SHO2. Loaded on the same day. Estimated yield of 1 ton/acre as fed. |
| 10/14/13 | Second manure application on both SHO1 and SHO2 using a Case IH 7250 tractor towing a Houle 4300 gallon tank and a Case IH MX220 tractor towing a 4300 gallon Badger tank. Rate applied was 4300 gallons/acre. Manure sourced from Home Pit 1, which was well agitated prior to application. The manure dry matter content was unknown, but was estimated to be high. |

In mid-July 2013, the SHO2 watershed was accidentally aerated, due to outdated information the participating farmer received from USDA-NRCS. Stone staff visited the site with NRCS on July 29, 2013 to view the impact the aeration had on field conditions. Figure 19 shows slots made by the aerator in the SHO2 watershed. Although there was evidence of aeration in several areas in the SHO2 watershed, it appeared that the aerator may not have been set properly for the soil conditions. The pattern of slots was inconsistent and in most areas could not be discerned at all. Further, soil cracking throughout both study watersheds appeared more

*Figure 19. Slots made by aerator, SHO2 watershed, July 29, 2013*

*Figure 20. Soil cracks, SHO2 watershed, July 29, 2013*

significant than the partial aeration of SHO2 in terms of opening up the soil (Figure 20). Between this aeration event and January 31, 2014, there were no paired runoff events at the Shoreham site (with the exception of small events that could not be accurately measured because ice-affected flow measurements). Given the minimal degree of soil aeration achieved at SHO2 and considering the passage of time, project leaders expect that there is little or no lingering effect of this misapplied aeration.

In 2014, there were four hay cuts and three manure applications on the Shoreham study fields (Table 20 and Figure 21). The participating farmer commented that the summer of 2014 was particularly dry in Shoreham. In late-October 2014, the SHO1 watershed was aerated prior to manure application. The SHO2 watershed was not aerated before manure application. Calibration phase monitoring continued until the aeration of SHO1 on October 29, 2014, although few runoff events occurred. The treatment phase commenced with the aeration of the SHO1 study watershed.

*Table 20. Management activities in the Shoreham study watersheds (SHO1 and SHO2) in 2014*

| Date | Activity |
|---|---|
| 5/29/14 | First hay cut on both SHO1 and SHO2. The estimated yield was 3.5 ton/acre. |
| 6/04/14 | Dry fertilizer (46-0-0 urea) broadcast on both SHO1 and SHO2 at a rate of 150 lb./acre. |
| 6/05/14 | Manure applied to both SHO1 and SHO2 with a tank spreader at a rate of 5000 gal./acre. Manure was sourced from the home farm pit and was very well agitated prior to application. The farmer noted that the manure pit was dry. |
| 7/05/14 | Second hay cut on both SHO1 and SHO2. The estimated yield was 2 ton/acre. |
| 7/08/14 | Second manure application on both SHO1 and SHO2 with a tank spreader at a rate of 5000 gal./acre. Manure was sourced from the home farm pit and was very well agitated prior to application. |
| 8/11/14 | Third hay cut on both SHO1 and SHO2. The estimated yield was 2 ton/acre. |
| 8/12/14 | Second application of dry fertilizer (46-0-0 urea) broadcast on both SHO1 and SHO2 at a rate of 150 lb./acre. |
| 9/26/14 | Fourth hay cut on both SHO1 and SHO2. The estimated yield was 1 ton/acre. |
| 10/29/14 | Field aeration performed on SHO1. |
| 10/30/14 | Third manure application on both SHO1 and SHO2 using a tank spreader. |


*Figure 21. SHO2 watershed during manure application.*

Due to several complications, no aeration or manure application occurred following the first hay cut in 2015, contrary to the agreed upon management. Following second cut, the SHO1 field was aerated and manure was spread on both study watersheds.

### 5.2.6. Williston site

The Williston study watersheds are adjacent to one another in a field with very low topographic relief (<1 % slope). Most of the area in the WIL1 and WIL2 watersheds was in corn or pumpkin production in 2011. However, certain areas previously in grass were plowed and planted in corn in 2012 in preparation for the study. Management activities in the study watersheds in 2012 are summarized in Table 21.

*Table 21. Management activities in the Williston study watersheds (WIL1 and WIL2) in 2012*

| Date | Activity |
|---|---|
| 4/29/12 | Manure application, surface spread with Knight Hy-Push at a rate of 15 tons/acre. Manure source was farm's main pit, pit was not agitated, and there was substantial water in the pit. Manure was incorporated with disc chisel plow on 5/1/12. |
| 5/24/12 | Tillage with Sunflower finishing harrow. |
| 5/26/12 | Planted Syngenta N53-w3 corn seed at a rate of 34,000 seeds/acre, 30-in. row width. |
| 5/30/12 | Spray application of Lumax pesticide (EPA# 100-1152) at 2.5 oz/acre. Spray application of Atrazine 90DF (EPA# 9779-253) at 0.5 lb/acre. |
| 9/8/12 | Winter rye cover crop planted, helicopter seeding at 100 lb/acre. |
| 11/9/12 | Corn harvest with Snapper head-on chopper. Estimated yield 6 tons/acre. 95% residue left on field. |
| 12/8/12 | Manure application, surface spread with Knight Hy-Push at a rate of 15 tons/acre. Manure source was farm's main pit, pit was not agitated, and there was no substantial water in the pit. Manure was not incorporated. |

In 2013, manure was surface applied to WIL1 and WIL2 in early May, followed by tillage with a finishing harrow, and planting corn (Table 22). A winter rye cover crop was aerially seeded into the standing corn on both watersheds on September 1, 2013. This is a standard practice on this field. The corn was chopped on October 9. 2013. After corn harvest, manure was surface applied on WIL2 and injected on WIL1. The difference in manure application method is apparent in Figure 22, taken by the time-lapse camera on the day of application, November 10, 2013. This manure application marked the beginning of treatment period monitoring.

*Table 22. Management activities in the Williston study watersheds (WIL1 and WIL2) in 2013*

| Date | Activity |
|---|---|
| 5/713 | Manure was surface applied to both WIL1 and WIL2 with a Jamesway low nozzle spreader. Each watershed received 4.5 loads with a 9,000 gallon tanker. Manure was sourced from a main pit and was moderately agitated before application. Substantial water was present in the main pit. |
| 5/9/13 | Tillage with Sunflower finishing harrow to a depth of 4-5 inches. |
| 5/16/13 | Planted Mycogen F2F569 corn seed in rows 30-inches on center at a rate of 34,000 seeds/acre. |
| 5/20/13 | Spray application of Lumax pesticide (EPA# 100-1152) at 2.5 oz./acre and Atrazine 90DF (EPA# 9779-253) at 0.5 lb./acre. |
| 9/1/13 | WIL1 and WIL2 seeded with a winter rye cover crop by helicopter at 100 lbs/acre. The stand quality looked very light after corn harvest. |
| 10/9/13 | Corn harvested with whole plant corn chopper. Estimated yield of 16 tons/acre. 5% residue cover was left on field. |
| 11/10/13 | Manure surface applied to WIL2 with a Jamesway low nozzle spreader. Manure was injected on WIL1. Each watershed received 4.5 loads with a 9,000 gallon tanker. Manure was sourced from a main pit and was moderately agitated before application. Substantial water was present in the main pit. |


*Figure 22. WIL2 watershed (left of flag) and WIL1 watershed (right of flag) after manure application*

On May 7, 2014, manure was injected on WIL1 (treatment watershed) and surface applied on WIL2 (control watershed), followed by chisel plowing of both watersheds (Table 23). Chisel plowing of both watersheds was contrary to the intended reduced tillage practice for WIL1. The producer notified Stone immediately of this error. As a result of this accidental plowing, no treatment phase runoff data could be obtained between May 7, 2014 and November 4, 2014. The experimental treatment was reestablished on November 4, 2014 following corn harvest when manure was injected on WIL1 and was surface applied and incorporated with a chisel plow on WIL2. The difference in manure application method is apparent in Figure 23, taken by the time-lapse camera the day following application. As it happened, there were no paired runoff events recorded at the Williston stations between May 7 and December 25, 2014.

*Table 23. Management activities in the Williston study watersheds (WIL1 and WIL2) in 2014*

| Date | Activity |
|---|---|
| 5/7/14 | On WIL1, five loads of manure were injected with a Jamesway 9,000 gallon spreader. On WIL2, four loads of manure were surface applied using a Jamesway 9,000 gallon spreader with low nozzle. Manure applied in both watersheds was sourced from the main pit and was agitated well. Immediately following manure application, both watersheds were chisel plowed, contrary to the intended reduced tillage practice on WIL1. |
| 5/30/14 | The study fields were tilled with a Sunflower finishing harrow 4 to 5 inches deep. |
| 6/1/14 | In both watersheds, corn (Mycogen F499) was planted in rows 30-inches on center at a rate of 36,000 seeds per acre. |
| 7/1/14 | Pesticide (Round-Up, EPA 524-308) was sprayed in both study watersheds. |
| 9/23/14 | Using a helicopter, winter rye seed was spread on both study watersheds at a rate of 100 lb./acre. |
| 10/27/14 | Corn was chopped on both WIL1 and WIL2. The estimated yield was 18 tons/acre and 5% residue was left on the field. |
| 11/4/14 | On WIL1, five loads of manure were injected with a Jamesway 9,000 gallon spreader. On WIL2, four loads of manure were surface applied using a Jamesway 9,000 gallon spreader with low nozzle. Manure applied in both watersheds was sourced from the main pit and was agitated well. Substantial water was in the main pit. |


*Figure 23. WIL2 watershed (left of flag) and WIL1 watershed (right of flag) after manure application*

### 5.3. Cover Crop Density Measurement

Cover crops were planted at the three corn sites in 2013 and 2014 by broadcasting seed after corn harvest or interseeding into standing corn using a helicopter. Under these conditions cover crop catch was fair at best (<10% cover). To date, the only clearly successful cover crop was winter wheat planted on the FRA1study watershed using a small grain drill after corn harvest in 2014. This cover crop was drilled after an earlier aerial interseeding of summer rye failed to germinate. The resulting coverage in mid-May, 2015 (Figure 24) was 45%.

The following sections describe cover crop seeding and percent cover at the Franklin, Pawlet, and Williston sites through 2014.

*Figure 24. Winter wheat cover crop at FRA1 on May 12. 2015*

### 5.3.1. Franklin site

Winter rye cover crop seed was spread over standing corn at the Franklin site (FRA1 only) on September 17, 2013 using a helicopter. Due to aerial application, some seed may have landed within the boundary of FRA2, the control watershed. Any seed landing in FRA2 was buried on October 11 when the watershed was chisel plowed. Establishment was poor in FRA1. Figure 25 presents typical surface cover beneath a quadrat in FRA1 two months after the cover crop was seeded.

*Figure 25. Typical cover in FRA1 watershed, November 21, 2013*

Although cover crop establishment on FRA1 was generally poor, successful growth was seen in a few rows. Figure 26 shows several rows in which cover crop density was reasonably good. The reasons why the cover crop established more successfully in these narrow rows is not fully understood. The participating farmer noted that the harvesting equipment used in some portions of the field had “floatation” tires, which may have produced better seed contact with the soil, than in other areas of the field where trucks with narrow tires were used. The farmer also questioned the uniformity of seed application because the pilot apparently spread up and down the slope, starting and stopping the seeder over each corn strip.

Percent cover measurements were recorded at FRA1 on October 18 and November 21, 2013. These surveys yielded very similar results. On both dates, about three quarters of the watershed area was bare soil and about one fifth had crop residue cover (Figure 27). Weeds and cover crop together comprised only 2-3% of the surface area.

*Figure 26. Rows with successful cover crop establishment, FRA1, November 21, 2013*

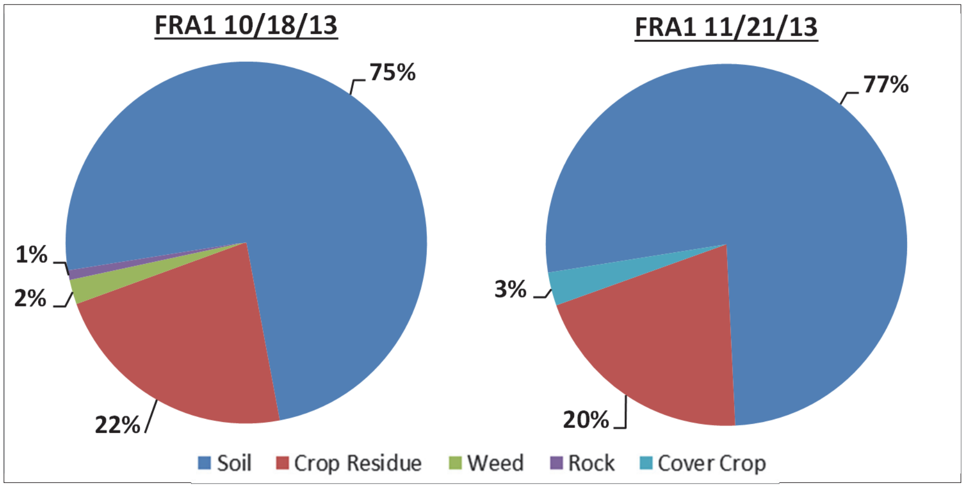



*Figure 27. Percent cover in FRA1 watershed on October 18 and November 21, 2013*

Percent cover measurements were also made for FRA1 prior to spring tillage in 2014. On May 5, 2014, 9% of the FRA1 watershed was covered in winter rye (Figure 29), an increase from 3% measured November 21, 2013. Approximately 75% of the watershed was bare soil, with the remaining area covered by crop residue, cover crop, and weeds.

Summer rye was interseeded on FRA1 into standing corn on July 5, 2014. The participating farmer reported no germination. Therefore, winter wheat seed was drilled on FRA1 on October 14, 2014 after corn harvest. Figure 28 presents typical surface cover in FRA1 on October 20, 2014, three months after the summer rye cover crop was interseeded and six days after the winter wheat was drilled. Approximately 85% of both watersheds was bare soil.


*Figure 28. Typical cover in FRA1 watershed, October 20, 2014.*

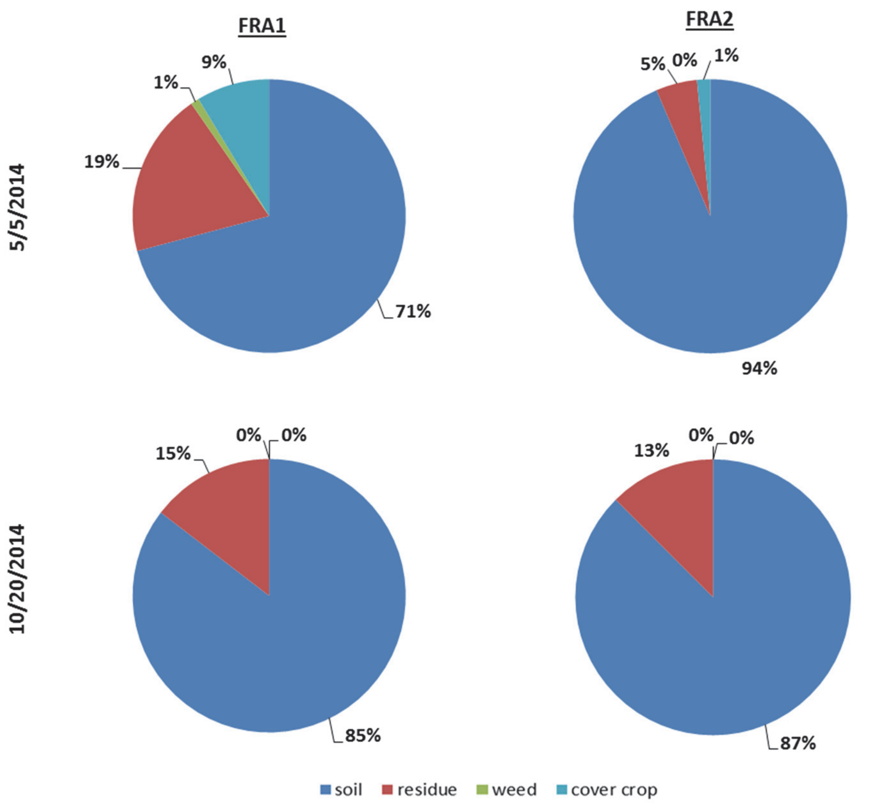



*Figure 29. Percent cover in the FRA1 and FRA2 watersheds on May 5 and October 20, 2014.*

### 5.3.2. Pawlet site

*Figure 30. Typical cover in PAW2 watershed, November 14, 2013*

Cover crop seed was mistakenly spread on both Pawlet study watersheds on October 15, 2013, rather than to PAW1 (the treatment watershed) only. Establishment was poor on both PAW1 and PAW2, likely due to seeding very late in the season. Figure 30 illustrates typical surface cover observed one month after seeding.

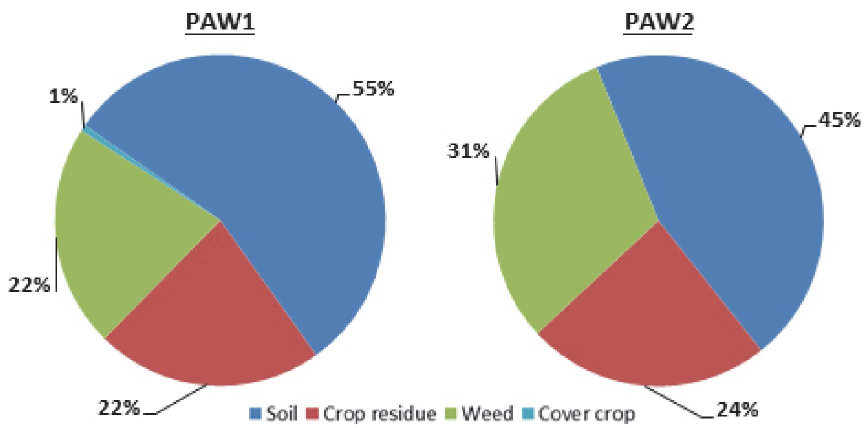


*Figure 31. Percent cover in PAW1 and PAW2 watersheds on November 14, 2013*

Percent cover measurements made on November 14, 2013 and April 2014 indicated that the catch was very poor (0-2%) on both watersheds (Figure 31and Figure 33). Slightly more than half of the surveyed area in PAW1 was bare soil, followed by crop residue and weeds. The PAW2 watershed had slightly greater weed and crop residue cover than PAW1, and therefore approximately 10 percent less bare soil. While the total vegetative cover was 45 percent on PAW1 and 55 percent on PAW2, the extent of the cover crop was negligible in both watersheds.

*Figure 32. Typical cover in PAW1 watershed, November 18, 2014.*

Cover crop establishment at PAW1 in the fall of 2014 was fair, but far better than in 2013. Figure 32 illustrates typical surface cover observed on PAW1 about two months after seeding. Percent cover measurements were made at PAW1 and PAW2 on October 28 and November 18, 2014 (Figure 33). Similar results were obtained: 9-10% of the watershed was covered in winter rye. Slightly more than half of the surveyed area in PAW1 was bare soil, followed by crop residue, cover crop, and weeds.

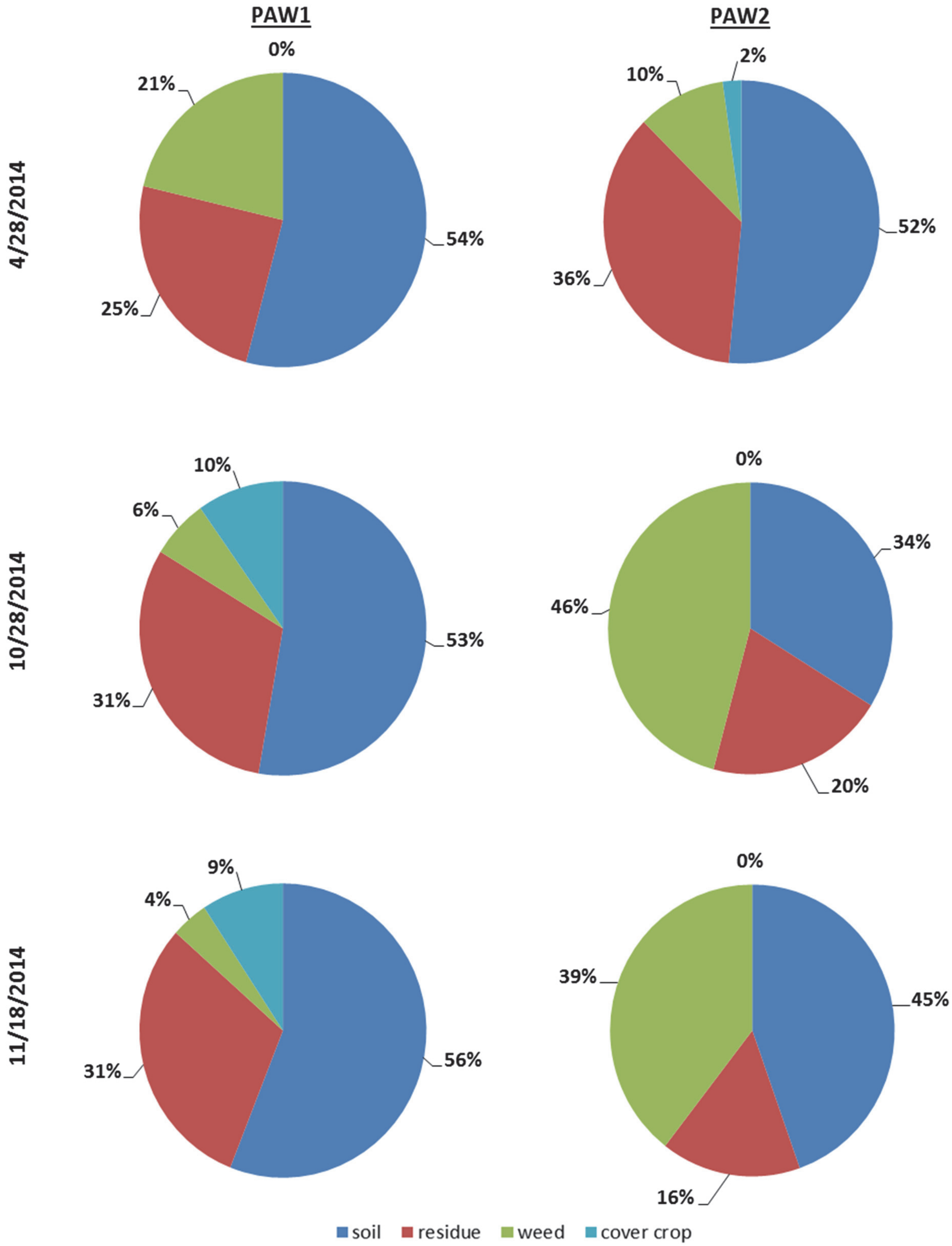



*Figure 33. Percent cover in the PAW1 watershed on April 28, October 28, and November 18, 2014.*

### 5.3.3. Williston site

Records show that winter rye seed was spread over standing corn at the Williston site (both WIL1 and WIL2) on September 1, 2013 using a helicopter. Because seeding a cover crop was the standard practice on these fields, this practice was continued on both the control and treatment watersheds. Establishment was very poor. Figure 34 illustrates typical surface cover observed in both WIL1 and WIL2 two months after seeding.


*Figure 34. Typical cover in WIL1 watershed, October 30, 2013*

Percent cover measurements were made at WIL1 and WIL2 on October 30, 2013 (Figure 35). Bare soil, crop residue, and weeds each made up about one third of the total cover. No cover crop was observed. The surface condition of WIL1 and WIL2 were very similar on the assessment date.

On the same date cover crop seed was reportedly spread on WIL1 and WIL2, the pilot seeded the fields directly across the Winooksi River. Establishment on these fields was good. Based on successful establishment on neighboring fields and the lack of any cover crop on WIL1 and WIL2, the participating farmer speculated that the pilot made an error and did not actually seed WIL1 and WIL2.

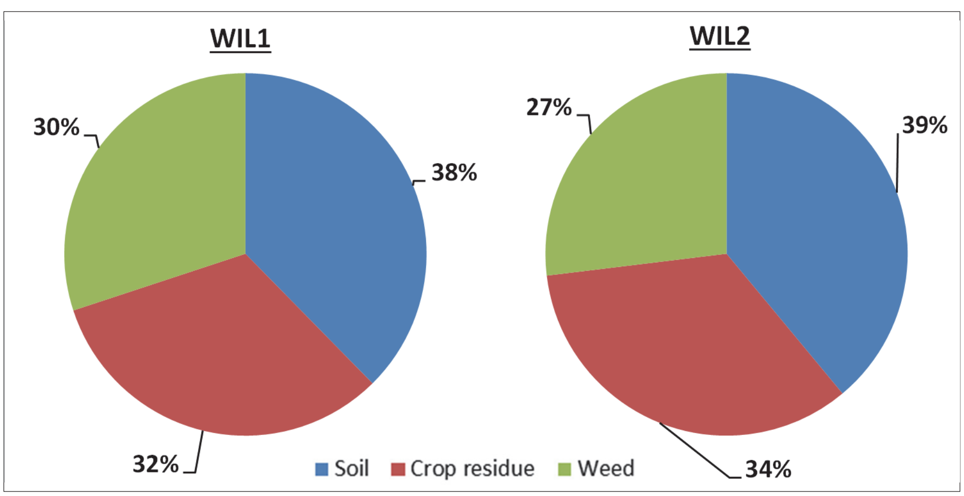



*Figure 35. Percent cover in WIL1 and WIL2 watersheds on October 30, 2013*

Winter rye seed was aerially spread on both WIL1 and WIL2 on September 23, 2014. Because seeding a cover crop was the standard practice on these fields, this practice was continued on both the control and treatment watersheds. As in 2013, establishment was very poor (<1%). Figure 36 illustrates typical surface cover observed in both WIL1 and WIL2 two months after seeding.

Percent cover measurements were made at WIL1 and WIL2 on November 20, 2014 (Figure 37). Winter rye cover was negligible on both watersheds. Bare soil constituted approximately two thirds of the total cover, followed by crop residue and weeds.

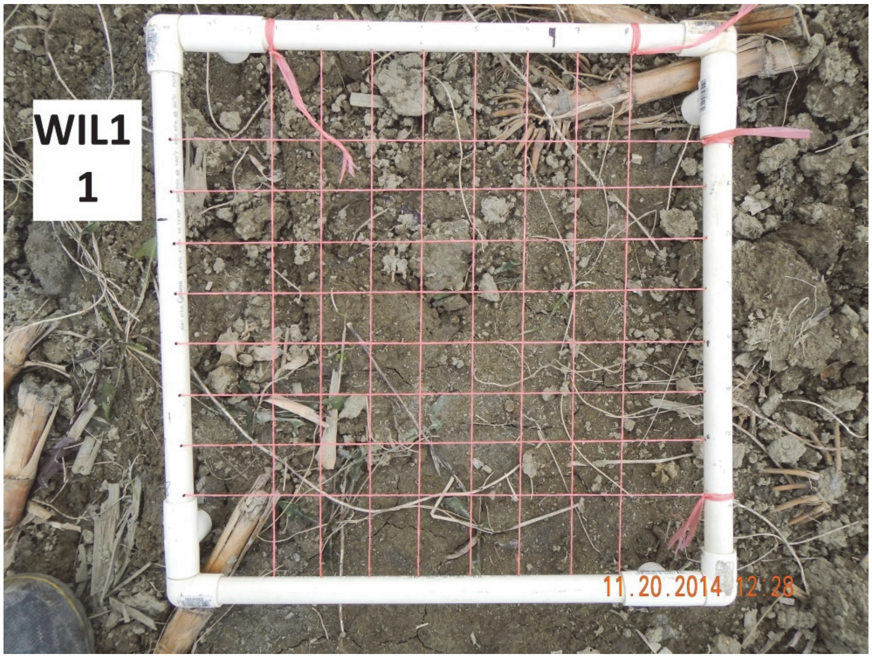



*Figure 36. Typical cover in WIL1 watershed, November 20, 2014.*

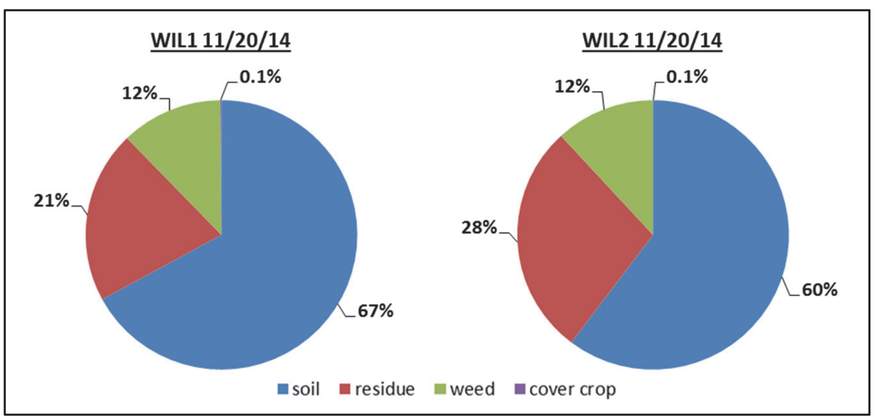



*Figure 37. Percent cover in WIL1 and WIL2 watersheds on November 20, 2014.*

# 6. WEATHER DATA

The following series of graphs (Figure 38 through Figure 61) present daily precipitation totals at each site from 2012 through June 2015. These data are from the onsite tipping bucket rain gages. Daily precipitation totals are presented for April 1–November 30 of each year between 2012 and 2014 and April 1 through June 30, 2015. The tipping bucket rain gages do not accurately record solid precipitation and attempting to differentiate winter rainfall from snowmelt over the whole season is beyond the scope of this study. Some snowmelt in early spring and late fall is likely included in the daily precipitation totals presented.

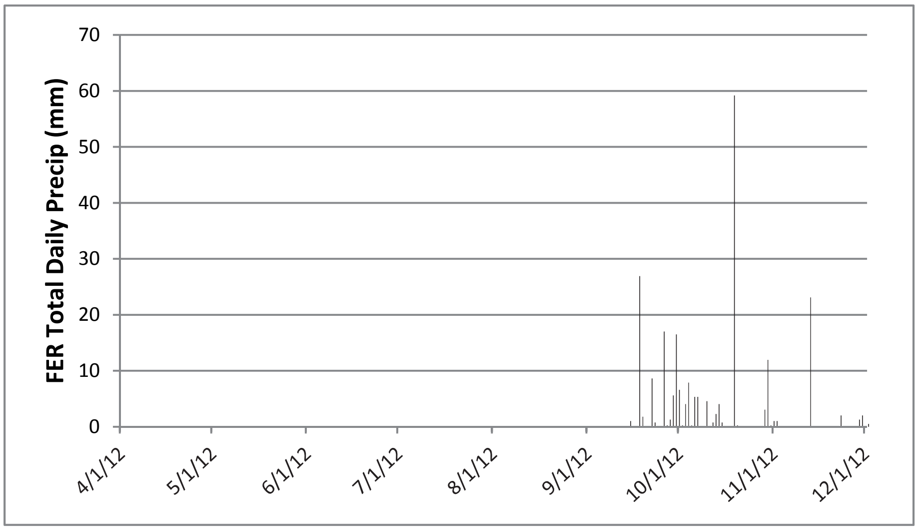



*Figure 38. Ferrisburgh total daily precipitation (mm) for 2012*

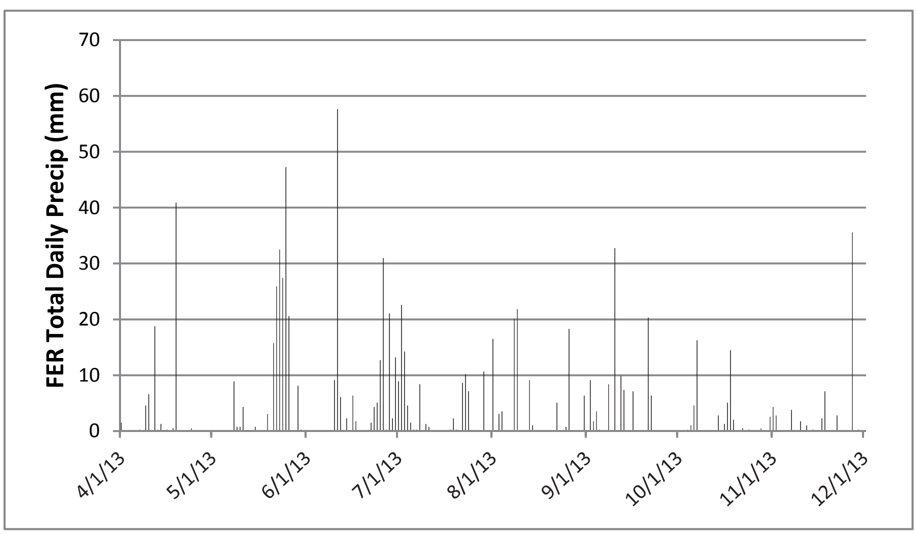



*Figure 39. Ferrisburgh total daily precipitation (mm) for 2013*

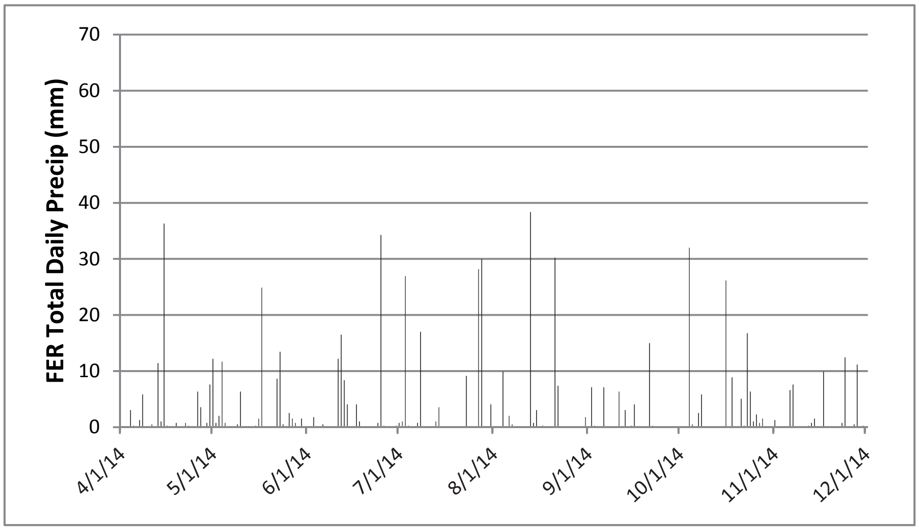



*Figure 40. Ferrisburgh total daily precipitation (mm) for 2014*

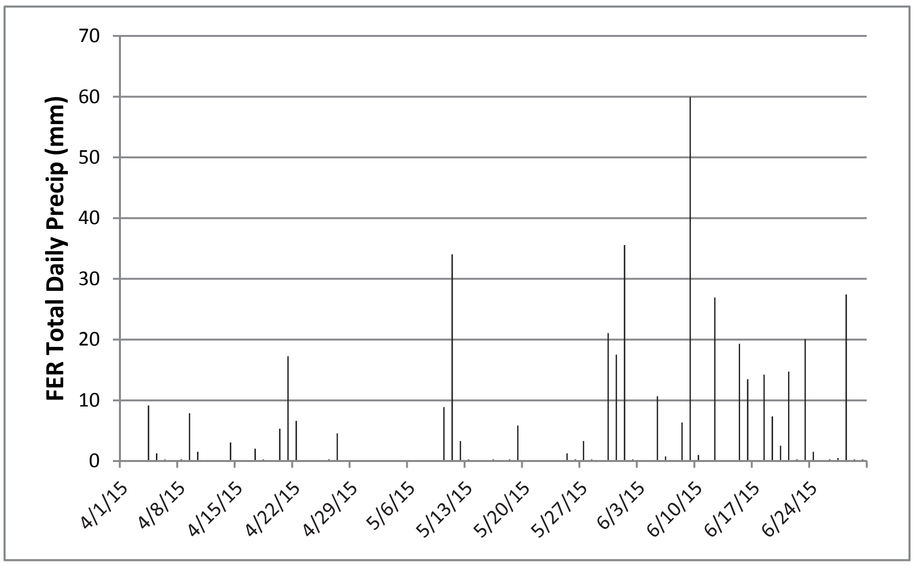



*Figure 41. Ferrisburgh total daily precipitation (mm) for 2015*

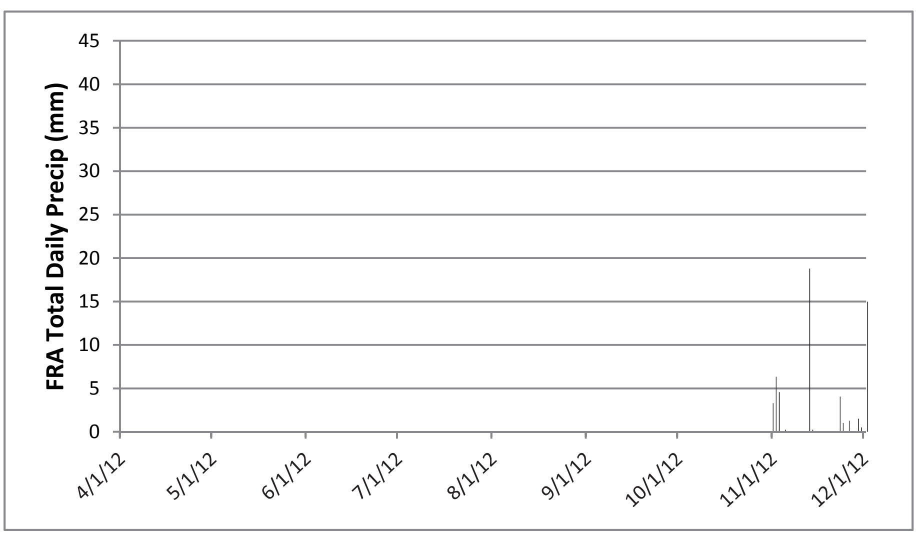



*Figure 42. Franklin total daily precipitation (mm) for 2012*

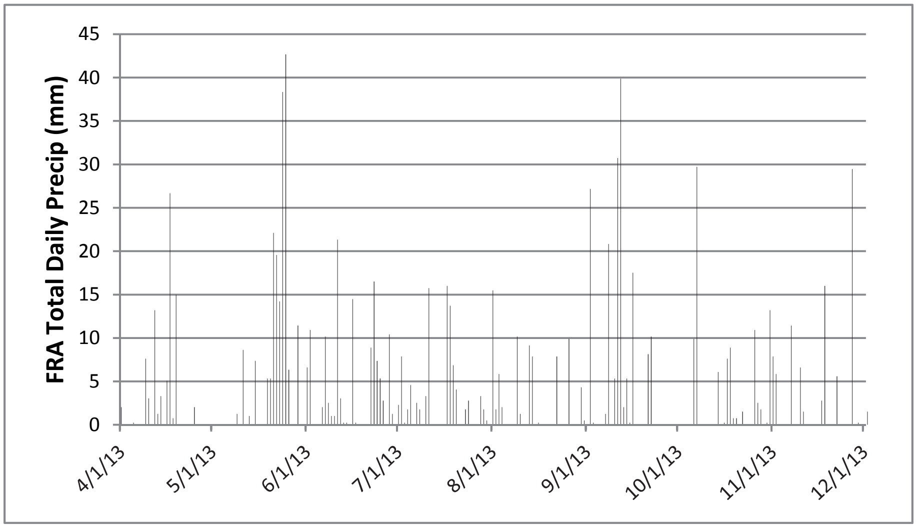



*Figure 43. Franklin total daily precipitation (mm) for 2013*

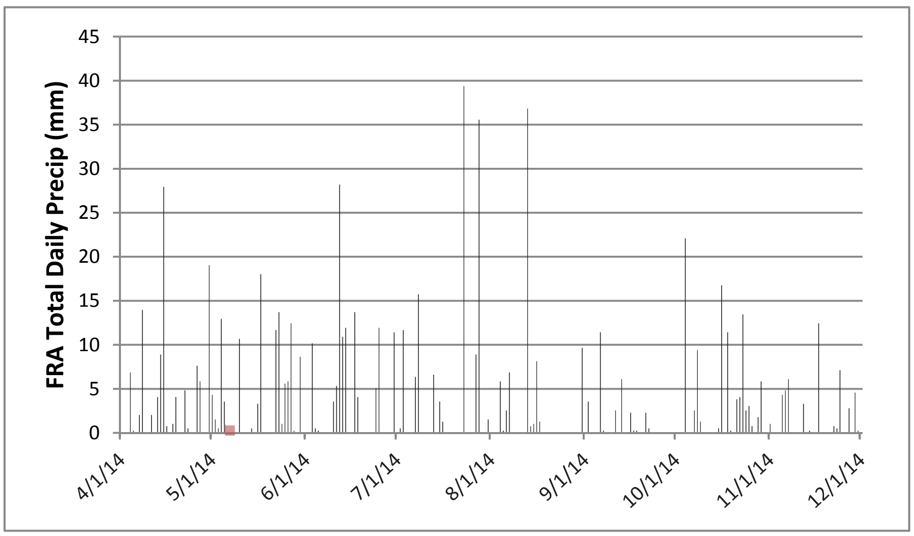



*Figure 44. Franklin total daily precipitation (mm) for 2014. Data gap (5/6 – 5/7) highlighted in red*

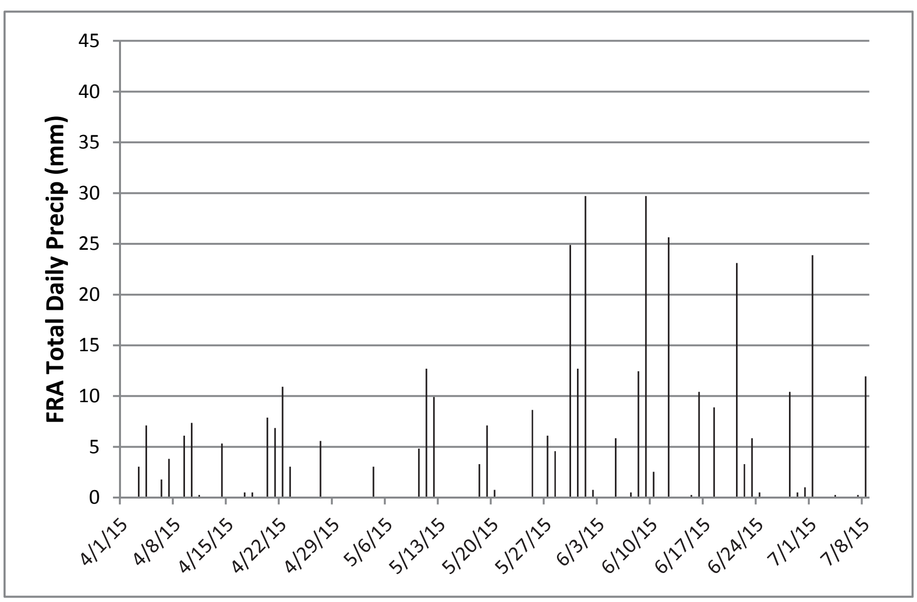



*Figure 45. Franklin total daily precipitation (mm) for 2015*

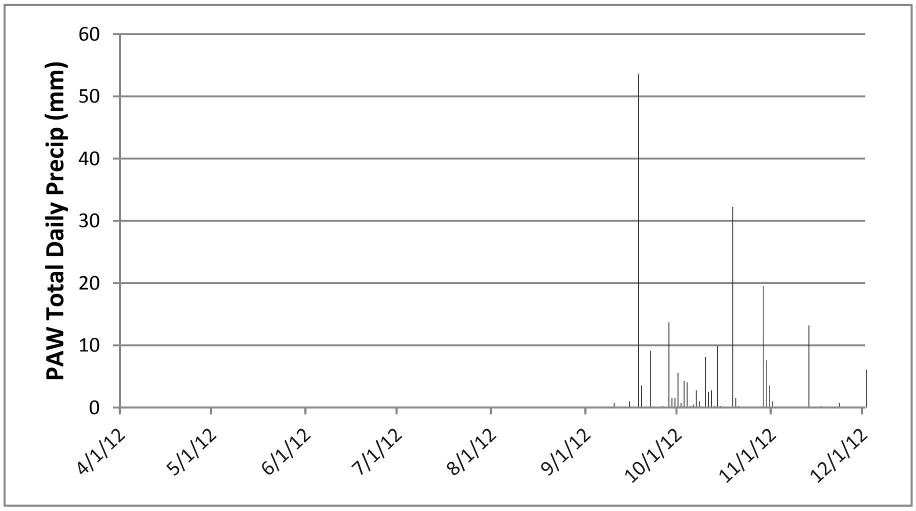



*Figure 46. Pawlet total daily precipitation (mm) for 2012*

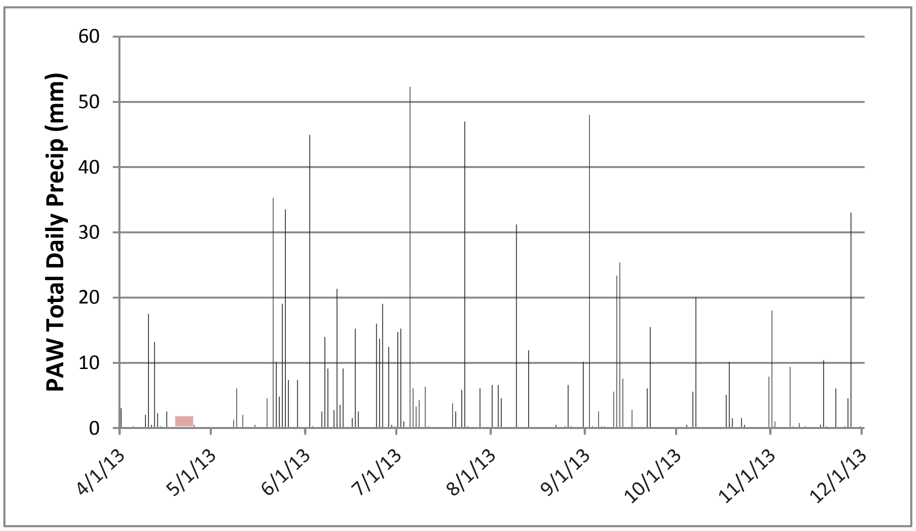



*Figure 47. Pawlet total daily precipitation (mm) for 2013. Data gap (4/19 – 4/23) highlighted in red*

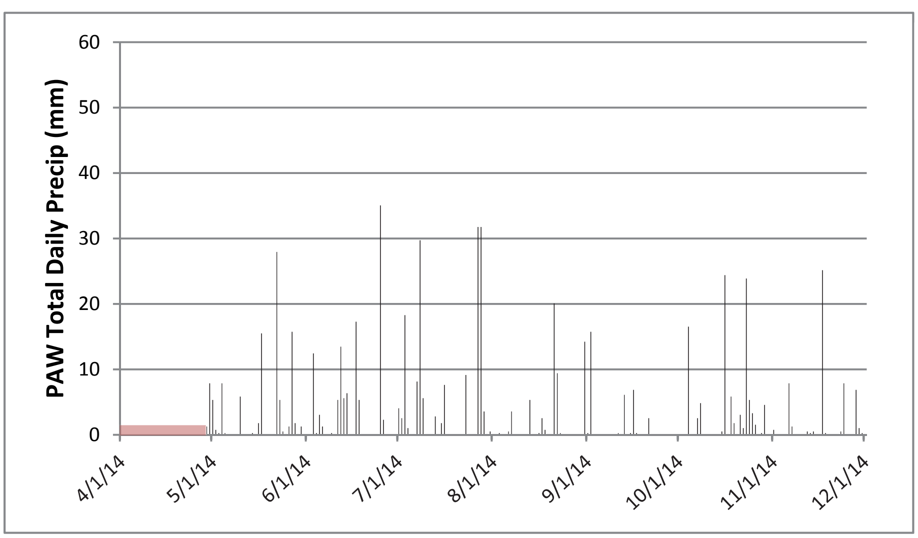



*Figure 48. Pawlet total daily precipitation (mm) for 2014. Data gap (4/1 – 4/27) highlighted in red*

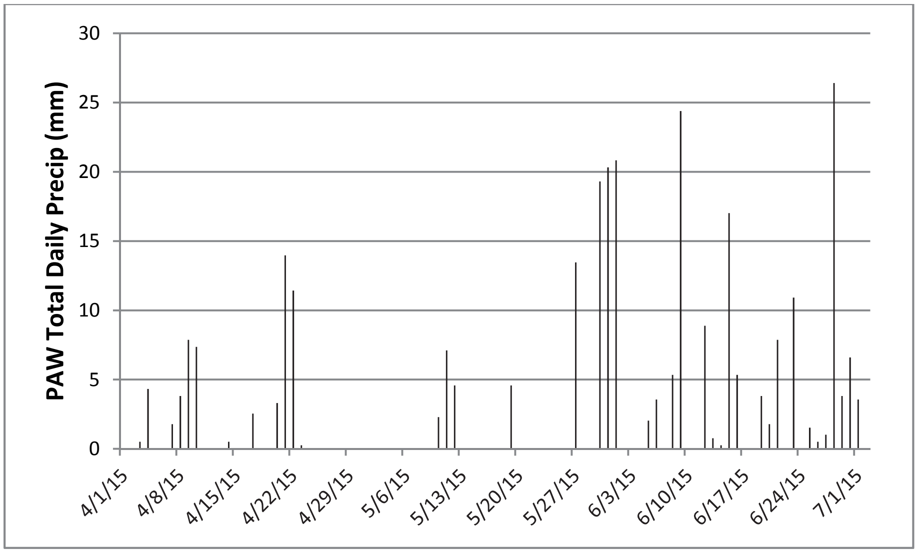



*Figure 49. Pawlet total daily precipitation (mm) for 2015*

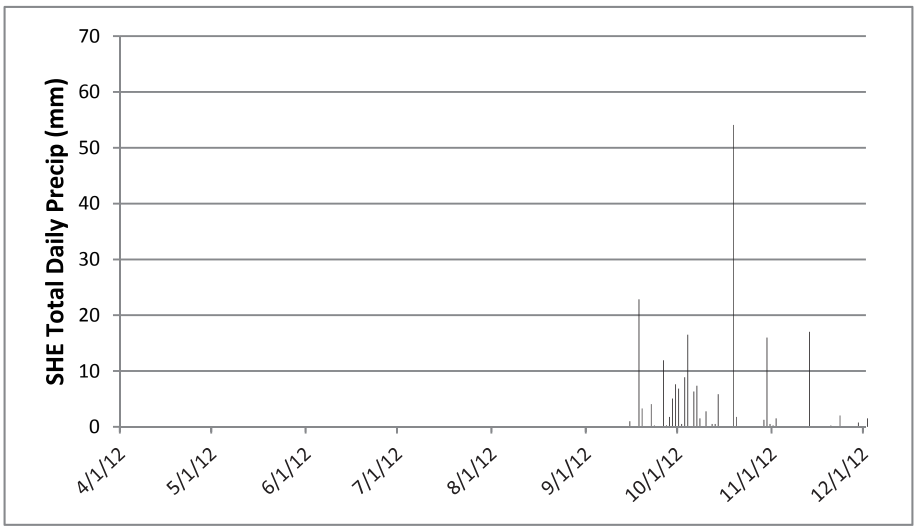



*Figure 50. Shelburne total daily precipitation (mm) for 2012*

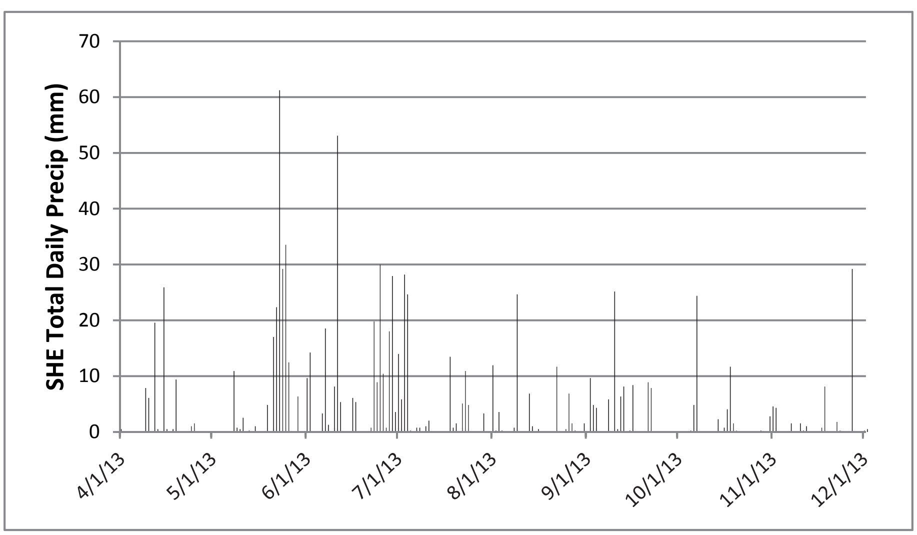



*Figure 51. Shelburne total daily precipitation (mm) for 2013*

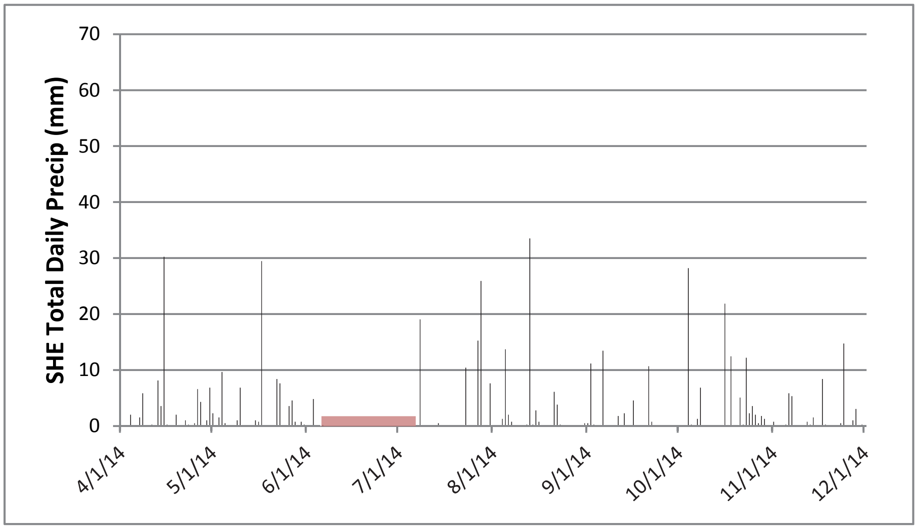



*Figure 52. Shelburne total daily precipitation (mm) for 2014*

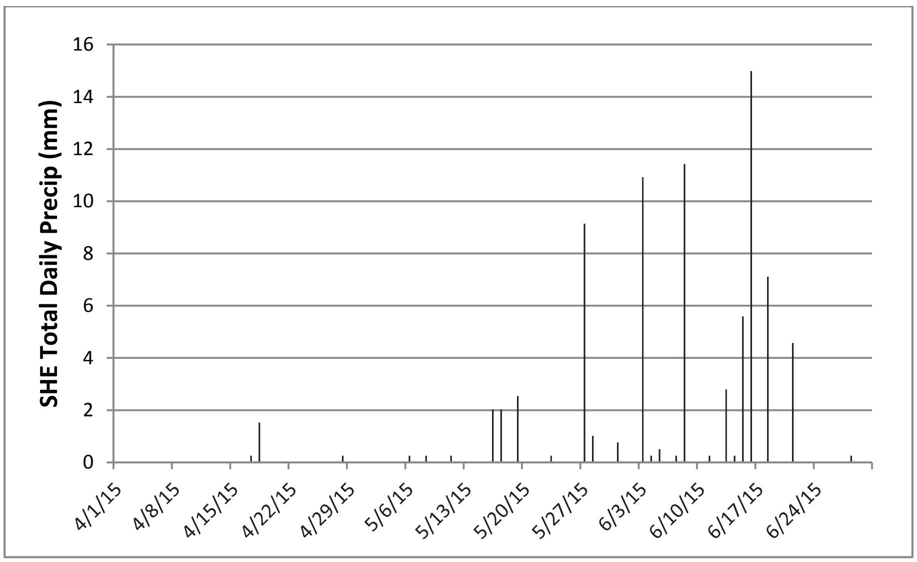



*Figure 53. Shelburne total daily precipitation (mm) for 2015*

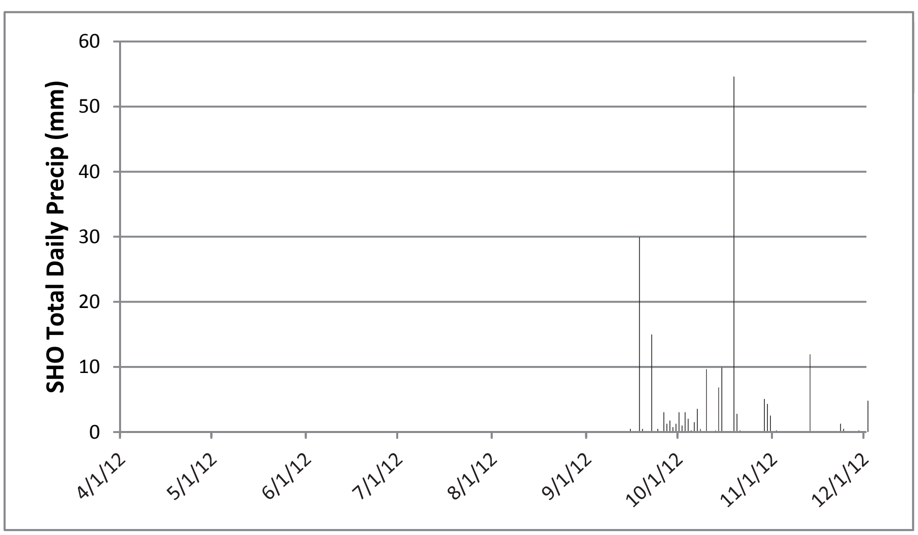



*Figure 54. Shoreham total daily precipitation (mm) for 2012*

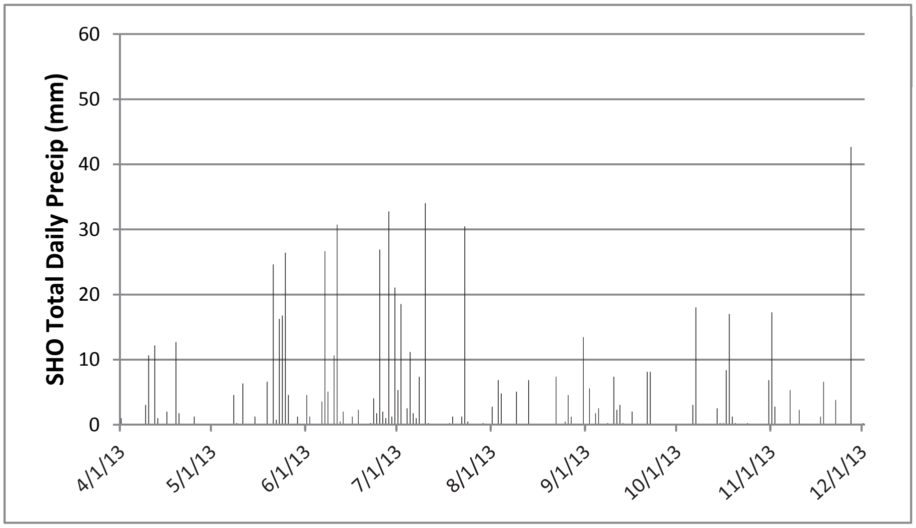



*Figure 55. Shoreham total daily precipitation (mm) for 2013*

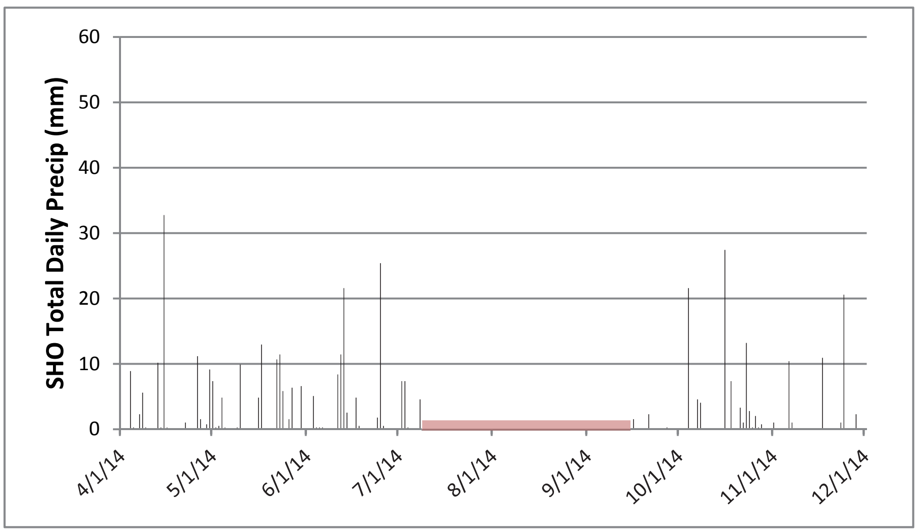



*Figure 56. Shoreham total daily precipitation (mm) for 2014. Data gap (7/9 – 9/15) highlighted in red*

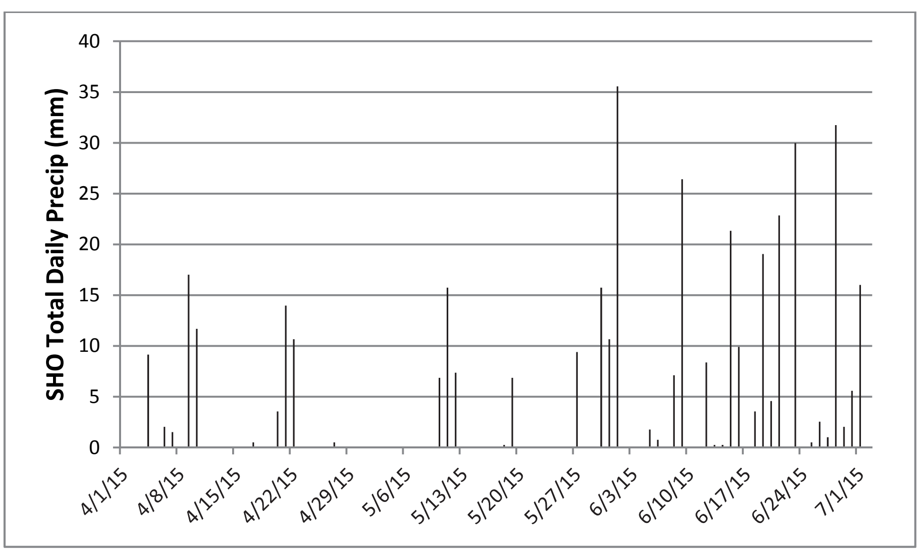



*Figure 57. Shoreham total daily precipitation (mm) for 2015*

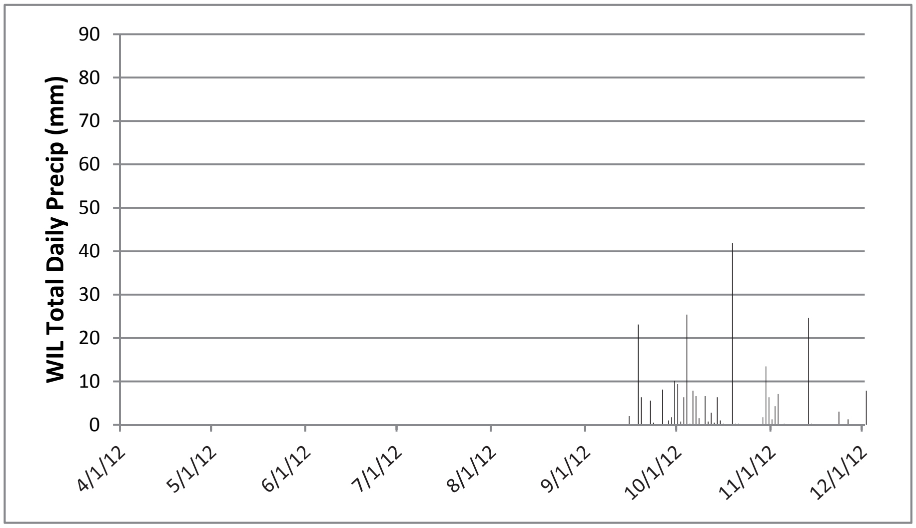



*Figure 58. Williston total daily precipitation (mm) for 2012*

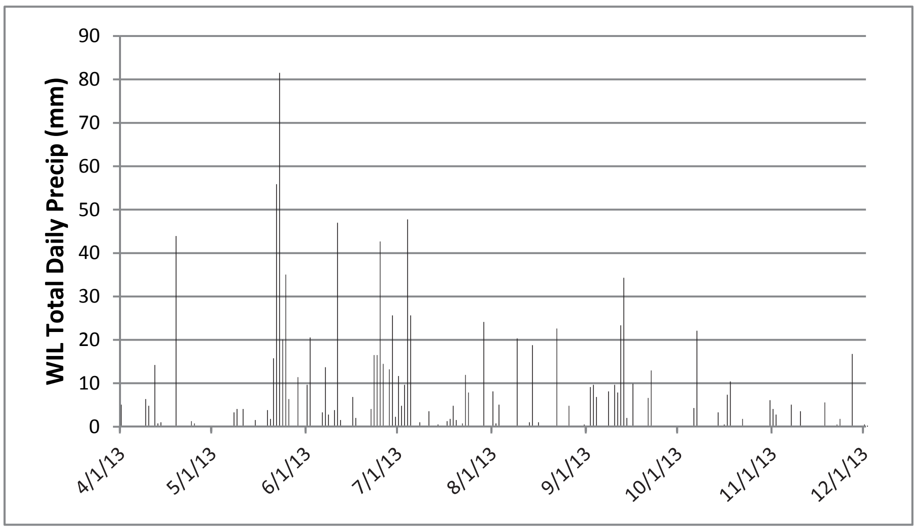



*Figure 59. Williston total daily precipitation (mm) for 2013. Data gap (4/17 – 4/18) highlighted in red*

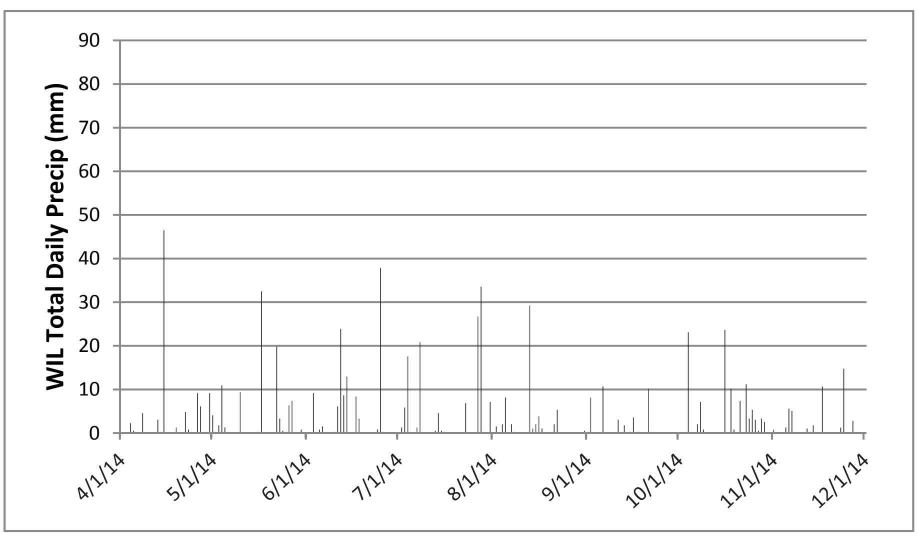



*Figure 60. Williston total daily precipitation (mm) for 2014*

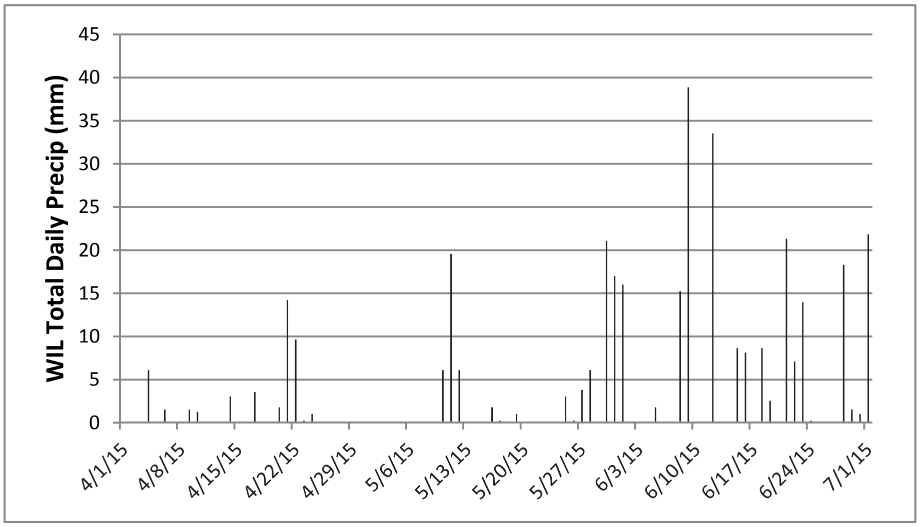



*Figure 61. Williston total daily precipitation (mm) for 2015*

Monthly precipitation totals presented for each site in Table 24 through Table 29 attest to the abnormally wet spring and early summer in 2013, especially at the sites in Chittenden County. In May and June, all sites received substantially more rain than the long-term normal. The Ferrisburgh, Franklin, Shelburne, and Williston sites received more than twice the long-term normal monthly rainfall total in May. In June, the Shelburne and Williston sites again received more than twice the normal rainfall. The highest rainfall totals were at Williston for both months; 245 mm in May and 247 mm in June. The late summer and early fall were much dryer. All sites except Ferrisburgh received below average rainfall in August and Ferrisburgh, Pawlet, Shoreham, and Williston all received below average rainfall in October. The Shoreham site received below average rainfall every month between July and November.

Monthly precipitation totals presented in Table 24 through Table 29 indicate that 2014 was a relatively dry year across all sites. Precipitation totals were generally comparable to 30-year normals between April and June and July was slightly wetter than normal. However, in August, September, and November all sites received precipitation totals substantially below 30-year normals. September was the driest month, with totals ranging from 32 percent of normal in Franklin to 49 percent of normal in Shelburne. Despite near normal rainfall in October, the fall was dry, which is reflected in the absence of appreciable runoff on all sites except Pawlet until the major Christmas rain-on-snow event.

In the spring of 2015, precipitation totals across all sites were slightly below normal in April. In May, precipitation totals were mixed, with the southernmost sites, Pawlet and Shoreham, receiving below normal and the four sites from Ferrisburgh north receiving slightly above normal precipitation. June was exceptionally wet at all sites, with monthly totals ranging from 50% above normal at the Pawlet site (152.7 mm) to nearly three times normal at the Ferrisburgh site (263.7 mm). The four mid-Champlain Valley sites from Williston south to Shoreham all received more than twice as much precipitation than normal during June.

Note that precipitation totals for winter months are included in Table 24 through Table 29 and these must be interpreted with caution. The winter month totals will include a mixture of rainfall and snowmelt. Only a portion of the precipitation falling as snow is collected and melts to be recorded as liquid precipitation.

Table 24. *Air temperature and precipitation compared with long-term averages, FER site*

| Month | Mean/Normal[1] | | 2012 | | 2013 | | 2014 | | 2015 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean air temp. | Normal precip. | Mean air temp. | Total precip. | Mean air temp. | Total precip. | Mean air temp. | Total precip. | Mean air temp. | Total precip. |
| | (° C) | (mm) | (° C) | (mm) | (° C) | (mm) | (° C) | (mm) | (° C) | (mm) |
| January | -7.4 | 52 | -- | -- | -5.3 | 27 | -7.9 | 73.4 | -8.5 | 19.0 |
| February | -5.8 | 45 | -- | -- | -4.1 | 27 | -7.3 | 22.9 | -13.9 | 0.8 |
| March | -0.6 | 56 | -- | -- | 0.4 | 64 | -5.0 | 35.6 | -3.0 | 22.1 |
| April | 7.1 | 72 | -- | -- | 7.0 | 75 | 6.7 | 80.0 | 6.2 | 59.7 |
| May | 13.5 | 88 | -- | -- | 14.6 | 196 | 13.7 | 89.9 | 16.4 | 96.5 |
| June | 18.8 | 94 | -- | -- | 17.9 | 175 | 18.9 | 84.1 | 17.4 | 263.7 |
| July | 21.4 | 106 | -- | -- | 22.3 | 102 | 20.8 | 122.7 | | |
| August | 20.4 | 99 | -- | -- | 19.5 | 106 | 19.2 | 94.2 | | |
| September | 15.8 | 92 | 13.9 | 80 | 14.8 | 107 | 15.3 | 43.4 | | |
| October | 8.9 | 91 | 11.0 | 117 | 9.8 | 52 | 11.0 | 110.0 | | |
| November | 3.4 | 80 | 2.1 | 30 | 1.9 | 62 | 2.9 | 53.1 | | |
| December | -3.4 | 60 | -0.6 | 63 | -4.9 | 34 | -1.3 | 55.4 | | |
| **Annual Total** | -- | 935 | -- | -- | -- | 1027 | -- | 865 | | |
| **Annual Mean** | 7.7 | -- | -- | -- | 7.8 | -- | 7.3 | -- | | |

[1] Source: NCDC 2011; 1981 – 2010 climate normals for Burlington NWS station USW00014742

Table 25. *Air temperature and precipitation compared with long-term averages, FRA site*

| Month | Mean/Normal[1] | | 2012 | | 2013 | | 2014 | | 2015 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean air temp. | Normal precip. | Mean air temp. | Total precip. | Mean air temp. | Total precip. | Mean air temp. | Total precip. | Mean air temp. | Total precip. |
| | (° C) | (mm) | (° C) | (mm) | (° C) | (mm) | (° C) | (mm) | (° C) | (mm) |
| January | -7.4 | 52 | -- | -- | -6.7 [2] | 1.5 [2] | -9.1 | 57.2 | -13.5 | 35.6 |
| February | -5.8 | 45 | -- | -- | -2.2 [3] | 19 [3] | -8.2 | 25.7 | -15.9 | 3.6 |
| March | -0.6 | 56 | -- | -- | -0.3 | 45 | -6.3 | 57.2 | -4.2 | 24.6 |
| April | 7.1 | 72 | -- | -- | 6.4 | 80 | 6.2 | 109.7 | 5.8 | 70.1 |
| May | 13.5 | 88 | -- | -- | 15.0 | 184 | 14.2 [4] | 114.6 [4] | 16.2 | 98.6 |
| June | 18.8 | 94 | -- | -- | 17.8 | 126 | 19.1 | 117.1 | 17.3 | 171.5 |
| July | 21.4 | 106 | -- | -- | 21.6 | 91 | 20.4 | 131.1 | | |
| August | 20.4 | 99 | -- | -- | 18.8 | 76 | 18.9 | 73.2 | | |
| September | 15.8 | 92 | -- | -- | 14.4 | 169 | 15.0 | 29.5 | | |
| October | 8.9 | 91 | -- | -- | 9.8 | 94 | 10.9 | 99.6 | | |
| November | 3.4 | 80 | 0.8 | 42 | 1.1 | 87 | 2.4 | 48.3 | | |
| December | -3.4 | 60 | -2.1 | 86 | -6.5 | 9 | -2.5 | 59.4 | | |
| **Annual Total** | -- | 935 | -- | -- | -- | 961 | -- | 923 | | |
| **Annual Mean** | 7.7 | -- | -- | -- | 9.8 | -- | 6.7 | -- | | |

[1] Source: NCDC 2011; 1981 – 2010 climate normals for Burlington NWS station USW00014742

[2] No data collected January 24-31, 2013

[3] No data collected February 1- 11, 2013

[4] No data collected May 6-7, 2014

*Table 26. Air temperature and precipitation compared with long-term averages, PAW site*

| Month | Mean/Normal[1] | | 2012 | | 2013 | | 2014 | | 2015 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean air temp. | Normal precip. | Mean air temp. | Total precip. | Mean air temp. | Total precip. | Mean air temp. | Total precip. | Mean air temp. | Total precip. |
| | (° C) | (mm) | (° C) | (mm) | (° C) | (mm) | (° C) | (mm) | (° C) | (mm) |
| January | -7.5 | 65 | -- | -- | -5.0 | 42 | -8.0 | 59.7 | -8.7 | 43.2 |
| February | -6.3 | 55 | -- | -- | -3.6 | 36 | -7.0 | 36.6 | -13.2 | 0.76 |
| March | -0.8 | 70 | -- | -- | 0.1 | 60 | -- [3] | -- [3] | -2.7 | 29.0 |
| April | 6.7 | 73 | -- | -- | 7.2 [2] | 42 [2] | -- [3] | -- [3] | 7.0 | 57.7 |
| May | 13.0 | 94 | -- | -- | 14.8 | 132 | 14.2 | 91.7 | 16.7 | 71.6 |
| June | 17.9 | 101 | -- | -- | 18.4 | 189 | 19.2 | 108.0 | 17.9 | 152.7 |
| July | 20.3 | 121 | -- | -- | 22.8 | 169 | 20.7 | 158.2 | | |
| August | 19.2 | 103 | -- | -- | 19.6 | 79 | 19.3 | 57.2 | | |
| September | 14.4 | 94 | 13.5 | 85 | 14.8 | 138 | 15.7 | 32.3 | | |
| October | 8.1 | 97 | 11.4 | 108 | 10.1 | 53 | 11.1 | 99.3 | | |
| November | 2.6 | 83 | 1.8 | 15 | 1.7 | 85 | 2.0 | 53.1 | | |
| December | -3.9 | 71 | -0.3 | 70 | -3.5 | 60 | -0.9 | 71.1 | | |
| **Annual Total** | -- | 1027 | -- | -- | -- | 1043 | -- | 770 | | |
| **Annual Mean** | 7.0 | -- | -- | -- | 8.2 | -- | 7.7 | -- | | |

[1] Source: NCDC 2011; 1981 – 2010 climate normals for Rutland Airport NWS station USC00436995

[2] No data collected April 19 – April 23, 2013

[3] No data collected March 13 - April 27, 2014

*Table 27. Air temperature and precipitation compared with long-term averages, SHE site*

| Month | Mean/Normal[1] | | 2012 | | 2013 | | 2014 | | 2015 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean air temp. | Normal precip. | Mean air temp. | Total precip. | Mean air temp. | Total precip. | Mean air temp. | Total precip. | Mean air temp. | Total precip. |
| | (° C) | (mm) | (° C) | (mm) | (° C) | (mm) | (° C) | (mm) | (° C) | (mm) |
| January | -7.4 | 52 | -- | -- | -5.0 | 20 | -7.6 | 45.7 | -8.3 | 21.6 |
| February | -5.8 | 45 | -- | -- | -4.2 | 15 | -6.3 | 25.4 | -13.1 | 2.1 |
| March | -0.6 | 56 | -- | -- | 0.4 | 45 | -5.0 | 30.5 | -2.3 | 11.7 |
| April | 7.1 | 72 | -- | -- | 6.7 | 73 | 6.7 | 74.4 | 6.3 | 62.0 |
| May | 13.5 | 88 | -- | -- | 14.6 | 203 | 13.7 | 79.0 | 16.4 | 94.5 |
| June | 18.8 | 94 | -- | -- | 17.8 | 245 | -- [2] | -- [2] | 17.3 | 242.1 |
| July | 21.4 | 106 | -- | -- | 22.3 | 117 | 20.8 [2] | 78.7 [2] | | |
| August | 20.4 | 99 | -- | -- | 20.0 | 72 | 19.6 | 66.0 | | |
| September | 15.8 | 92 | 15.0 | 58 | 15.4 | 90 | 16.1 | 45.5 | | |
| October | 8.9 | 91 | 11.5 | 131 | 10.5 | 53 | 11.4 | 99.8 | | |
| November | 3.4 | 80 | 2.4 | 22 | 2.4 | 53 | 3.3 | 42.9 | | |
| December | -3.4 | 60 | -0.5 | 55 | -4.4 | 37 | -1.0 | 56.6 | | |
| **Annual Total** | -- | 935 | -- | -- | -- | 1023 | -- | 646.5 | | |
| **Annual Mean** | 7.7 | -- | -- | -- | 8.04 | -- | 6.1 | -- | | |

[1] Source: NCDC 2011; 1981 – 2010 climate normals for Burlington NWS station USW00014742

[2] No data collected June 7 – July 8, 2014

*Table 28. Air temperature and precipitation compared with long-term averages, SHO site*

| Month | Mean/Normal[1] | | 2012 | | 2013 | | 2014 | | 2015 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean air temp. | Normal precip. | Mean air temp. | Total precip. | Mean air temp. | Total precip. | Mean air temp. | Total precip. | Mean air temp. | Total precip. |
| | (° C) | (mm) | (° C) | (mm) | (° C) | (mm) | (° C) | (mm) | (° C) | (mm) |
| January | -7.5 | 65 | -- | -- | -5.8 | 32 | -8.4 | 66.0 | -9.0 | 30.7 |
| February | -6.3 | 55 | -- | -- | -4.3 | 24 | -7.0 | -- [2] | -13.7 | 3.8 |
| March | -0.8 | 70 | -- | -- | 0.3 | 63 | -5.0 | 40.9 [2] | --[4] | 25.9 |
| April | 6.7 | 73 | -- | -- | 6.9 | 46 | 7.2 | 84.3 | --[4] | 70.6 |
| May | 13.0 | 94 | -- | -- | 15.0 | 110 | 14.0 | 83.6 | 16.6 | 72.9 |
| June | 17.9 | 101 | -- | -- | 18.1 | 180 | 19.2 | 82.8 | 17.4 | 235.2 |
| July | 20.3 | 121 | -- | -- | 22.6 | 116 | 21.1 | -- [3] | | |
| August | 19.2 | 103 | -- | -- | 19.9 | 54 | 19.2 | -- [3] | | |
| September | 14.4 | 94 | 13.6 | 55 | 15.1 | 41 | 15.4 | -- [3] | | |
| October | 8.1 | 97 | 10.9 | 111 | 10.0 | 58 | 10.9 | 88.6 | | |
| November | 2.6 | 83 | 1.6 | 14 | 1.3 | 82 | 2.0 | 47.2 | | |
| December | -3.9 | 71 | -1.1 | 67 | -4.6 | 50 | -1.7 | 80.5 | | |
| **Annual Total** | -- | 1027 | -- | -- | -- | 856 | -- | -- | | |
| **Annual Mean** | 7.0 | -- | -- | -- | 7.9 | -- | 7.2 | -- | | |

1 Source: NCDC 2011; 1981 – 2010 climate normals for Rutland Airport NWS station USC00436995

2 No precipitation data collected January 16 – March 3, 2014

3 No precipitation data collected July 9 – September 15, 2014

4 No valid temperature data collected from March 25 – May 1, 2015

*Table 29. Air temperature and precipitation compared with long-term averages, WIL site*

| Month | Mean/Normal[1] | | 2012 | | 2013 | | 2014 | | 2015 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean air temp. | Normal precip. | Mean air temp. | Total precip. | Mean air temp. | Total precip. | Mean air temp. | Total precip. | Mean air temp. | Total precip. |
| | (° C) | (mm) | (° C) | (mm) | (° C) | (mm) | (° C) | (mm) | (° C) | (mm) |
| January | -7.4 | 52 | -- | -- | -6.2 | 24 | -8.5 | 68.8 | -9.6 | 22.9 |
| February | -5.8 | 45 | -- | -- | -4.9 | 18 | -7.8 | 16.8 | -15.0 | 2.8 |
| March | -0.6 | 56 | -- | -- | 0.0 | 47 | -6.5 | 27.2 | -3.4 | 26.9 |
| April | 7.1 | 72 | -- | -- | 6.7 [3] | 79 [3] | 6.5 | 88.6 | 6.1 | 62.4 [4] |
| May | 13.5 | 88 | -- | -- | 14.4 | 245 | 13.7 | 98.8 | 16.3 | 86.1 |
| June | 18.8 | 94 | -- | -- | 17.8 | 247 | 18.8 | 113.8 | 17.2 | 196.9 |
| July | 21.4 | 106 | -- | -- | 21.9 | 159 | 20.6 | 127.0 | | |
| August | 20.4 | 99 | -- | -- | 19.3 | 84 | 19.1 | 58.9 | | |
| September | 15.8 | 92 | 13.8 | 59 | 14.5 | 140 | 15.2 | 38.6 | | |
| October | 8.9 | 91 | 10.8 | 140 | 9.7 | 57 | 10.8 | 104.4 | | |
| November | 3.4 | 80 | 1.3 | 42 | 1.4 | 40 | 2.8 | 45.2 | | |
| December | -3.4 | 60 | -1.1 [2] | 65 [2] | -5.2 | 15 | -1.8 | 35.3 | | |
| **Annual Total** | -- | 935 | -- | -- | -- | 1155 | -- | 823 | | |
| **Annual Mean** | 7.7 | -- | -- | -- | 7.5 | -- | 6.9 | -- | | |

[1] Source: NCDC 2011; 1981 – 2010 climate normals for Burlington NWS station USW00014742

[2] No data collected December 12 – December 13, 2012

[3] No data collected April 17 – April 18, 2013

[4] No data collected April 24 – April 28, 2015

# 7. RUNOFF MONITORING DATA

## 7.1. Status Overview

Calibration period monitoring began in September 2012. In August 2013, event discharge and analytical data collected through July were processed and regression analyses were performed to determine the strength of regression relationships between each watershed pair. This was done so that prior to fall 2013 harvest operations project leaders could advise the participating farms regarding the timing of conservation practice implementation. For each watershed pair, regression analyses were performed on event discharge and event mean concentrations and export of TP, TDP, TN, TDN, TSS, and chloride.

The interim statistical analyses indicated that calibration period regressions on event discharge and TP, TDP, and TSS event mean concentration and export were reasonably strong in most cases for the three cornfield sites (FRA, PAW, and WIL) and two of the three hayfield sites (FER and SHE). The regression relationships tended to be weaker for the Shoreham site, which had the fewest paired runoff events.

Based on the results of the interim statistical analyses, agronomic considerations, and the overall monitoring program schedule, project leaders made decisions regarding implementation of the conservation practices at each site. These decisions were revisited by project leaders in March 2014, considering management practices implemented in the fall of 2013 and additional monitoring data collected through January 2014. Meetings were held with each participating farmer early in 2014 to review monitoring results to date and discuss agronomic practices planned for 2014.

Fewer runoff events occurred on the study sites in 2014 than in 2013. The paucity of runoff data in 2014, combined with delays resulting from misapplication of conservation practices in two cases (Pawlet and Williston) required treatment period monitoring to be extended at all sites. Extension of the monitoring program has been made possible through a funding award from the Lake Champlain Basin Program. Monitoring at the WASCoB stations was extended to July 8, 2015, at which time the autosampler programs were stopped. All other stations are currently operating and monitoring will continue through the end of calendar year 2015. A National Institute of Food and Agriculture (NIFA) research grant secured by UVM for a complementary study will allow continued monitoring at the WIL and SHE sites for several additional years, although the practices investigated will change in 2016.

Table 30 summarizes the implementation of conservation practices at each paired site through July 2015. The current monitoring plan for each site is also described.

*Table 30. Status of conservation practice implementation and monitoring plan*

| Site | Implementation of Conservation Practices | 2015 Monitoring Plan |
|---|---|---|
| FER | Soil aeration of the treatment watershed (FER2) occurred on June 12, 2014, followed by manure application to both watersheds. This was the only aeration performed in 2014.<br>**2015**: Soil aeration on SHE1 followed by manure application to both watersheds was performed following the second hay cut and is also planned following the third cut. | Continue treatment period monitoring through December 2015. |
| FRA | In 2013, FRA1 (the treatment watershed) was aerially seeded with winter rye into the standing corn. Following corn harvest, manure was injected on the FRA1 corn strips and surface applied on FRA2. The FRA2 corn strips were then chisel plowed. This began the treatment period. In the spring of 2014, vertical tillage was performed on the corn strips in both watersheds to prepare a seedbed for planting. Following corn harvest in 2014, manure was injected on the FRA1 corn strips and surface applied on FRA2. The FRA2 corn strips were chisel plowed. Winter wheat cover crop was then drilled on FRA1.<br>**2015:** As in 2014, vertical tillage was performed on the corn strips in both watersheds to prepare a seedbed for planting. Following corn harvest in 2015, manure will be injected on the FRA1 corn strips and surface applied on FRA2. The FRA2 corn strips will be chisel plowed. Cover crop seed will be drilled in FRA1. | Continue treatment period monitoring through December 2015. |
| PAW | In 2013, winter rye cover crop seed was mistakenly seeded on both PAW1 (the treatment watershed) and PAW2 (the control watershed) following corn harvest. Establishment was very poor in both watersheds. By April 28, 2014, cover crop accounted for <1% cover in PAW1 and 2% cover in PAW2. The misapplication of the treatment precluded monitoring in the spring and summer of 2014.<br>Following corn harvest in the fall of 2014, winter rye seed was broadcast on the PAW1 watershed on September 23, 2014. Although cover crop establishment was poor (9-10%), treatment phase monitoring commenced in mid-October, 2014. However, weed cover was much higher in PAW2 (46%) than PAW 1 (6%), possibly obscuring the effect of the cover crop.<br>**2015:** After corn harvest in fall 2015, cover crop seed will be planted on PAW1 only. The intent is to drill the seed soon after the corn is harvested. | Continue treatment period monitoring through December 2015. |
| SHE | Soil aeration of the treatment watershed (SHE1) occurred on June 10, 2014, followed by manure application to both watersheds. This was the only aeration performed in 2014.<br>**2015**: Soil aeration on SHE1 followed by manure application to both watersheds was performed following the second hay cut and is also planned following the third cut. | Continue treatment period monitoring through December 2015. Monitoring to be extended beyond 2015 with UVM. |
| SHO | Soil aeration of the treatment watershed (SHO1) occurred on October 29, 2014, followed by manure application to both watersheds. This was the only aeration performed in 2014.<br>**2015**: Soil aeration on SHO1 followed by manure application to both watersheds was performed following the second hay cut and is also planned following the third cut. | Continue treatment period monitoring through December 2015. |
| WIL | Following corn harvest in 2013, manure was injected on WIL1 (the treatment watershed) and surface applied on WIL2 (the control watershed). This began the treatment period. In Spring 2014, manure was again injected on WIL1 and surface applied on WIL2; however, both watersheds were then chisel plowed, contrary to the intended reduced tillage of WIL1. No runoff events were recorded between the plowing date and November 4, 2014, when the intended management difference was reestablished.<br>**2015:** Manure was injected on WIL1 (the treatment watershed) and surface applied on WIL2 (the control watershed) in the spring of 2015. Following manure application, the WIL1 field was rolled in preparation for planting while the WIL2 field was chisel plowed and harrowed. In the fall, manure will be injected on WIL1 and surface applied on WIL2. | Continue treatment period monitoring through December 2015. Monitoring to be extended beyond 2015 with UVM. |

Monitoring at the WASCoB site was discontinued on July 8, 2015 and the stations have since been decommissioned. Because no additional data will be collected, statistical analyses of the WASCoB data are presented in this final report (see Section 7.5 and Appendix J).

Due to the paucity of runoff events in 2014 and ongoing monitoring at all stations except the WASCoB, statistical analysis of the 2014-2015 paired watershed runoff data will be performed at the conclusion of monitoring. This final report presents the same statistical summaries of 2012-2013 data published in the Year 2 Annual Report. The only additional runoff data presented are tabulated discharge and constituent concentration and load data for valid 2014 events. The event discharge and constituent event mean concentration (EMC) data are in Appendix G and the event discharge and constituent mass loading data are in Appendix H.

## 7.2. Summary of Event Mean Concentrations by Site through 2013

Summary statistics for calibration period data through 2013 are presented in Table 31 – Table 36. Table 31–Table 33 present summary statistics for event discharge ("HQ") and event mean concentrations for the hay sites and Table 34 – Table 36 present data for the corn sites. Data from events affected by icing, bypass, or non-representative sampling are not included. Also, runoff events at the Franklin and Williston sites in the fall of 2013 after initiation of the experimental treatment are not included in the statistical summaries presented here. These data will be analyzed with other treatment period data collected in 2014 and 2015.

### 7.2.1. Hay site pairs

At the FER1 station, the maximum event mean concentrations of TP (15,560 µg/L), TDP (15,140 µg/L), TN (100.6 mg/L), and $Cl^-$ (155 mg/L) were far higher than any observed at the other stations (Table 31). These EMC values were from an event on December 6, 2013, which began shortly following manure application. Manure application on the FER2 watershed was in fact cut short due to rain before spreading was finished, in part explaining the lower EMCs from FER2 compared with FER1 for this event. Relative to other events at FER1, the December 6 event also produced exceptionally high TDN and TSS values.

Despite the timing of the event and the exceptionally high TP and TDP concentrations measured, the mass of phosphorus lost in runoff during the December 6, 2013 event was only a small fraction of the P applied in manure, 2.0 percent at FER1 and 1.9 percent at FER2. Approximately 98 percent of the P applied in manure remained on the field. Total P mass transport during the December 6 event was 0.58 kg (0.32 kg/ha) from FER1 and 0.48 kg (0.16 kg/ha) from FER2. The mass of TP applied in manure was estimated as 29 kg (15.9 kg/ha) at FER1 and 25 kg (8.6 kg/ha) at FER2, calculated from the manure volume applied to the fields and a typical literature value for TP concentration in liquid dairy manure (8 lb./1000 gal. as $P_2O_5$ or 0.42 g/L as P) from the University of Vermont Extension's *Nutrient Recommendations for Field Crops in Vermont* (2004). This comparison was made with the expectation that this event should approximate "worst case" conditions for nutrient washoff and transport.

*Table 31. Event discharge and mean concentration statistics through 2013, FER site*

| FER1 | HQ (L) | TP (µg/L) | TDP (µg/L) | TN (mg/L) | TDN (mg/L) | TSS (mg/L) | Cl (mg/L) |
|---|---|---|---|---|---|---|---|
| **Range** | 0 – 764,878 | 188 – 15,560 | 144 – 15,140 | 1.1 - 100.6 | 1 - 34.1 | 15.3 - 700 | 1 - 155 |
| **Mean[1]** | 42,205 | 548 | 463 | 2.7 | 2.3 | 96.7 | 3.9 |
| **Median[1]** | 58,594 | 423 | 397 | 2.1 | 1.9 | 82.9 | 4.1 |
| **Std. Dev.[2]** | 0.8 | 0.4 | 0.5 | 0.4 | 0.4 | 0.5 | 0.6 |
| **Coef.Var.[2]** | 18.1 | 15.7 | 17.6 | 101.4 | 107.0 | 24.0 | 96.2 |
| **N** | 23 | 17 | 16 | 17 | 16 | 17 | 16 |
| **FER2** | **HQ (L)** | **TP (µg/L)** | **TDP (µg/L)** | **TN (mg/L)** | **TDN (mg/L)** | **TSS (mg/L)** | **Cl (mg/L)** |
| **Range** | 992 – 1,201,853 | 343 – 4,040 | 230 – 3,840 | 1.6 - 19.7 | 1.2 - 7.9 | 4.4 - 288.1 | 1.3 - 47.3 |
| **Mean[1]** | 46,754 | 619 | 562 | 2.5 | 2.3 | 28.8 | 11.6 |
| **Median[1]** | 49,416 | 515 | 492 | 2.3 | 2.0 | 26.5 | 15.5 |
| **Std. Dev.[2]** | 0.8 | 0.2 | 0.3 | 0.2 | 0.2 | 0.5 | 0.5 |
| **Coef.Var.[2]** | 17.1 | 8.5 | 10.6 | 56.2 | 63.0 | 32.9 | 43.4 |
| **N** | 36 | 27 | 21 | 28 | 21 | 28 | 28 |

[1] Anti-log of statistic calculated on $\log_{10}$ transformed data
[2] Calculated on $\log_{10}$ transformed data

Despite being about an acre (0.96 A or 0.39 ha) smaller, the SHE2 watershed is more prone to runoff than the SHE1 watershed; 34 events were recorded at SHE2 compared with 24 at SHE1. The small unpaired events recorded at SHE2 were generally not sampled, but their inclusion in the summary statistics (Table 32) for total event discharge lower the calculated mean and median values for SHE2 relative to SHE1.

Constituent EMCs tended to be lower for both SHE1 and SHE2 than for other study watersheds. There was no commercial fertilizer applied and only one manure application to SHE1 and SHE2 during the monitoring period, and no runoff events closely followed the manure application. Despite the low nutrient inputs on these permanent hay fields, TP event mean concentrations (mean = 249 µg/L at SHE1 and 312 µg/L at SHE2), while lower than from any other study watersheds, were nonetheless roughly an order of magnitude higher than proposed criteria for wadeable streams in Vermont (VTDEC 2014) and roughly 20-30 times higher than relevant in-lake criteria for Lake Champlain (14 µg/L for Shelburne Bay and 10 µg/L for the main lake segment; VTANR and NYSDEC 2002).

*Table 32. Event discharge and mean concentration statistics through 2013, SHE site*

| SHE1 | HQ (L) | TP (µg/L) | TDP (µg/L) | TN (mg/L) | TDN (mg/L) | TSS (mg/L) | Cl (mg/L) |
|---|---|---|---|---|---|---|---|
| **Range** | 0 – 2,156,106 | 123 - 748 | 88 - 630 | 0.8 - 12.7 | 0.7 - 2 | 3.8 - 152.2 | 0.5 - 14.9 |
| **Mean[1]** | 82,765 | 249 | 185 | 1.5 | 1.04 | 13.7 | 3.1 |
| **Median[1]** | 121,757 | 201 | 130 | 1.3 | 1.05 | 11.0 | 2.4 |
| **Std. Dev.[2]** | 0.9 | 0.2 | 0.3 | 0.3 | 0.1 | 0.3 | 0.4 |
| **Coef.Var.[2]** | 17.8 | 9.8 | 12.1 | 146.8 | 747.1 | 28.9 | 74.1 |
| **N** | 24 | 20 | 20 | 20 | 20 | 20 | 20 |
| **SHE2** | **HQ (L)** | **TP (µg/L)** | **TDP (µg/L)** | **TN (mg/L)** | **TDN (mg/L)** | **TSS (mg/L)** | **Cl (mg/L)** |
| **Range** | 1,418 – 1,984,944 | 131 - 698 | 114 - 635 | 0.9 - 2.1 | 0.7 - 1.7 | 1.8 - 20.4 | 7.1 - 29.5 |
| **Mean[1]** | 56,813 | 312 | 276 | 1.3 | 1.10 | 6.3 | 12.8 |
| **Median[1]** | 86,112 | 293 | 246 | 1.3 | 1.09 | 6.1 | 10.7 |
| **Std. Dev.[2]** | 0.8 | 0.2 | 0.2 | 0.1 | 0.1 | 0.3 | 0.2 |
| **Coef.Var.[2]** | 17.0 | 8.4 | 8.8 | 84.9 | 244.2 | 32.7 | 19.6 |
| **N** | 34 | 23 | 22 | 23 | 22 | 23 | 23 |

[1] Anti-log of statistic calculated on $\log_{10}$ transformed data
[2] Calculated on $\log_{10}$ transformed data

The SHO2 watershed is less than half the size of the SHO1 watershed and has produced fewer runoff events. Many runoff events at SHO1 were not paired and were therefore not sampled. Total and dissolved P and N concentrations tended to be lower at SHO2 than SHO1, while TSS concentrations were higher (Table 33).

*Table 33. Event discharge and mean concentration statistics through 2013, SHO site*

| SHO1 | HQ (L) | TP (µg/L) | TDP (µg/L) | TN (mg/L) | TDN (mg/L) | TSS (mg/L) | Cl (mg/L) |
|---|---|---|---|---|---|---|---|
| **Range** | 395 – 561,791 | 168 – 1,698 | 167 – 1,780 | 1.7 - 5.1 | 0.9 - 5 | 6.9 - 77.5 | 1.7 - 21.1 |
| **Mean[1]** | 39,519 | 419 | 397 | 2.6 | 2.2 | 18.7 | 4.2 |
| **Median[1]** | 57,132 | 283 | 254 | 2.5 | 2.4 | 17.4 | 3.3 |
| **Std. Dev.[2]** | 0.9 | 0.4 | 0.4 | 0.2 | 0.2 | 0.3 | 0.4 |
| **Coef.Var.[2]** | 19.3 | 15.5 | 15.8 | 37.9 | 72.6 | 25.6 | 60.4 |
| **N** | 24 | 8 | 8 | 8 | 8 | 8 | 8 |
| **SHO2** | **HQ (L)** | **TP (µg/L)** | **TDP (µg/L)** | **TN (mg/L)** | **TDN (mg/L)** | **TSS (mg/L)** | **Cl (mg/L)** |
| **Range** | 0 – 82,244 | 214 - 829 | 198 - 695 | 1.4 - 2.5 | 0.7 - 2.5 | 21.3 - 62.5 | 1.4 - 6.2 |
| **Mean[1]** | 12,331 | 324 | 295 | 2.0 | 1.7 | 27.5 | 2.7 |
| **Median[1]** | 34,799 | 258 | 250 | 2.1 | 1.8 | 24.9 | 2.0 |
| **Std. Dev.[2]** | 0.9 | 0.2 | 0.2 | 0.1 | 0.2 | 0.1 | 0.2 |
| **Coef.Var.[2]** | 21.3 | 9.5 | 8.1 | 31.8 | 78.0 | 10.3 | 58.3 |
| **N** | 11 | 8 | 8 | 8 | 8 | 8 | 8 |

[1] Anti-log of statistic calculated on $\log_{10}$ transformed data
[2] Calculated on $\log_{10}$ transformed data

### 7.2.2. Corn site pairs

Table 34-36 present summary statistics for calibration period runoff events from corn sites that occurred between September 2012 and December 2013. These tables do not include events at the Franklin and Williston sites that occurred after conservation practices were implemented (i.e., after fall manure applications).

Under conventional management, the FRA1 watershed was more prone to runoff than the FRA2 watershed; 20 events were recorded at FRA1 compared with 14 at FRA2 during the calibration period. The small unpaired events recorded at FRA1 were generally not sampled, but their inclusion in the summary statistics (Table 34) for total event discharge lowers the calculated mean and median values for FRA1 relative to FRA2. Both FRA1 and FRA2 yielded relatively high event mean concentrations of total and dissolved P and N. Nitrogen concentrations have been especially high, which is discussed further in Section 7.4.

*Table 34. Event discharge and mean concentration statistics through October 11, 2013, FRA site*

| FRA1 | HQ (L) | TP (µg/L) | TDP (µg/L) | TN (mg/L) | TDN (mg/L) | TSS (mg/L) | Cl (mg/L) |
|---|---|---|---|---|---|---|---|
| Range | 31 – 1,437,397 | 195 – 2,080 | 154 - 853 | 2.1 - 20.4 | 1.4 - 19.3 | 12.2 – 2,398 | 2.5 - 34.2 |
| Mean[1] | 80,781 | 594 | 369 | 5.7 | 4.5 | 58.1 | 11.4 |
| Median[1] | 134,134 | 585 | 417 | 4.3 | 2.9 | 34.7 | 11.5 |
| Std. Dev.[2] | 1.1 | 0.3 | 0.3 | 0.4 | 0.4 | 0.7 | 0.4 |
| Coef.Var.[2] | 21.5 | 11.2 | 10.2 | 46.9 | 61.0 | 38.3 | 34.8 |
| N | 20 | 11 | 11 | 11 | 11 | 11 | 11 |
| **FRA2** | **HQ (L)** | **TP (µg/L)** | **TDP (µg/L)** | **TN (mg/L)** | **TDN (mg/L)** | **TSS (mg/L)** | **Cl (mg/L)** |
| Range | 0 – 1,374,919 | 230 – 1,910 | 173 - 870 | 2.2 - 26.6 | 1.4 - 26.6 | 8.8 – 1,414 | 2.8 - 42.5 |
| Mean[1] | 176,708 | 606 | 404 | 6.1 | 4.7 | 48.3 | 10.4 |
| Median[1] | 207,884 | 620 | 485 | 5.0 | 3.3 | 30.4 | 7.8 |
| Std. Dev.[2] | 0.6 | 0.3 | 0.2 | 0.4 | 0.4 | 0.7 | 0.4 |
| Coef.Var.[2] | 11.2 | 10.6 | 8.9 | 47.5 | 65.3 | 39.9 | 36.4 |
| N | 14 | 9 | 9 | 9 | 9 | 9 | 9 |

[1] Anti-log of statistic calculated on $\log_{10}$ transformed data

[2] Calculated on $\log_{10}$ transformed data

The Pawlet study watersheds have produced more runoff events than any other study watersheds. PAW1 (6.0 A, 2.6 ha) is medium-sized compared with other study watersheds and PAW2 (3.1 A, 1.4 ha) is among the smallest, yet they appear to be the most prone to runoff off all the watersheds. Total and dissolved P and N EMCs have been highly variable and have occasionally been quite high (maximum of 2,280 µg/L P at PAW1 and 1.555 µg/L P at PAW2; Table 35). However, the more exceptional results from the Pawlet watersheds have been the exceedingly high total suspended solids concentrations measured during certain events (maximum TSS EMCs were 4,428 mg/L for PAW1 and 1,850 mg/L for PAW2).

*Table 35. Event discharge and mean concentration statistics through 2013, PAW site*

| PAW1 | HQ (L) | TP (µg/L) | TDP (µg/L) | TN (mg/L) | TDN (mg/L) | TSS (mg/L) | Cl (mg/L) |
|---|---|---|---|---|---|---|---|
| **Range** | 0 – 818,197 | 68 – 2,280 | 9 - 734 | 0.9 - 34.1 | 0.6 - 36.5 | 3.7 – 4,428 | 1.4 - 43.5 |
| **Mean[1]** | 76,466 | 382 | 87 | 3.3 | 2.0 | 125.6 | 9.7 |
| **Median[1]** | 126,151 | 390 | 67 | 3.1 | 1.6 | 140.0 | 10.2 |
| **Std. Dev.[2]** | 0.8 | 0.5 | 0.5 | 0.4 | 0.4 | 0.8 | 0.3 |
| **Coef.Var.[2]** | 15.6 | 17.6 | 23.3 | 75.5 | 144.5 | 38.4 | 33.4 |
| **N** | 40 | 29 | 29 | 29 | 29 | 29 | 28 |
| **PAW2** | **HQ (L)** | **TP (µg/L)** | **TDP (µg/L)** | **TN (mg/L)** | **TDN (mg/L)** | **TSS (mg/L)** | **Cl (mg/L)** |
| **Range** | 350 – 370,825 | 72 – 1,555 | 16 - 974 | 0.6 – 31 | 0.3 - 22.1 | 7.9 – 1,850 | 2.2 - 43.7 |
| **Mean[1]** | 32,153 | 323 | 78 | 2.3 | 1.3 | 89.8 | 7.8 |
| **Median[1]** | 47,616 | 332 | 60 | 2.1 | 0.9 | 90.2 | 7.9 |
| **Std. Dev.[2]** | 0.7 | 0.4 | 0.5 | 0.4 | 0.5 | 0.7 | 0.4 |
| **Coef.Var.[2]** | 16.1 | 15.2 | 28.1 | 110.7 | 400.2 | 35.2 | 39.3 |
| **N** | 45 | 33 | 32 | 33 | 32 | 33 | 32 |

[1] Anti-log of statistic calculated on $\log_{10}$ transformed data
[2] Calculated on $\log_{10}$ transformed data

Both WIL1 and WIL2 have tended to produce runoff with high concentrations of total phosphorus. For the calibration period, the mean of the WIL2 EMC exceeded 1,100 µg P/L (Table 36). The highest TP EMC measured at WIL2 was 3,300 µg/L. TDP EMCs from WIL2 have also been very high.

*Table 36. Event discharge and mean concentration statistics through November 10, 2013, WIL site*

| WIL1 | HQ (L) | TP (µg/L) | TDP (µg/L) | TN (mg/L) | TDN (mg/L) | TSS (mg/L) | Cl (mg/L) |
|---|---|---|---|---|---|---|---|
| **Range** | 0 – 520,034 | 295 – 1,558 | 180 - 575 | 1.4 - 6 | 0.7 - 6.4 | 7.7 - 596 | 0.7 - 3.6 |
| **Mean[1]** | 17,324 | 624 | 295 | 2.4 | 1.8 | 69.4 | 1.8 |
| **Median[1]** | 16,291 | 652 | 278 | 2.0 | 1.5 | 60.0 | 1.9 |
| **Std. Dev.[2]** | 0.8 | 0.2 | 0.1 | 0.2 | 0.3 | 0.6 | 0.2 |
| **Coef.Var.[2]** | 19.7 | 6.5 | 5.6 | 50.1 | 106.7 | 30.3 | 78.2 |
| **N** | 18 | 15 | 15 | 15 | 15 | 15 | 15 |
| **WIL2** | **HQ (L)** | **TP (µg/L)** | **TDP (µg/L)** | **TN (mg/L)** | **TDN (mg/L)** | **TSS (mg/L)** | **Cl (mg/L)** |
| **Range** | 1724 – 233,489 | 429 – 3,300 | 222 – 2,780 | 1.1 - 6.4 | 0.4 - 5.4 | 16.2 – 1,383.5 | 0.7 - 6.8 |
| **Mean[1]** | 12,029 | 1,126 | 564 | 2.5 | 1.2 | 145.9 | 1.8 |
| **Median[1]** | 9,898 | 1,293 | 545 | 2.3 | 1.1 | 166.3 | 1.4 |
| **Std. Dev.[2]** | 0.6 | 0.3 | 0.3 | 0.2 | 0.3 | 0.6 | 0.3 |
| **Coef.Var.[2]** | 15.3 | 8.7 | 10.6 | 57.4 | 324.0 | 25.8 | 128.4 |
| **N** | 23 | 20 | 20 | 20 | 20 | 20 | 20 |

[1] Anti-log of statistic calculated on $\log_{10}$ transformed data
[2] Calculated on $\log_{10}$ transformed data

## 7.3. Comparison of EMCs across Paired Watersheds through 2013

Figure 62 through Figure 70 show boxplots comparing the distributions of EMCs of the monitored constituents among the study watersheds for calibration period events through 2013. In the box plots, the horizontal line within each box represents the median group value and the lower and upper ends of the box represent the 25th and 75th quartiles, respectively. The whiskers extend downward from the end of the box to a level representing [1st quartile – 1.5*(interquartile range)] and upward to the level of [3rd quartile + 1.5*(interquartile range)]. Outliers not falling within + 1.5 times the interquartile range are plotted as points. The horizontal line in each figure is the grand mean EMC across all sites.

The WIL and FRA sites (both corn) tend to have the highest TP EMCs, whereas PAW (corn) and SHE (continuous hay) tend to have the lowest (Figure 62). TP concentrations have been most variable at PAW and least variable at FER and SHE (both hay). PAW and SHE have generally shown the lowest TDP concentrations, and WIL and FER the highest (Figure 63).

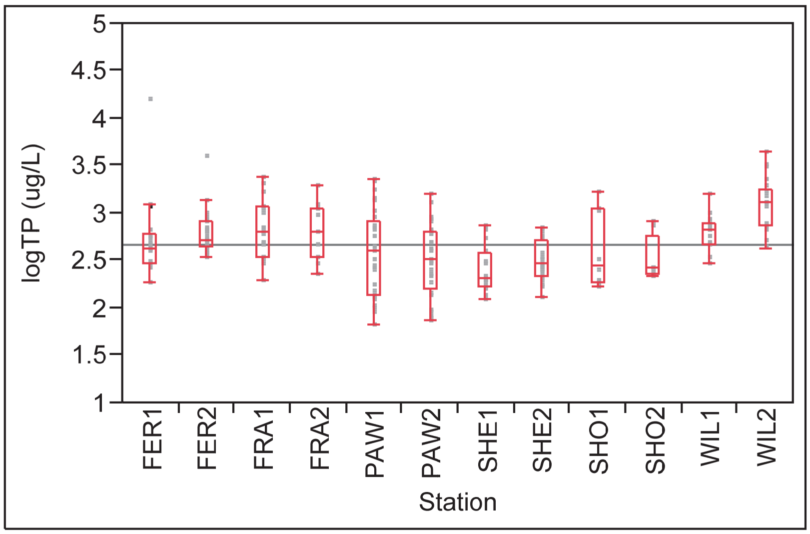



*Figure 62. Distributions of total P EMCs for 2012-2013, by site*

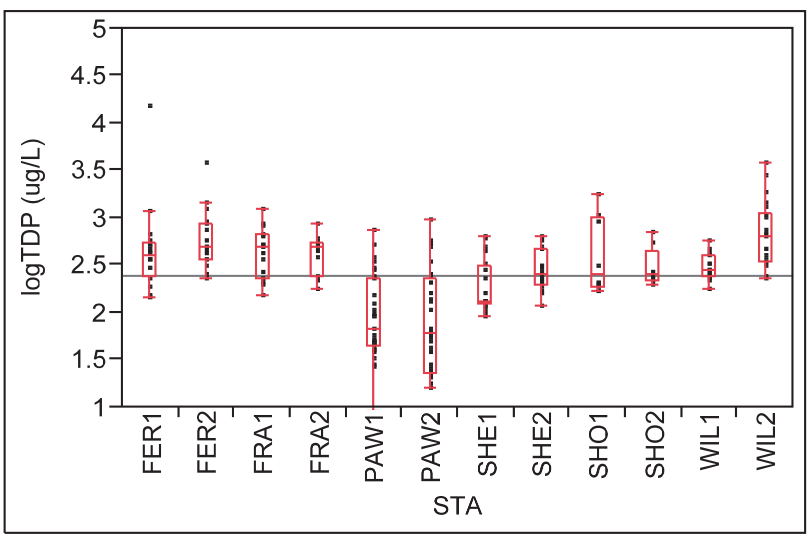



*Figure 63. Distributions of total dissolved P EMCs through 2013, by site*

Event mean concentrations of TP and TDP are clearly positively correlated with soil phosphorus levels among the study watersheds. Composite soil samples were collected from the study watersheds between October and December 2012 and were analyzed by both USDA ARS Grassland Soil and Water Research Laboratory (Temple, TX) and the UVM Agricultural and Environmental Testing Laboratory. USDA ARS reported nutrient mass in each field in pounds per acre; these results were presented in the Year 1 report. Through December 2013, there was a reasonably strong relationship between the soil nutrient mass data calculated by USDA ARS and event mean concentrations of TP in runoff. Both total P and inorganic P in soil were positively associated with median TP EMCs in runoff, with $R^2$ values of 0.79 and 0.82, respectively (Figure 64). Surprisingly, total and inorganic P levels in soil explained less of the observed variance in median TDP EMCs ($R^2 = 0.33$ for total soil P and $R^2 = 0.35$ for inorganic soil P).

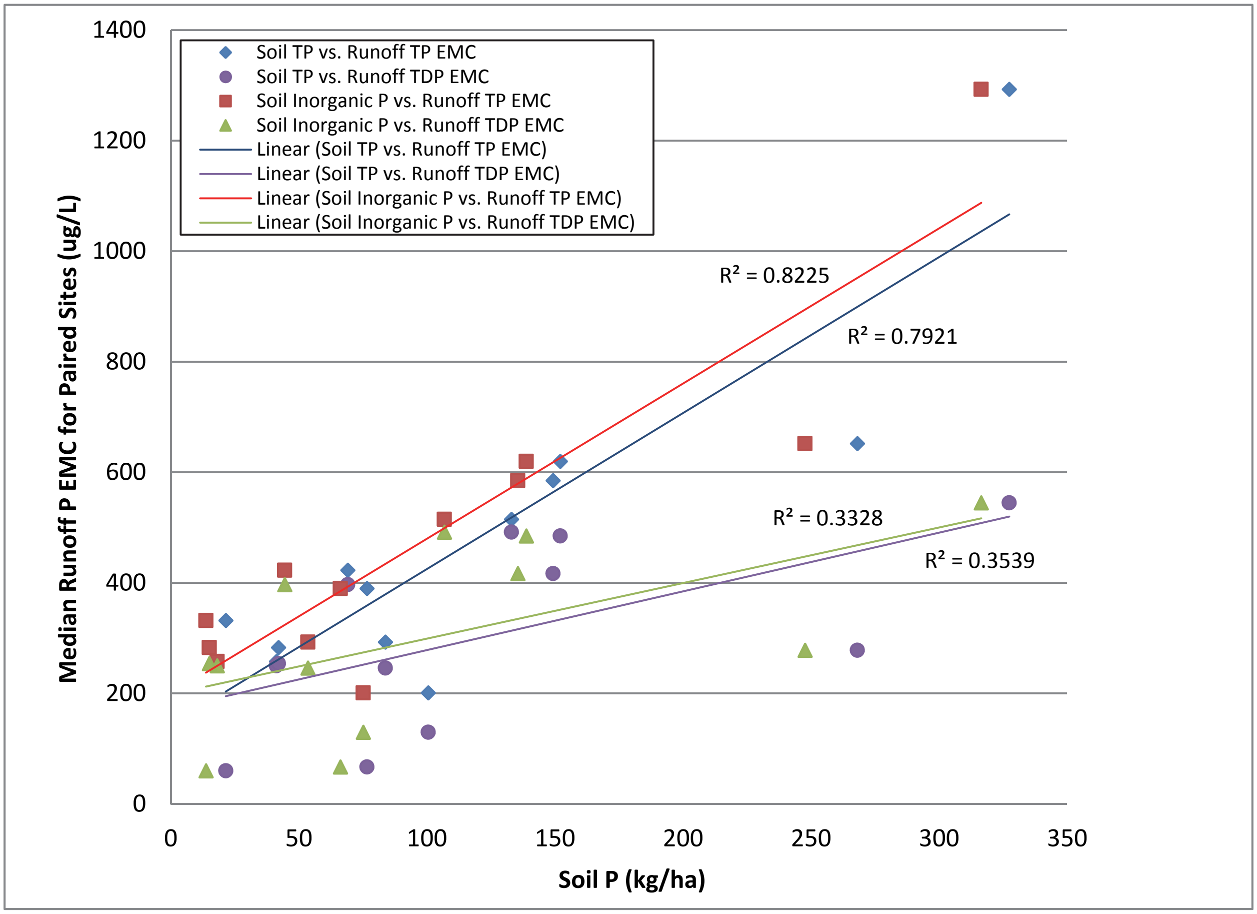



*Figure 64. Relationships between soil P[1] and median P EMCs[2] in runoff from study watersheds*

*1. Soil P values based on analyses conducted by USDA ARS Grassland Soil and Water Research Laboratory (Temple, TX) of watershed composite soil samples collected from Oct. – Dec., 2012 (See Year 1 Report)*

*2. Median TP and TDP concentrations in runoff calculated as the anti-log of the median of log10 transformed EMCs for each station through January 2014 (see Table 31-Table 36)*

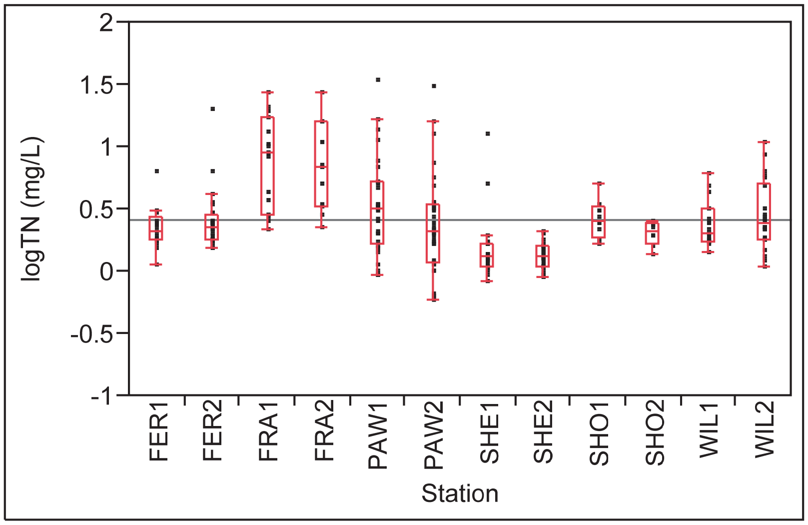



*Figure 65. Distributions of total N EMCs through 2013, by site*

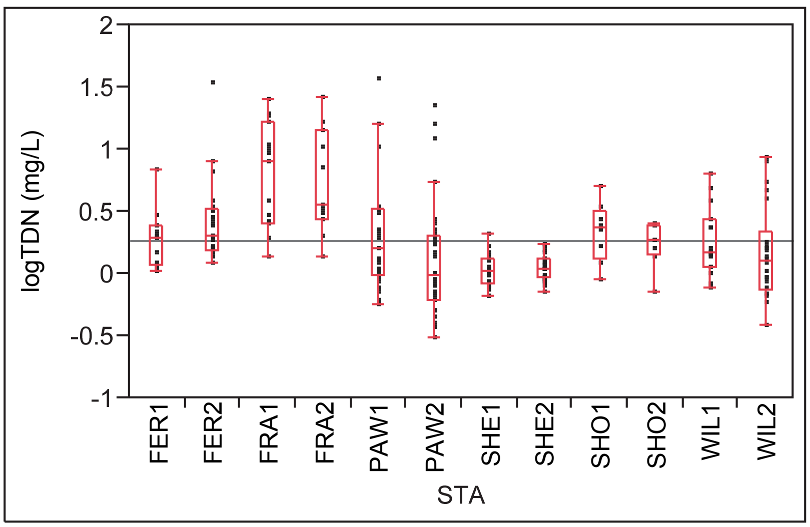



*Figure 66. Distributions of total dissolved N EMCs through 2013, by site*

The FRA and PAW sites (both corn) have shown the highest TN and TDN EMCs, with N levels at FRA being highly variable (Figure 65 and Figure 66). N concentrations at SHE (permanent hay) have generally been the lowest and least variable among the monitored fields. The high N concentrations in runoff from the FRA1 and FRA2 watersheds may reflect high inputs; in both 2012 and 2013, the application rates of commercial nitrogen fertilizer at the FRA site were far higher than in the other study watersheds. A preliminary comparison of TN and TDN concentrations in runoff with total and inorganic soil N levels calculated by USDA ARS demonstrated only very weak relationships.

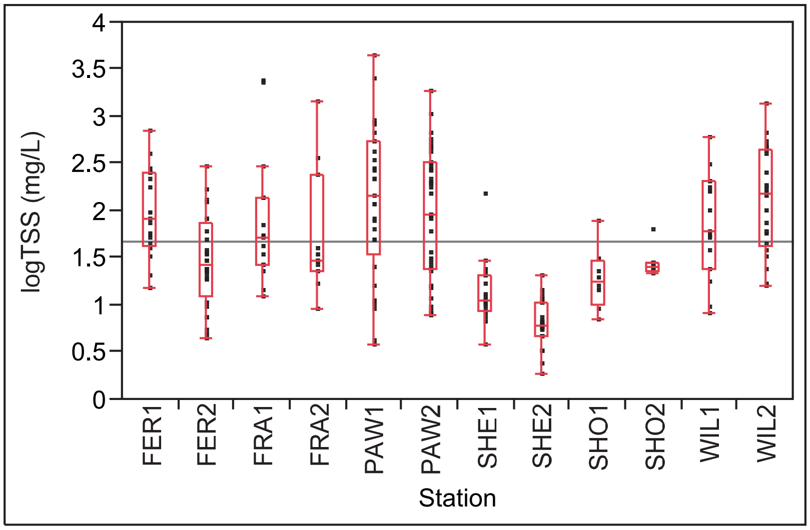



*Figure 67. Distributions of TSS EMCs through 2013*

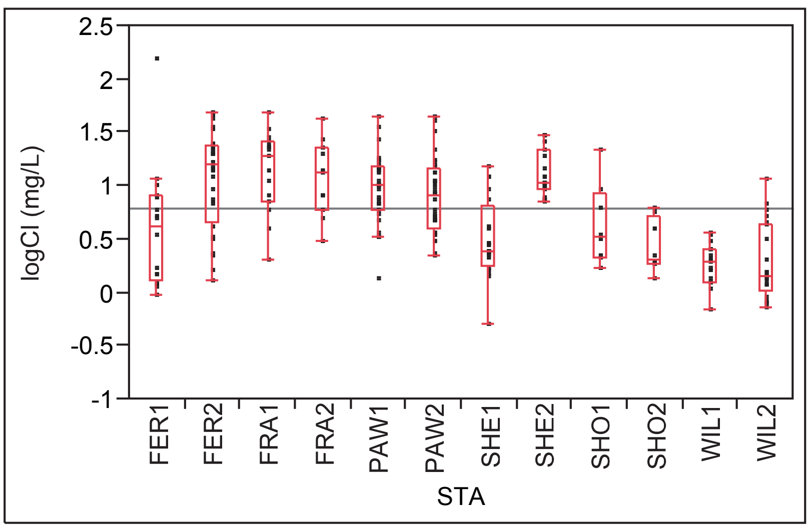



*Figure 68. Distributions of chloride EMCs through 2013*

PAW, WIL and FRA (all corn) have generally recorded the highest and most variable TSS EMCs (Figure 67). TSS concentrations have been lowest and least variable at SHE and SHO, suggesting markedly lower erosion rates on these permanent hay fields.

Figure 68 illustrates the distributions of event mean chloride concentrations by station. FRA (corn), PAW (corn), and FER2 (hay) have produced the highest chloride concentrations; chloride concentrations have tended to be lowest at WIL (corn) and SHO (hay).

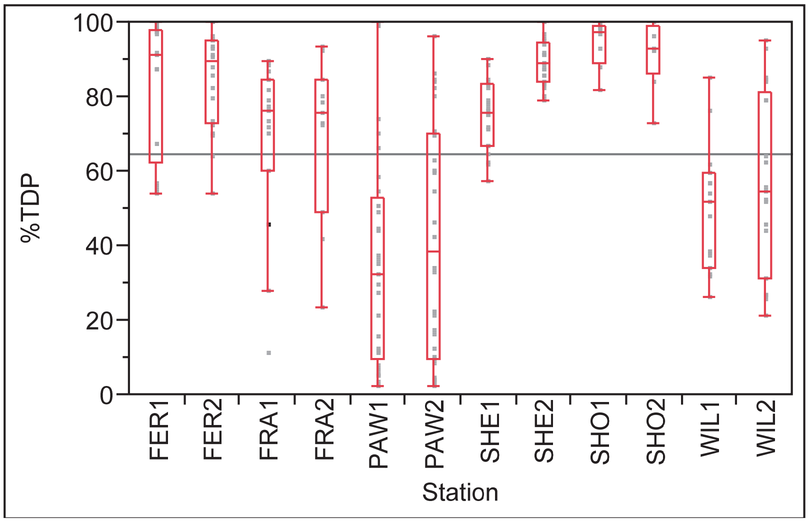



*Figure 69. Percent of total phosphorus as dissolved through 2013*

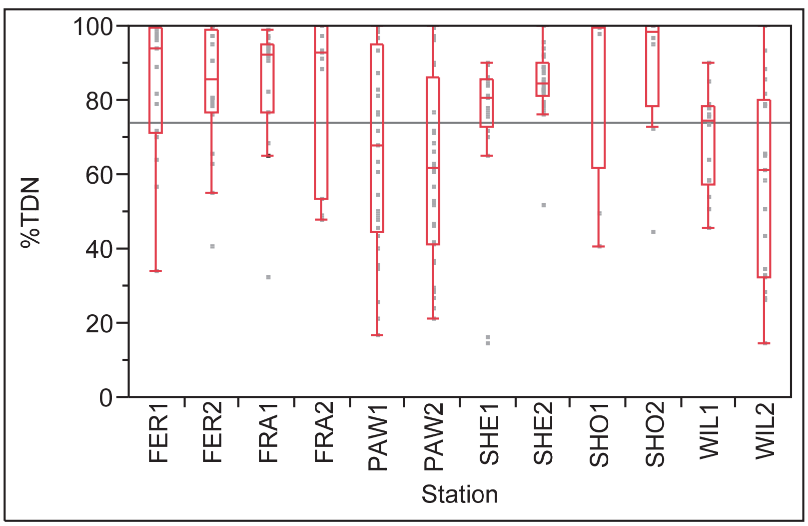



*Figure 70. Percent of total nitrogen as dissolved through 2013*

On the average across all monitored stations, about 65 percent of TP has occurred as TDP (Figure 69). However, there have been strong differences among the stations. Although they have occasionally exhibited high proportions of TDP, PAW and WIL (both corn) have generally shown the lowest percentage of dissolved P, with PAW averaging 50 percent or lower dissolved P and sometimes less than 10 percent. On the other hand, FER, SHE, and SHO (all hay) have tended to have the highest proportion of dissolved P, with TDP comprising almost 100 percent of TP on some events. Finding the highest proportion of dissolved P in runoff from the hayland sites (FER, SHE, and SHO) and the lowest and most variable from the corn sites (PAW and WIL) is not surprising given the low erosion potential from hayland.

On average, nearly 75 percent of TN measured at the paired watershed monitoring stations occurred as TDN (Figure 70). All stations except SHE1 and WIL1 expressed 100 percent of TN in the dissolved form at times. Variability was highest at PAW, WIL, and FRA sites, consistent with the greater erosion potential from these corn fields.

## 7.4. Calibration Period Regression Analysis Results through 2013

The data set used for the primary statistical analyses includes total event discharge (Q), event mean concentration (TP, TDP, TN, TDN, TSS, and Cl), and total event load (TPx, TDPx, TNx, TDNx, TSSx, and Clx) for each event at each monitored location. Because significant regression relationships between variables measured at the control and treatment watershed pairs during the pre-treatment (calibration) period are fundamental requirements of the paired watershed analysis, these regression relationships were re-evaluated with all the calibration period data through 2013. All regression models were calculated using $\log_{10}$ transformed data. Table 37 through Table 42 present calibration period regression equations and statistics for each watershed pair at each study site. Note that pre-treatment (calibration period) events which occurred in

2014 at the Shoreham, Ferrisburgh, and Shelburne sites may be added to the regression models in the final analyses.

Calibration regressions in Table 37 through Table 42 for all monitored variables between watershed pairs are statistically significant at $P < 0.10$ with the exception of the TDP and TDN concentration at the Williston site. Because the relationships between the two watersheds for TDP and TDN at the WIL site are not significant, it will not be possible to assess the effect of implementing the conservation practice at this site on these dissolved constituents. For all other constituent/site combinations, the calibration regressions provide a significant basis for comparing the effects of treatment as long as the changes are large enough to be detected within the error of the regression relationships.

In Table 37-Table 42, the regression equation describes the line that best fits the paired, log-transformed data points (by the sum of least squares regression method). The coefficient of determination, $r^2$, is a statistic representing the goodness of fit of the regression model. $R^2$ values range from 0 to 1, with higher values indicating better model fit to the data (i.e., less unexplained variance). The adjusted $R^2$ statistic adjusts the $R^2$ based on the number of terms in the regression model and the sample size; it is therefore a more comparable statistic than $R^2$ in many regression applications. The F ratio tests the null hypothesis that all of the regression coefficients (the intercept and slope terms in the equation) are equal to zero. The F ratio is the ratio of the mean regression sum of squares divided by the mean error sum of squares. In Table 37-Table 42, the value of Prob>F is the probability that the regression model's intercept and slope terms are zero. For example, a Prob>F value of <0.01 means that there is less than a one percent chance that both the slope and intercept are zero, indicating that the equation is valid (i.e., the independent variable is not purely random with respect to the dependent variable).

### 7.4.1. Ferrisburgh site (hay)

Regression equations for all variables were statistically significant, with $R^2$ values in the 0.6 – 0.9 range, except for chloride export (Clx) with $R^2 = 0.42$ (still significant at $P < 0.005$) (Table 37). Observed data occurred over two to three orders of magnitude, suggesting a reasonable likelihood that the range of treatment period data will overlap that of the calibration period, a feature that is required for useful interpretation of treatment effects. Discharge and concentration and export of most constituents did not differ significantly between FER1 and FER2 (statistics included in Appendix I); mean TSS concentration at FER1 was significantly higher than at FER2 and mean chloride concentration and export were higher at FER2 than at FER1. Finally, it should be noted that the regressions for P and N concentration are highly leveraged by a single outlier (representing the runoff event that occurred immediately after a manure application). Additional calibration period events that occurred in the spring of 2014 prior to aeration of the FER2 field will be added to the regression models presented in the final report to the Lake Champlain Basin Program.

*Table 37. Calibration period linear regression statistics, FER site*

| Variable | Symbol | Equation | $R^2$ adj. | F Ratio | *Prob > F* |
|---|---|---|---|---|---|
| Event Discharge | Q | log(FER2 Q) = 0.536 log(FER1 Q) + 2.81 | 0.75 | 55.0 | <0.001 |
| TP Concentration (µg /L) | [TP] | log(FER2 TP) = 0.604 log(FER1 TP) + 1.13 | 0.87 | 99.7 | <0.001 |
| TDP Concentration (µg/L) | [TDP] | log(FER2 TDP) = 0.593 log(FER1 TDP) + 1.14 | 0.78 | 49.8 | <0.001 |
| TN Concentration (mg/L) | [TN] | log(FER2 TN) = 0.553 log (FER1 TN) + 0.230 | 0.82 | 67.7 | <0.001 |
| TDN Concentration (mg/L) | [TDN] | log(FER2 TDN) = 0.523 log(FER1 TDN) + 0.205 | 0.67 | 29.6 | <0.001 |
| TSS Concentration (mg/L) | [TSS] | log(FER2 TSS) = 0.577 log(FER1 TSS) + 0.513 | 0.61 | 24.2 | <0.001 |
| Cl Concentration (mg/L) | [Cl] | log(FER2 Cl) = 0.764 log(FER1 Cl) + 0.372 | 0.82 | 62.9 | <0.001 |
| TP Export (g) | TPx | log(FER2 TPx) = 0.570 log(FER1 TPx) + 1.27 | 0.86 | 95.6 | <0.001 |
| TDP Export (g) | TDPx | log(FER2 TDPx) = 0.621 log(FER1 TDPx) + 1.15 | 0.84 | 72.3 | <0.001 |
| TN Export (g) | TNx | log(FER2 TNx) = 0.518 log(FER1 TNx) + 1.66 | 0.75 | 45.3 | <0.001 |
| TDN Export (g) | TDNx | log(FER2 TDNx) = 0.516 log(FER1 TDNx) + 1.62 | 0.59 | 21.53 | <0.001 |
| TSS Export (g) | TSSx | log(FER2 TSSx) = 0.671 log(FER1 TSSx) + 1.49 | 0.82 | 71.6 | <0.001 |
| Cl Export (g) | Clx | log(FER2 Clx) = 0.540 log(FER1 Clx) + 1.88 | 0.42 | 11.1 | 0.005 |

### 7.4.2. Franklin site (corn)

Regression equations for all variables were highly significant, with $R^2$ values greater than 0.85 for all variables (Table 38). Observed P and N concentrations occurred over a one to two order of magnitude range; it is possible that dramatically different conditions in the treatment period (e.g., much larger or smaller runoff volumes) may generate data in a different range, potentially making interpretation of change difficult. No significant differences in discharge, concentration, or export between the FRA1 and FRA2 watersheds were observed.

*Table 38. Calibration period linear regression statistics, FRA site*

| Variable | Symbol | Equation | $R^2$ adj. | F Ratio | *Prob > F* |
|---|---|---|---|---|---|
| Event Discharge | Q | log(FRA2 Q) = 1.21 log(FRA1 Q) – 1.26 | 0.98 | 528.9 | <0.001 |
| TP Concentration (µg /L) | [TP] | log(FRA2 TP) = 0.910 log(FRA1 TP) + 0.262 | 0.98 | 399.4 | <0.001 |
| TDP Concentration (µg/L) | [TDP] | log(FRA2 TDP) = 0.830 log(FRA1 TDP) + 0.493 | 0.85 | 47.9 | <0.001 |
| TN Concentration (mg/L) | [TN] | log(FRA2 TN) = 0.929 log (FRA1 TN) + 0.090 | 0.88 | 59.5 | <0.001 |
| TDN Concentration (mg/L) | [TDN] | log(FRA2 TDN) = 1.05 log(FRA1 TDN) + 0.002 | 0.99 | 538.0 | <0.001 |
| TSS Concentration (mg/L) | [TSS] | log(FRA2 TSS) = 0.906 log(FRA1 TSS) + 0.086 | 0.98 | 383.2 | <0.001 |
| Cl Concentration (mg/L) | [Cl] | log(FRA2 Cl) = 0.932 log(FRA1 Cl) + 0.128 | 0.98 | 321.7 | <0.001 |
| TP Export (g) | TPx | log(FRA2 TPx) = 1.11 log(FRA1 TPx) – 0.383 | 0.97 | 235.4 | <0.001 |
| TDP Export (g) | TDPx | log(FRA2 TDPx) = 1.11 log(FRA1 TDPx) – 0.326 | 0.95 | 157.8 | <0.001 |
| TN Export (g) | TNx | log(FRA2 TNx) = 1.09 log(FRA1 TNx) – 0.397 | 0.93 | 104.6 | <0.001 |
| TDN Export (g) | TDNx | log(FRA2 TDNx) = 1.16 log(FRA1 TDNx) – 0.631 | 0.97 | 265.2 | <0.001 |
| TSS Export (g) | TSSx | log(FRA2 TSSx) = 1.04 log(FRA1 TSSx) – 0.418 | 0.96 | 185.0 | <0.001 |
| Cl Export (g) | Clx | log(FRA2 Clx) = 1.19 log(FRA1 Clx) – 0.775 | 0.98 | 332.9 | <0.001 |

### 7.4.3. Pawlet site (corn)

Calibration between PAW1 and PAW2 appears to be very strong for all monitored variables (Table 39). Values of $R^2$ are in the 0.60 – 0.90 range. This site has the highest number of monitored events among the study sites. Data were recorded over 3 – 4 orders of magnitude, suggesting a strong likelihood that the ranges recorded during the treatment period will overlap those of the calibration period. Although not statistically significant for all constituents, there is a tendency for discharge, concentration, and export to be higher from PAW1 than from PAW2 (data not shown). Because there would be a greater chance of showing significant change at high concentrations, PAW1 was selected as the treatment watershed.

*Table 39. Calibration period linear regression statistics, PAW site*

| Variable | Symbol | Equation | $R^2$ adj. | F Ratio | *Prob > F* |
|---|---|---|---|---|---|
| Event Discharge | Q | log(PAW2 Q) = 0.720 log(PAW1 Q) + 1.09 | 0.72 | 103.5 | <0.001 |
| TP Concentration (µg /L) | [TP] | log(PAW2 TP) = 0.667 log(PAW1 TP) + 0.746 | 0.61 | 43.0 | <0.001 |
| TDP Concentration (µg/L) | [TDP] | log(PAW2 TDP) = 0.923 log(PAW1 TDP) + 0.076 | 0.67 | 55.0 | <0.001 |
| TN Concentration (mg/L) | [TN] | log(PAW2 TN) = 0.829 log (PAW1 TN) – 0.108 | 0.75 | 79.7 | <0.001 |
| TDN Concentration (mg/L) | [TDN] | log(PAW2 TDN) = 0.839 log(PAW1 TDN) – 0.168 | 0.71 | 67.9 | <0.001 |
| TSS Concentration (mg/L) | [TSS] | log(PAW2 TSS) = 0.693 log(PAW1 TSS) + 0.434 | 0.62 | 45.2 | <0.001 |
| Cl Concentration (mg/L) | [Cl] | log(PAW2 Cl) = 0.920 log(PAW1 Cl) – 0.011 | 0.83 | 125.8 | <0.001 |
| TP Export (g) | TPx | log(PAW2 TPx) = 0.640 log(PAW1 TPx) + 0.149 | 0.88 | 199.1 | <0.001 |
| TDP Export (g) | TDPx | log(PAW2 TDPx) = 0.737 log(PAW1 TDPx) – 0.135 | 0.82 | 120.6 | <0.001 |
| TN Export (g) | TNx | log(PAW2 TNx) = 0.750 log(PAW1 TNx) + 0.125 | 0.84 | 137.8 | <0.001 |
| TDN Export (g) | TDNx | log(PAW2 TDNx) = 0.786 log(PAW1 TDNx) – 0.033 | 0.78 | 97.6 | <0.001 |
| TSS Export (g) | TSSx | log(PAW2 TSSx) = 0.656 log(PAW1 TSSx) + 0.891 | 0.77 | 90.0 | <0.001 |
| Cl Export (g) | Clx | log(PAW2 Clx) = 0.705 log(PAW1 Clx) + 0.475 | 0.81 | 108.7 | <0.001 |

### 7.4.4. Shelburne site (hay)

Calibration between SHE1 and SHE2 is not universally strong, but still statistically significant for all measured variables (Table 40). Values of $R^2$ are in the 0.20 – 0.80 range. Concentration data were recorded over a fairly narrow range, raising some potential concern over comparability to treatment period data if field conditions (i.e., events closely following manure application) are very different from those of the calibration period. Differences in monitored variables between SHE1 and SHE2 were inconsistent. Mean TDP concentration and mean Cl concentration and load were significantly higher from SHE2 than from SHE1 (data not shown) but mean TSS concentration was higher from SHE1 than SHE2. The two watersheds behaved comparably for other constituents. Selection of SHE1 as the treatment watershed was made based on agronomic considerations. Additional calibration period events which occurred in the spring of 2014 prior to aeration of the SHE1 field will be added to the regression models presented in the final report to the Lake Champlain Basin Program.

*Table 40. Calibration period linear regression statistics, SHE site*

| Variable | Symbol | Equation | $R^2$ adj. | F Ratio | *Prob > F* |
|---|---|---|---|---|---|
| Event Discharge | Q | log(SHE2 Q) = 0.596 log(SHE1 Q) + 2.21 | 0.83 | 110.8 | <0.001 |
| TP Concentration (µg /L) | [TP] | log(SHE2 TP) = 0.740 log(SHE1 TP) + 0.683 | 0.82 | 88.0 | <0.001 |
| TDP Concentration (µg/L) | [TDP] | log(SHE2 TDP) = 0.617 log(SHE1 TDP) + 1.01 | 0.77 | 64.3 | <0.001 |
| TN Concentration (mg/L) | [TN] | log(SHE2 TN) = 0.165 log (SHE1 TN) + 0.068 | 0.22 | 6.3 | 0.022 |
| TDN Concentration (mg/L) | [TDN] | log(SHE2 TDN) = 0.503 log(SHE1 TDN) + 0.016 | 0.49 | 19.3 | <0.001 |
| TSS Concentration (mg/L) | [TSS] | log(SHE2 TSS) = 0.328 log(SHE1 TSS) + 0.403 | 0.16 | 4.6 | 0.047 |
| Cl Concentration (mg/L) | [Cl] | log(SHE2 Cl) = 0.466 log(SHE1 Cl) + 0.880 | 0.59 | 28.0 | <0.001 |
| TP Export (g) | TPx | log(SHE2 TPx) = 0.595 log(SHE1 TPx) + 0.836 | 0.74 | 54.9 | <0.001 |
| TDP Export (g) | TDPx | log(SHE2 TDPx) = 0.614 log(SHE1 TDPx) + 0.839 | 0.75 | 57.6 | <0.001 |
| TN Export (g) | TNx | log(SHE2 TNx) = 0.538 log(SHE1 TNx) + 1.13 | 0.67 | 39.1 | <0.001 |
| TDN Export (g) | TDNx | log(SHE2 TDNx) = 0.589 log(SHE1 TDNx) + 1.05 | 0.78 | 67.2 | <0.001 |
| TSS Export (g) | TSSx | log(SHE2 TSSx) = 0.576 log(SHE1 TSSx) + 1.18 | 0.67 | 39.1 | <0.001 |
| Cl Export (g) | Clx | log(SHE2 Clx) = 0.480 log(SHE1 Clx) + 2.12 | 0.60 | 29.0 | <0.001 |

### 7.4.5. Shoreham site (hay)

Most calibration regressions between SHO1 and SHO2 were strong; all relationships were statistically significant (Table 41). Values of $R^2$ ranged from 0.35 to 0.98. However, data were recorded over a fairly narrow range, generally less than two orders of magnitude; N concentrations were in a particularly narrow range. Calibration period monitoring was continued into 2014 with the goal of extending the range and improving some of the regressions. Additional calibration period events which occurred prior to the aeration of the SHO1 field on October 29, 2014 will be added to the regression models presented in the final report to the Lake Champlain Basin Program.

Concentrations and loads of measured constituents tended to be higher in runoff from SHO1 than from SHO2. This pattern suggests that application of treatment to SHO1 might yield more measureable results; therefore SHO1 was selected as the treatment watershed.

*Table 41. Calibration period linear regression statistics, SHO site*

| Variable | Symbol | Equation | $R^2$ adj. | F Ratio | *Prob > F* |
|---|---|---|---|---|---|
| Event Discharge | Q | log(SHO2 Q) = 0.646 log(SHO1 Q) + 0.813 | 0.35 | 6.37 | 0.033 |
| TP Concentration (µg /L) | [TP] | log(SHO2 TP) = 0.703 log(SHO1 TP) + 0.739 | 0.89 | 40.8 | 0.003 |
| TDP Concentration (µg/L) | [TDP] | log(SHO2 TDP) = 0.656 log(SHO1 TDP) + 0.842 | 0.93 | 65.3 | 0.001 |
| TN Concentration (mg/L) | [TN] | log(SHO2 TN) = 0.858 log (SHO1 TN) – 0.030 | 0.92 | 56.7 | 0.002 |
| TDN Concentration (mg/L) | [TDN] | log(SHO2 TDN) = 0.992 log(SHO1 TDN) – 0.092 | 0.98 | 217.1 | <0.001 |
| TSS Concentration (mg/L) | [TSS] | log(SHO2 TSS) = 0.172 log(SHO1 TSS) + 1.19 | 0.50 | 6.0 | 0.070 |
| Cl Concentration (mg/L) | [Cl] | log(SHO2 Cl) = 0.653 log(SHO1 Cl) + 0.022 | 0.62 | 9.1 | 0.039 |
| TP Export (g) | TPx | log(SHO2 TPx) = 0.810 log(SHO1 TPx) – 0.528 | 0.66 | 10.7 | 0.031 |
| TDP Export (g) | TDPx | log(SHO2 TDPx) = 0.806 log(SHO1 TDPx) – 0.530 | 0.61 | 8.9 | 0.041 |
| TN Export (g) | TNx | log(SHO2 TNx) = 1.22 log(SHO1 TNx) – 1.55 | 0.49 | 5.7 | 0.075 |
| TDN Export (g) | TDNx | log(SHO2 TDNx) = 1.43 log(SHO1 TDNx) – 2.09 | 0.59 | 8.1 | 0.047 |
| TSS Export (g) | TSSx | log(SHO2 TSSx) = 0.840 log(SHO1 TSSx) – 0.064 | 0.62 | 9.1 | 0.039 |
| Cl Export (g) | Clx | log(SHO2 Clx) = 0.925 log(SHO1 Clx) – 0.808 | 0.59 | 8.3 | 0.045 |

### 7.4.6. Williston site (corn)

Calibration regressions between WIL1 and WIL2 ranged from moderately weak ($R^2$ = 0.39) to strong ($R^2$ = 0.90) and were non-significant for TDP and TDN concentrations (Table 42). Observed data generally varied over 2 to 3 orders of magnitude, except for TN and TP concentrations which occurred over a fairly narrow range. The combined effect of non-significant relationships between the dissolved N and P concentrations and the narrow range of N and P concentrations may be that response to treatment will be challenging to measure for nutrient concentrations at this site. The two watersheds behaved fairly similarly with respect to mean concentrations and loads in runoff, although TP, TDP, and TSS concentrations were significantly higher from WIL2 than from WIL1.

*Table 42. Calibration period linear regression statistics, WIL site*

| Variable | Symbol | Equation | $R^2$ adj. | F Ratio | *Prob > F* |
|---|---|---|---|---|---|
| Event Discharge | Q | log(WIL1 Q) = 1.08 log(WIL2 Q) – 0.345 | 0.59 | 25.0 | <0.001 |
| TP Concentration (μg /L) | [TP] | log(WIL1 TP) = 0.444 log(WIL2 TP) + 1.45 | 0.48 | 14.1 | 0.002 |
| TDP Concentration (μg/L) | [TDP] | log(WIL1 TDP) = 0.043 log(WIL2 TDP) + 278.8 | 0.002 | 1.03 | 0.330 |
| TN Concentration (mg/L) | [TN] | log(WIL1 TN) = 0.592 log (WIL2 TN) + 0.161 | 0.48 | 14.1 | 0.002 |
| TDN Concentration (mg/L) | [TDN] | log(WIL1TDN) = 0.340 log(WIL2 TDN) + 0.225 | 0.08 | 2.21 | 0.161 |
| TSS Concentration (mg/L) | [TSS] | log(WIL1 TSS) = 1.06 log(WIL2 TSS) + 0.185 | 0.90 | 123.1 | <0.001 |
| Cl Concentration (mg/L) | [Cl] | log(WIL1 Cl) = 0.535 log(WIL2 Cl) + 0.168 | 0.43 | 11.7 | 0.005 |
| TP Export (g) | TPx | log(WIL1 TPx) = 0.835 log(WIL2 TPx) + 0.088 | 0.69 | 32.2 | <0.001 |
| TDP Export (g) | TDPx | log(WIL1 TDPx) = 0.676 log(WIL2 TDPx) + 0.168 | 0.50 | 15.0 | 0.002 |
| TN Export (g) | TNx | log(WIL1 TNx) = 0.894 log(WIL2 TNx) + 0.293 | 0.68 | 31.1 | <0.001 |
| TDN Export (g) | TDNx | log(WIL1 TDNx) = 0.794 log(WIL2 TDNx) + 0.550 | 0.39 | 10.0 | 0.007 |
| TSS Export (g) | TSSx | log(WIL1 TSSx) = 0.937 log(WIL2 TSSx) + 0.382 | 0.90 | 123.9 | <0.001 |
| Cl Export (g) | Clx | log(WIL1 Clx) = 0.879 log(WIL2 Clx) + 0.370 | 0.45 | 12.5 | 0.004 |

## 7.5. 2013-2015 WASCoB Results

Eighteen events were monitored over the three year period at the WASCoB inflow (WAS1) and outflow (WAS2) stations. Descriptive statistics for event mean concentrations (EMCs) and event loads are summarized in Table 43 and Table 44. Data were log10-transformed to satisfy the assumption of normal distribution. Due to the flow measurement problems discussed earlier, load data are considered suspect in many cases. Thus, the subsequent analysis will focus exclusively on EMC data.

*Table 43. Descriptive statistics for WASCoB event mean concentration data.*

| WAS1 | TP (µg/L) | TDP (µg/L) | TN (mg/L) | TDN (mg/L) | TSS (mg/L) | Cl (mg/L) |
|---|---|---|---|---|---|---|
| Range | 332 – 6,500 | 69 – 2,825 | 1.58 – 38.65 | 1.24 – 42.99 | 39 – 3,130 | 4.3 – 68.3 |
| Mean[1] | 732 | 249 | 7.81 | 5.98 | 242 | 18.2 |
| Median[1] | 528 | 216 | 7.96 | 7.21 | 160 | 24.3 |
| Std. Dev.[2] | 0.36 | 0.36 | 0.39 | 0.46 | 0.62 | 0.36 |
| Coef.Var.[2] | 12.55 | 15.17 | 43.77 | 59.00 | 25.84 | 28.76 |
| N | 17 | 17 | 17 | 17 | 17 | 17 |
| **WAS2** | **TP (µg/L)** | **TDP (µg/L)** | **TN (mg/L)** | **TDN (mg/L)** | **TSS (mg/L)** | **Cl (mg/L)** |
| Range | 214 – 4,870 | 37 – 1,270 | 2.10 – 32.35 | 0.98 – 32.18 | 36 – 5,255 | 5.3 – 53.5 |
| Mean[1] | 679 | 162 | 6.37 | 4.28 | 248 | 16.1 |
| Median[1] | 722 | 160 | 6.76 | 2.82 | 174 | 16.0 |
| Std. Dev.[2] | 0.36 | 0.69 | 0.34 | 0.46 | 0.66 | 0.30 |
| Coef.Var.[2] | 12.64 | 17.64 | 42.66 | 72.88 | 27.47 | 24.76 |
| N | 18 | 18 | 18 | 18 | 18 | 18 |

[1] Anti-log of statistic calculated on $log_{10}$ transformed data
[2] Calculated on $log_{10}$ transformed data

*Table 44. Descriptive statistics for WASCoB constituent mass load data*

| WAS1 | TP (g) | TDP (g) | TN (g) | TDN (g) | TSS (g) | Cl (g) |
|---|---|---|---|---|---|---|
| Range | 4 – 5,102 | 2 – 2,217 | 68 – 51,387 | 49 – 52,224 | 819 – 2,188,411 | 205 – 87,323 |
| Mean[1] | 237 | 78 | 2,716 | 2,026 | 81,696 | 6,053 |
| Median[1] | 516 | 149 | 3,418 | 2,310 | 155,775 | 8,414 |
| Std. Dev.[2] | 0.93 | 0.90 | 0.84 | 0.85 | 1.15 | 0.72 |
| Coef.Var.[2] | 39.03 | 47.81 | 24.60 | 25.78 | 23.35 | 19.14 |
| N | 16 | 16 | 16 | 16 | 16 | 16 |
| **WAS2** | **TP (g)** | **TDP (g)** | **TN (g)** | **TDN (g)** | **TSS (g)** | **Cl (g)** |
| Range | 18 – 4,215 | 3 – 1,365 | 254 – 71,357 | 222 – 71,644 | 3,562 – 3,268,677 | 816 – 113,450 |
| Mean[1] | 371 | 89 | 3,944 | 2,635 | 138,197 | 9,158 |
| Median[1] | 748 | 111 | 4,673 | 2,036 | 276,901 | 8,903 |
| Std. Dev.[2] | 0.81 | 0.80 | 0.73 | 0.78 | 1.08 | 0.62 |
| Coef.Var.[2] | 31.68 | 40.97 | 20.41 | 22.77 | 21.10 | 15.59 |
| N | 16 | 16 | 16 | 16 | 16 | 16 |

[1] Anti-log of statistic calculated on $log_{10}$ transformed data
[2] Calculated on $log_{10}$ transformed data

Although some differences were observed for some monitored events, when data for all events were combined, there were no statistically significant differences observed between P, N, TSS, or Cl EMCs measured at the inflow and outflow of the WASCoB, as determined by t-Test (Table 45). These results were confirmed on non-transformed data using the nonparametric Kruskal-Wallis test. As shown in the box plots (Figure 71 –Figure 76) below, there was a tendency for some EMCs to be more variable at the WASCoB outlet (e.g., [TDP], [TDN], [TSS]) but this pattern may be due to the effects of groundwater or un-monitored surface runoff entering the WASCoB between the two monitoring stations and diluting or enriching the outflow.

*Table 45. Comparison of inflow and outflow mean EMC by Student's t-Test and Kruskal-Wallis nonparametric test*

| | Mean Inflow EMC[1] | Mean Outflow EMC[1] | t | *P* | Kruskal-Wallis *P* |
|---|---|---|---|---|---|
| TP (µg/L) | 732 | 679 | -0.27 | 0.79 | 0.75 |
| TDP (µg/L) | 249 | 162 | -1.46 | 0.15 | 0.11 |
| TN (mg/L) | 7.96 | 6.76 | -0.70 | 0.48 | 0.36 |
| TDN (mg/L) | 5.98 | 4.28 | -0.93 | 0.36 | 0.40 |
| TSS (mg/L) | 242 | 248 | 0.05 | 0.96 | 0.92 |
| Cl (mg/L) | 18.2 | 16.1 | -0.48 | 0.64 | 0.42 |

[1] Anti-log of statistic calculated on $\log_{10}$ transformed data

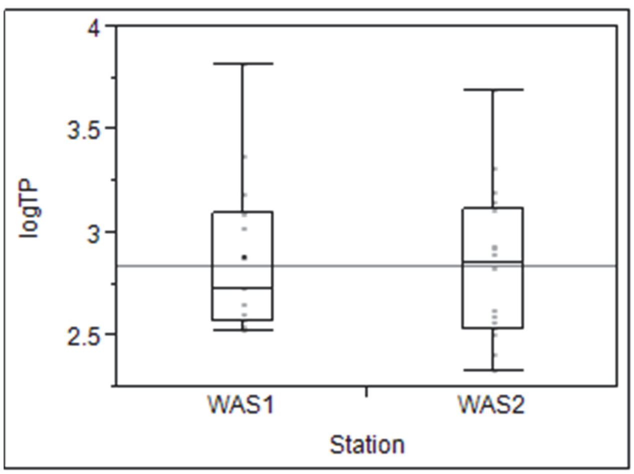



*Figure 71. Box plot of total P EMCs, 2013-2015*

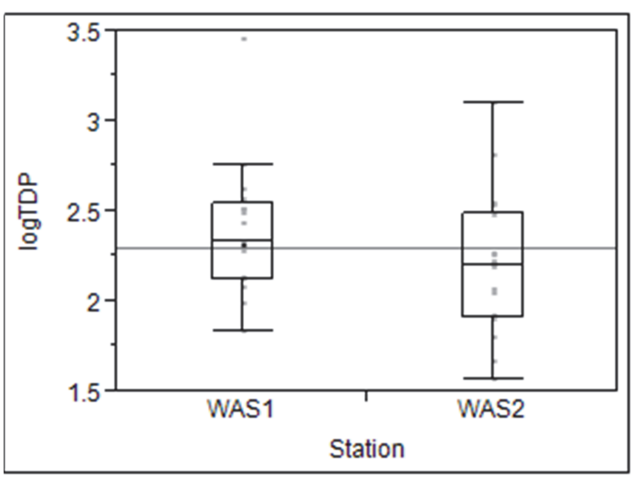



*Figure 72. Box plot of total dissolved P EMCs, 2013-2015*

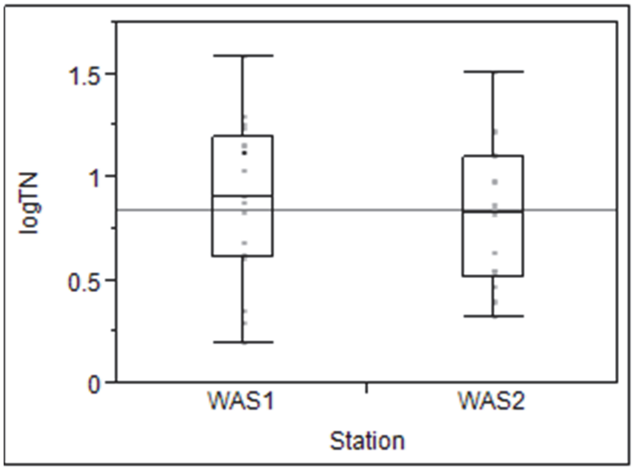



*Figure 73. Box plot of total N event mean concentrations at the WASCoB, 2013-2015*

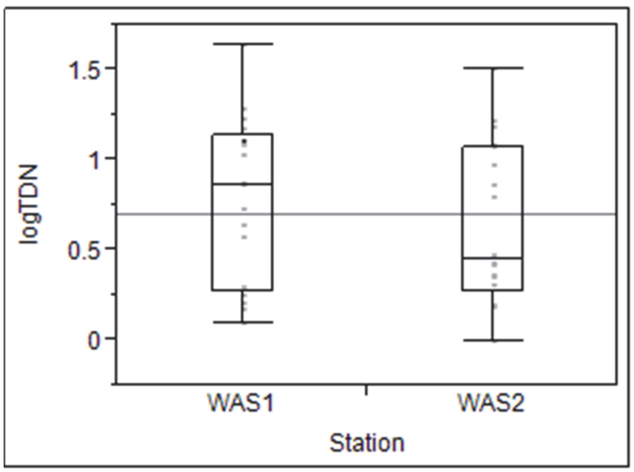



*Figure 74. Box plot of total dissolved N event mean concentrations at the WASCoB, 2013-2015*

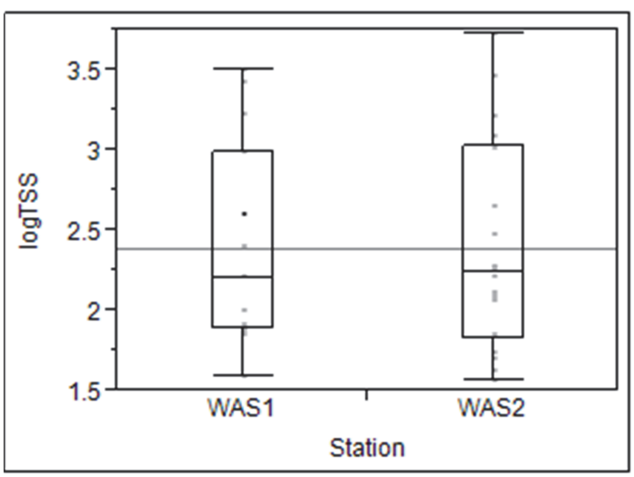



*Figure 75. Box plot of total suspended solids event mean concentrations at the WASCoB, 2013-2015*

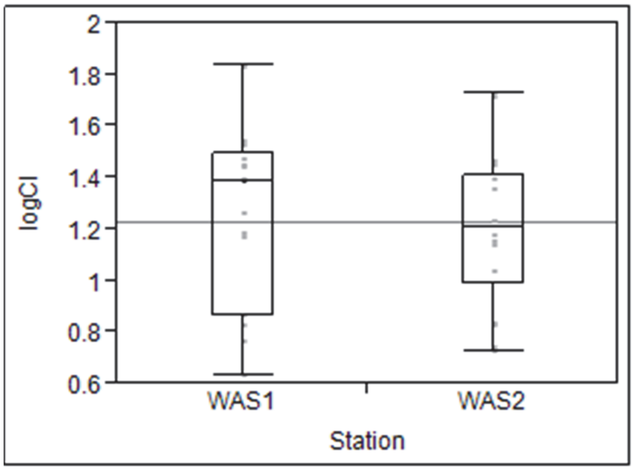



*Figure 76. Box plot of chloride event mean concentrations at the WASCoB, 2013-2015*

There were some differences in mean EMCs between the three monitoring years at both the inflow and the outflow of the WASCoB for TDP, TDN, and Cl (Table 46). As shown in Figure 77 and Figure 78, TP and TDP concentrations at both stations tended to be highest in 2013, and decreased in 2014 and 2015. The differences were not significant for TP. This pattern was reversed for TN and TDN (Figure 79 and Figure 80); EMCs for TN and TDN tended to increase at both stations from 2013 – 2015. TSS concentration showed no consistent pattern across the three years (Figure 81). Chloride EMCs increased significantly in 2015 (Figure 82).

Despite these differences between monitored years, there were no significant differences between input and output EMCs for P, N, TSS, or Cl in any individual monitored year. Figure 83 shows an example of annual inflow-outflow EMC comparisons for TP.

*Table 46. Comparison of annual means at WAS1 and WAS2 by ANOVA*

| | | 2013 | 2014 | 2015 | F | *P* |
|---|---|---|---|---|---|---|
| TP (µg/L) | WAS1 | 968 | 626 | 577 | 0.662 | 0.531 |
| | WAS2 | 1024 | 616 | 456 | 1.741 | 0.209 |
| TDP (µg/L) | WAS1 | 416 | 163 | 185 | **2.767** | **0.097** |
| | WAS2 | 261 | 103 | 137 | 1.944 | 0.178 |
| TN (mg/L) | WAS1 | 5.5 | 7.7 | 12.8 | 1.318 | 0.299 |
| | WAS2 | 4.8 | 5.4 | 10.1 | 1.700 | 0.216 |
| TDN (mg/L) | WAS1 | 3.8 | 5.5 | 12.5 | 2.187 | 0.149 |
| | WAS2 | 2.5 | 3.4 | 9.5 | **3.439** | **0.059** |
| TSS (mg/L) | WAS1 | 294 | 253 | 176 | 0.172 | 0.843 |
| | WAS2 | 386 | 244 | 150 | 0.603 | 0.560 |
| Cl (mg/L) | WAS1 | 15.1 | 12.3 | 35.0 | **2.768** | **0.097** |
| | WAS2 | 13.2 | 11.4 | 26.9 | **3.284** | **0.066** |

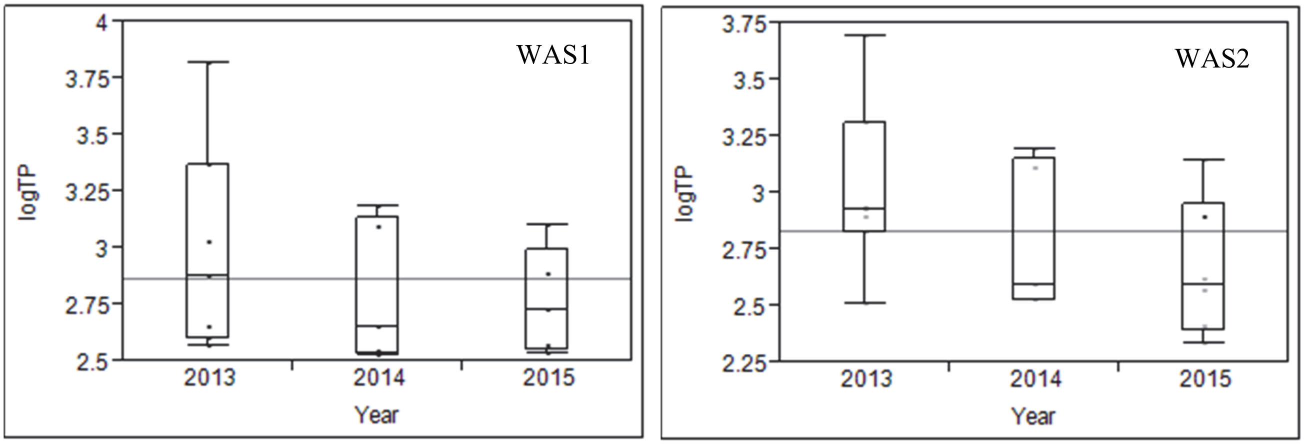



*Figure 77. Box plots of annual total P event mean concentrations at WAS1 and WAS2, 2013-2015*

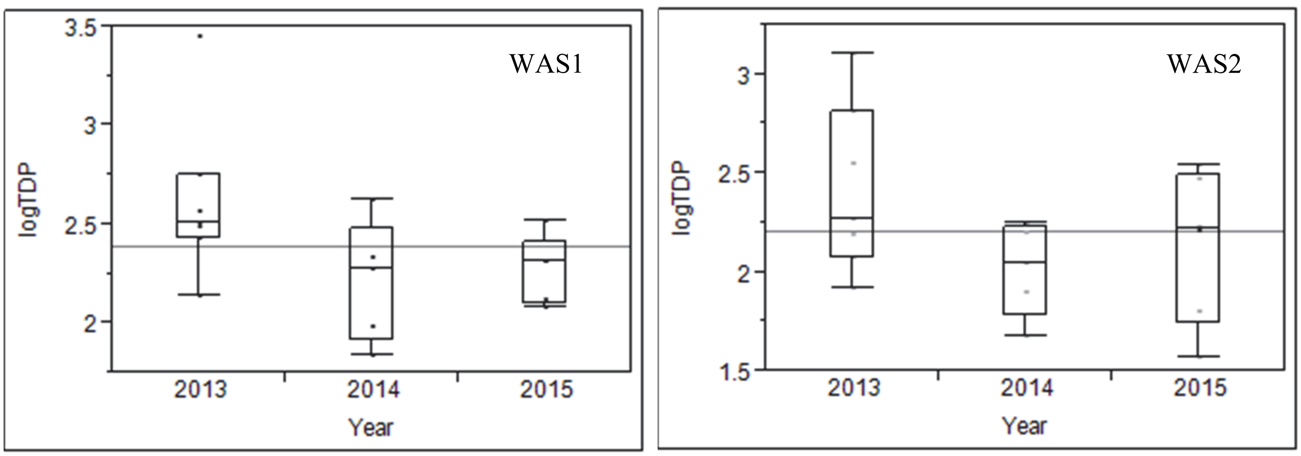



*Figure 78. Box plots of annual total dissolved P event mean concentrations at WAS1 and WAS2, 2013-2015.*

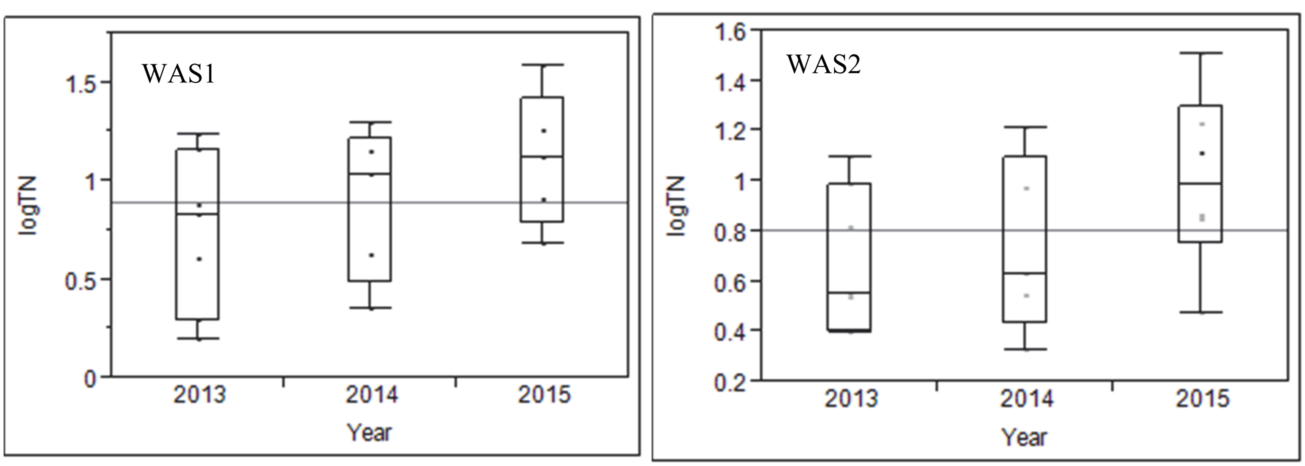



*Figure 79. Box plots of annual total N event mean concentrations at WAS1 and WAS2, 2013-2015*

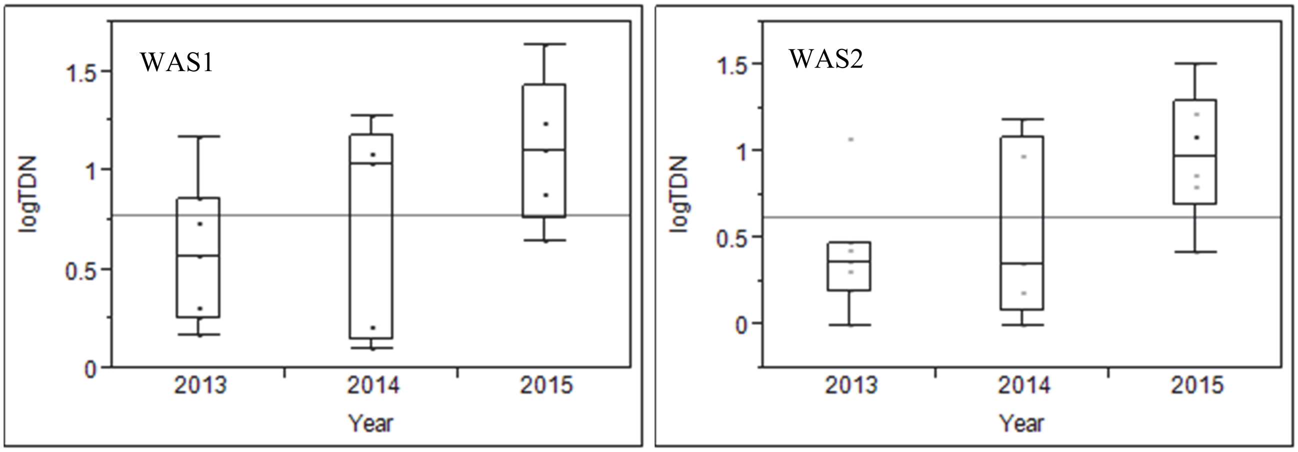



*Figure 80. Box plots of annual total dissolved N event mean concentrations at WAS1 and WAS2, 2013-2015*

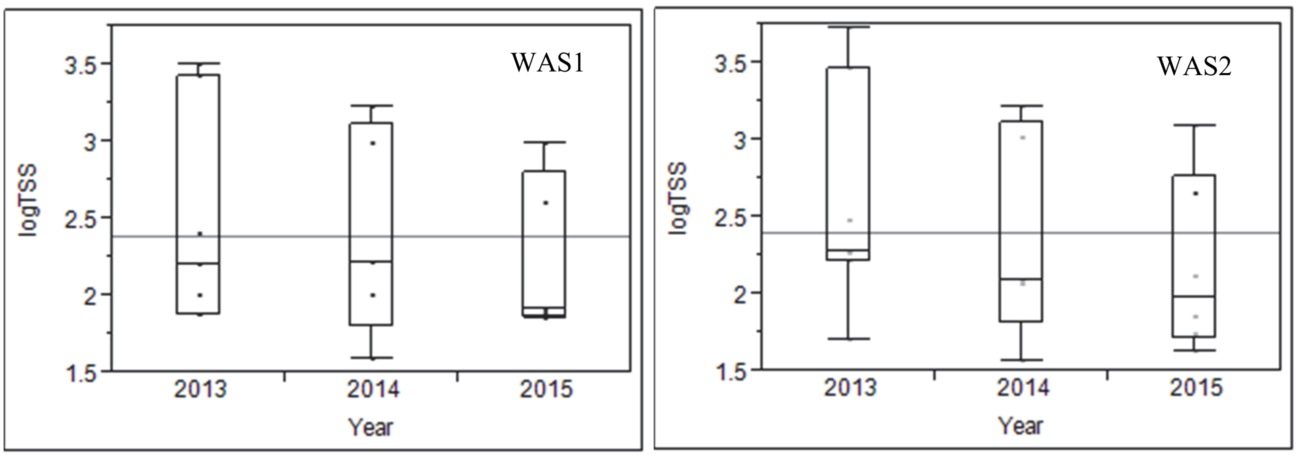



*Figure 81. Box plots of annual total suspended solids event mean concentrations at WAS1 and WAS2, 2013-2015*

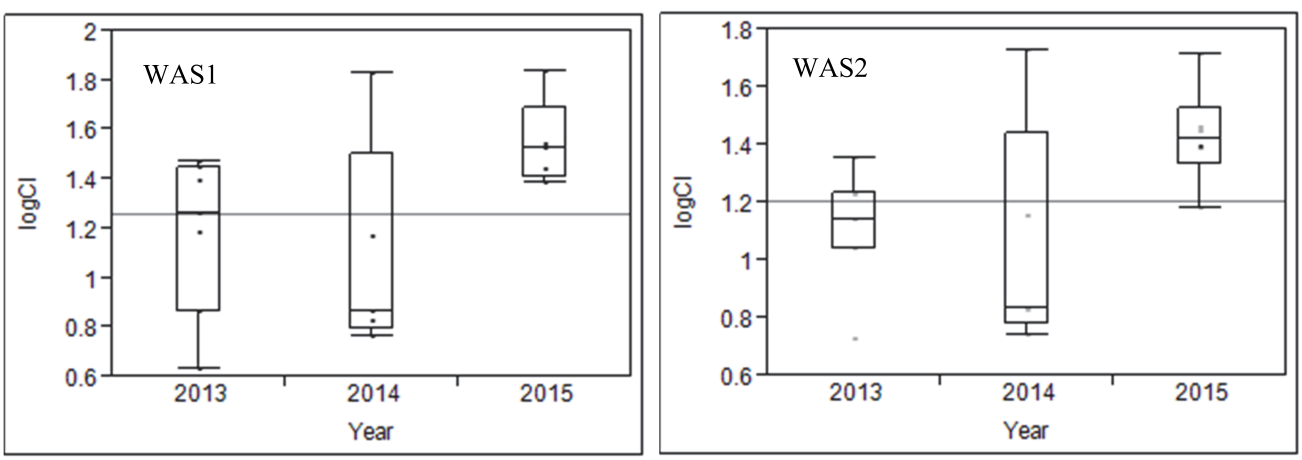
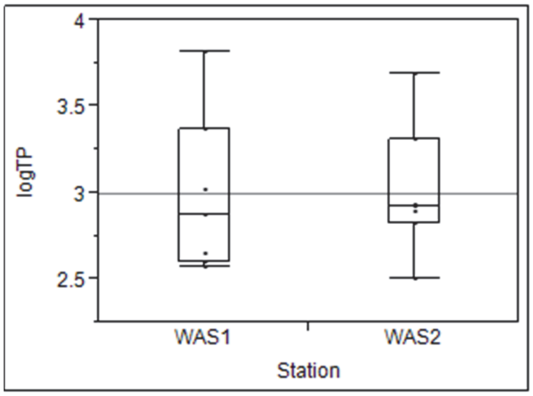
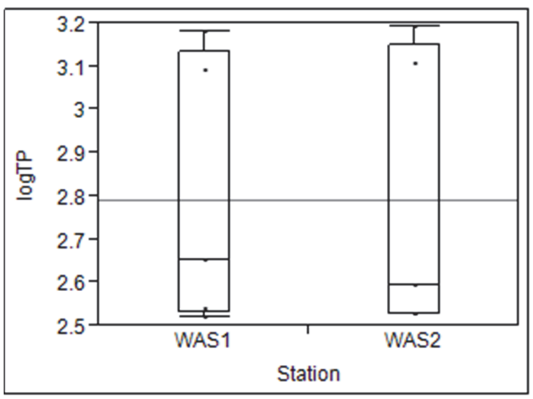



*Figure 82. Box plots of annual chloride event mean concentrations at WAS1 and WAS2, 2013-2015*

2013




2014




2015

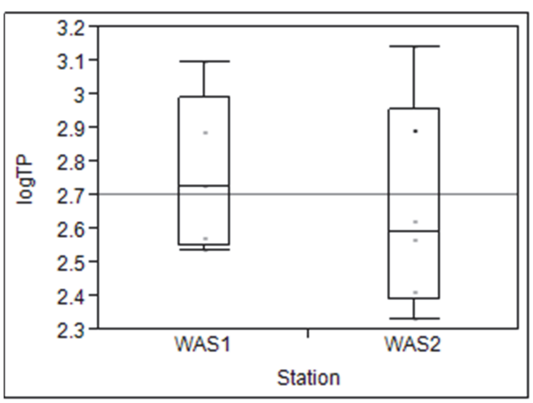



*Figure 83. Box plot comparing annual inflow and outflow event mean concentrations for total P in 2013, 2014, and 2015*

### 7.5.1. Concentration Reductions

Despite the lack of significant differences between inflow and outflow mean EMCs, the data were examined for patterns in EMC reduction percentages observed for individual monitored events. Reduction percentage was calculated as (([inflow] – [outflow])/[inflow])*100. Negative percentages indicate higher EMC in outflow than in inflow. Results are summarized in Table 47. These results should be interpreted with caution. Previous analysis showed no statistically significant differences between inflow and outflow mean EMCs. Further, any apparent reductions may be influenced by dilution or enrichment from groundwater influx or unmonitored surface runoff entering the WASCoB during precipitation events. Apparent changes in soluble and conservative chloride, ranging from a 42% decrease to an 89% increase, suggest that such influences could be significant.

*Table 47. Concentration reductions (%) between WASCoB inflow and outflow. Negative values indicate outflow concentration > inflow concentration*

| Start date | TP | TDP | TN | TDN | TSS | Cl |
|---|---|---|---|---|---|---|
| 5/22/2013 | 13.9 | 13.9 | 14.3 | 19.7 | 27.7 | 7.7 |
| 9/11/2013 | -14.4 | -14.5 | -80.4 | -84.5 | 49.9 | -23.5 |
| 10/7/2013 | 25.1 | 55.0 | 62.1 | 59.1 | -9.9 | 42.5 |
| 10/31/2013 | 20.2 | 5.1 | 54.7 | 56.5 | -16.3 | 38.5 |
| 11/18/2013 | 13.4 | 73.0 | -42.0 | 50.5 | -67.9 | 9.9 |
| 11/27/2013 | -74.1 | 41.8 | -56.1 | 12.9 | -292.1 | -88.7 |
| 12/5/2013 | -66.9 | 42.6 | 37.3 | 45.6 | -124.5 | 40.8 |
| 4/15/2014 | -2.6 | 49.1 | -1.9 | 21.0 | 3.1 | 9.1 |
| 4/30/2014 | -4.2 | 19.2 | 75.0 | 81.5 | -5.7 | -17.1 |
| 5/4/2014 | 2.4 | 31.7 | 5.5 | 5.7 | 23.9 | 17.4 |
| 6/14/2014 | 12.8 | 63.0 | 15.8 | 18.8 | 7.2 | 20.7 |
| 12/24/2014 | -1.8 | 5.7 | 13.0 | 12.4 | -17.4 | 3.2 |
| 6/1/2015 | 30.4 | 8.7 | 16.3 | 25.2 | 9.7 | 24.6 |
| 6/9/2015 | -10.4 | 17.6 | 5.5 | 3.4 | -25.1 | -2.1 |
| 6/12/2015 | -1.3 | 21.4 | 1.3 | 3.4 | -10.6 | -1.9 |
| 6/21/2015 | 31.0 | 51.6 | 12.1 | 16.8 | 21.6 | 17.2 |
| 7/1/2015 | 37.4 | 69.6 | 37.8 | 41.0 | 48.8 | 26.5 |
| Mean | 0.6 | 32.6 | 10.0 | 22.9 | -22.2 | 7.3 |
| Median | 2.4 | 31.7 | 13.0 | 19.7 | -5.7 | 9.9 |

% reduction = (([inflow] – [outflow])/[inflow])*100

As shown in Table 47, apparent reductions in EMC were highly variable across different events, ranging from reductions of up to 80% to more than 100% increases in outflow concentrations. Across all monitored events, TSS EMC in outflow tended to be higher than inflow (average 22% increase). Apparent TP reductions were below 2.5%, while TN reductions averaged about 10%. Interestingly, reductions in dissolved constituents (TDP and TDN) were substantially higher than for the other constituents, averaging 33% and 22%, respectively. All events except one (9/11/2013) showed net reductions in TDP and TDN EMCs through the WASCOB. Overall, apparent reductions of Cl EMC were less than 10%.

Calculated reduction percentages for each monitored constituent are plotted against time in Figure 84. The largest increases in EMC with passage through the WASCoB occurred in 2013, notably for TP, TN, and TSS.

Fewer such increases and more consistent apparent reductions were observed in 2014 and 2015. It is not known if this pattern represents a “break-in” or settling period for the newly constructed WASCoB or if the pattern is an artifact of monitoring challenges.

This pattern is also shown in comparisons of calculated reductions among the monitored years in Figure 85–Figure 90.

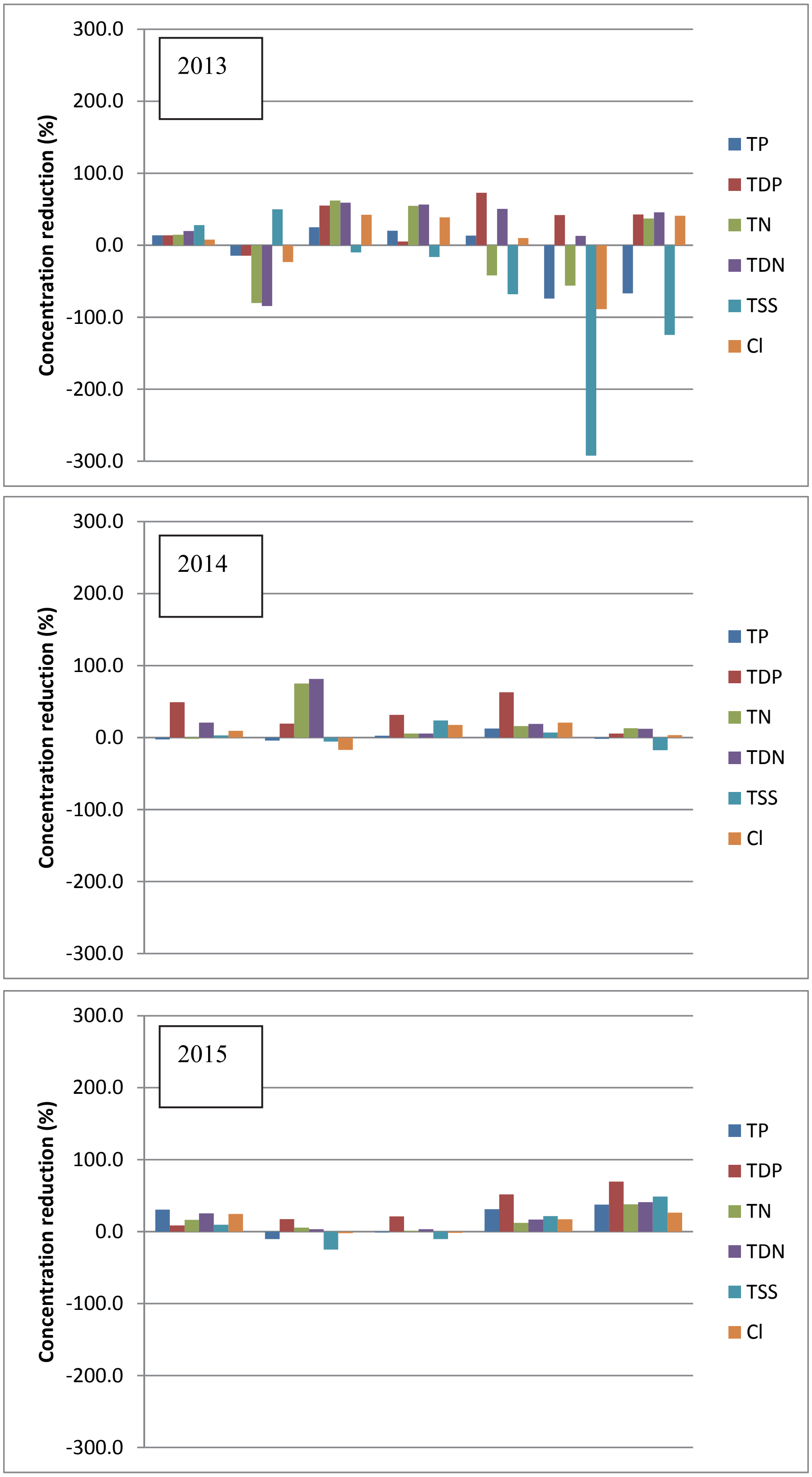



*Figure 84. Apparent EMC reductions in individual events through the WASCoB over the monitoring period.*

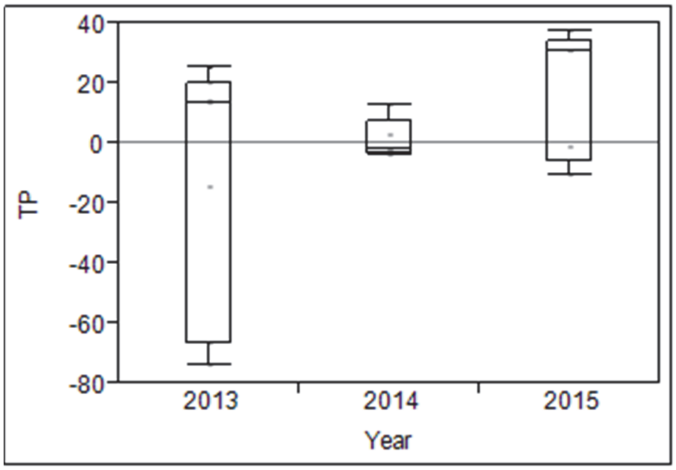



*Figure 85. Box plot comparing calculated total P percent reductions, 2013-2015*

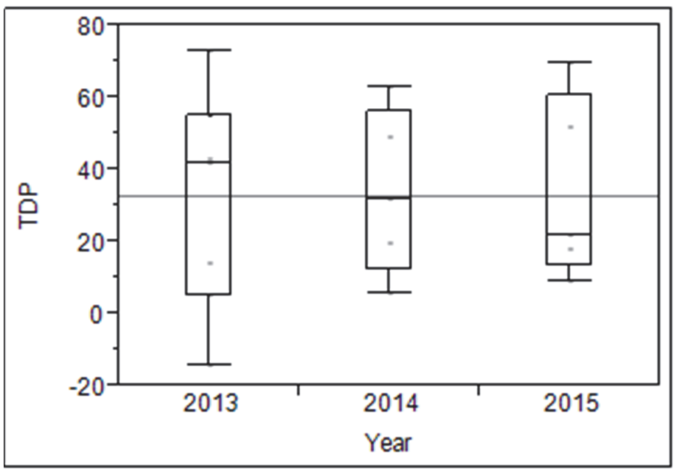



*Figure 86. Box plot comparing calculated total dissolved P percent reductions, 2013-2015.*

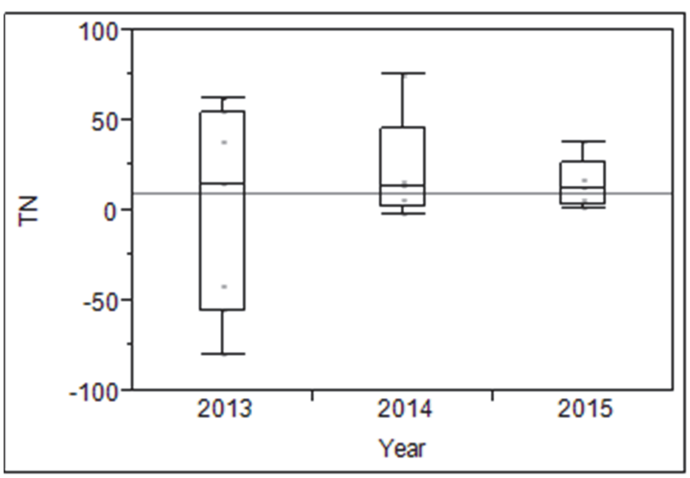



*Figure 87. Box plot comparing calculated total N percent reductions, 2013-2015*

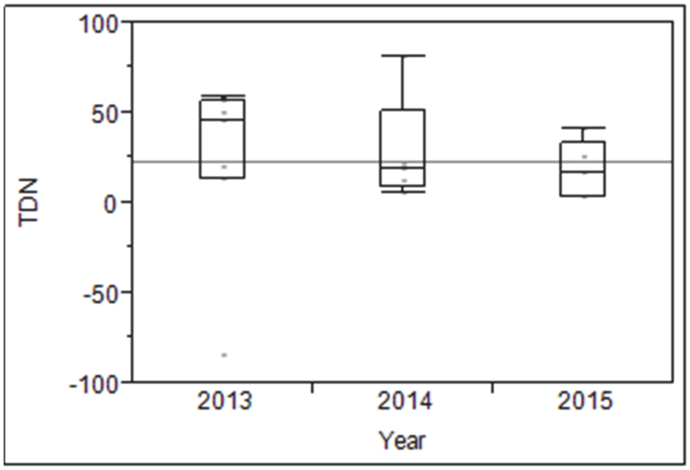



*Figure 88. Box plot comparing calculated total dissolved N percent reductions, 2013-2015*

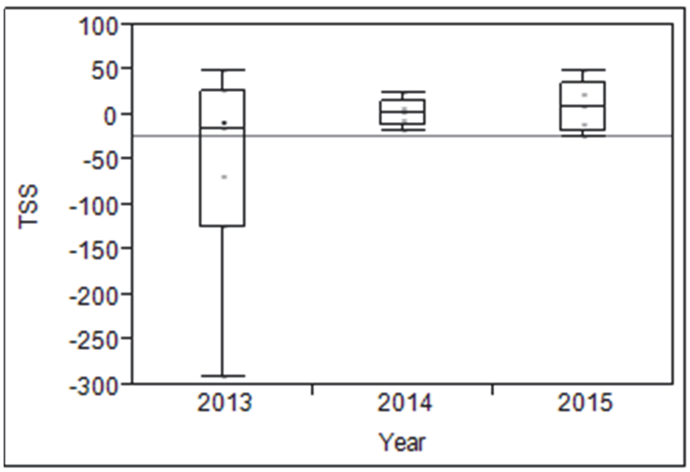



*Figure 89. Box plot comparing calculated total suspended solids percent reductions, 2013-2015*

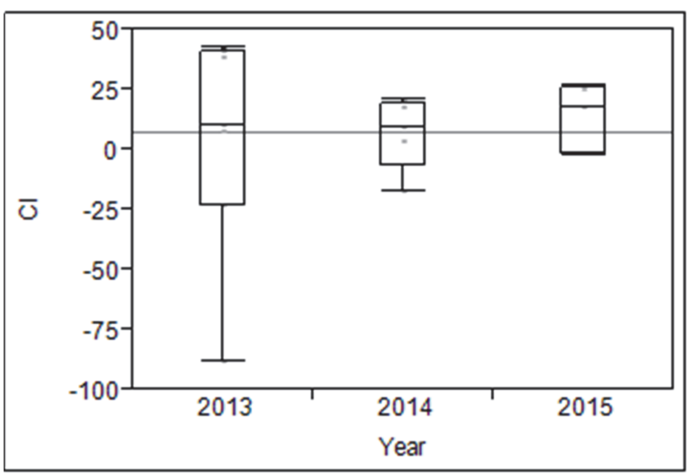



*Figure 90. Box plot comparing calculated chloride percent reductions, 2013-2015*

Finally, potential correlations between total event precipitation and apparent EMC percent reduction were examined. No significant correlations were found. As shown in the example for TP EMC in Figure 91, there were no statistically significant correlations between precipitation event magnitude and calculated EMC reductions through the WASCoB for any monitored constituents.

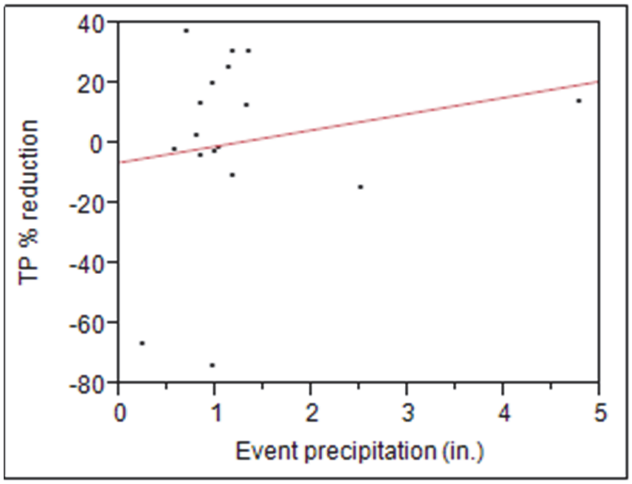



*Figure 91. Regression plot comparing total event precipitation and calculated total P percent reductions, 2013-2015*

### 7.5.2. Conclusions

There is no statistically significant evidence that the WASCoB consistently reduced P, N, or TSS concentrations in cropland runoff. Event load data, although confounded by questionable flow data, tend to support the same conclusion. The observed performance was substantially lower than the 50 – 90% sediment and nutrient reductions sometimes reported in the literature (e.g., Edwards et al. 1999, White et al. 2008). The reasons for the poor performance of this WASCoB are uncertain, but several possibilities exist. Lack of vegetation along the sides of the structure may have resulted in erosion directly into the pool, especially during the first year. Unmonitored nutrients could be entering the WASCoB through direct runoff or groundwater influx. The WASCoB could be undersized in relation to its contributing area, and the resulting short retention/settling times could be inadequate to achieve significant removal, especially of particulate-bound constituents.

## 7.6. Results of Sediment Collection and Analysis

Through December 2014, sediment deposition within the flumes and their attached approach channels has been negligible at the FRA and WIL sites and at all three hay sites. Events with significant sediment deposition (operationally defined as one liter or more) have occurred at only three stations: PAW1, PAW2, and WAS1. In 2013, the PAW1 flume and approach channel accumulated sediment during nine events, with collected volumes ranging from 1 to 34 L. Both the PAW2 and WAS2 stations accumulated sediment during two events. In 2014, there were no sampled runoff events that deposited significant sediment in the flume or approach. The change from 2013 is largely attributable to the fact that the Pawlet stations were not monitored through the spring and summer of 2014, due to misapplication of the cover crop.

For each station/event with significant sediment accumulation in 2013, Table 48 presents the masses of solids ("Solids in Flume") and total phosphorus ("TP in Flume Sediment") deposited in the flume and approach channel. Note that Table 48 includes data for certain events at the Pawlet site where problems in discharge measurement (blowout at PAW1 on Event 10) and autosampler collected samples (Event 1 at PAW1) dictated that these data not be included in the paired watershed statistical analyses. While these data were not considered sufficiently accurate for inclusion in paired watershed statistical analyses, we considered them adequate for the sediment and total phosphorus mass comparison. Similarly, in one instance (PAW1, Event 16), the total solids and total phosphorus content of deposited sediment were estimated as averages from the preceding events.

In most cases, the mass of solids deposited in the flume was minor compared to the amount transported in runoff (measured as TSS). With two exceptions, the mass of solids deposited in the flume/approach was 6 percent or less of the total mass of solids transported (TSS+ deposited sediment; Table 48). The exceptions were Event 5 (84.8 % of total mass transported deposited in the flume) and Event 16 (19.0 % of total mass transported deposited in the flume) at PAW1. In these two events, the high percentage of solids deposited in the flume/approach results from relatively low TSS loads rather than from substantial sediment deposition in the flume/approach. In particular, Event 5 was a very small event that transported only 0.2 kg of solids as TSS, and the solids in the flume (1.2 kg) were likely mobilized in one of the large events preceding it and deposited near the entrance to the flume approach, creating a condition where a small event carried these sediments into the flume.

*Table 48. Mass of solids and total phosphorus deposited in flume/approach relative to mass in runoff*

| Station | Event | Hydro Event End Date | Event Discharge (L) | TSS Load (kg) | Solids in Flume (kg) | Total Solids Load (kg) | % of Total Solids In Flume | TP Load in Runoff (g) | TP in Flume Sediment (g) | TP Load Total (g) | % of TP Load in Flume | Note |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PAW1 | 1 | 3/13/2013 | 423,744 | 841.3 | 23.6 | 864.9 | 2.7 | 1112.3 | 19.3 | 1131.6 | 1.7 | A |
| PAW1 | 5 | 4/14/2013 | 8,447 | 0.2 | 1.2 | 1.4 | 84.8 | 1.1 | 1.3 | 2.4 | 54.1 | |
| PAW1 | 7 | 4/20/2013 | 194,857 | 164.7 | 2.0 | 166.6 | 1.2 | 261.1 | 2.2 | 263.3 | 0.8 | |
| PAW1 | 10 | 6/4/2013 | 312,411 | 4376.9 | 25.4 | 4402.3 | 0.6 | 2655.5 | 24.6 | 2680.1 | 0.9 | B |
| PAW2 | 10 | 6/3/2013 | 247,840 | 458.5 | NS | NS | NS | 385.4 | NS | NS | NS | C |
| PAW1 | 11 | 6/9/2013 | 159,903 | 43.0 | 2.7 | 45.7 | 6.0 | 42.6 | 2.5 | 45.1 | 5.5 | |
| PAW1 | 12 | 6/15/2013 | 547,895 | 27.4 | 0.5 | 27.9 | 1.8 | 74.6 | 0.5 | 75.1 | 0.6 | |
| PAW1 | 13 | 6/19/2013 | 218,166 | 966.0 | 15.5 | 981.5 | 1.6 | 462.5 | 14.1 | 476.6 | 3.0 | |
| PAW2 | 13 | 6/19/2013 | 102,149 | NS | 0.9 | NS | NS | NS | 0.6 | NS | NS | D |
| PAW1 | 14 | 6/27/2013 | 367,295 | 915.3 | 31.2 | 946.5 | 3.3 | 655.7 | 22.6 | 678.3 | 3.3 | |
| PAW1 | 16 | 7/4/2013 | 324,507 | 37.8 | 8.9 | 46.7 | 19.0 | 90.5 | 8.1 | 98.6 | 8.2 | E |
| WAS1 | 1 | 5/30/2013 | 3,547,450 | 893.2 | 12.1 | 905.3 | 1.3 | 1320.1 | 8.8 | 1328.9 | 0.7 | |
| WAS1 | 3 | 10/8/2013 | 784,935 | 2076.9 | 2.5 | 2079.4 | 0.1 | 5102.1 | 2.1 | 5104.1 | 0.0 | |

N.S. = No sample collected
A. Autosampling error. Low siphon sample analyzed. Event excluded from paired watershed analysis.
B. Bypass flow occurred. Discharge and TSS and TP loads presented for comparison with sediment deposited in flume. Event excluded from statistical analysis.
C. Sediment sample analyzed but volume removed from flume not recorded
D. Sediment sample analyzed and volume recorded but corresponding runoff sample not obtained
E. Sediment volume recorded but no sediment sample analyzed. Solids and TP concentrations of sediment estimated as averages of PAW1 events in 2013

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# APPENDICES

# APPENDIX A: STUDY WATERSHED DESCRIPTIONS

## A.1. **Ferrisburgh Site**

The Ferrisburgh study watersheds are located close to one another, separated by an intermittent stream. Each watershed is comprised of heavy clay soils of the Vergennes and Covington series. These soils have high runoff potential, classified as hydrologic soil group D. The FER1 watershed (Figure 1) is 4.5 acres (1.8 ha), substantially smaller than the 7.2 acre (2.9 ha) FER2 watershed (Figure 2), and FER1 is more sloping. There is a 4-inch diameter tile line that discharges immediately below the FER1 station. The area of the field drained by the tile is unknown, although the line is believed to be short, likely less than 100 feet (30 m) in length. On April 9, 2013, the end of the tile line was capped by AAFM, in an attempt to make the FER1 and FER2 watersheds more hydrologically comparable. Both watersheds were in corn production in the year preceding this study and were seeded to red clover with a cover of peas/oats in April of 2012.

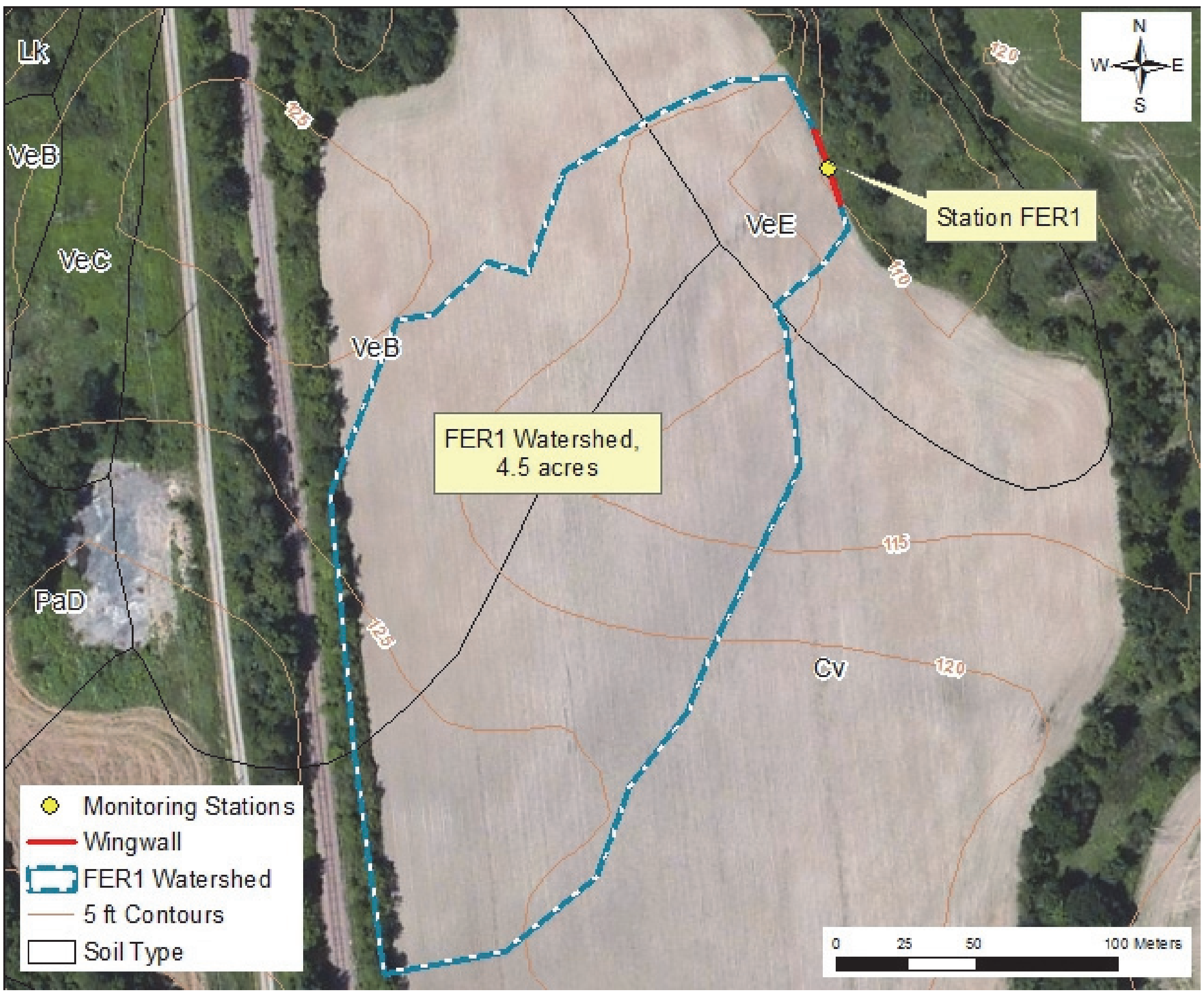


*Figure 1. FER1 watershed*

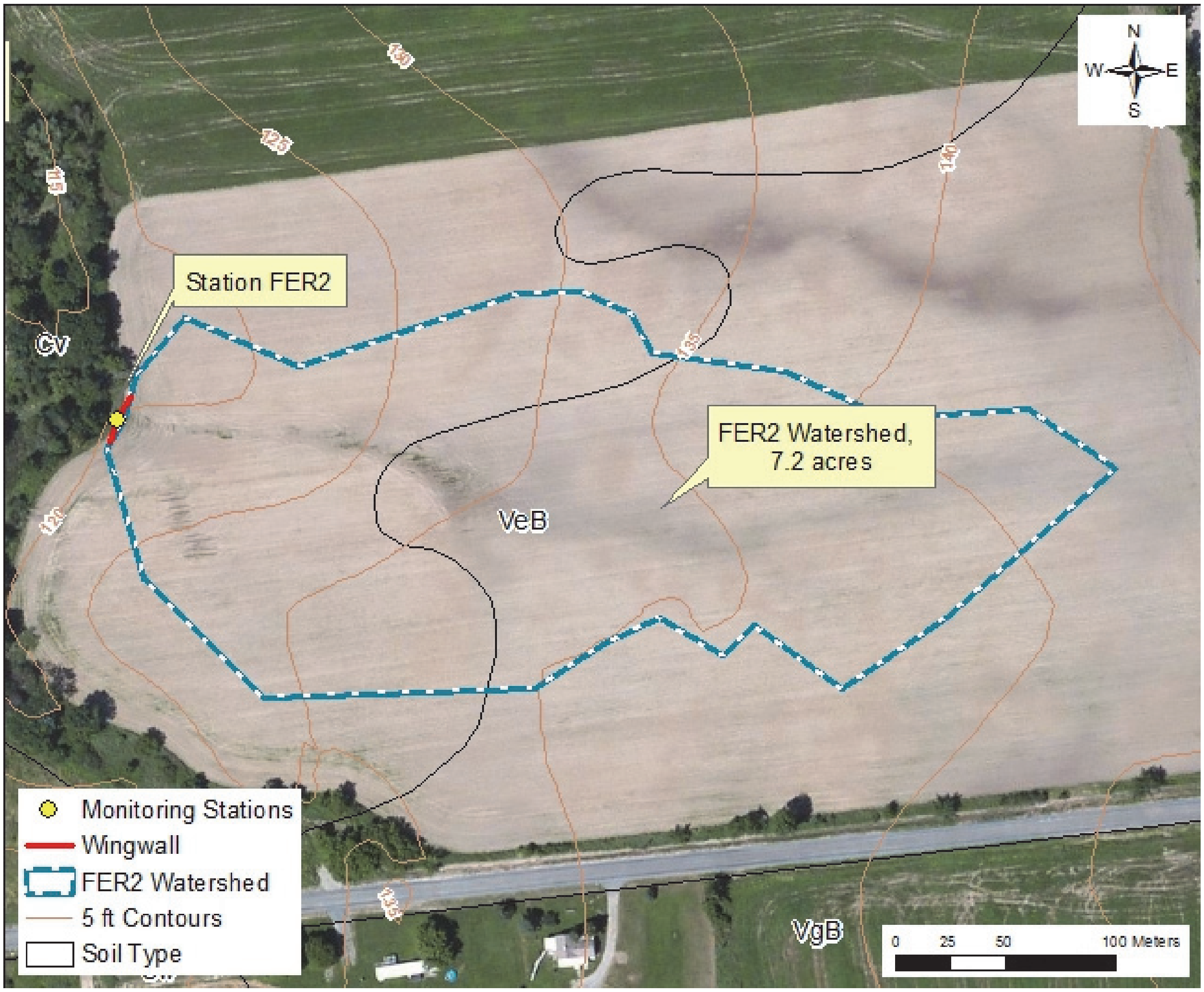


*Figure 2. FER2 watershed*

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## A.2. Franklin and WASCoB Sites

The Franklin study watersheds are distinct drainages within a large strip cropped field. The field is currently managed as a single unit. Corn and hay are grown in alternating strips planted on contour. In the spring of 2012 the strips were switched; grass was planted in the former corn strips and corn was planted into the hay strips after first cut. The strips are now opposite from the pattern shown in Figure 3. The predominant soil texture in the FRA1 and FRA2 watersheds is silt loam (Munson, Scantic, Belgrade, St. Albans), with lesser amounts of Georgia and Massena stony loam. FRA1 and FRA2 are similar in size [15.6 acres (6.3 ha) and 13.4 acres (5.4 ha), respectively], slope, and aspect. There are tile outlets located at the base of the slope, west of the FRA1 and FRA2 stations; the tile lines reportedly run up through the sags in the FRA1 and FRA2 watersheds. During large runoff events, the tile outlets become submerged.

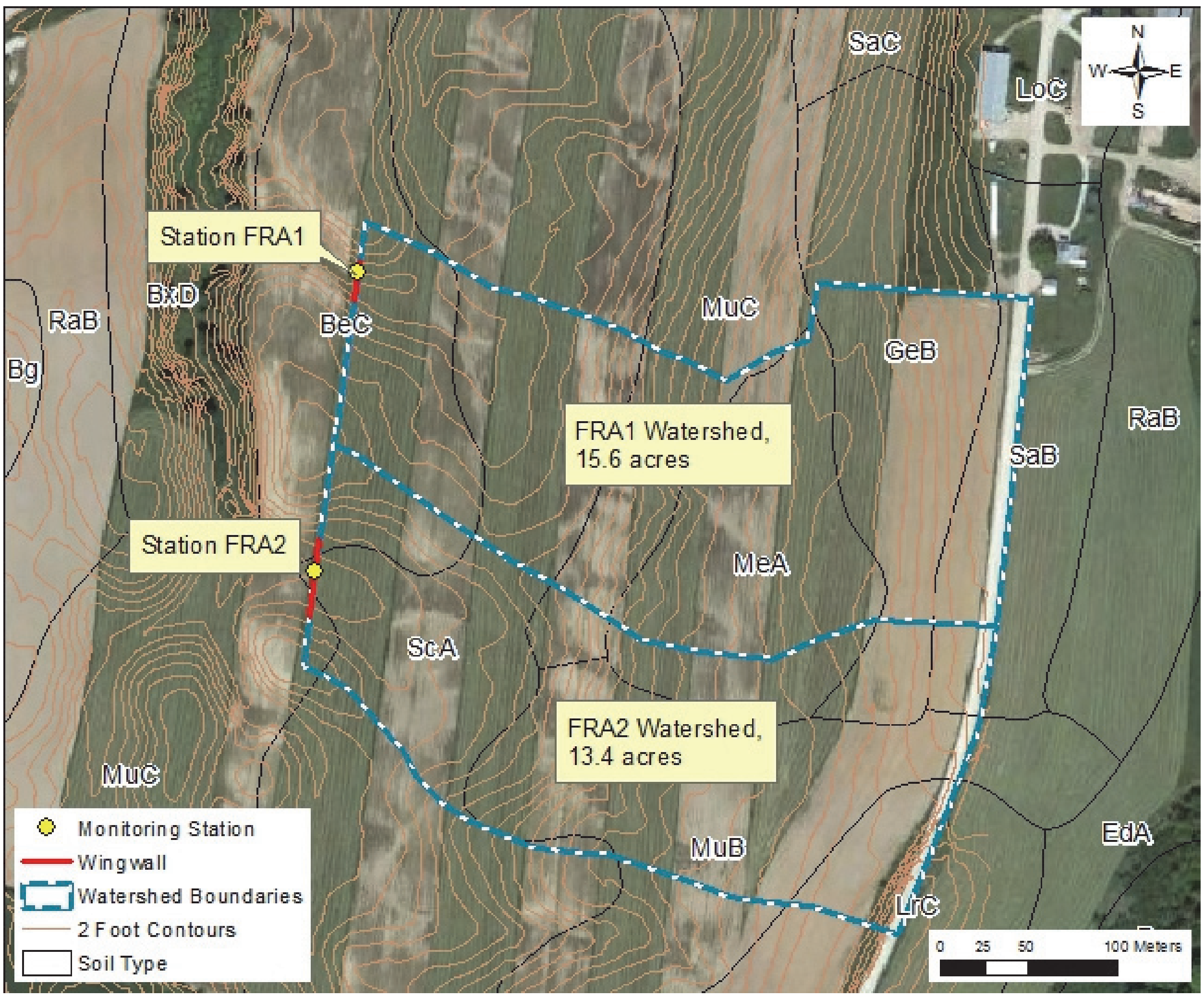


*Figure 3. FRA1 and FRA2 watersheds*

The WASCoB stations (Figure 4) are located on the same farm as the FRA1 and FRA2 stations. The field draining to the WASCoB is the largest field in the study: 22.7 acres (9.2 ha). The area draining to the upstream monitoring station (WAS1) is slightly less, 22.1 acres (8.9 ha), because 0.58 acres (0.23 ha) of cornfield drains directly to the WASCoB, bypassing the WAS1 station. The downstream station, WAS2, monitors the WASCoB outlet, receiving runoff from the entire field area. The field is in continuous corn production. Soils in the WASCoB field are Raynam (60%) and Binghamville (40%) silt loams, which are classified as moderately runoff prone (hydrologic soil group C). The extent of tile drainage in the WASCoB field is unknown.

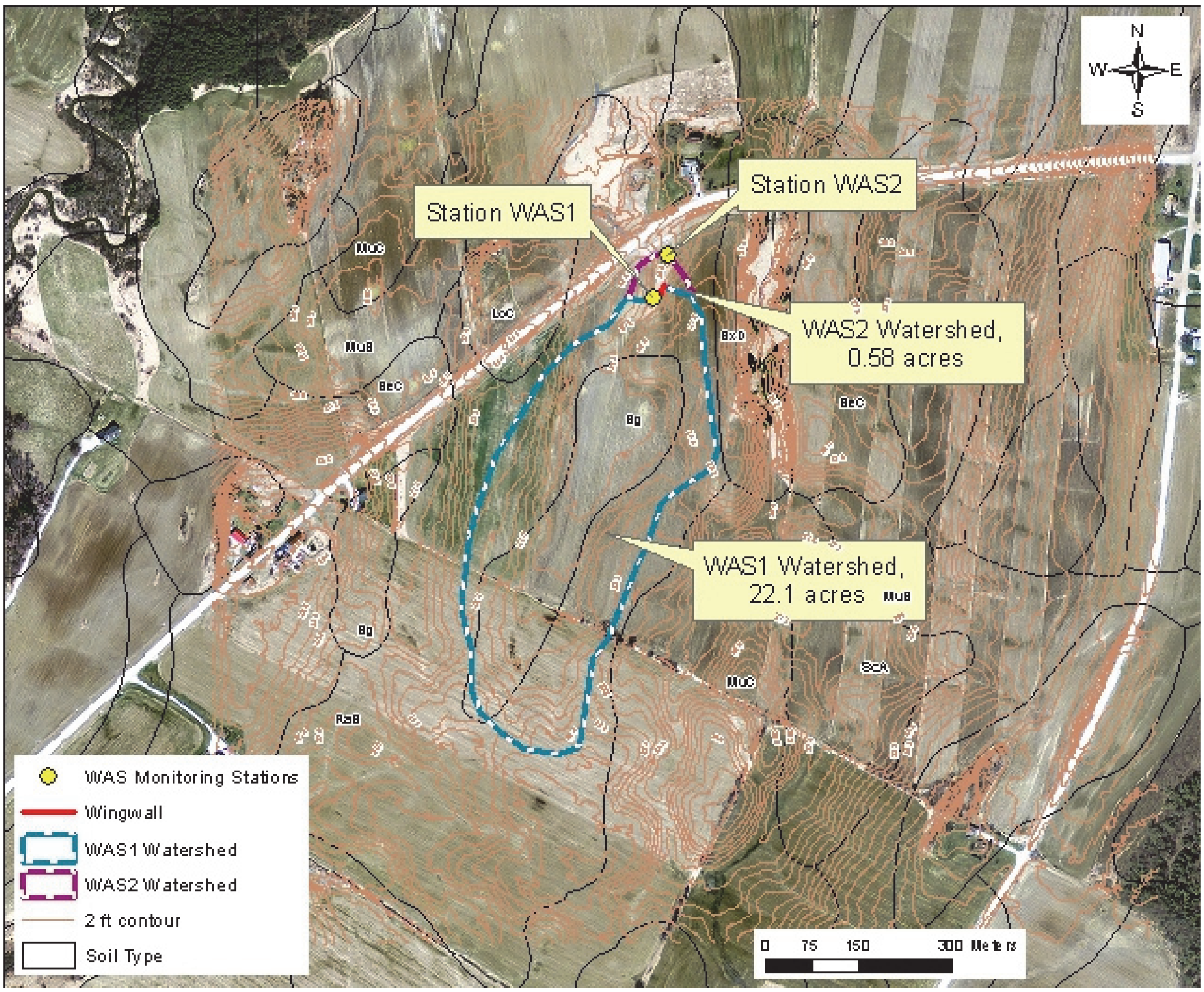


*Figure 4. WAS1 and WAS2 watersheds*

## A.3. Pawlet Site

The Pawlet study watersheds are located approximately 500 m apart in West Pawlet. Field maps are included as Figures 5 and 6. Both fields are in continuous corn production. The PAW1 watershed is nearly twice as large as the PAW2 watershed. Bomoseen and Pittstown soils make up more than 96% of the PAW1 watershed. Bomoseen and Pittstown soils are the most extensive (41%) soil type in the PAW2 watershed also, followed by Raynham silt loam (34%) and Macomber-Dutchess complex (24%). All these soils are classified as moderately runoff prone (hydrologic soil group C). There is no known tile drainage in either the PAW1 or PAW2 watershed. The PAW1 watershed was defined by wingwalls in the western portion of the field to avoid both a newly installed drainage tile and road runoff on the eastern side of the field.

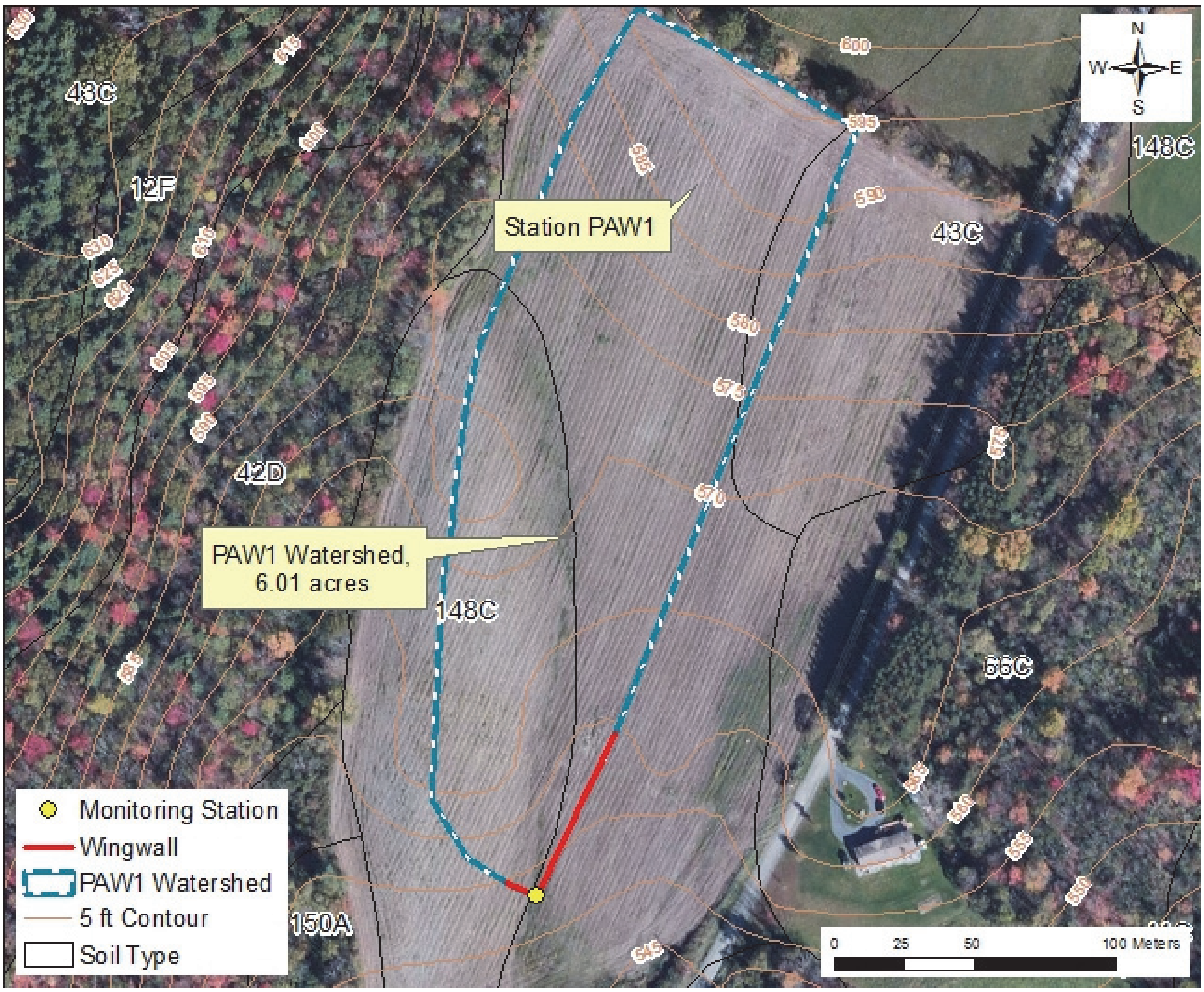


*Figure 5. PAW1 watershed*

In 2013, an error was found in the previously reported watershed boundary delineation for the PAW2 watershed. In this watershed, the orientation of the crop rows influences the drainage area. This watershed is the only paired study watershed that was not surveyed, because it was substituted after the originally intended area (adjacent to PAW1) was surveyed and then determined to be unworkable. Apparently the watershed delineation made using coarse topographic data was in error (Figure 6). The corrected boundary was determined using a GPS unit to mark waypoints along the apparent height of land. An area of 0.35 acres that appears to drain away from the PAW2 station was excluded, a 10 percent reduction in mapped watershed area.

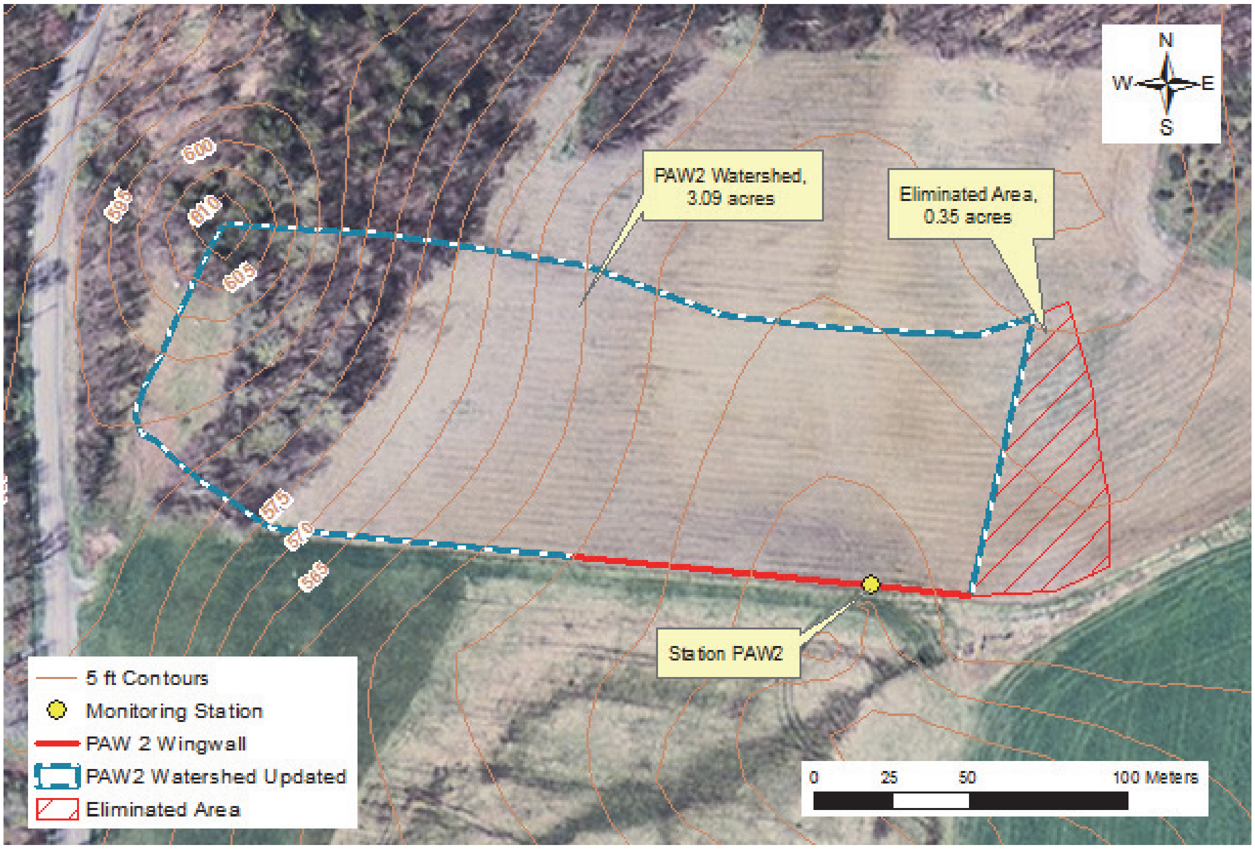


*Figure 6. PAW2 watershed*

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## A.4. **Shelburne Site**

The Shelburne study watersheds are in permanent hay production. Both watersheds have clay soils; Covington silty clay comprises almost 90% of the area of SHE1 and Vergennes clay comprises 100% of the area of SHE2 (Figures 7 and 8). These soils have high runoff potential, classified as hydrologic soil group D. The SHE1 and SHE2 watersheds are similar in size, slope, and aspect. There is no known tile drainage in the SHE2 watershed. During station construction at SHE1 a broken section of drainage tile was removed from the area of the flume. During the winter of 2012-2013, a small sinkhole developed over a tile line within the watershed, opposite the instrument shelter. This tile line appeared collapsed and filled with soil, but it may have conveyed some water under the soil berm. After its discovery, the pipe was crushed and the hole was backfilled with bentonite.

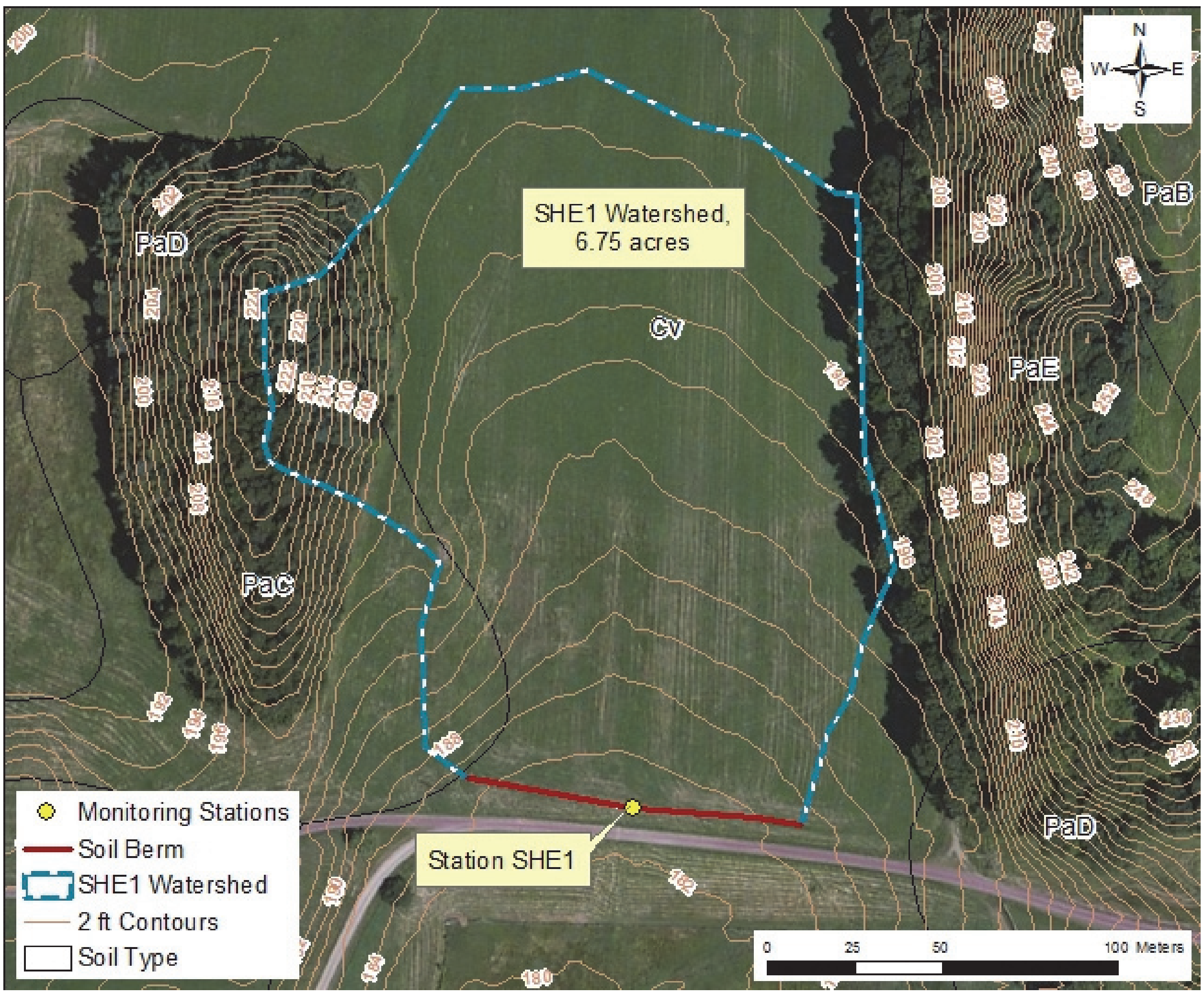


*Figure 7. SHE1 watershed*

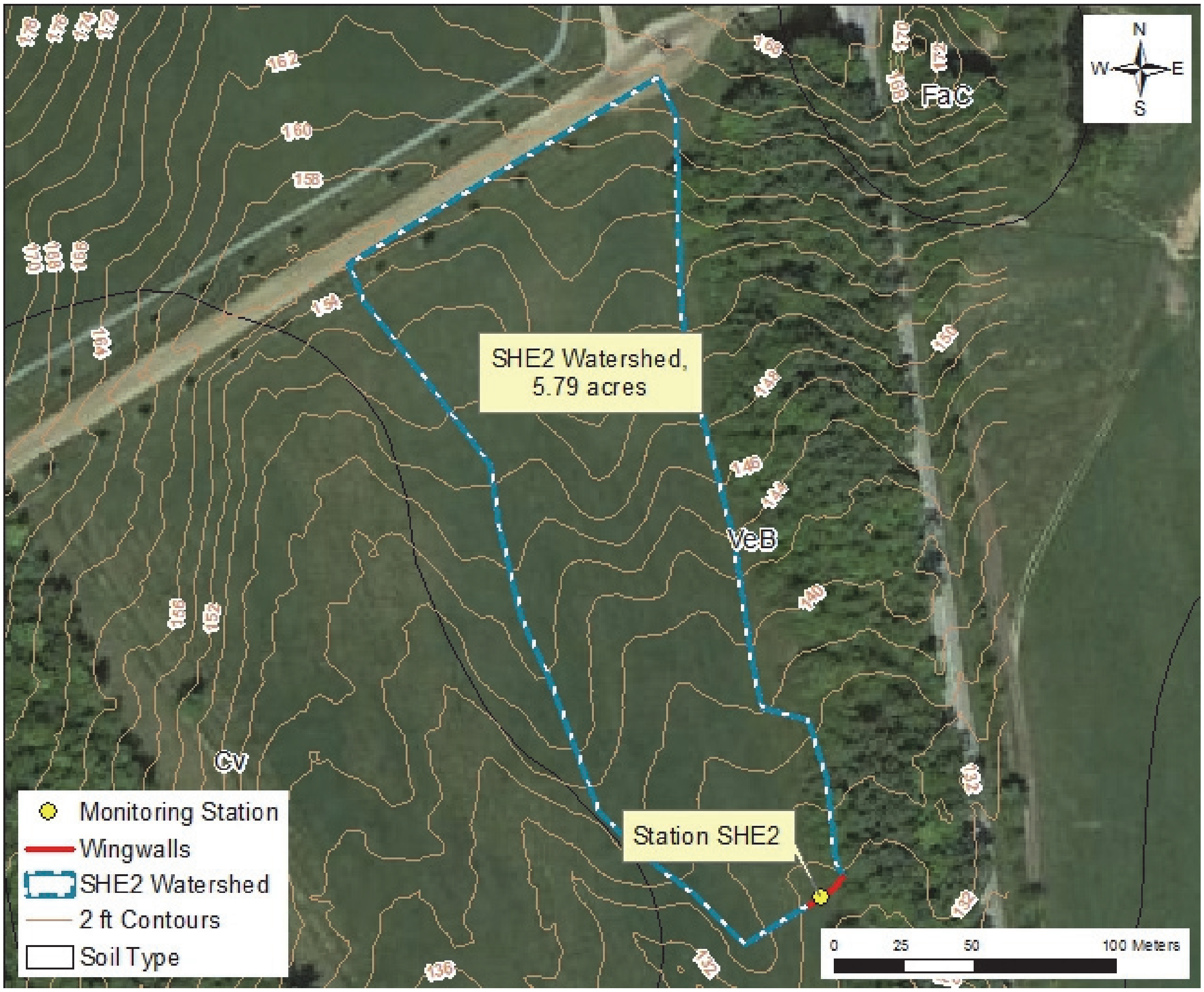


*Figure 8. SHE2 watershed*

## A.5. **Shoreham Site**

The Shoreham study watersheds are distinct drainage areas within a large hayfield. The field is currently managed as a single unit. Historically the area was an orchard. The SHO1 watershed is more than twice the size of SHO2 (Figures 9 and 10). SHO2 is substantially steeper than SHO1. Vergennes clay comprises 100% of both the SHO1 and SHO2 watersheds. These soils have high runoff potential, classified as hydrologic soil group D. During construction activities we found the soil to be particularly sticky and massive. Deep soil cracks develop in these fields during dry conditions. There is no known tile drainage at either SHO1 or SHO2.


*Figure 9. SHO1 watershed*

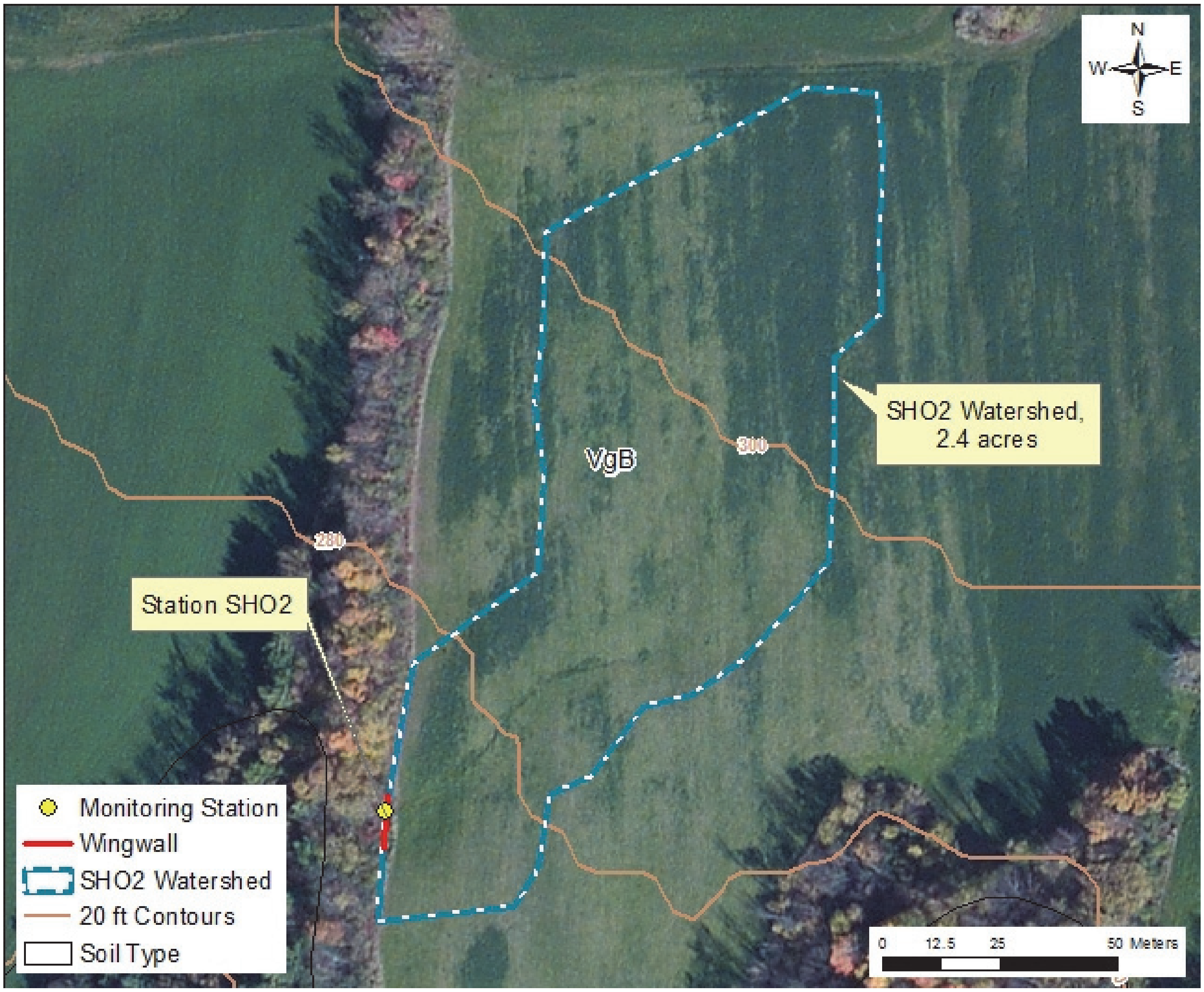

*Figure 10. SHO2 watershed*

## A.6. **Williston Site**

The Williston study watersheds are adjacent to one another in a field with very low topographic relief (Figure 11). The monitoring stations are located near the end of two vegetated drainage swales that extend into the cropped field. The WIL1 and WIL2 watersheds are partially defined by a soil berm on their southwestern boundary. Given uncertain runoff flow paths in this flat field, the soil berm was constructed to establish a consistent watershed boundary. The WIL1 watershed is more than twice as large as the WIL2 watershed, which is the smallest watershed in the study at only slightly more than 2.0 acres (0.81 ha). Limerick silt loam comprises 86% of the WIL1 watershed, whereas the dominant soil in the WIL2 watershed is Winooski very fine sandy loam (65%), followed by Limerick silt loam (35%). Limerick silt loam is classified as hydrologic soil group C and Winooski very fine sandy loam is in hydrologic soil group B. There is no known tile drainage in either the WIL1 or WIL2 watershed.

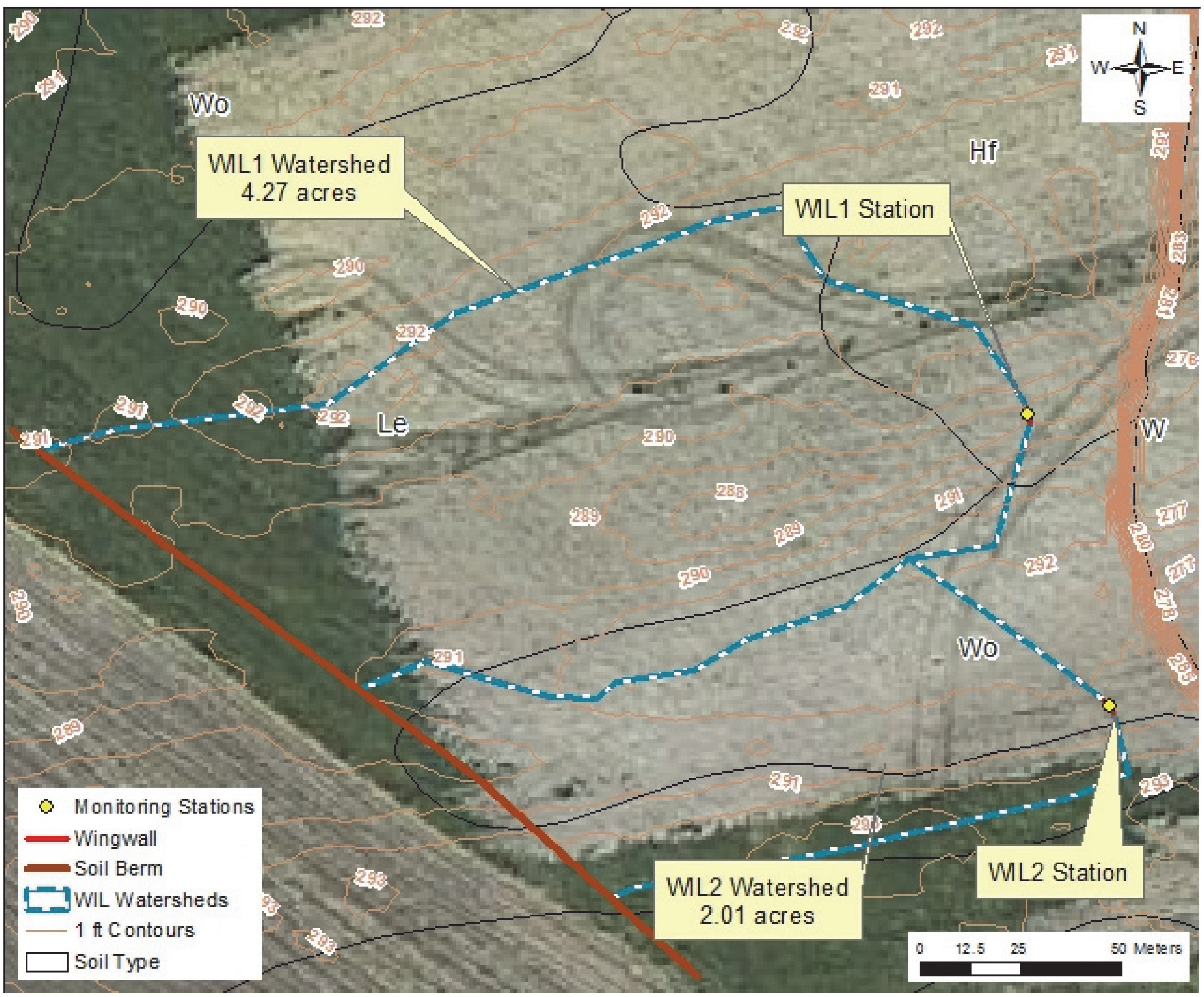


*Figure 11. WIL1 and WIL2 watersheds*

Most of the area in the WIL1 and WIL2 watersheds was in corn or pumpkin production in 2011. However, due to the small size of the WIL1 and WIL2 watersheds, certain areas previously in grass were plowed and planted in corn in 2012 to increase the likelihood of detecting a response due to the reduced tillage/manure injection treatment. The northern side of the WIL1 watershed was in hay production in 2011 and was planted in corn in preparation for the study. Similarly, grass strips bordering the drainage swales were plowed and planted in corn. This was done to reduce treatment (through filtration, settling, and uptake) of runoff draining to the swales.

On October 30, 2013, it was discovered that a narrow, 0.23 acre strip along the northern side of the WIL1 watershed had not been converted to corn production. Maintaining this area (5 percent of the watershed area) in grass should not have a substantial effect on the study and no corrective action was taken.

# APPENDIX B: QUALITY ASSURANCE PROJECT PLAN, VERSION 2.0

**QA Project Plan:**

**Agricultural Practice Monitoring and Evaluation**
**Version 2.0**

**Prepared by:**
Stone Environmental, Inc.
535 Stone Cutters Way
Montpelier, VT 05602

**Prepared for:**
Lake Champlain Basin Program
54 West Shore Road
Grand Isle, VT 05458

July 9, 2013
Version 2

| | |
|---|---|
| Julie Moore, PE, Project Manager, Stone Environmental | 3-5-14 Date |
| Chris Stone for Kim Watson, RQAP-GLP, Project QA Officer, Stone Environmental | 3-5-14 Date |
| Chris Stone, President, Stone Environmental | 3-5-14 Date |
| Eric Howe, Project Officer, LCBP | 2/27/14 Date |
| For Laura — Laura DiPietro, Project Officer, VT AAFM | 3-6-14 Date |
| Michael Jennings, Quality Assurance Program Manager, NEIWPCC | 2/27/14 Date |

**QA Project Plan:**

**Agricultural Practice Monitoring and Evaluation**
**Version 2.0**

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Stone Environmental, Inc.
535 Stone Cutters Way
Montpelier, VT 05602

**Prepared for:**
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54 West Shore Road
Grand Isle, VT 05458

July 9, 2013
Version 2

| | |
|---|---|
| Julie Moore, PE, Project Manager, Stone Environmental | Date |
| Kim Watson, RQAP-GLP, Project QA Officer, Stone Environmental | Date |
| Chris Stone, President, Stone Environmental | Date |
| Eric Howe, Project Officer, LCBP | Date |
| Laura DiPietro, Project Officer, VT AAFM | Date |
| Michael Jennings, Quality Assurance Program Manager, NEIWPCC | Date |

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## A – Project Management

### A.3 Distribution List

NEIWPCC: Michael Jennings, Quality Assurance Program Manager, mjennings@neiwpcc.org
Clair Ryan, Contract Manager, cryan@neiwpcc.org
*Address*: NEIWPCC, 116 John Street, Boott Mills South, Lowell, MA 01852
*Phone*: (978) 323-7929

LCBP: Eric Howe, Project Officer, ehowe@lcbp.org, (802) 372-0218
William Howland, Program Manager, whowland@lcbp.org
Kathy Jarvis, LCBP Office Manager, kjarvis@lcbp.org
*Address*: LCBP, 54 West Shore Road, Grand Isle, VT 05458
*Phone*: (802) 372-3213

Stone Environmental:
Julie Moore, PE, Project Manager, jmoore@stone-env.com, (802) 229-1881
Kim Watson, Project QA Officer, kwatson@stone-env.com, (802) 229 2196
Chris Stone, President, cstone@stone-env.com, (802) 229-6433
*Address*: 535 Stone Cutters Way, Montpelier, VT 05602
*Phone*: (802) 229-4541

Stone Environmental subcontractors:
Evan Fitzgerald, Fitzgerald Environmental, evan@fitzgeraldenvironmental.com
Joe Bartlett, Fitzgerald Environmental, joe@fitzgeraldenvironmental.com
*Address*: 316 River Road, Colchester, VT 05446
*Phone*: (802) 419-0808

Dan Redondo, Vermont Wetland Plant
Supply, dredondo@vermontwetlandplants.com
*Address*: P.O. Box 153, Orwell, VT 05760
*Phone*: 802-948-2553

Jennifer Alexander, Poultney-Mettowee Natural Resources Conservation District,
jad0403@yahoo.com
*Address*: PO Box 209, Poultney, VT 05764
*Phone*: (820) 558-6470

Mike Winslow, Lake Champlain
Committee, mikew@lakechamplaincommittee.org
*Address*:208 Flynn Ave., Bldg 3, Studio 3F, Burlington, VT 05401
*Phone*: (802) 658-1414

State of Vermont:

Laura DiPietro, Deputy Director, Division of Agricultural Res. Management, Vermont Agency of Agriculture, Food, & Markets, laura.dipietro@state.vt.us
*Address*: 116 State St., Montpelier, VT 05620
*Phone*: (802) 828-1289

Eric Smeltzer, Environmental Scientist, Vermont Department of Environmental Conservation, eric.smeltzer@state.vt.us
*Address*: 103 South Main St., Building 10 North, Waterbury, VT 05671-0408
*Phone*: (802) 338-4830

US Department of Agriculture:

Fletcher Potter, State Resources Conservationist, VT NRCS, kip.potter@vt.usda.gov
*Address*: 356 Mountain View Dr., Suite 105, Colchester, VT 05446
*Phone*: (802) 951-6796

**A.4 Project/Task Organization**

The roles and responsibilities of all project personnel are described in Table 1. Project organization is outlined in Figure A1.

NEIWPCC:
Michael Jennings, Quality Assurance Program Manager: Review and approve QAPP and subsequent revisions in terms of quality assurance aspects.

LCBP:
Eric Howe, LCBP Project Officer: Point of communication for VT Agency of Agriculture, Farms and Markets Project Officer and NEIWPCC.

VT Agency of Agriculture, Farms and Markets
Laura DiPietro, VAAFM Project Officer: Overall coordination of the project and point of communication for Stone Environmental Project Manager and the LCBP.

Stone Environmental, Inc.:
Staff members from Stone Environmental, Inc. (and their authorized subcontractors) will report to their 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 ascertaining that the work performed is technically correct and meets all aspects of the QAPP.

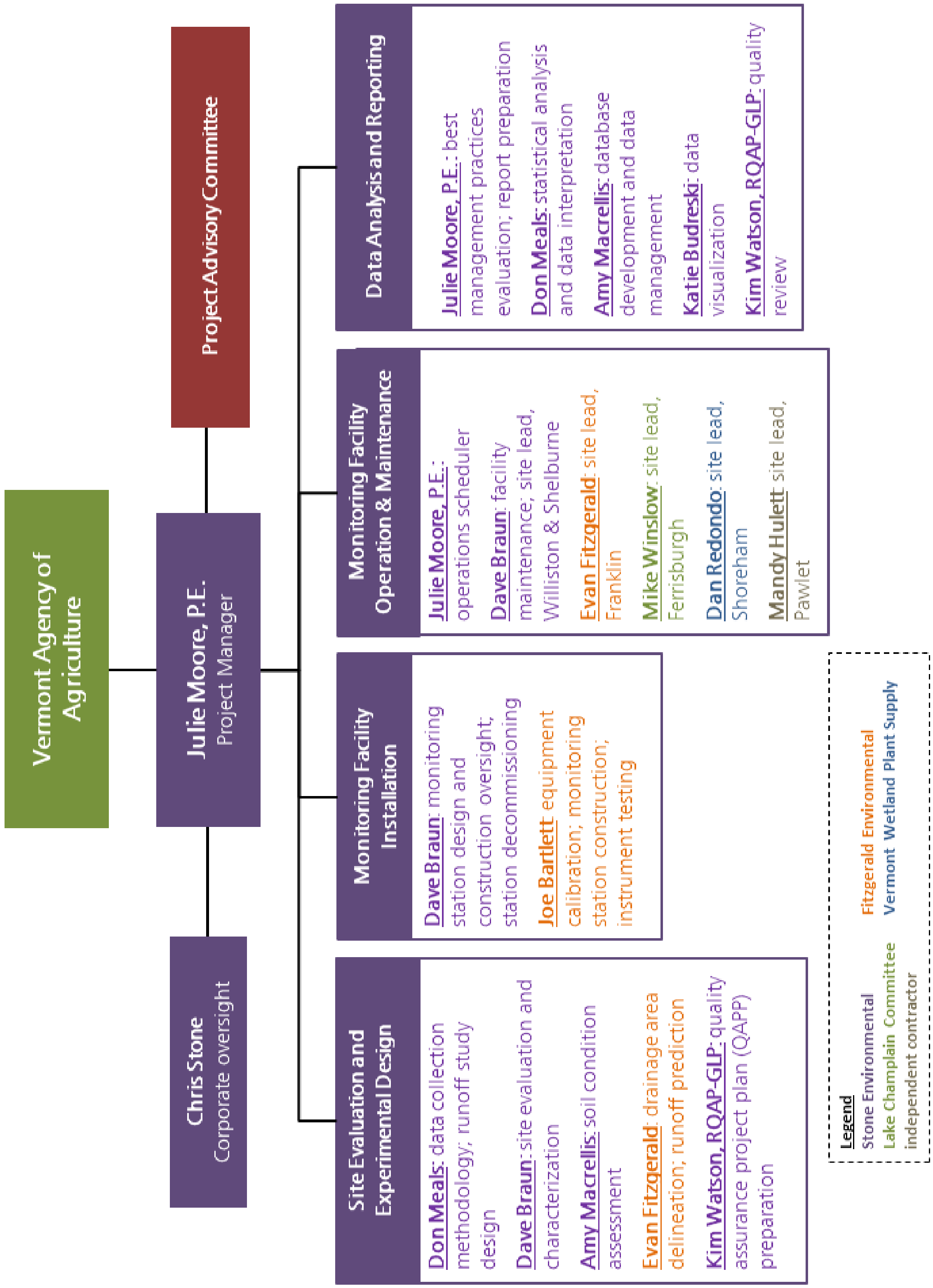
**Table 1: Roles and Responsibilities**

| Individual(s) assigned | Responsible for: | Authorized to: |
|---|---|---|
| **Stone Environmental** | | |
| Julie Moore, PE | Project manager, monitoring program manager, operations scheduler, best management practices evaluation, report preparation, conveying approved QAPP to subcontractors | Coordinate all aspects of project operations<br>Document and approve all major field operations repairs and project changes<br>Manage personnel schedules, including the courier service, and assign duties<br>Interim/Final Report Preparation |

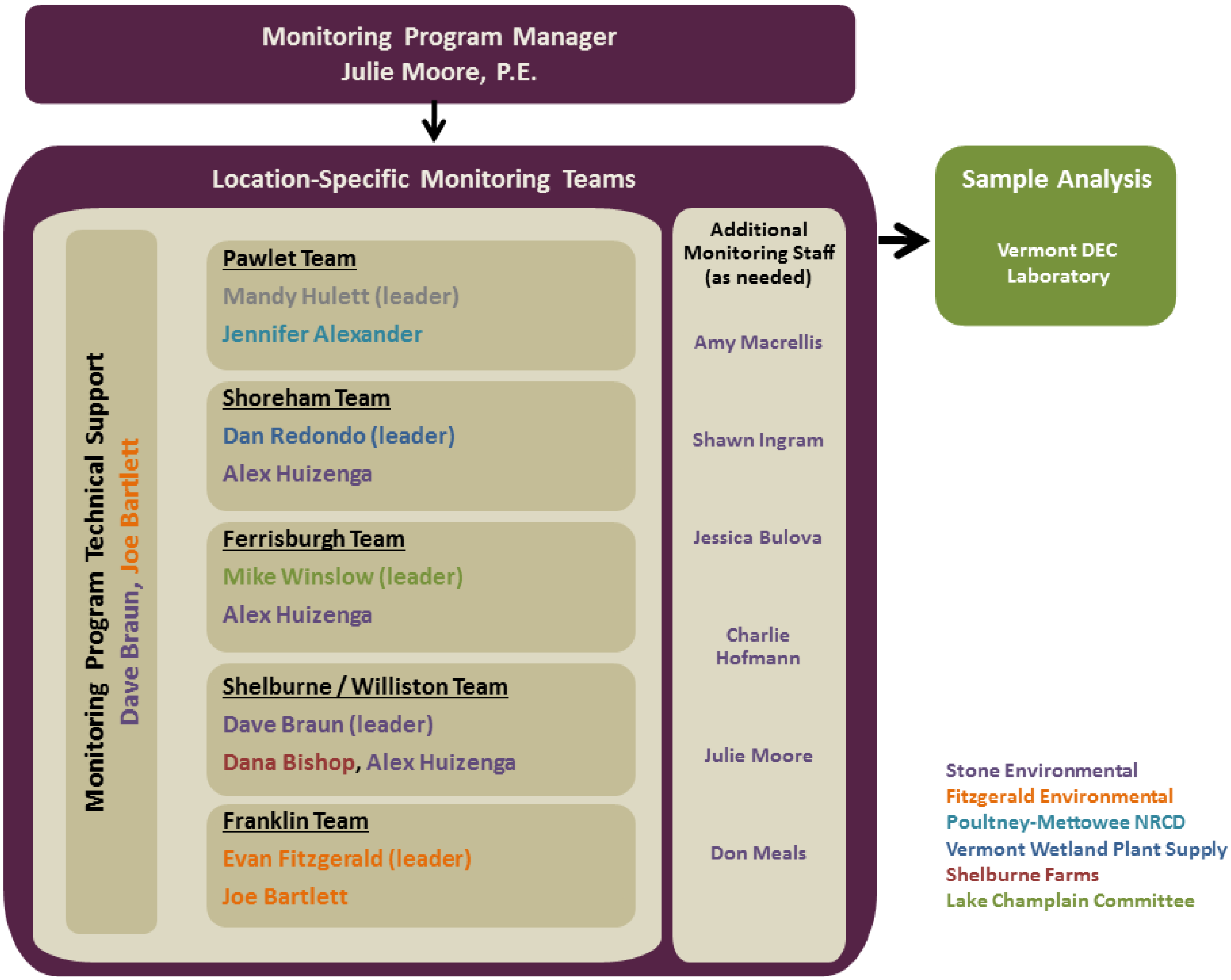
| Individual(s) assigned | Responsible for: | Authorized to: |
|---|---|---|
| David Braun | Monitoring station design, site evaluation and characterization, construction oversight, non-routine maintenance, site lead for Williston and Shelburne sites, station decommissioning | Develop and approve final station designs<br>Supervise station construction<br>Repair damage/breakdown in field stations<br>Calibrate and maintain monitoring equipment<br>Collect, handle, and ship water samples<br>Conduct routine operation and maintenance of field stations |
| Don Meals | Study design, data collection methodology, data analysis and interpretation | Approve overall study design<br>Receive and verify collected data<br>Conduct statistical data analysis<br>Interpret project findings and prepare interim/final reports |
| Jeremy Krohn | Agricultural practices data collection/compilation | Collect, verify, and record agricultural management data |
| Amy Macrellis | Soil conditions assessment, database development and data management | Collect soil samples and other field characterization data<br>Develop and maintain data management system<br>Provide data reports and outputs |
| Katie Budreski | Data visualization | Collect, analyze, and present spatial data in GIS and other software platforms |
| Charles Hofmann | Monitoring data management, GIS support | Develop and maintain data management system<br>Provide data reports and outputs<br>Provide support for GIS analysis |
| Kim Watson, RQAP-GLP | Quality review, maintaining the approved QAPP | Evaluate all aspects of project operations for compliance with approved QAPP<br>Resolve QA/QC issues |
| **Subcontractors** | | |
| Evan Fitzgerald, Fitzgerald Environmental | Drainage area delineation; runoff prediction, site lead for Franklin sites | Calibrate and maintain monitoring equipment<br>Collect, handle, and ship water samples<br>Conduct routine operation and maintenance of field stations |
| Joe Bartlett, Fitzgerald Environmental | Equipment calibration; monitoring station construction; instrument testing, and non-routine maintenance | Construct, calibrate, test, and maintain monitoring stations<br>Test, adjust, and repair field instruments<br>Repair damage/breakdown in field stations |
| Dan Redondo, Vermont Wetland Plant Supply | Site lead for Shoreham site | Calibrate and maintain monitoring equipment<br>Collect, handle, and ship water samples<br>Conduct routine operation and maintenance of field stations |

| Individual(s) assigned | Responsible for: | Authorized to: |
| --- | --- | --- |
| Jennifer Alexander, Poultney-Mettowee Natural Resources Conservation District | Site lead for Pawlet site | Calibrate and maintain monitoring equipment<br>Collect, handle, and ship water samples<br>Conduct routine operation and maintenance of field stations |
| Mike Winslow, Lake Champlain Committee | Site lead for Ferrisburgh site | Calibrate and maintain monitoring equipment<br>Collect, handle, and ship water samples<br>Conduct routine operation and maintenance of field stations |

**Figure 1: Project Organizational Chart**
**Project Team:**



**Field Team:**


Monitoring Program Manager
Julie Moore, P.E.
Location-Specific Monitoring Teams
Monitoring Program Technical Support
Dave Braun, Joe Bartlett
Pawlet Team
Mandy Hulett (leader)
Jennifer Alexander
Shoreham Team
Dan Redondo (leader)
Alex Huizenga
Ferrisburgh Team
Mike Winslow (leader)
Alex Huizenga
Shelburne / Williston Team
Dave Braun (leader)
Dana Bishop, Alex Huizenga
Franklin Team
Evan Fitzgerald (leader)
Joe Bartlett
Additional Monitoring Staff (as needed)
Amy Macrellis
Shawn Ingram
Jessica Bulova
Charlie Hofmann
Julie Moore
Don Meals
Sample Analysis
Vermont DEC Laboratory
Stone Environmental
Fitzgerald Environmental
Poultney-Mettowee NRCD
Vermont Wetland Plant Supply
Shelburne Farms
Lake Champlain Committee

## A.5 Problem Definition/Background

Lake Champlain continues to suffer from the effects of excessive phosphorus (P) loading from sources in the Lake Champlain Basin (LCB). It is estimated that more than 90% of the lake's current annual P load is derived from nonpoint sources (ANR 2008). Nonpoint source P derived from agricultural land is a significant component of the lake's annual P load (Troy et al. 2007). Although federal and state programs, as well as landowners, have made unprecedented investments in best management practices (BMPs) to address P, sediment, and other pollutants from agricultural operations in the LCB, these efforts have not yet yielded the desired water quality results. Vermont farmers are facing increasing pressure to reduce their contributions to water pollution in Lake Champlain. In 2011, the USEPA withdrew their 2002 approval of the Vermont portion of the Lake Champlain total maximum daily load (TMDL) for P. A new TMDL will require quantitative estimates of pollutant reduction performance to provide reasonable assurance that conservation practices will reduce P loads to Lake Champlain. Vermont farmers have shown strong interest in implementing BMPs such as conservation tillage, manure and nutrient management, and cover crops over the past decades. The effectiveness of many of these practices on reducing P and sediment losses from agricultural land, however, is not well documented. Although many producers attribute significant agronomic and water quality benefits to these management practices, only a limited number of studies exist from sites with similar climate and landscape settings to Vermont. In addition, many reported studies are plot-scale with simulated rainfall; such results may not apply directly to the field or watershed scales.

This study addresses an urgent need to evaluate and document the effectiveness of conservation practices in the Lake Champlain basin. The studies conducted by this project will yield multiple benefits, including:

- Accurate estimates of pollutant reductions achievable by several BMPs in Vermont-specific climate, landscape, and management settings;
- Scientifically sound data on BMP performance in support of TMDLs and other pollution reduction programs;
- Data that inform incentive program structure to ensure that the most effective practices are emphasized; and
- Identification of potential modifications to BMPs that may improve performance.

This project is designed to meet the stated purpose of USDA-NRCS Conservation Practice Standard 799 – Monitoring and Evaluation, which is to *sample and measure water quality parameters to evaluate conservation system and practice performance*. More information about NRCS Conservation Practice Standards can be found at: www.nrcs.usda.gov/technical/Standards/nhcp.html

The project will employ a paired-watershed design in order to document the effects of improved management on runoff losses of nutrients and sediments at the field scale. Practices to be evaluated include: soil aeration on hayland prior to manure applications; cover cropping; reduced tillage with manure injection and cover cropping; reduced tillage with manure injection and no cover cropping; and a water and sediment control basin treating runoff from corn land. The principal hypothesis to be tested is that application of these management practices will significantly reduce runoff losses of nutrients and sediment from agricultural fields in corn and hay production.

**A.6 Project/Task Description**

The agricultural practices to be evaluated in the project are:

- Aeration on hayland (VT NRCS Practice Standard 633) prior to manure application;
- Reduced tillage (VT NRCS Practice Standard 329) with manure injection and cover cropping on corn land;
- Reduced tillage (VT NRCS Practice Standard 329[1]) with manure injection and no cover cropping on corn land;
- Cover cropping (VT NRCS Practice Standard 340) on corn land; and
- A water and sediment control basin (WASCoB) (VT NRCS Practice Standard 638) treating runoff from corn land.

These practices will be evaluated on field/watershed sites at working farms in the Vermont-portion of the Lake Champlain Basin; locations of the monitored farms are shown in Figure 2. The project will consist of nine major tasks, including:

**1. Study design**: The overall study design will follow the approaches described above and will include site assessments on the pre-selected study farms.

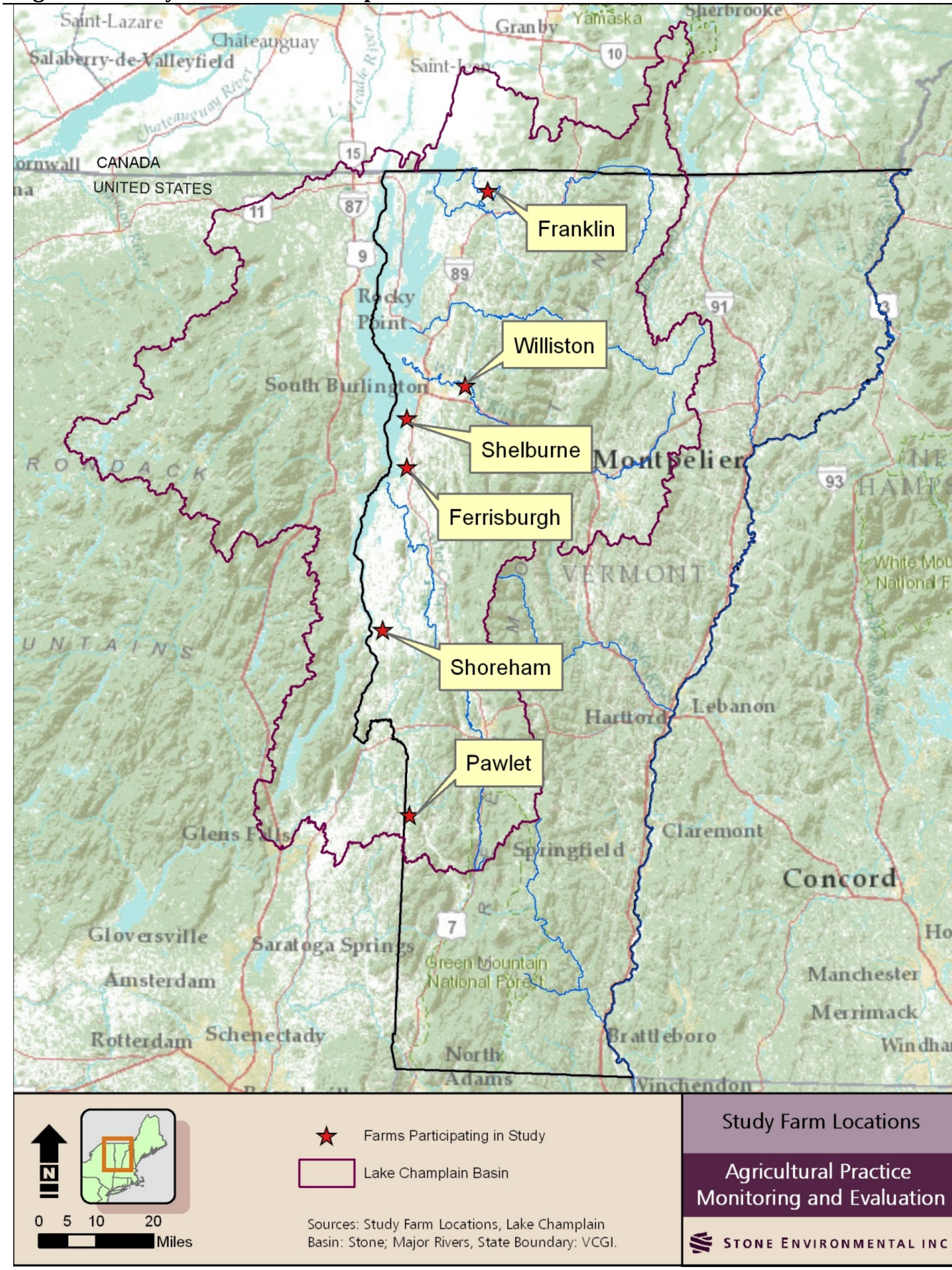
**2. QAPP preparation and approval**: A Quality Assurance Project Plan will be prepared and approved prior to commencement of the field work and data acquisition aspects of the project.

**3. Site characterization**: Basic characterization data will be collected for each field/watershed. A topographic survey will be done to define the area draining to each monitoring station. The general physical and chemical properties of soils in the selected fields will be evaluated through laboratory analysis of soil samples collected from the 1 – 15 cm depth in each field. Samples will be analyzed for pH and available P, K, Mg, Ca, Fe, Mn, and Zn following extraction in modified Morgan solution, and for organic matter and soil particle size. Agronomic management activities will be recorded for each field/watershed throughout the project, with data obtained from the farmer and from observations by project staff.

**4. Monitoring facility design and construction**: Monitoring facilities will include a meteorological station at each participating farm for the continuous monitoring of rainfall and air temperature. The primary hydraulic device used at each paired-watershed runoff monitoring station and at the upstream WASCoB station will be an appropriately-sized H-flume with an ultrasonic water level sensor installed to continuously measure stage during runoff events. Stage data will be converted to flow rate based on the established hydraulic properties of the flume. At the downstream WASCoB monitoring station, a pressure transducer will be used to compute discharge. At both the paired-watershed and WASCoB sites, an autosampler will be programmed to collect a flow-proportional water sample from each monitored runoff event. Water temperature and conductivity will be measured using a sensor and data logger installed in the runoff channel just below the flume.I In the case of the downstream WASCoB station, the temperature and conductivity sensor was installed within the pond itself. Each station will include a communication system (Appendix A) that will allow remote monitoring and adjustment of station status and will push monitoring data to a remote server in near real-time.

[1] Absence of cover cropping represents an exception from Practice Standard 329

**Figure 2: Study Site Location Map**



**5. Study implementation (including site monitoring and implementation of treatments)**: By agreement with site landowners, exact site locations will not be publicly disclosed. The exact locations of the sites are maintained on file at Stone Environmental; the HUC12 location of each site is provided in Section B.1.2 of this document. Event monitoring at each paired watershed monitoring station will be conducted identically during the calibration and treatment periods. During each monitored event, discharge will be measured continuously. Event composite samples will be analyzed for total phosphorus (TP), total dissolved phosphorus (TDP), total nitrogen (TN), total dissolved nitrogen (TDN), chloride (Cl), and total suspended solids (TSS) concentration. We will monitor up to 20 runoff events (weather permitting) each year of the study. Monitoring will generally be conducted between April 1 – November 30, with additional sampling during the winter months to obtain data about practice performance outside of the growing season. Specifically, autosamplers will be operated remotely during rain storms and thaws in winter months to "opportunistically" collect samples when the flumes are clear. Project staff will carefully monitor flow level and temperature and activate autosamplers if/when rain is imminent, and then stop the autosampler at the end of the event or slightly early if ice appears to build up or temperature drops to preclude collection of invalid flow data and non-representative sampling due to ice/snow accumulation in the flume. As called for in the paired-watershed design, calibration monitoring under present management will be conducted for 1 – 1.5 field seasons, with the exact duration depending on having monitored a reasonable range of magnitude of runoff events and on statistical analysis of the calibration period data (USEPA 1993). After the calibration period, the new management practice will be implemented on the treatment field/watershed. Monitoring then continues for 1.5 – 2 field seasons after treatment is established. At the WASCoB site, the inlet and outlet of the basin will be monitored for the same parameters and for a similar period as the paired-watershed sites.

**6. Data management and analysis**: A relational database will be developed and used for the organization and management of farm management practice data, weather data (temperature and rainfall), hydrologic data (runoff level and flow rate), runoff temperature and specific conductance, autosampler logs, and analytical results. The data set used for the primary statistical analyses will include total event discharge ($m^3$), event mean concentration (mg/L), and total event load (kg) for each monitored constituent for each event at each monitored location. Basic descriptive statistics, pair-wise comparisons, and exploratory data analysis will be conducted on this data set. For the paired-watershed sites, changes in event discharge, event mean concentration, and event mass export in response to treatment will be tested using analysis of covariance (ANCOVA). For the WASCoB site, effects of treatment will be evaluated based on an input/output comparison (e.g., t-Test), both for individual events and over the entire monitoring period.

**7. Project communication and reporting**: The Project Manager will coordinate the efforts of all project personnel and serve as a single point of contact for the client's project-related questions. Project personnel will communicate with landowners at the field/watershed sites on a regular basis, both to obtain agronomic management information and to provide information about project results on an ongoing basis. The Project Team will work with the Vermont Agency of Agriculture, Food, & Markets (AAFM) to establish a Project Advisory Committee (PAC) that will include personnel from USDA-NRCS, USGS, AAFM, ANR, UVM, the Lake Champlain Basin Program, landowners, and others with an expressed interest in the project. Project staff will seek discussion with and advice from the PAC on major project decisions or proposed modifications. The PAC will meet approximately semi-annually.

**8. Practice evaluation**: Evaluation of the performance of each practice tested will be made on the basis of the paired-watershed analysis of event discharge, mean concentration, and/or load changes resulting from the practice implementation. Experiences of the farmer and observations by project staff in the field will also be factored into an assessment of overall practice performance. In consultation with AAFM and NRCS, the Project Team will suggest any potential modifications to conservation practice implementation requirements, based on the efficacy of the practices as implemented on the participating farms. Where the same practice is implemented on more than one farm, pollutant reductions due to treatment may be compared and contrasted.

**9. Site decommissioning**: At the conclusion of the study, the Project Team will work with each farm owner, NRCS and AAFM to determine whether the monitoring stations should be decommissioned or left in place to support future study. Should the farm owner wish to decommission the monitoring site(s), the Project Team will remove the equipment and return it to the farmer and restore the monitoring sites to their pre-project condition, including CREP buffers or other features modified during the project that are specified in the landowners' long-term contracts with USDA.

Work will be conducted from May 2012 through March 2015. Installation of monitoring facilities will take place in summer and fall, 2012. At the paired-watershed sites, calibration monitoring will commence late in the 2012 cropping season and continue through much or all of the 2013 growing season. At least one complete cropping season will be required for adequate calibration monitoring; it is possible that calibration monitoring will need to be extended further if sufficient high-flow events following manure application do not occur during 2013. For treatment with effects exerted primarily in fall and spring (e.g., cover cropping), calibration monitoring will continue through spring of 2014. The exact timing of the implementation of treatments will depend on the treatment (e.g., aeration treatments will commence at the first hay cut after adequate calibration, whereas cover crop treatment will not occur until late summer/fall). Post-treatment monitoring will continue through at least spring 2015. The final report for this project will document the complete record of the timing of these activities.

Above-below monitoring at the WASCoB site will begin in late 2012 and continue through the 2014 cropping season. The overall project schedule is shown in Table 2.

**Table 2: Project Schedule**

| Task | Objective | Task | Deliverable | Timeline |
|---|---|---|---|---|
| 1 | Study design | Visit pre-selected study farms and select fields for monitoring | Identified field/watersheds for monitoring and treatment | 31-Jul-2012 |
| 2 | QAPP | Development and approval of Quality Assurance Project Plan | Approved QAPP | 7-Jun-2012 |
| 3 | Site characterization | Topographic survey and soil sampling | Topographic map and watershed boundary delineation for each monitored site; soil physical and chemical data | 30-Nov-2012 |
| 4 | Monitoring facility design and construction | Design monitoring stations, specify and purchase equipment and instrumentation, construct monitoring stations, install instruments | Fully functioning monitoring stations at each field/watershed monitoring site | 30-Sep-2012 |
| 5 | Monitoring Program Implementation | Collect water quality and agricultural management monitoring data | Monitoring data for:<br>Year 1 (2012)<br>Year 2 (2013)<br>Year 3 (2014) | 1-Apr-2013<br>1-Apr-2014<br>30-Sep-2015 |
| 6 | Data management and analysis | Build project database and manage monitoring data; conduct data analysis | Functioning data management system for entry, storage, and retrieval of all project data | 31-Dec-2012 |
| 7 | Project communication and reporting: | Communicate with project landowners, Project Advisory Committee, and management agency personnel | Collection of agronomic management data; quarterly reports to AAFM, semi-annual PAC meetings | ongoing |
| 8 | Practice evaluation | Analyze and interpret monitoring data to evaluate performance of tested management practices; suggest modifications based on project experience | Quantitative and qualitative evaluation of pollutant-reduction performance of evaluated management practices. | 31-Dec-2015 |
| 9 | Decommission sites | Remove station installations and return monitoring equipment to farmers | Monitoring sites restored to original condition | 31-Dec-2015 |
| | Complete final report | Compile project summary, maps, results, etc. | Final Report | 31-Dec-2015 |
| | Contract End Date | QAPP Expiration | None | 31-Mar-2016 |

## A.7 Quality Objectives and Criteria for Measurement Data

Objectives: 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, completeness, representativeness, comparability, completeness, and traceability.

Table 3 summarizes data quality requirements associated with the sampling program and the accuracy and precision levels reported by the analytical laboratory for each parameter. The analytical laboratory for the water samples is the Vermont Department of Environmental

Conservation (VT DEC) Laboratory, which is currently located on the University of Vermont campus in Burlington. The DEC laboratory is accredited by the National Environmental Laboratory Accreditation Conference Institute (TNI) for the target water quality parameters (Total Phosphorus, Total Dissolved Phosphorus, Total Dissolved Nitrogen, Chloride, and Total Dissolved Solids). Meteorological monitoring will produce data to characterize ambient temperature and rainfall conditions during the study. Flow measurement will document the rate and total quantity of runoff from each study field/watershed during each monitored event. Analysis of flow-proportional water samples will provide the event mean concentration (EMC) of each monitored constituent. Mass of each monitored constituent will be computed as the product of total event runoff volume and EMC. To ensure data quality objectives are met, all sampling activities will be well documented and will occur in strict accordance with the specifications presented in this QAPP. The data quality indicators considered in the study design include accuracy, precision, representativeness, comparability, completeness, and traceability.

### A.7.1 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. The Vermont DEC Laboratories Quality Assurance Plan (VT DEC 2012) provides acceptance criteria for spiked sample results for each analyte tested, with the exception of TSS which cannot be spiked. Calibration procedures, blank samples, and sample handling protocols provide additional information used to evaluate the accuracy of each analytical procedure.

### A.7.2 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 samples (see Section B.2.3). 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 3. Field duplicates will be prepared and delivered to the laboratory (blind) at a minimum rate of 10%.

### A.7.3 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. The treatments to be tested will be representative of other applications of the same treatment because they will conform to established USDA-NRCS practice standards. By continuously measuring event runoff from the entire field/watershed and collecting flow-proportional samples for chemical analysis, the data gathered will accurately represent water and pollutant export under true field conditions. The study sites themselves are not intended to be representative of all agricultural land in the LCB, or of some “average” condition for the Basin. This would be impossible to achieve. However, the study sites have been chosen for characteristics that are reasonably typical of dairy agricultural land in the Basin according to criteria that include soil type and slope, typical cropping practices, suitable crop rotation, and willingness of the landowner to participate in the project. By testing some of the practices (e.g., soil aeration) in different settings, we will represent some of the variability of response to treatment to be expected across the LCB. Thus, the processes (treatments) to be evaluated are believed to be representative of actual field conditions and management activities.

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.

### A.7.4 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 during both calibration and treatment periods and across all field/watershed monitoring sites. Such consistency will be reinforced by training and supervision of field staff (see section A.8). Comparability of laboratory measurements is ensured through following the Vermont DEC Laboratory Quality Assurance Plan, Revision 20, dated January 2012, and respective SOP for a given analyte.

### A.7.5 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 field/watershed runoff is determined to be 95 percent.

% Completeness = # of Usable Points / Total # of Data Points Collected x 100

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

### A.7.6 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.

**Table 3: Data Quality Requirements and Assessments**

| Matrix | Parameter | Units | PQL[1] | Accuracy[2] | Accuracy protocol | Precision Lab/Field[3] | Precision protocol | Method Range |
|---|---|---|---|---|---|---|---|---|
| Water | Level (ISCO 2110) | cm | N/A | The greater of ±0.396c m or 0.526 cm per foot (0.305 m) from calibration point | N/A | N/A | N/A | Varies with size of primary device |
| Water | Level (ISCO 2150) | cm | N/A | ±0.3 cm from 1 to 305 cm | N/A | N/A | N/A | 1.0 to 305 cm |
| Water | Velocity (ISCO 2150) | m/s | N/A | ±0.03 m/s from -1.5 to +1.5 m/s; ±2% of reading from 1.5 to 6.1 m/s | N/A | N/A | N/A | -1.5 to +6.1 m/s |
| Water | Total P | µg/L | 5 µg/L | 85-115% | Spike recovery | 15/20 | Field duplicate | 5 – 200 µg/L |
| Water | Total Dissolved P | µg/L | 5 µg/L | 85-115% | Spike recovery | 15/20 | Field duplicate | 5 – 200 µg/L |
| Water | Total N | mg/L | 0.1 mg/L | 85-115% | Spike recovery | 10/20 | Lab duplicate | 0.05 to 2.0 mg/L as N |
| Water | Total Dissolved N | mg/L | 0.1 mg/L | 85-115% | Spike recovery | 10/20 | Lab duplicate | 0.05 to 2.0 mg/L as N |
| Water | Total Suspended Solids | mg/L | 1 mg/L | 80-120%[4] | N/A | 15[4]/20 | Lab duplicate | 1 – 2000 mg/L |
| Water | Chloride | mg/L | 2 mg/L | 85-110% | Spike recovery | 5/20 | Lab duplicate | 2 – 25 mg/L |
| Water | Temperature | $^{o}$C | N/A | 0.1$^{o}$C | N/A | N/A | N/A | 5 to 40 $^{o}$C |
| Water | Specific Conductivity | µS/cm | N/A | The greater of 3% of reading or 5 µS/cm | N/A | N/A | N/A | 0 to 10,000 µS/cm |
| Air | Temperature | $^{o}$C | N/A | ± 0.47°C at 25°C | 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 are 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.

## A.8 Special Training Requirements/Certifications

Personnel with considerable expertise and experience in performing the project tasks will conduct all sampling and analysis for the project. Because station operation and maintenance, field data collection, and runoff sample collection will be done by subcontracted personnel at some sites, initial training will be led for all field personnel by the Stone Environmental Monitoring Program Manager, who 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 station maintenance, sample retrieval, and collection of agronomic data (see Appendix C). 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 DEC laboratory under the direction of the Laboratory Director. No additional specialized training or certifications are necessary for personnel to conduct the project tasks.

### A.9 Documentation and Records

It will be the responsibility of the Project QA Manager to ensure that appropriate project personnel have the most current approved version of the QAPP. Distribution will be in electronic form only; any changes, revisions, or distribution of new versions of the QAPP will be documented in quarterly reports made to the AAFM.

All project data will be maintained in the project database, which will be subject to redundant storage through normal procedures at Stone Environmental.

All project data (in summary form) will be included in the project Final Report. In addition to complete documentation, analysis, and discussion of project tasks, appendices to the Final Report will include:

- Raw data from all monitored events, including flow and concentration data;
- Raw data from all QA/QC activities, including analysis of duplicates, blanks, and spikes;
- Meteorological data collected on-site and from National Weather Service stations if necessary;
- Summaries of agronomic management data for both calibration and treatment periods;
- Summaries of field notes describing monitoring station operation and field observations.

These data will be presented in printed form in the annual and final reports, and will be archived. Appropriate summaries will be presented to the PAC and transmitted electronically, in spreadsheet form, to AAFM. Oral presentation of the preliminary study data and the final report will be made by the investigators to appropriate audiences.

In addition to use of field data forms (Appendix C), project personnel will maintain detailed field logs during field activities, especially during and after monitored runoff events. Electronic versions of project data and records will be maintained by Stone Environmental for a period of not less than 5 years after completion of the project.

## B – Data Generation and Acquisition

### B.1 Sampling Process Design (Experimental Design)

### B.1.1 Experimental design

### B.1.1.1 Paired watershed experiments

The project will use a paired-watershed design (USEPA 1993) at the field-watershed scale to test the effects of treatment on event discharge and pollutant concentration and export in surface runoff from study fields. The paired-watershed design includes two fields (watersheds)—control and treatment—and two time periods—calibration and treatment. The control watershed accounts for year-to-year climate variations and the management practices remain consistent during the entire study. The treatment watershed undergoes a change in management (e.g., soil aeration or cover cropping) at some point during the study. During the calibration period, the watersheds in each pair are treated identically and paired water quality data are collected. For this monitoring study, total event discharge, event mean concentration, and total event export data will be collected and/or computed for each monitored event. At the start of the treatment period, a change in management is applied to the treatment watershed, while the control watershed remains in the original management. The basis of the paired-watershed approach is that there is a quantifiable relationship (i.e., a linear regression model) between paired data from the watersheds (calibration) and that this relationship is valid until a change is made in one of the watersheds (treatment). At that time, a new relationship will exist. The difference between the calibration and treatment relationships is used to evaluate and quantify the effect of treatment.

The agricultural practices to be evaluated using a paired-watershed design are:

- Aeration on hayland (VT NRCS Practice Standard 633) prior to manure application [Ferrisburgh, Shelburne, Shoreham];
- Reduced tillage (VT NRCS Practice Standard 329) with manure injection and cover cropping on corn land [Williston] ;
- Reduced tillage (VT NRCS Practice Standard 329[2] ) with manure injection and no cover cropping on corn land [Franklin];
- Cover cropping (VT NRCS Practice Standard 340) on corn land [Pawlet]; and
- A water and sediment control basin (WASCoB) (VT NRCS Practice Standard 638) treating runoff from corn land [Franklin].

### B.1.1.2. Water and Sediment Control Basin (WASCoB)

At one of the farms participating in the paired-watershed experiment, a Water and Sediment Control Basin (WASCoB) was installed in 2011 to treat runoff from an adjacent cornfield. For the evaluation of the WASCoB treatment, an above-below design will be applied, wherein flow and pollutant concentrations will be measured simultaneously at the inlet and the outlet of the WASCoB. Total event discharge, event mean concentration, and total event export data will be collected and/or computed for each monitored event.

## B.1.2 Sampling locations

### B.1.2.1 Paired-watershed sites

The locations of the participating farms are shown in Figure 2. These sites were pre-selected. Within each farm, a pair of field/watersheds was selected in advance of the study for monitoring based on the following criteria:

- Capability to isolate two drainages either through natural topography or constructed wingwalls, or both;
- Both fields of similar soil type based on NRCS soil survey;
- Both fields currently under similar crop, with no rotation planned for the entire study period;
- Both fields previously untreated with respect to the treatment to be tested (e.g., soil aeration);

[2] Absence of cover cropping represents an exception from Practice Standard 329

- Similar management history;
- Roughly comparable size (ideally, within a factor of 0.5 – 2 times in area); and
- Ability of the farmer to apply treatment to one of fields at the appropriate point in the study.

Following identification of candidate field/watersheds, the sites will be characterized (see Section A.6) and the exact drainage area determined by topographic survey. Field/watersheds will be mapped in a Geographic Information System (GIS). Because landowner confidentiality is required, monitoring sites will be identified by town and HUC-12 only. Site locations are given in Table 4.

**Table 4: Sampling Locations**

| Site Location | HUC-12 | HUC-12 Name |
|---|---|---|
| Ferrisburgh | 020100080603 | Lakeshore-Town Farm Bay |
| Franklin | 020100081101 | Rock River |
| Pawlet | 020100010203 | Mettawee River-Flower Brook to Indian River |
| Shelburne | 020100080801 | LaPlatte River |
| Shoreham | 020100080303 | Lakeshore-East Creek to Crane Point |
| Williston | 020100030702 | Winooski River-Huntington River to Alder Brook |

Monitoring stations will be installed at the outlets of the field/watersheds where runoff can be concentrated by a combination of natural topography and field work (e.g., wingwalls, berms).

### B.1.2.2 WASCoB site

At the farm in Franklin (Figure 2), paired-watersheds will be monitored in one field and a WASCoB will be monitored in an adjacent field. This WASCoB, which was installed in 2011, receives runoff from conventionally tilled corn land. The WASCoB was selected in advance of the study for monitoring because it is the first such structure constructed by the Vermont Agency of Agriculture, Food, and Markets and there are no data at present regarding its effectiveness. Monitoring stations will be installed at the inlet and outlet of the WASCoB.

## B.1.3 Field characterization sampling

### B.1.3.1 Paired-watershed sites

At the paired-watershed sites, the area draining to each monitoring point was delineated during the site selection phase of the project, prior to submission of this QAPP, with funding outside of the LCBP-funded project. The drainage boundaries (watersheds) were delineated through heads up digitizing in an ArcGIS geodatabase. Three data sources were used to define the boundaries: existing elevation data captured by LiDAR (Light Detection And Ranging) where available, detailed survey conducted by Stone Environmental, and locations of features that affect drainage patterns, such as culverts, roads, and ditches. LiDAR data are currently available for the Franklin, Williston, and Shelburne sites. At these sites, a detailed survey was performed to: 1) verify and, as necessary, correct the watershed boundaries inferred from the LiDAR elevation data; and 2) to generate a detailed elevation profile in the immediate vicinity of the proposed monitoring stations to aid in design and construction of flume wingwalls and/or soil berms used to channel field runoff to the flumes. Surveys were conducted using either an autolevel or a total station. Watershed boundaries suggested by the topographic data were adjusted based on locations of roads, ditches, and culverts that were observed by Stone during initial site visits. At the remaining three sites, the best available elevation data (digital elevation model data based on 10-m postings) are not sufficiently detailed to delineate the study watershed boundaries. At these sites, a more extensive survey was conducted to define topographic breakpoints, slopes, and low points, to generate a three dimensional terrain map. At the Pawlet site, corn row orientation was also an important factor influencing drainage patterns; the watershed boundaries delineated for this site follow the microtopography of the prevailing row orientation in certain areas.

The general physical and chemical properties of soils in the selected fields will be evaluated through laboratory analysis. Within each field/watershed in corn production, soil samples from the 0-20 cm (0-8 in) depth will be collected at nodes in a sampling grid using a stainless steel probe. In fields/watersheds in hay production, soil samples from the 0-10 cm (0-4 in) depth will be collected. Samples from each field/watershed will be composited and homogenized using a trowel. Subsamples will be taken from each composite for analysis of physical properties (e.g., soil texture) by the University of Vermont Agricultural and Environmental Testing Lab and chemical properties by the Agricultural & Forestry Experiment Station Analytical Laboratory at the University of Maine, where all Vermont soil samples are currently being analyzed. Analyses will be performed for soil pH (1:2, V:V, in dilute calcium chloride), organic matter (loss on ignition), and soil particle size (by wet sieving and the hydrometer method). Available P, K, Ca, Mg, Fe, Mn, and Zn will be analyzed (by ICP, EPA method 200.7 [USEPA 1994]) following extraction with modified Morgans solution, and will be reported on a volume basis ($mg/dm^3$).

Using the calculated drainage areas, SSURGO soils maps (USDA-NRCS), published rainfall frequency/duration maps, slope, and cover, rainfall-runoff modeling will be performed for each watershed using standard USDA-NRCS methods (i.e., TR-55 model). Predicted runoff volumes will be used to guide monitoring station construction, primarily to appropriately size flumes.

#### B.1.3.2 WASCoB site

Existing data from the design and construction of the WASCoB structure include contributing drainage area and modeled discharge rates for a range of design storms will be assembled. These existing data and the “as-built” plans will be considered in designing monitoring systems for the WASCoB. Within the watershed area draining to the WASCoB, soil samples will be collected, processed, and analyzed according to the procedures identified previously in B.1.3.1.

### B.1.4 Event sampling

We will monitor discrete runoff events that generate discharge at our monitoring stations. For the purpose of this study, we generally define a runoff event for monitoring as a discrete episode of discharge from the flume (persisting for hours or days) generated by precipitation. Thus defined, the event begins when discharge begins and ends when discharge ceases at one or both of the paired watersheds. Because of the difficulty of accurately measuring extremely low flows and to prevent the sampling system from sucking air at very low flows, we will define a discharge event as beginning at a threshold stage of approximately 1 cm. That said, if an event occurred the total runoff flow was calculated, including the tails of the hydrograph. Generally, we wait until runoff at both ceased or the level at both stations fell below 1 cm. before making a field visit. However, if a field visit is made at a time when effective flow has ceased at only one field/watershed of a pair, we will stop sampling and process accumulated samples from both of the field/watersheds, but will continue to count the flow over the tail of the hydrograph in the total event discharge. In cases where multiple precipitation events in rapid succession generate sustained discharge, we will consider the period of continuous discharge to be a single runoff event.

An exception to the above protocol may occur in long, low-intensity runoff events generated by snowmelt in winter thaws or spring runoff. In cases where episodic runoff is not generated by discrete precipitation events, we may define the runoff event either as that discharge that occurs during the above-freezing portion of the day (when flow freezes at night, for example) or as the accumulated discharge over a period of days defined either by ambient weather or by logistical convenience.

We plan to monitor up to 20 runoff events (weather permitting) at each monitoring station in each year of the study. Generally, monitoring will target runoff events that occur between April 1 and November 30. We propose to extend the monitoring season at the WASCoB, reduced tillage/manure injection, and cover crop-only treatment sites, with a limited program of winter/early spring event sampling. These practices were identified for winter and early spring monitoring because of the interest in quantifying reductions in sediment and nutrient export attributable to these practices outside of the growing season. At these sites, autosamplers will be operated remotely during rain storms and thaws in winter months to “opportunistically” collect samples when the flumes are clear. Project staff will carefully monitor flow level and temperature and activate autosamplers if/when rain is imminent, and then stop the autosampler at the end of the event or slightly early if ice appears to build up or the temperature drops to preclude collection of invalid flow data and non-representative sampling due to ice/snow accumulation in the flume.

Available project resources permit us to monitor up to 20 runoff events a year at each monitoring station. In order to ensure that we collect data representative of a full seasonal span each year and, at the same time, collect data during critical periods of BMP performance (e.g., late fall and early spring for cover crop treatments, runoff closely following manure applications on hayland aeration treatments), we require some flexibility in selecting which events to include for full sampling and analysis. Therefore, we will use our best judgment to stratify the events we choose to monitor so that critical periods/conditions are included. In this process, samples from some events that occur under conditions already frequently sampled may be discarded so that we retain the capacity to monitor later events that represent critical conditions. For example, if we have monitored several events on a pair of hay fields that occurred several weeks or more after a manure application, we may choose to not submit samples for analysis for similar events that occur before the next manure application. Similarly, if we have monitored several comparable events on corn fields before cover crops are planted, we may decide to not submit samples from additional events under those conditions so that we can monitor runoff events that occur following cover crop establishment. The hydrologic magnitude of the event will, of course, be another consideration. Within the limits of our resources, we will monitor events of particularly large magnitude (e.g., a 25-year storm) even if we have previously monitored smaller events under similar field conditions.

### B.1.5 Sample parameters

As noted earlier (Section B.1.3), soil samples from the field characterization will be analyzed for available P, K, Mg, Ca, Fe, Mn, and Zn following extraction in modified Morgan solution, and for pH, organic matter, and soil particle size. Water samples from runoff events will be analyzed for TP, TDP, TN, TDN, TSS, and Cl.

The following table summarizes the number and type of samples that are anticipated in this study. The number of water samples is based on the assumption of 20 warm-weather runoff events/year at 14 stations plus up to four thaw events/year at six stations monitoring cover crop treatments over the three years of the study. A minimum of 10% additional QC samples are included.

**Table 5: Sample numbers and types to be collected.**

| Sample Matrix | Analytical Parameters | Sample Container | Number of Samples | Sample Preservation | Hold Time (days) |
|---|---|---|---|---|---|
| Soil | pH | Polyethylene bag | 14 | None | 180 |
| Soil | Available P | Polyethylene bag | 14 | None | 180 |
| Soil | Available K | Polyethylene bag | 14 | None | 180 |
| Soil | Available Mg | Polyethylene bag | 14 | None | 180 |
| Soil | Available Ca | Polyethylene bag | 14 | None | 180 |
| Soil | Available Fe | Polyethylene bag | 14 | None | 180 |
| Soil | Available Mn | Polyethylene bag | 14 | None | 180 |
| Soil | Available Zn | Polyethylene bag | 14 | None | 180 |
| Soil | Organic matter | Polyethylene bag | 14 | None | 180 |
| Soil | Particle size | Polyethylene bag | 14 | None | 180 |
| Water | TP[1] | Polyethylene bottle (composite) / 60-mL glass vial (aliquot for lab) | 1003 | None | 28 |
| Water | TDP[1] | Polyethylene bottle (composite) / 60-mL glass vial (aliquot for lab) | 1003 | Filtered (0.45 µm) in field | 28 |
| Water | TN | Polyethylene bottle (composite) / 50-mL plastic centrifuge tube, blue cap (aliquot for lab) | 1003 | Cool (<6°C), 0.1 mL $H_2SO_4$ | 28 |

| Sample Matrix | Analytical Parameters | Sample Container | Number of Samples | Sample Preservation | Hold Time (days) |
|---|---|---|---|---|---|
| Water | TDN | Polyethylene bottle (composite) / 50-mL plastic centrifuge tube, blue cap (aliquot for lab) | 1003 | Filtered (0.45 µm) in field, cool (<6°C), 0.1 mL $H_2SO_4$ | 28 |
| Water | TSS | Polyethylene bottle (composite) / 500-mL plastic bottle (aliquot for lab ) | 1003 | Cool (<6°C) | 7 |
| Water | Cl | Polyethylene bottle (composite) / 50 mL plastic centrifuge tube, purple cap (aliquot for lab) | 1003 | None | 28 |
| Water | Temperature | N/A[2] | N/A[3] | N/A | N/A |
| Water | Specific Conductance | N/A[2] | N/A[3] | N/A | N/A |

1 VT DEC 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.
2 Measured in situ
3 Measured continuously

**B.2 Sampling Methods**

Monitoring and sampling methods will be consistent across all monitoring stations, study sites, and study periods. Trained field personnel will be responsible for satisfactory sampling operations, maintenance of sampling stations, and processing of field data, under the direction of the Monitoring Program Manager. Field personnel will be responsible for recording failures of sampling systems and taking corrective action immediately. The Monitoring Program Manager will be responsible for ensuring that immediate and subsequent corrective actions are effective and fully documented.

## B.2.1 Flow measurement

## B.2.1.1 Paired watershed sites

The primary hydraulic device used at each paired watershed runoff monitoring station and at the upstream WASCoB station will be an appropriately-sized H-flume manufactured by Tracom. Each flume will be bolted to a rectangular plywood approach channel of varying length (approach channel length was 5 ft for 1.5-ft H flumes and 6 ft for 2.0-ft and the 2.5-ft H flumes). Plywood wingwalls embedded at least 60 cm in the ground will be installed as necessary to direct runoff into the flume approach channel. The approach channel will be mounted to the wingwall such that the opening is nearly flush with the ground. Through the life of the monitoring program, the flume will be kept level through regular adjustments using a system of turnbuckles.

An ultrasonic water level sensor (ISCO 2110 Ultrasonic Flow Module) will be installed in each flume 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 flow rate based on the established hydraulic properties of the flume. These data will be used for generation of runoff event hydrographs and total event discharge, and in calculation of pollutant export.

#### B.2.1.2 Downstream WASCoB station

Due to backwater conditions in the channel downstream of the WASCoB, a different flow monitoring system was used at the downstream station (WAS2) from those at the other monitoring stations. A pressure transducer module (ISCO 720 Module) was installed within the pond to measure pond levels. This instrument's stated accuracy is ±0.008 m/m from 0.01 to 1.52 m and ±0.012 m/m above 1.52 m.

When the 720 pressure transducer module is connected to an ISCO 6712 autosampler, the autosampler can compute discharge according to a rating table of entered stage-discharge points. A preliminary rating table was developed using HydroCAD and the dimensions and elevations of the outlet structures. This rating table will be adjusted as necessary through discharge measurements over a range of pond stages. Averaged level and flow rate data will be logged at stage-dependent intervals (15 minutes at stages < 1 cm or 1 min at stages >=1 cm) on a connected Interface Module (ISCO 2105-Ci Interface Module).These data will be used for generation of runoff event hydrographs and total event discharge, and in calculation of pollutant export.

### B.2.2 Sampling instrumentation

An ISCO 6712 autosampler will be connected to the ISCO 2105-Ci Interface Module. The autosampler will be programmed to pump subsamples of runoff water on a flow-proportional basis into bulk (10-L polyethylene) sample containers. Runoff samples will be collected through a screened ~1 cm tygon intake line from a mixing trough that receives the H-flume discharge. In the case of the WAS2 station, the sampler intake will be secured within the WASCoB, near the outlet. Each runoff event will be represented by a single composite sample. The composite sample will be split in the field to obtain aliquots for chemical analysis for total P (TP), total dissolved P (TDP), total N (TN), total dissolved N (TDN), total suspended solids (TSS), and chloride (Cl). All monitoring instrumentation will be powered by two 6-volt deep cycle batteries connected in series and recharged by a solar panel/solar controller.

### B.2.3 Automated runoff event sampling protocols

Flow-proportional sampling is challenging because flow rates and total event discharge are highly variable and unpredictable. If individual subsample collection is too infrequent (e.g., in small runoff events), an event may be poorly representative and insufficient sample volume may be collected to perform the intended analyses. If subsamples are collected too frequently (e.g., in an unexpectedly large runoff 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 to two sets of containers at different intervals of accumulated flow. Each bottle set will consist of two 10-L polyethylene carboys. The first bottle set (Set A) is intended to capture a representative runoff sample from small to medium sized events and the second bottle set (Set B) is intended to capture sample from medium to large events. 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.

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 750 mL 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 Bottle #1 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 this 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 event mean concentrations mathematically proportioned by flow data at a later date.

Using this sampling program, most small storms will provide sufficient sample (approximately 750 mL is needed) to perform the required analyses and most large storms will not exceed the container capacity; runoff events varying in size by more than a factor of 300 can be representatively and automatically sampled. In addition to optimizing the autosampler program as described above, sampler pacing settings may be adjusted seasonally and in advance of major predicted storms, with the intent of representatively sampling every runoff-producing storm. Adjustment to the program 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 runoff event or exceeding the capacity of all sample bottles in Set B may result in rejection of the event sample.

Within 24 hours of a monitored runoff event resulting in acceptable samples, field technicians will process the bulk sample into appropriate splits for delivery to the VT DEC laboratory. Sample will be poured into a 14-L polyethylene churn splitter, a device that consistently agitates the water to deliver representative subsamples from a spigot. A dedicated churn splitter will be stored in each instrument shelter and will be cleaned after each use with potable water from a well or other source that does not contain phosphorus-based corrosion inhibitors, with a final distilled water rinse. Aliquots will be collected from the churn splitter in containers provided by the DEC laboratory for transport and delivery to the lab.

Sample splits for TDP and TDN analyses will be filtered in the field by dispensing sample from the churn splitter directly into a filtration apparatus containing a Durapore® 0.45 µm membrane filter supplied by the VT DEC laboratory. The filtrate will be dispensed directly into the appropriate sample container, identified in Table 5.

Sample splits collected for TN and TDN analysis will be acidified immediately using one drop of concentrated sulfuric acid supplied by the DEC laboratory. A medicine dropper will be used to dispense the acid into the filled sample container.

Following the sample retrieval process, the polyethylene sample containers, the churn splitter, and the filtration apparatus will be double rinsed with potable water, then rinsed a third time with distilled water. The containers will be reinstalled and the station reset for the next event.

If insufficient sample is available to conduct all the intended analyses, and yet sampling is determined to have been reasonably representative of the event (a minimum of three sample aliquots were collected), then samples may be submitted for analysis according to the following priority system, which reflects the fact that TP, TN, and TSS samples require a homogeneously mixed split, whereas for TDP, TDN, and chloride the procedure is to let the sample settle for at least one minute before filtering:

- TP
- TN
- TSS
- TDP
- TDN
- Chloride

Note that samples from some events may not be submitted for analysis (see Section B.1.4); however flow data and water temperature and conductance data will be collected and maintained for all runoff events that exceed the minimum stage threshold (see Section B.1.4).

Based on previous experience in event monitoring of agricultural fields, we anticipate that it is possible that sediment eroded from the field (especially corn fields before full crop canopy development and after harvest) will remain deposited in the flume and approach channel after event flow has ceased. While for the purpose of this study, we consider nutrient export from the field to include only that contained in water that exits the flume, we believe that sediment deposited in the flume/approach channel represents sediment lost from the field and therefore it must be included in estimated TSS loss. Although we do not have resources to precisely quantify this component of field export, we will estimate significant sediment mass deposited in the flume/approach after a runoff event by the following standard procedure:

- After flow has ceased, the field technician will shovel any sediment accumulation in the flume/approach into graduated polyethylene buckets to obtain an estimate of sediment volume (+1 L). The total volume will be recorded.
- If the sediment volume is less than 1 L, the accumulation will be considered negligible and the sediment discarded downstream of the monitoring station.
- If the sediment volume exceeds 1 L, a subsample of the accumulated sediment will be collected in a clean plastic jar for subsequent total phosphorus and density analysis (dry weight) in order to derive an estimate of the phosphorus and sediment mass in the flume/approach. Remaining sediment will be discarded downstream of the monitoring station.

### B.2.4 In situ runoff quality measurements

Water temperature and conductivity will be measured continuously in the runoff stream using a HOBO® U24-001 Conductivity Data Logger installed in the mixing trough in the runoff channel below the flume. At the WAS2 station, this instrument will be installed next to the sample intake line in the pond. These data will be downloaded on site using a waterproof shuttle device and brought into the project database.

### B.2.5 Meteorological data

A simple meteorological station (Onset HOBO®) will be installed at each participating farm for the 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. Continuous precipitation monitoring will be supplemented by an inexpensive manual rain gage located at each site as a backup.

### B.2.6 Agronomic and field management data

Data on agronomic and field management activities such as tillage (date, method), manure, nutrient, and agrichemical applications (date, method, rate), planting (date, method, variety), and harvest (date, method, yield) will be collected for each study field directly from the participating farmers. These data will be collected and maintained from farm records and/or by interviewing participating farmers using standard forms (Appendix C). Information on field management will be supplemented by direct observation by field sampling personnel, including field notes and time-lapse photography from repeatable photopoints at each monitoring site.

On fields where cover crops are part of the treatment, we will assess the quality of the cover crop establishment in the fall by estimating plant density as percent ground cover within 30 days of the cover crop planting date by one of two alternative methods: (1) the traditional line-intersect method, where a 30 x 30 cm quadrat frame strung with wires creating 64 cross-grids is placed ~50 cm above the ground and the number of grid crosses that are over cover crop plants are counted and converted to a percent ground cover (Laycock and Canaway 1980, Kershaw 1973) ; or (2) a digital image analysis procedure that measures the proportion of pixels in a digital image determined to be green as an estimate of percent crop soil cover (Rasmussen et al. 2007).

### B.3 Sampling Handling & Custody

Each step in the sample handling and custody process will be documented to ensure traceability of samples from generation to analysis. For each sampling event, a sample retrieval sheet (Appendix C) will document sample ID, sample type, source, and volume. The analytes for which splits are prepared, the personnel responsible for sample splitting, and the data and time sample splits are prepared will be recorded. Samples will be transported to the laboratory within the stated holding times for each analyte by project staff (Stone Environmental or subcontractor) or courier service.

Soil samples will be delivered to the University of Vermont Agricultural and Environmental Testing Laboratory (AETL), where they will enter the lab’s custody system, be assigned a lab identification number. The soil particle size analysis will be performed AETL; a portion of the sample will also be sent to the Agricultural & Forestry Experiment Station Analytical Laboratory at the University of Maine for chemical analysis, where all Vermont soil samples are currently being analyzed. Within the Maine lab, samples will be handled and analyzed according to the lab's approved QAPP (MAFES Analytical Laboratory 2006).

A Chain of Custody form will be completed by the sampler and will accompany all water quality samples delivered to the Department of Environmental Conservation lab for analysis (Appendix C). The Chain of Custody form includes sample IDs, number of containers of each sample being sent to the lab, and the analyses to be performed.

### B.4 Analytical Methods

All water samples will be analyzed by the standard methods of the VT DEC Laboratory. These methods and relevant data quality objectives, assessment procedures, and reporting limits are described in the laboratory's Quality Assurance Plan, Revision 20, dated January 2012 (VT DEC 2012). Soil and sediment samples will be analyzed through the UVM Agricultural and Environmental Testing Lab per the methods indicated in Table 6.

Internal assessments and response actions with regard to laboratory analysis within the VT DEC and UVM Agricultural and Environmental Testing laboratories will occur under the terms of each lab's approved QA plan. Project investigators will examine data reports from the labs for problems or conditions of concern noted by analysts. Data flagged by the laboratory will be followed up with the analyst to determine the specific reason for the remark. Unless specifically advised otherwise by the analyst, estimated values will be considered usable for subsequent analysis with other project data. Corrective action within each lab will be the responsibility of each lab director; decisions and documentation of corrections, modifications, or rejection of data reported to the project staff will be the responsibility of the Monitoring Program Manager.

Methods for all analyses are summarized below:

**Table 6: Analytical Methods**

| Sample Matrix | Analytical Parameter | Lab | Method | Reference |
|---|---|---|---|---|
| Soil | pH | MAFES | Potentiometric measurement of soil slurry (1:2, V:V) with dilute calcium chloride, using electronic pH meter. | 1 |
| Soil | Available P | MAFES | Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter.<br>Analysis: Molybdate blue procedure with colorimetric analysis. | 1 |
| Soil | Available K | MAFES | Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter.<br>Analysis: ICP-AES. | 1 |
| Soil | Available Mg | MAFES | Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter.<br>Analysis: ICP-AES. | 1 |

| Sample Matrix | Analytical Parameter | Lab | Method | Reference |
|---|---|---|---|---|
| Soil | Available Ca | MAFES | Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter. Analysis: ICP-AES. | 1 |
| Soil | Available Fe | MAFES | Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter. Analysis: ICP-AES. | 1 |
| Soil | Available Mn | MAFES | Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter. Analysis: ICP-AES. | 1 |
| Soil | Available Zn | MAFES | Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter. Analysis: ICP-AES. | 1 |
| Soil | Organic matter | MAFES | Loss of weight on ignition | 1 |
| Soil | Particle size | AETL | Wet sieve and hydrometer | 2 |
| Water | TP | VT DEC | 4500-P H | 3 |
| Water | TDP | VT DEC | 4500-P H | 3 |
| Water | TN | VT DEC | 4500-N C-modified | 3 |
| Water | TDN | VT DEC | 4500-N C-modified | 3 |
| Water | TSS | VT DEC | 2540-D | 3 |
| Water | Cl | VT DEC | 4500-$Cl^-$ G | 3 |

References:
1. 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 October 15, 2009
2. 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 (2ed). American Society of Agronomy/Soil Science Society of America, Madison, WI.
3. Standard Methods for the Examination of Water and Wastewater; 21st Ed. 2005.

### B.5 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 samples will be duplicated in the field by collecting a second aliquot from the churn splitter 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 and QA Officer will be relied upon in evaluating results. Rejecting sample results based on wide variability is a possibility. Evaluation criteria noted in this section and in Section A7 above will be used for data review. Notations of field duplicate excursions and blank contamination will be noted in the final report.

Laboratory quality control will be conducted under the approved plans for the respective laboratories. QA/QC procedures used in the University of Maine Agricultural & Forestry Experiment Station Analytical Laboratory are documented in the laboratory's approved Quality Assurance Plan, dated November 2006 (MAFES Analytical Laboratory 2006). QA/QC procedures used in the VT DEC laboratory are documented in the laboratory's approved QA Plan, Revision 20, dated January 2012 (VT DEC 2012).

### B.6 Instrument/Equipment Testing, Inspection, and Maintenance

Prior to initiating data collection at each site, the monitoring instruments will be inspected to verify their proper functioning. Level sensing instruments (ISCO 2110 flowmeters and ISCO 720 module) will be tested over the range of expected water levels, at approximately 15-cm depth intervals. For the 2110 ultrasonic level flowmeters, a single point calibration will be performed at 0-cm. The accuracy of the level readings will be assessed by stacking blocks of known thickness beneath the beam of the ultrasonic sensor. For the 720 pressure transducer module, the water depth will be measured with a ruler and compared with the recorded level displayed on the connected auosampler. After calibration, the instruments will be accepted if the difference between the measured water depths recorded and the flowmeter are within the stated accuracy of the instruments (see Table 3) over the range of flow levels expected. If any sensor is found to be less accurate than stated by the manufacturer, it will be replaced.

Specific conductance measurement of the HOBO® U24-001 Conductivity Data Logger will be calibrated using a low range (~447 µS/cm) standard. If after calibration the instrument is found to be less accurate than stated by the manufacturer (see Table 3), the instrument will be replaced. The temperature sensor on the HOBO® U24-001 Conductivity Data Logger cannot be calibrated by the user. Proper operation will be verified using a NIST traceable thermometer in a water-filled vessel. If the instrument is found to be less accurate than stated by the manufacturer (see Table 3), the instrument will be replaced.

The HOBO Data Logging Rain Gauge - RG3 used for rainfall measurement will be calibrated by slowly releasing a known volume of water equivalent to a specific rainfall depth into the collection funnel. In repeated testing, the tipping bucket mechanism will be adjusted until the recorded water volume is within 2% of the known addition in two successive tests. The air temperature sensor supplied with this instrument cannot be calibrated by the user. Temperature readings in air will be compared with a NIST traceable thermometer. If the sensor instrument is found to be less accurate than stated by the manufacturer (see Table 3), the instrument will be replaced.

Routine maintenance (conducted on maintenance visits every two weeks and/or immediately following each monitored event) will include:

- Downloading the HOBO® data loggers (precipitation / air temperature and conductivity / water temperature)
- Checking/cleaning the tipping bucket funnel, the solar panel, and the sample intake tubing and screen
- Cleaning the ultrasonic level and conductivity sensors
- Checking/replacing instrument desiccant
- Checking/servicing batteries
- Verifying that the flume is level
- Clearing vegetation from around the stations
- Checking for erosion and rodent holes near the flume approach and wingwalls

Maintenance logs will be maintained by the Project Manager and made available to the Project QA Officer. The logs will document any maintenance and service of the equipment. A log entry will include the following information:

- Name of person maintaining the instrument/equipment
- Date and description of the maintenance procedure
- Date and description of any instrument/equipment problems
- Date and description of action to correct problems
- List of follow-up activities after maintenance
- Date the next maintenance will be needed

Instrument and equipment testing, inspection, and maintenance for water analysis will be routinely carried out by the VT DEC Laboratory under its EPA approved Quality Assurance Plan, Revision 20, dated January 2012.

Instrument and equipment testing, inspection, and maintenance for soil and sediment analysis will be conducted under the normal QA programs in force at the UVM Agricultural and Environmental Testing Laboratory and the University of Maine Agricultural & Forestry Experiment Station Analytical Laboratory.

### B.7 Instrument/Equipment Calibration and Frequency

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

After installation, the accuracy of level sensing by the ISCO 2110 flowmeter will be verified at least weekly by analyzing the level data transmitted to Stone's server. The level will be adjusted if it differs from zero by more than +/- 0.002 m on dry days when the flume is clear of debris. An exception is that during sunny days heating of the sensor can result in substantial negative level readings. This problem is minimized to the extent practicable by shading the sensor from direct sunlight. The problem is not of significant concern during most rainfall/runoff events because the sky is typically overcast. However, because of this sensor anomaly, the accuracy of the level data will be assessed--and adjusted if necessary--after dark (usually at approximately 9:00 P.M.). Further, the sensor level may be zeroed even when the departure is only +/- 0.001 m or 0.002 m from zero during dry weather, particularly when the level data from one station in a pair is consistently higher or lower than the other station in the pair.

The tipping bucket rain gage will be calibrated annually using the procedure above.

The conductivity sensor/logger will be recalibrated monthly using an appropriate conductivity standard.

Instrument and equipment calibration for water analysis will be routinely carried out by the VT DEC laboratory under their EPA approved Quality Assurance Plan, Revision 20, dated January 2012.

Instrument calibration for manure analysis will be conducted under the normal QA programs in force at the UVM Agricultural and Environmental Testing Laboratory.

### B.8 Inspection/Acceptance of Supplies & Consumables

All supplies and consumables for field activities purchased from commercial vendors will be inspected for compliance with the acceptance criteria by Stone Environmental prior to use. Supplies or consumables not meeting the acceptance criteria upon inspection will not be used. Any equipment determined to be in an unacceptable condition will be replaced. Supplies and consumables will be stored in accordance with identified storage requirements of each item.

The VT DEC laboratory will perform their own inspections and acceptance of supplies as described in their Quality Assurance plan. The DEC lab will also be responsible for supplying sampling teams with clean sample containers specified for each analyte in water (see Table 5).

### B.9 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 supplement on-site meteorological data during monitored events or 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 each 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, soils mapping based on the USDA-NRCS county soil surveys, and engineering plans prepared for design and construction of the WASCoB in Franklin, under the direction of Vermont AAFM.

The supplementary data will not contribute directly to project decision-making, with the exception of field agronomic practices data recorded by the participating farmer. These farm record data will be subject to verification by Stone Environmental, to the extent possible through on site observation and time-lapse photography.

### B.10 Data Management

The Stone Environmental Project Manager 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 VT DEC and UVM Agricultural and Environmental Testing laboratory directors have the same responsibility for the laboratory data and information they generate.

Detailed field logs will be maintained by project personnel during field activities, especially during runoff events. Standard field data sheets (Appendix C) will document sample location, station and field conditions, date and time of collection, and personnel responsible for collection for all samples collected in the field. The Chain of Custody sheets will be used by the laboratory to confirm sample receipt and crosswalk field-assigned sample IDs with those assigned by the laboratory. Soil samples collected for field characterization or other purposes will be logged into the UVM Agricultural and Environmental Testing Lab's sample tracking system. Copies of all field sheets will be maintained in the project file at the offices of Stone Environmental.

Data management within the respective laboratories will be conducted according to their standard systems. Final reports for analytical data from the VT DEC lab will be issued after all internal review has been completed. Electronic copies of data reports will be transmitted to project investigators. The UVM lab follows similar procedures.

Field and laboratory data – including continuous sensor data pushed to the Stone Environmental server by station instrumentation and manually-entered data from field logs – will be entered into a database by project personnel. Following data entry, recorded values will be error-checked against original data reports and field sheets by the QA manager or his/her designee. Final error-checked copies of data files will be maintained in redundant storage at the offices of Stone Environmental.

All electronic files will be backed up on a regular basis. At the conclusion of the project all relevant information, project files and electronic data will be turned over to the LCBP and VT AAFM Project Officers for archiving. The files will be archived for a minimum of five years at Stone Environmental following completion of the project.

## C – Assessment/Oversight

### C.1 Assessments and Response Actions

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 will review all project output. 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.

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.

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 recorded during dry weather, drift from the zero in recorded water level during dry weather, 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 incidents of instrument malfunctions and other problems. Certain basic maintenance activities will be conducted after every runoff event, to clean bulk sample containers, churn splitters, sampler lines, and flumes (if necessary) and to reset the sampler to a standby condition. Site visits will be conducted for more intensive maintenance activities approximately monthly during the monitoring period. A Maintenance Checklist will be completed during each maintenance visit (Appendix C). Deficiencies noted will be corrected by the responsible personnel so that each station is ready to effectively collect monitoring data during the next runoff event. 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 at the end of each event (Appendix C). The Monitoring Program Manager or her designee will ensure data for each event is entered into the project database as it available. Once there is a complete data record for an event in the database, the Monitoring Program Manager or her designee will assess the quality of all event data (e.g., flow, analytical, weather) and will be responsible for verifying/validating all sample tracking information and laboratory analysis data. Any event data deficiencies will be flagged with a qualifying statement in the project database and necessary corrective action will be taken immediately.

Internal assessments and response actions with regard to laboratory analysis within the VT DEC Laboratory will occur under the terms of the lab's approved QA plan (VT DEC 2012). Project investigators will examine data reports from the DEC lab for problems or conditions of concern noted by analysts, based on *Sample Remark codes*. Examples of such codes include:

**Table 7: Sample Remark Codes**

| Sample Remark Code | VT DEC 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. |

Data flagged by the laboratory will be followed up with the analyst to determine the specific reason for the remark, if the reason is not clear. Unless specifically advised otherwise by the analyst, estimated values will be considered usable for subsequent analysis with other project data. The impact of missing data points on the analysis and interpretation of the study data and on the study conclusions will be discussed in the study final report.

The overall status of monitoring data collection will be assessed through regular examination of accumulating data (e.g., time series plots) and regular informal reports to the PAC by the data analysis/interpretation staff at Stone Environmental. In this way, any anomalies in the ongoing data stream will be detected and addressed as promptly as possible.

### C.2 Reports to Management

Preparation and distribution of laboratory analytical reports will be conducted according to the standard procedures of the laboratory conducting the analyses. All QA/QC data associated with project samples will be available to project investigators. Progress reports addressing all project activities will be submitted quarterly to the AAFM and semi-annually to the project PAC by the last day of June and December of each project year. Interim project results will be presented in an annual report delivered to AAFM by February 15th of each year. A final report will be prepared for AAFM documenting all methods, data, and project results by the end of March 2015. The final report will include complete documentation and discussion of project QA/QC data. All of these reports will be prepared by project investigators and submitted to the AAFM Project Manager. The AAFM Project Manager will be responsible for distribution of progress reports and the final report.

# D – Data Validation and Usability

## D.1 Data Review, Verification, and Validation

The data quality will be reviewed for logical consistency and coding errors as identified in appropriate standards. The Stone Environmental QA Officer will be responsible for overall validation and final approval of the data in accordance with project purpose and use of the data.

Upon inspection by Stone Environmental of the field-collected and laboratory analytical data, the data are accepted for the study unless there is a noted occurrence of field instrumentation malfunction, or a laboratory note indicating that the required analysis was not performed in accordance with one or more of the criteria associated with the particular analysis. These conditions will be clearly noted within field data collection notes and on laboratory analytical reports. Data will be reviewed and evaluated using the data quality objectives noted above and will be deemed usable for the overall study objectives. If a data point is deemed unusable the data would be flagged and noted as such.

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.

## D.2 Verification and Validation Methods

The Monitoring Program Manager or her designee will be responsible for the verification and validation of measurements taken in the field and field data records. Results will be conveyed to data users in the form of spreadsheets and annual reports. Verification and validation within the DEC laboratory will be conducted under the approved procedures in place. Any discrepancies or excursions discovered in this verification and validation process will be discussed between the Quality Assurance Officer and the Stone Environmental Project Manager and the resolution will be documented in the final project report. See Section D.3, below, for more details.

## D.3 Reconciliation with User Requirements

During the course of the project, situations may arise that will require some degree of corrective action or reconciliation, ranging from simple corrections on routine field documentation to systematic problems that may necessitate shutting down a process until the problem is corrected. Described below are how situations requiring reconciliation are to be handled and documented in both the field and the laboratory for the purposes of this project.

Any or all deviations from stated work plans and this QAPP will be reconciled with the Stone Environmental Project Manager. Reconciliations will be documented as a memorandum to the project file with copies sent to all individuals noted in the distribution list. If there are limitations regarding the use of both primary and secondary data these will be documented as such and reported to the project team.

In field operations, malfunctions may occur and require subsequent corrective action. Wherever possible, immediate corrective action will be taken; such actions will be clearly described in the field logs, but no formal documentation is required unless further corrective action is deemed necessary. Reconciliation of the situation will be fully documented by monitoring team personnel and reported to the Project Manager.

Some potential malfunction or error conditions that may arise and the planned responses include:

| Condition | Response |
| --- | --- |
| Severe tunneling or erosion damage observed at monitoring station after runoff event, indicating probable errors in flow measurement and representative sampling | Reject data for that event at that site if more than 30% of field runoff is estimated to have bypassed the flume |
| Event sample lost or in error from one field of site pair | Do not include event in paired-watershed analysis; however data from properly-sampled field will be included in overall field characterization |
| No runoff from one field of site pair | Do not include event in paired-watershed analysis for pollutant concentrations; however, assign flow and export values of zero for that event and include data from both fields of the pair for paired-watershed analysis |
| Field or lab duplicates outside limits | Evaluate and determine need for rejection of data for that sample |

In the course of data analysis, the assumptions for the general linear model of independence, constancy of variance, and normality of distribution will be tested and appropriate transformations will be made on flow, concentration, and load data to assure the validity of use of parametric statistical analysis. 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 the most current version of JMP statistical software (SAS Institute).

Once the data are compiled, the QA Officer and Stone Environmental Project Manager will review the data quality to determine if it falls within acceptable limits per user requirements. Limitations of the data will be discussed with the end user and documented within the project final report. Completeness will be evaluated to determine if the completeness goal for this project has been met. If the quality of the data does not meet the project's requirements, the data may be reevaluated to determine why the data quality did not meet the goals. Efforts will be made to determine inconsistencies in the base data or correct errors in the attribute data. If inconsistencies are found in the quality of the base data, an effort will be made to identify and obtain more accurate base data and will be documented in the final report.

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# Appendices

## Appendix A: Runoff monitoring station diagram

# Appendix B: Example of Single-stage Passive Sampling Array

# Appendix C: Forms

## AAFM Agricultural Practice Monitoring and Evaluation Project (112540-W)

### Monthly maintenance checklist

Technician:_______________________________________ Date:_________________________

Manual rain gauge:__________inches (*read then empty*) Time:_________________________

Tipping bucket: □ Debris checked/cleared □ Downloaded □ Relaunched
Battery: __________ volts Battery replaced? Y N □ Status is launched/logging

| ACTIVITY | SITE:________ | SITE:________ | NOTES |
|---|---|---|---|
| U24-001 logger downloaded | □ | □ | |
| U24-001 calibration check (*record readings*) | □ Not done / NA<br>Exact Time:<br>Temp. (°C):<br>Sp. Cond. (µS): | □ Not done / NA<br>Exact Time:<br>Temp. (°C):<br>Sp. Cond. (µS): | |
| Clean U24-001 sensor window | □ | □ | |
| Camera downloaded and restarted | □ | □ | |
| Camera batteries | □ OK<br>□ Replaced | □ OK<br>□ Replaced | |
| Sampler program active and disabled | □ | □ | |
| Sampler tubing is attached | □ | □ | |
| Sample carboys installed properly | □ | □ | |
| 2110 module desiccant | □ OK<br>□ Replaced | □ OK<br>□ Replaced | |
| Restock sampling supplies | □ | □ | |
| Scan or retrieve forms. Restock forms and labels if needed. | □ | □ | |
| Cleaned the ultrasonic level sensor (*only clean if dirty*) | □ No<br>□ Yes | □ No<br>□ Yes | |
| Clear any debris from flume, approach, and splash trough | □ | □ | |
| Check the flume level. Relevel if necessary | □ OK<br>□ Leveled | □ OK<br>□ Leveled | |
| Check/fill battery electrolyte levels. Clean terminals if corroded | □ OK<br>□ Filled | □ OK<br>□ Filled | |
| Check solar panel. Clean if needed | □ | □ | |
| Mow weeds | □ | □ | |
| Check flume and wingwalls for erosion, rodent holes, etc. | □ OK<br>□ Repaired | □ OK<br>□ Repaired | |
| Field Condition: | | | |
| Comments: | | | |

**AAFM Agricultural Practice Monitoring and Evaluation Project (112540-W)**
**Sample retrieval/Routine maintenance by sampler form – PAGE 1**

Collected by:_______________________________ Date:____________________________

Weather:_____________________________________________________________________________

Manual rain gauge:_________inches (*read then empty*) Time:____________________________

Tipping bucket: Funnel: □ OK □ Cleaned; Datalogger LED blinking: □ Yes □ No (*notify Stone if no*)

| | Site: _______1 | Site: _______2 |
|---|---|---|
| FIELD STATUS | | |
| Station condition | □ OK □ Other____________________ | □ OK □ Other____________________ |
| Field/crop condition | | |
| AUTOSAMPLER | | |
| Part A status:<br>(circle one) | 1. ACTIVE, DISABLED<br>2. PART A DONE<br>3. ACTIVE, Enabled | 1. ACTIVE, DISABLED<br>2. PART A DONE<br>3. ACTIVE, Enabled |
| If ACTIVE and enabled, display reads: | PART A<br>____, ____ bottle__ _after____ pulses | PART A<br>____, ____ bottle_ __after____ pulses |
| Part B status:<br>(circle one) | 1. ACTIVE, DISABLED<br>2. PART B DONE<br>3. ACTIVE, Enabled | 1. ACTIVE, DISABLED<br>2. PART B DONE<br>3. ACTIVE, Enabled |
| If ACTIVE and enabled, display reads: | PART B<br>____, ____ bottle___ after____ pulses | PART B<br>____, ____ bottle___ after____ pulses |
| RUNOFF SAMPLE COLLECTION | | |
| Time you stopped the autosampler (pressed the red button) | _______________ AM or PM | _______________ AM or PM |
| Current water level in flume | ________ cm or □ No Flow | ________ cm or □ No Flow |
| Carboy volume (L) | A1: A2: B3: B4: | A1: A2: B3: B4: |
| Carboys split (circle) | A1 A2 A1+A2 composite<br>B3 B4 B3+B4 composite | A1 A2 A1+A2 composite<br>B3 B4 B3+B4 composite |
| Sample ID assigned | _______ - _________ - _______<br>(Site ID) (mmddyy) (carboy(s)) | _______ - _________ - _______<br>(Site ID) (mmddyy) (carboy(s)) |
| Splits collected (circle) | TP TN TSS TDP TDN $Cl^-$ | TP TN TSS TDP TDN $Cl^-$ |
| Duplicates collected? | TP TN TSS TDP TDN $Cl^-$ | TP TN TSS TDP TDN $Cl^-$ |
| TN/TDN splits acidified? | Yes No | Yes No |
| SEDIMENT IN FLUME | | |
| Sediment in flume/ flume approach (circle) | None Dusting Significant | None Dusting Significant |
| If significant, remove sediment, measure volume, and sample | Sediment volume: _______ L NA<br>Sample collected? Yes No NA | Sediment volume: _______ L NA<br>Sample collected? Yes No NA |

**AAFM Agricultural Practice Monitoring and Evaluation Project (112540-W)**
**Sample retrieval/Routine maintenance by sampler form – PAGE 2**

| RESETTING STATIONS | | |
|---|---|---|
| STOP then Re-RUN SAMPLING PROGRAM | □ Sampler ACTIVE, DISABLED | □ Sampler ACTIVE, DISABLED |
| Sampler suction line and pump tubing attached? | □ OK □ Other_______________ | □ OK □ Other_______________ |
| Carboys and churn splitter triple rinsed? | Yes No NA | Yes No NA |
| Carboys installed properly? | Yes No | Yes No |
| Debris cleared from: | Flume/approach: Yes No None<br>Splash trough: Yes No None<br>Sampler intake: Yes No None | Flume/approach: Yes No None<br>Splash trough: Yes No None<br>Sampler intake: Yes No None |
| Check wingwalls for undercutting, rodent holes, etc. | □ OK<br>□ Problem__________________<br>Problem fixed? Yes No NA | □ OK<br>□ Problem__________________<br>Problem fixed? Yes No NA |
| Additional comments: | | |

v. 3

# Chain of Custody

Stone Project ID: 112540-W

Lab Program #: 182

Stone Contact: Julie Moore, 279-5323, jmoore@stone-env.com

| Collection Date | Sample ID | Total # of Containers | Analytes (circle those collected) |
|---|---|---|---|
| | | | TP TDP TN TDN TSS Cl- |
| | | | TP TDP TN TDN TSS Cl- |
| | | | TP TDP TN TDN TSS Cl- |
| | | | TP TDP TN TDN TSS Cl- |
| | | | TP TDP TN TDN TSS Cl- |
| | | | TP TDP TN TDN TSS Cl- |
| | | | TP TDP TN TDN TSS Cl- |
| | | | TP TDP TN TDN TSS Cl- |

Sampled by: ______________________ ______________________

print name signature

# Chain of Custody: Soil

Stone Project ID: 112540-W

Stone Contact: Julie Moore, 279-5323, jmoore@stone-env.com

Analytical Lab: Agricultural and Environmental
Testing Lab University of Vermont,
Plant & Soil Science Dept.
Room 262 Jeffords Hall
Burlington, VT 05405-1737
802-656-3030
agtesting@uvm.edu
Attention: Joel Tilley

| Collection Date | Sample ID (Site-MMDDYY-SED)* | Total # of Containers Submitted | Analyses Requested |
|---|---|---|---|
| | | | Bulk density TP other: |
| | | | Bulk density TP other: |
| | | | Bulk density TP other: |
| | | | Bulk density TP other: |
| | | | Bulk density TP other: |
| | | | Bulk density TP other: |
| | | | Bulk density TP other: |
| | | | Bulk density TP other: |

*Example: PAW1-031313-SED

Sampled by: ________________________ ________________________
print name signature

**Appendix D: Stone Environmental Standard Operating Procedures (SOPs) Master List**

## Chapter 1 ADMINISTRATION

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| SEI-1.1.11 | Orientation and Training of Stone Environmental, Inc. (Stone) Employees | 11/22/93 | 09/02/10 | 09/02/10 |
| SEI-1.2.4 | General Procedures For Regulatory Agency Inspections, Sponsors Audits, or Third Party Inspections | 11/22/93 | 01/18/02 | 02/04/2011 |
| SEI-1.3.4 | Assignment of Internal Study Numbers and/or Project Numbers | 04/14/94 | 03/29/12 | 03/29/12 |
| SEI-1.4.11 | Curriculum Vitae | 05/12/93 | 06/30/05 | 02/04/2011 |
| SEI-1.5.4 | Filing Procedures for Project/Study Records | 06/20/94 | 01/18/02 | 08/03/05 |
| SEI-1.6.3 | Backing up the Corporate Network File System | 01/17/01 | 01/18/08 | 01/18/08 |
| SEI-1.7.3 | Archiving Project Folders from the Corporate Network | 01/17/01 | 01/18/08 | 01/18/08 |
| SEI-1.8.1 | Data Recovery Procedure | 08/03/05 | 01/18/08 | 01/18/08 |

## Chapter 2 PROTOCOLS AND REPORTS

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| SEI-2.1.5 | Protocol Preparation Requirements | 09/02/93 | 01/18/02 | 02/04/2011 |
| SEI-2.2.5 | Final Report Requirements | 09/02/93 | 03/15/02 | 02/04/2011 |
| SEI-2.3.1 | Interim, Progress, and Quarterly Reporting | 07/29/99 | 01/18/02 | 02/04/2011 |

## Chapter 3 STANDARD OPERATING PROCEDURES

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| SEI-3.1.8 | Creating and Revising Standard Operating Procedures | 04/09/93 | 11/26/01 | 02/04/2011 |
| SEI-3.2.6 | Review of Standard Operating Procedures by Personnel | 11/16/93 | 11/26/01 | 02/04/2011 |
| SEI-3.4.3 | Retirement of Standard Operating Procedures | 04/14/94 | 01/15/02 | 02/04/2011 |
| SEI-3.5.2 | Creating and Revising Study Specific Procedures | 03/14/97 | 01/15/02 | 02/04/2011 |

## Chapter 4 DOCUMENTATION

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| SEI-4.1.5 | Documentation of Amendments or Deviations from Protocols and Standard Operating Procedures | 04/12/93 | 01/15/02 | 10/17/07 |
| SEI-4.2.6 | Chain of Custody Records | 04/09/93 | 03/15/02 | 10/17/07 |
| SEI-4.4.4 | Documentation of Project Specific Phone Conversations and Correspondence | 09/02/93 | 03/15/02 | 10/17/07 |
| SEI-4.5.10 | Data Handling, Storage, Retrieval and Error Coding | 09/02/93 | 07/11/03 | 10/17/07 |
| SEI-4.6.6 | Significant Figures, Rounding Procedures and Use of Conversion Factors | 12/08/93 | 02/28/03 | 10/17/07 |
| SEI-4.7.4 | Labeling Reagents, Solutions and Standards | 04/18/94 | 02/19/03 | 10/17/07 |
| SEI-4.8.3 | Documentation and Reconstruction of Pesticide Use History | 04/14/94 | 02/19/03 | 04/17/08 |
| SEI-4.10.3 | Computer Software Verification | 04/21/94 | 04/04/03 | 12/28/05 |
| SEI-4.14.2 | Quality Control Check on Transcribed Data, Data Calculations, Figures, and Tables | 07/29/99 | 03/06/03 | 05/02/08 |
| SEI-4.15.2 | Construction of Maps to Illustrate Groundwater Elevation and Depth to Groundwater Contours | 07/19/99 | 03/06/03 | 05/02/08 |
| SEI-4.17.1 | Receipt, Storage, and Documentation of Test Substances | 03/03/00 | 12/17/01 | 05/02/08 |
| SEI-4.18.1 | Data Collection and Analysis Practices for the Campbell Scientific, Incorporated, Data Loggers and Related Hardware | 05/05/00 | 03/06/03 | 05/02/08 |
| SEI-4.19.1 | Receipt and Storage of Electronic Data | 12/13/00 | 02/28/03 | 02/04/2011 |

## Chapter 5 EQUIPMENT

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| SEI-5.1.5 | Maintenance and Decontamination of Field Equipment | 04/09/93 | 02/20/04 | 04/17/08 |
| SEI-5.3.4 | Use of Borrowed and Rented Equipment | 04/18/94 | 02/20/04 | 04/11/08 |
| SEI-5.6.4 | Maintenance of Bailers | 11/22/93 | 02/20/04 | 04/11/08 |

| | | | | |
|---|---|---|---|---|
| SEI-5.11.2 | Maintenance and Calibration of the Oakton ORPTester (Oxidation and Reduction Potential (ORP) Meter) | 02/16/96 | 02/20/04 | 04/9/08 |
| SEI-5.14.2 | Use, Maintenance and Calibration of Electronic Balances Model GL1002R, OHAUS CT-200 Top Loading, Adam Equipment 2T200 and/or Other Similar Models | 06/17/97 | 02/20/04 | 04/9/08 |
| SEI-5.19.2 | Maintenance, and Calibration of the Cole Parmer Model DspH3 and 1484-44 and Similar Type pH and Conductivity Meters | 06/17/97 | 02/24/04 | 04/17/08 |
| SEI-5.20.2 | Maintenance, and Calibration of the Cole Parmer Model 19815-00 Conductivity Meter | 03/10/98 | 02/24/04 | 04/17/08 |
| SEI-5.21.2 | Maintenance, and Calibration of the Cole Parmer Model 59000-25 pH Tester | 03/10/98 | 02/24/04 | 04/17/08 |
| SEI-5.22.2 | Maintenance, and Calibration of the Troll SP4000 Datalogger | 05/14/99 | 02/24/04 | 04/17/08 |
| SEI-5.23.3 | Maintenance, and Calibration of the pH/CON 10 Meter | 05/14/99 | 02/24/04 | 04/14/08 |
| SEI-5.24.2 | Maintenance, and Calibration of the GPI Industrial Grade Flow Meter | 06/08/99 | 05/15/03 | 04/17/08 |
| SEI-5.25.0 | Use, Maintenance, and Calibration of the Multi-Parameter Troll 9000 and 9500 | 04/18/08 | na | na |
| SEI-5.26.0 | Use, Maintenance, and Calibration of the Lamotte Model 2020e Turbidity Meter | 06/23/05 | na | 04/14/08 |
| SEI-5.27.0 | Use, Maintenance, and Calibration of the Hydrolab MS5 Water Quality Multiprobes | 04/17/08 | na | na |
| SEI-5.28.0 | Use, Maintenance and Calibration of the HACH LDO Portable Dissolved Oxygen Meters (HACH Models HQ10 and HQ30d) | 02/04/2011 | na | 02/04/2011 |
| SEI-5.29.0 | Use, Maintenance, and Calibration of the MultiRAE IR Multi-Gas Monitor (PGM-54) | 02/04/2011 | na | 02/04/2011 |

## Chapter 6 FIELD WORK

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| SEI-6.1.6 | Collection of Soil Samples for Preliminary Site Selection | 10/26/92 | 11/18/05 | 04/2/08 |
| SEI-6.2.6 | Water Level measurement, Use, Maintenance and Calibration of Electronic Water Level Indicators | 04/09/93 | 02/20/04 | 04/2/08 |
| SEI-6.3.4 | Surface Water Sampling | 04/09/93 | 02/24/04 | 04/2/08 |
| SEI-6.4.5 | Installation, Development and Decommissioning of | 04/09/93 | 08/01/07 | 04/10/08 |

| | | | | |
|---|---|---|---|---|
| | Monitoring Wells and Observation Wells | | | |
| SEI-6.6.9 | Installation and Testing of Bladder Pumps for Sampling of Monitoring Wells | 04/09/93 | 03/31/04 | 05/02/08 |
| SEI-6.8.5 | Guelph Permeameter Testing, Use, Maintenance and Calibration of the Guelph Permeameter | 04/12/93 | 02/20/04 | 05/02/08 |
| SEI-6.10.4 | Soil Characterization Study | 04/09/93 | 03/31/04 | 04/15/08 |
| SEI-6.11.8 | Slug Tests | 04/12/93 | 03/02/06 | 05/02/08 |
| SEI-6.12.9 | Porous Cup Lysimeter Installation, Testing, and Sampling | 05/17/93 | 04/16/04 | 11/17/05 |
| *SEI-6.13.8* | *Porous Cup Lysimeter Sampling (Included in SOP 6.12.9)* | *06/02/93* | *Retired* | *Retired* |
| SEI-6.14.3 | Test System Preparation, Care and Observations | 04/18/94 | 04/16/04 | 05/02/08 |
| SEI-6.16.4 | Handling, Collection and Transportation of Samples | 11/22/93 | 04/16/04 | 04/14/08 |
| SEI-6.17.4 | Evaluation of Soil Texture, Moisture Content, and Mottling, Using the USDA Soil Classification Scheme | 11/15/94 | 04/16/04 | 05/02/08 |
| *SEI-6.18.2* | *Installation and Reading of Irometer AWatermark@ Soilmoisture Sensors* | *05/19/95* | *Retired* | *Retired* |
| SEI-6.19.2 | Use, Maintenance and Calibration of the IonScience PhoCheck 1000+ Photo Ionization Detector (PID) | 07/19/99 | 02/04/2011 | 02/04/2011 |
| SEI-6.20.3 | Undisturbed Soil Sample Collection Using a Thin Walled (Shelby) Tube | 02/16/96 | 11/18/05 | 04/17/08 |
| SEI-6.23.1 | Observation and Monitoring Well Surveying | 07/19/99 | 11/29/05 | 04/15/08 |
| SEI-6.24.1 | Locating Soil Sampling Points in a Sampling Area | 07/19/99 | 11/18/05 | 04/14/08 |
| SEI-6.25.3 | Operation and Maintenance of the Concord Model Ss4804 Soil Sampler | 06/17/97 | 11/18/05 | 05/02/08 |
| SEI-6.26.2 | Spray Tank Sample Collection | 06/17/97 | 11/18/05 | 04/17/08 |
| SEI-6.27.3 | Groundwater Sampling of Monitoring Wells | 03/03/00 | 11/18/05 | 04/16/08 |
| SEI-6.34.0 | Procedure for Sampling Groundwater Monitoring Wells Using Low Stress (Low Flow) Technique | 01/21/05 | 01/21/05 | 04/16/08 |
| SEI-6.35.0 | Passive Collection of Pore Water Samples Using Passive Diffusion Bags | 06/22/07 | na | 05/02/08 |
| SEI-6.36.0 | Procedure for Collection of Soil Gas Samples Using the GeoProbe® PRT System and Vacuum "Lung" Box | 6/22/07 | na | 05/02/08 |
| SEI-6.37.0 | Field Methods for Retrieval, Collection, Handling, and Preservation of Rock Samples to be Analyzed for VOCs and Physical Properties | 7/01/08 | na | 07/01/08 |

| | | | | |
|---|---|---|---|---|
| SEI-6.38.0 | Optical Brightener Testing | 9/10/08 | na | 09/10/08 |

## Chapter 7 ARCHIVES

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| SEI-7.1.4 | Transfer of Raw Data to the Sponsor or Client | 09/02/93 | 02/18/03 | 02/04/2011 |
| SEI-7.2.6 | Document Control, Record System and Archiving | 11/16/93 | 03/04/03 | 02/04/2011 |
| SEI-7.3.3 | Procedures to be Followed when Terminating a Study | 04/18/94 | 02/20/03 | 02/04/2011 |

## Chapter 8 MANAGEMENT

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| SEI-8.1.5 | Duties and Responsibilities of the Study Director | 09/02/93 | 03/18/03 | 02/04/2011 |
| SEI-8.2.4 | Duties and Responsibilities of Principal Investigator and/or Project Manager | 09/02/93 | 03/18/03 | 02/04/2011 |
| SEI-8.3.6 | Duties and Responsibilities of Test Facility Management | 11/22/93 | 02/18/03 | 02/04/2011 |
| SEI-8.4.0 | Client Inquiries, Data Revision Requests & Complaint Resolution | 10/20/05 | n/a | 02/04/2011 |

## Chapter 9 QUALITY ASSURANCE

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| SEI-9.1.1 | Use of Contract Quality Assurance | 07/19/99 | 2/18/03 | 04/18/08 |
| *SEI-9.2.0* | *Transfer of Data to Contract Quality Assurance (included* | *07/19/99* | *Retired* | *Retired* |
| SEI-9.3.1 | Construction and Maintenance of the Master Schedule | 07/19/99 | 2/18/03 | 04/18/08 |
| SEI-9.4.2 | Duties and Responsibilities of SEI Quality Assurance Personnel | 03/28/97 | 2/18/03 | 04/18/08 |

## Chapter 10 ENVIRONMENTAL DRILLING AND DIRECT PUSH TECHNOLOGY

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| SEI-10.1.6 | Determination of Aromatic and Chlorinated Volatile Organics and Light Weight Petroleum Hydrocarbon Compounds Using Solid Phase Microextraction (SPME) and A Gas Chromatograph in Soil and Water Samples (Modified SW846 Methods 8021/8015 & ASTM D6520) | 02/21/03 | 05/26/09 | 05/26/09 |
| SEI-10.2.0 | Determination of Polychlorinated Biphenyl (PCB) by Gas Chromatography with an Electron Capture Detector (ECD) in Sediment and Soil Samples | 08/17/04 | n/a | 02/15/08 |
| SEI-10.5.2 | Groundwater Profiling and K-Pro Testing | 08/13/02 | 05/13/08 | 05/13/08 |
| SEI-10.7.1 | Use, Calibration, and Maintenance of The YSI Model 699xl Multi-parameter Water Quality Monitoring System(Temperature, Specific Conductance, Ph, Redox Potential, Dissolved Oxygen) | 08/13/02 | 10/15/04 | 04/17/08 |
| | *Analysis of VOC=s in Water and Soils Using Solid* | | | |

| | | | | |
|---|---|---|---|---|
| *SEI-10.9.0* | *Phase Microextraction (SPME) and Capillary GC* | *12/12/00* | *Retire* | *Retire* |
| *SEI-10.10.0* | *Analysis of VOC=s in Water and Soils Using Equilibrium Headspace Sample Preparation and Capillary GC* | *12/12/00* | *Retire* | *Retire* |
| SEI-10.11.0 | Geologic Description of Unconsolidated Deposits | 01/18/02 | n/a | 04/17/08 |
| SEI-10.12.1 | Use, Calibration, and Maintenance of the Membrane Interface Probe (MIP) | 08/4/04 | 05/30/08 | 05/30/08 |
| SEI-10.13.0 | Policy Requirements for Manual Integration of Chromatographic Peaks | 08/05/04 | n/a | 05/02/08 |
| SEI-10.14.0 | On-Site Laboratory Waste Handling, Storage and Disposal | 10/20/04 | n/a | 05/02/08 |
| SEI-10.15.7 | The Determination of Volatile Organic Compounds By Gas Chromatography/Mass Spectrometry (SW846 EPA Method 8260) (includes water, soil and air) | 08/19/04 | 02/06/12 | 02/06/2012 |
| SEI-10.16.0 | Determination of Selected Elements in Soil and Sediment Samples Using Field Portable X-Ray Fluorescence Spectrum Analyzers, SW846 6200 | 10/22/04 | n/a | 05/02/08 |
| SEI-10.17.0 | Microwave Assisted Extraction of Volatile Organic Compounds From Rock Samples | 07/2/08 | n/a | 07/02/08 |
| SEI-10.18.0 | The Determination of Volatile Organic Compounds By Gas Chromatography/Dual ECD Detectors in Rock Samples (Using Cool On-Column Injection and Split Method Injection ) | 07/02/08 | n/a | 07/02/08 |

## Chapter 11 HEALTH AND SAFETY

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| SEI-11.1.2 | Preparing and Amending a Site Health and Safety Plan (HASP) | 12/13/00 | 11/29/05 | 10/17/07 |

## Chapter 12 GEOGRAPHIC INFORMATION SYSTEMS (GIS)

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| *SEI-12.1.0* | *Managing Paths in ArcView Project Files* | *draft* | n/a | n/a |

## Chapter 13 SURFACE DRINKING WATER STUDIES

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| SEI-13.1.1 | Watershed Estimation Process for Surface Drinking Water Studies | 05/30/01 | 03/18/03 | 02/04/2011 |
| SEI-13.2.1 | Training of Sampling Personnel for Surface Water Drinking Studies | 12/13/00 | 01/15/02 | 02/04/2011 |
| SEI-13.3.1 | Community Water System Visit and On-Site Data Collection for Surface Drinking Water Studies | 12/13/00 | 03/18/03 | 02/04/2011 |
| SEI-13.4.2 | Collection of Samples for Surface Drinking Water Studies | 12/13/00 | 04/04/03 | 02/04/2011 |
| SEI-13.5.1 | Assigning System Identification Numbers for Surface Drinking Water Studies | 12/13/00 | 05/08/02 | 02/04/2011 |
| SEI-13.6.0 | Composition of Watershed Shapefiles in Preparation For Community Water system Watershed Characterization | 04/04/03 | n/a | 02/04/2011 |
| SEI-13.7.0 | Composition of Community Water System Intake Shapefiles For Watershed Characterization | 04/04/03 | n/a | 02/04/2011 |

N.B. - italicized SOPs have been retired or are still in draft form
Retired SOPs will be removed from the list after one year.
n/a – not applicable

# APPENDIX C: SOIL SAMPLING PROCEDURE

STONE ENVIRONMENTAL INC
535 Stone Cutters Way
Montpelier, Vermont
05602 USA
Phone / 802.229.4541
Fax / 802.229.5417
Web Site / www.stone-env.com

## Observations & Remarks

| | | | |
|---|---|---|---|
| Project: | AAFM Runoff monitoring study | Date: | 12/11/12 |
| Client Study #: | | | |
| SEI Study #: | 112540-W | | |
| Subject: | Soil sampling for characterization analyses | | |

PURPOSE/OBJECTIVE:
Soil samples were collected from each study field to characterize nutrient and organic matter content, major cation concentrations, pH, particle size, and other qualities. Most analyses will be performed by the Maine Soil Testing Service. The Agricultural and Environmental Testing Laboratory at the University of Vermont is receiving and drying the samples prior to shipment to the Maine lab.

Soil samples will also be analyzed by the USDA-ARS Laboratory in Temple, Texas for various soil health indicators, including the Solvita Test.

PROCEDURE:
Soil samples were collected from each study field using a stainless steel soil probe. In each field/watershed, individual sample cores were composited in a 5-gallon bucket. To collect a representative composite sample from each field, scientists collected cores along transects spanning the drainage area, generally making a zigzag pattern of transects across the field. Along this course, cores were taken at intervals of 20 to100 paces, with fewer paces between samples in small watersheds and more paces between samples in larger watersheds. Obvious differences in texture were not observed across any watershed/field, except that certain field areas had more gravel than other areas. Therefore, it was appropriate to collect a single composite sample from the entire field rather than dividing the field/watershed into different sampling areas by soil type. This relatively uniform surface soil texture is consistent with the USDA-NRCS soil mapping data.

The sampling depth in cornfields was approximately 8 inches (20 cm). Corn stubble, residue, and larger pebbles were avoided when inserting the soil probe. In hayfields, the core depth was approximately 4 inches (10 cm). Each core was shaken by the grass stems into a 5-gallon bucket to remove the sod layer.

The composite sample was blended in the bucket using a garden trowel prior to subsampling. The trowel was used to transfer approximately two cups of soil from the bucket into each of two ziplock bags, one for analysis by the Maine Soil Testing Service and one for analysis by ARS.  The remaining soil was discarded. In addition to splitting the composite sample into portions for the Maine lab and ARS lab, duplicate splits were prepared from composite samples collected in the WIL and SHO1 watersheds.

The following notes indicate the soil sampling personnel and date for each study watershed.

**FRA1 and FRA2**

Jeremy Krohn collected soil samples from FRA1 and FRA2 on October 23, 2012. Separate samples were collected for the corn and hay strips in each watershed, yielding four composite samples: FRA1-Corn, FRA1-Hay, FRA2-Corn, and FRA2-Hay. The corn strips had recently been chopped for corn silage, but had not yet been plowed.

**PAW1 and PAW2**

Dave Braun collected soil samples from PAW1 and PAW2 on October 24, 2012. The corn had been chopped on both fields a few weeks prior, but the field had not yet been plowed.

**SHE1 and SHE2**

Serena Matt collected soil samples from SHE1 and SHE2 on October 26, 2012.

**FER1 and FER2**

Serena Matt collected soil samples from FER1 and FER2 on October 26, 2012.

**WAS**

Serena Matt collected a soil sample from field WAS (which drains to the WASCoB) on November 12, 2012.

**WIL1 and WIL2**

Serena Matt collected soil samples from WIL1 and WIL2 on November 12, 2012.

**SHO1 and SHO2**

Alex Huizenga collected soil samples from SHO1 and SHO2 on December 5, 2012.

Signed: Dave Braun

Date: 12/11/12

# APPENDIX D: AGRONOMIC INFORMATION FORM (CORN SITE)

# 2012 Agronomic Information Form (Corn site)

For 2012, please fill in the requested information. If the two monitored fields were managed identically, just fill it out once. If not, please fill out the information for each.

1) Indicate the date, rate, and method of spring manure application in 2012. For the rate, the number of spreader loads and spreader volume(s) is preferable to a guessed rate. For the equipment, indicate the brand/model and settings if variable.
   - Date:
   - Rate:
   - Method of application (e.g., high nozzle, low nozzle, dragline, injection):
   - Equipment:
   - Source of manure (identify pit):
   - Was pit agitated? If YES, how well?
   - Was manure incorporated? If YES, date and method:
   - Manure percent dry matter, if known:
   - Describe any recent management changes that noticeably changed manure, such as changes in the feeding regime:
   - Was there substantial water (from rain or snowmelt) in the pit?
   - Describe any additions to the manure pit, such as whey, since previous application:

2) Indicate the date of spring tillage (other than manure incorporation as described in #1). Describe the tillage method (including characteristics like depth/spacing if variable) and equipment used.
   - Date:
   - Tillage method:
   - Equipment:

3) Indicate the corn planting date, planting rate, row width, and variety.
   - Planting date:
   - Planting rate:
   - Row width:
   - Corn variety:

4) Indicate the date, rate, and method of all fertilizer applications in 2012, including any corn starter, and indicate the fertilizer type and formula (N-P-K).

- Date:
- Rate:
- Fertilizer type and formula (N-P-K):
- Method of application:

- Date:
- Rate:
- Fertilizer type and formula (N-P-K):
- Method of application:

- Date:
- Rate:
- Fertilizer type and formula (N-P-K):
- Method of application:

5) Indicate the date, rate, and method of all pesticide applications in 2012. Also indicate the chemical name and formulation.

- Date:
- Rate:
- Chemical name and formulation:
- Method of application:

- Date:
- Rate:
- Chemical name and formulation:
- Method of application:

- Date:
- Rate:
- Chemical name and formulation:
- Method of application:

6) Indicate harvest date, method, estimated yield, and residue cover.
- Date:
- Method:
- Yield (estimated tonnage per acre):
- Residue (% cover) left on field (visual assessment):

7) Indicate the date, rate, and method of fall manure application in 2012. For the rate, the number of spreader loads and spreader volume(s) is preferable to guessed rate. For the equipment, indicate the brand/model and settings if variable.
   - Date:
   - Rate:
   - Method of application (e.g., high nozzle, low nozzle, dragline, injection):
   - Equipment:
   - Source of manure (identify pit):
   - Was pit agitated? If YES, how well?
   - Was manure incorporated? If YES, date and method:
   - Manure percent dry matter, if known:
   - Describe any recent management changes that noticeably changed manure, such as changes in the feeding regime:
   - Was there substantial water (from rain or snowmelt) in the pit?
   - Describe any additions to the manure pit, such as whey, since previous application:

8) Indicate the date of fall tillage (other than manure incorporation as described in #7). Describe the tillage method (including characteristics like depth/spacing if variable) and equipment used.
   - Date:
   - Tillage method:
   - Equipment:

9) If a cover crop was planted, indicate the planting date, variety, method, and stand quality.
   - Date planted:
   - Variety planted:
   - Method/seeding rate:
   - Stand quality (visual assessment):

10) Was there any vehicle traffic on the field (other than farm machinery and our sampling vehicle)? If yes, please describe.

11) Describe the condition of the crop and any damage to the crop or the field (drought, erosion, observations, results of PSNT, etc.).

THANK YOU!

# APPENDIX E: AGRONOMIC INFORMATION FORM (HAY SITE)

# 2012 Agronomic Information Form (Hay Site)

For 2012, please fill in the requested information. If the two monitored fields were managed identically, just fill it out once. If not, please fill out the information for each. Feel free to call me (802-272-8819) if you have any questions.

1) What year were the ______ and ______ fields last seeded?

2) What are the plant species in the ______ and _____ fields (list from most to least dominant)?

3) For each hay cut, indicate the mowing date, date baled/bagged/loaded, and estimated yield.

<u>1st cut</u>
- Date:
- Date baled/bagged/loaded (if different):
- Yield (estimated tonnage per acre):

<u>2nd cut</u>
- Date:
- Date baled/bagged/loaded (if different):
- Yield (estimated tonnage per acre):

<u>3rd cut (if made)</u>
- Date:
- Date baled/bagged/loaded (if different):
- Yield (estimated tonnage per acre):

<u>4th cut (if made)</u>
- Date:
- Date baled/bagged/loaded (if different):
- Yield (estimated tonnage per acre):

4) Indicate the dates, rates, and methods of manure application in 2012. For the rate, the number of spreader loads and spreader volume(s) is preferable to a guessed rate. For the equipment, indicate the brand/model and settings.

<u>1st application (if made)</u>
- Date:
- Rate:
- Method:
- Equipment:
- Source of manure (identify pit):
- Was pit agitated? If YES, how well?
- Was manure incorporated? If YES, date and method:
- Manure percent dry matter, if known:

- Describe any recent management changes that noticeably changed manure, such as changes in the feeding regime:
- Was there substantial water (from rain or snowmelt) in the pit?
- Describe any additions to the manure pit, such as whey, since previous application:

<u>2nd application (if made)</u>

- Date:
- Rate:
- Method:
- Equipment:
- Source of manure (identify pit):
- Was pit agitated? If YES, how well?
- Was manure incorporated? If YES, date and method:
- Manure percent dry matter, if known:
- Describe any recent management changes that noticeably changed manure, such as changes in the feeding regime:
- Was there substantial water (from rain or snowmelt) in the pit?
- Describe any additions to the manure pit, such as whey, since previous application:

5) Indicate the date, rate, and method of all fertilizer applications in 2012 and indicate the fertilizer type and formula (N-P-K).

- Date:
- Rate:
- Fertilizer type and formula (N-P-K):
- Method of application:

- Date:
- Rate:
- Fertilizer type and formula (N-P-K):
- Method of application:

- Date:
- Rate:
- Fertilizer type and formula (N-P-K):
- Method of application:

6) Indicate the date, rate, and method of all pesticide applications in 2012. Also indicate the chemical name and formulation.

- Date:
- Rate:
- Chemical name and formulation:
- Method of application:

- Date:
- Rate:

- Chemical name and formulation:
- Method of application:

- Date:
- Rate:
- Chemical name and formulation:
- Method of application:

7) Please describe any other management activities on these fields in 2012.

8) Was there any vehicle traffic on the field (other than farm machinery and our sampling vehicle)? If yes, please describe.

9) Describe the condition of the crop and any damage to the crop or the field (drought, erosion, observations, results of PSNT, etc.).

# APPENDIX F: COVER CROP MEASUREMENT PROCEDURE

## STUDY SPECIFIC PROCEDURE

# *Cover Crop Measurement Procedure for the Agricultural Practice Monitoring and Evaluation Project*

SSP Number: 112540-W SSP#2

Version Number: 1

Date Issued: 10/28/13

Date of Revision: NA

## 1.0 OBJECTIVE

To facilitate collection of high-quality crop cover data.

## 2.0 MATERIALS

1. GPS unit (Trimble if possible) containing random sampling coordinates
2. Digital camera
3. Quadrat
4. Data sheets
5. Index Cards

## 3.0 PROCEDURE

1. Before going into the field, generate randomized coordinate pairs (X,Y) within each study watershed using the "Create Random Points" tool in ArcMap's Data Management toolbox. Generate a sufficient number of coordinate pairs for a season of cover crop measurements. Each coordinate pair should be labeled with a sequential location ID.
2. A subset of the coordinate pairs (approximately 20) should then be loaded on a GPS device (e.g. Trimble GeoXT). The watershed boundary polygons should also be loaded to the GPS device to assist with navigation.
3. A 30 x 30cm PVC-framed quadrat should be utilized. The frame is strung with string to create 64 cross-grids. Exact dimensions are graphically displayed in section 8.0 and are sourced from Laycock and Canaway (1980) and Kershaw (1973).
4. Once at the watershed of interest, begin by taking photographs of the field. Note field condition and any other qualitative information that may prove helpful in later data analysis.
5. Use the GPS device from Step 1 to navigate to the randomly generated sampling points. Once at a point, and from that point, toss the quadrat 5-10 ft in any direction. If the quadrat lands outside the watershed boundary, start over.
6. Repeat the procedure between 10-20 times per watershed, selecting coordinate pairs in order from the list of random points. Fewer (i.e., 10-12) quadrat measurements are needed where cover is relatively homogeneous. More (i.e., 16-20) are needed where the surface cover is more variable.
7. Ready the data sheet by noting the location ID. Stand directly over the quadrat. Beginning in the upper left-hand corner marked "Start", take note of the cover type (cover crop, crop residue, soil, weed) directly below the intersection of the first two strings. Move from left to right until the final intersection is reached in the lower right-hand corner of the quadrat. One full column on the data sheet should be completed per quadrat.

8. Take a picture of each quadrat from above. If available, include an index card with the location ID in the pho

## 4.0 AUTHORIZATION

Written by: Ryan Sleeper Date: 11/8/13

Ryan Sleeper, Water Quality Scientist, Stone Environmental, Inc.

Approved by: Dave Braun Date: 11/8/13

Dave Braun, Project Water Quality Scientist, Stone Environmental, Inc.

## 5.0 REFERENCES


Laycock, R.W., and P.M. Canaway. 1980. An optical point quadrat frame for the estimation of cover in closely-mown turf. J. Sports Turf Res. Inst. 56:91–92.

Kershaw, K.A. 1973. Quantitative and dynamic plant ecology. 2nd ed. Am. Elsevier Publishing Co., New York.


## 6.0 REVISION HISTORY

Not Applicable

## ATA SHEET

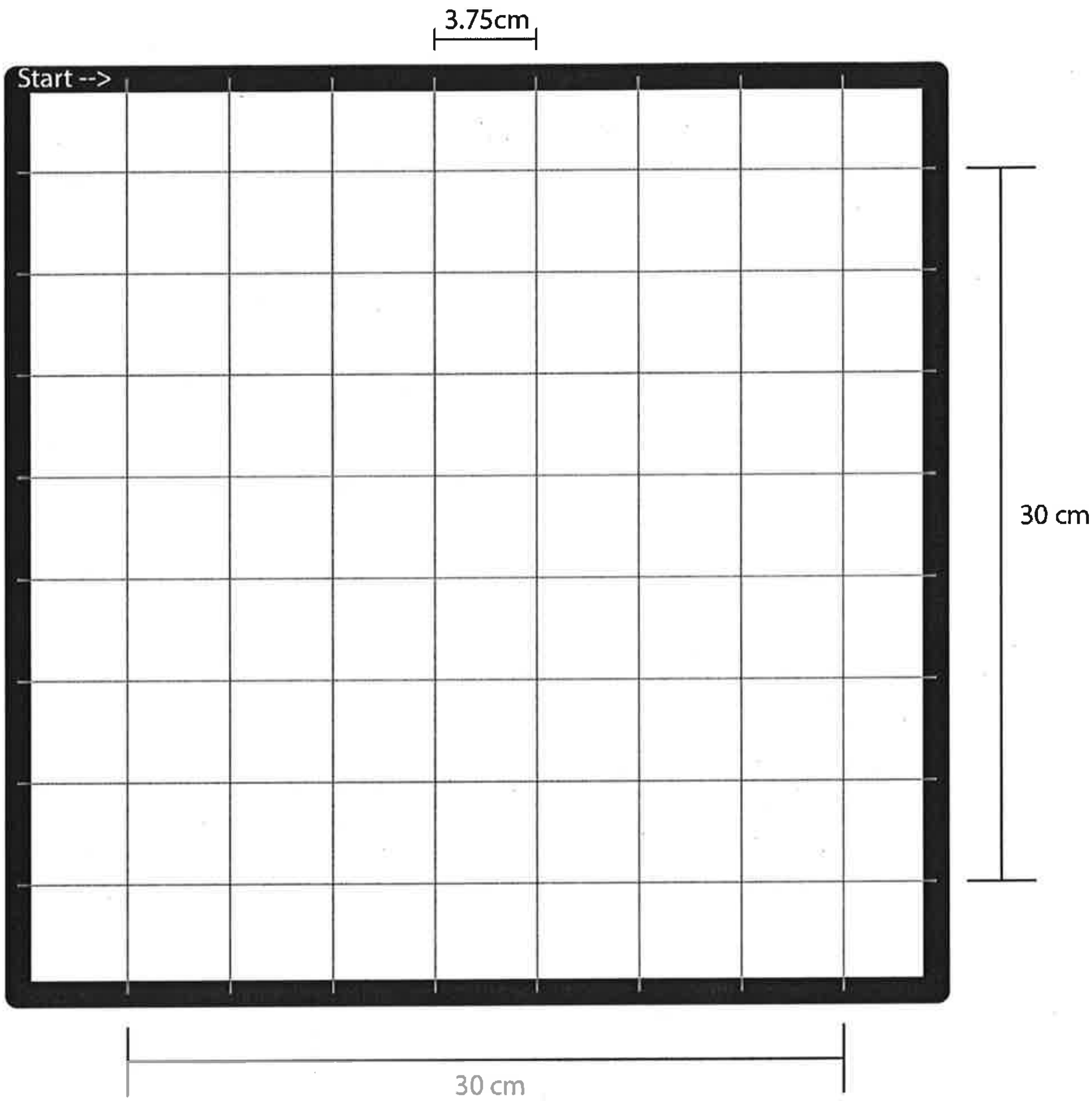
### Cover Crop Percent Coverage Data Sheet

Study watershed _______________ Name _______________ Date _______________

Key: C = cover crop, R = crop residue, S = soil, W = weed, A=rock

| | | Loc____ | Loc____ | Loc____ | Loc____ | Loc____ | Loc____ | Loc____ | Loc____ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 1 | 1 |
| | 2 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 2 | |
| | 3 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 3 | |
| | 4 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 4 | |
| | 5 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 5 | |
| | 6 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 6 | |
| | 7 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 7 | |
| | 8 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 8 | |
| 2 | 1 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 1 | 2 |
| | 2 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 2 | |
| | 3 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 3 | |
| | 4 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 4 | |
| | 5 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 5 | |
| | 6 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 6 | |
| | 7 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 7 | |
| | 8 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 8 | |
| 3 | 1 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 1 | 3 |
| | 2 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 2 | |
| | 3 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 3 | |
| | 4 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 4 | |
| | 5 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 5 | |
| | 6 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 6 | |
| | 7 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 7 | |
| | 8 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 8 | |
| 4 | 1 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 1 | 4 |
| | 2 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 2 | |
| | 3 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 3 | |
| | 4 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 4 | |
| | 5 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 5 | |
| | 6 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 6 | |
| | 7 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 7 | |
| | 8 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 8 | |
| 5 | 1 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 1 | 5 |
| | 2 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 2 | |
| | 3 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 3 | |
| | 4 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 4 | |
| | 5 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 5 | |
| | 6 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 6 | |
| | 7 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 7 | |
| | 8 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 8 | |
| 6 | 1 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 1 | 6 |
| | 2 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 2 | |
| | 3 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 3 | |
| | 4 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 4 | |
| | 5 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 5 | |
| | 6 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 6 | |
| | 7 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 7 | |
| | 8 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 8 | |
| 7 | 1 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 1 | 7 |
| | 2 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 2 | |
| | 3 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 3 | |
| | 4 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 4 | |
| | 5 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 5 | |
| | 6 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 6 | |
| | 7 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 7 | |
| | 8 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 8 | |
| 8 | 1 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 1 | 8 |
| | 2 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 2 | |
| | 3 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 3 | |
| | 4 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 4 | |
| | 5 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 5 | |
| | 6 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 6 | |
| | 7 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 7 | |
| | 8 | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | C R S W | 8 | |

## 8.0 QUADRAT DESIGN



# APPENDIX G: DISCHARGE AND EVENT MEAN CONCENTRATIONS OF 2014 EVENTS

| Station | Event | Start Date | Note | Discharge (L) | TP (µg/L) | TDP (µg/L) | TN (mg/L) | TDN (mg/L) | TSS (mg/L) | Cl (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| FER1 | 1 | 4/1/14 | | 354,271 | 1646 | 1618 | 8.39 | 9.97 | 26.5 | 12.3 |
| FER2 | 1 | 4/1/14 | | 340,536 | 1380 | 1300 | 8.15 | 9.79 | 21.7 | 11.1 |
| FER1 | 2 | 4/8/14 | | 3,300 | 487 | NS | 5.34 | NS | 35.0 | NS |
| FER2 | 2 | 4/7/14 | | 86,587 | 315 | 279 | 3.87 | 3.75 | 12.0 | 22.9 |
| FER2 | 3 | 4/13/14 | | 3,843 | NS | NS | NS | NS | NS | NS |
| FER1 | 4 | 4/15/14 | | 149,214 | 250 | 246 | 4.31 | 4.39 | 17.0 | 11.1 |
| FER2 | 4 | 4/15/14 | | 570,477 | 246 | 216 | 3.84 | 3.87 | 15.0 | 11.6 |
| FER2 | 5 | 5/1/14 | | 37,076 | NS | NS | NS | NS | NS | NS |
| FER1 | 6 | 5/4/14 | | 9,967 | 175 | 120 | 2.81 | 2.60 | 9.72 | 5.31 |
| FER2 | 6 | 5/3/14 | | 171,006 | 116 | 79.2 | 2.63 | 2.32 | 4.10 | 9.18 |
| FER1 | 7 | 12/24/14 | | 309,961 | 720 | 680 | 2.10 | 2.10 | 5.71 | 13.6 |
| FER2 | 7 | 12/24/14 | | Invalid | 606 | 564 | 2.53 | 2.50 | 4.64 | 4.67 |
| FER1 | 8 | 1/19/15 | | 37,457 | 3380 | 3010 | 9.14 | 8.34 | 21.5 | 28.7 |
| FER2 | 8 | 1/19/15 | | 39,219 | 2980 | 2820 | 10.0 | 9.62 | 21.0 | 22.3 |
| FRA2 | 1 | 3/11/14 | | 124,945 | NS | NS | NS | NS | NS | NS |
| FRA2 | 2 | 3/28/14 | | 1,182,468 | NS | NS | NS | NS | NS | NS |
| FRA1 | 3 | 3/30/14 | | 1,718,017 | NS | NS | NS | NS | NS | NS |
| FRA2 | 3 | 3/30/14 | | 1,975,469 | NS | NS | NS | NS | NS | NS |
| FRA2 | 4 | 3/31/14 | | 72,469 | NS | NS | NS | NS | NS | NS |
| FRA1 | 5 | 4/1/14 | | 754,827 | NS | NS | NS | NS | NS | NS |
| FRA2 | 5 | 4/1/14 | | 176,289 | NS | NS | NS | NS | NS | NS |
| FRA1 | 6 | 4/4/14 | | 247,227 | NS | NS | NS | NS | NS | NS |
| FRA1 | 7 | 4/8/14 | | 170,185 | 879 | 199 | 9.91 | 8.07 | 498 | 24.4 |
| FRA2 | 7 | 4/8/14 | | 34,346 | 635 | 187 | 10.6 | 8.94 | 266 | 21.6 |
| FRA1 | 8 | 4/15/14 | | 730,852 | 1578 | 240 | 9.76 | 6.55 | 1110 | 15.6 |
| FRA2 | 8 | 4/15/14 | | 344,287 | 1580 | 128 | 9.53 | 6.61 | 1570 | 13.4 |
| FRA1 | 9 | 4/30/14 | | 104,738 | 1562 | 109 | 5.64 | 3.20 | 1040 | 8.19 |
| FRA1 | 10 | 5/4/14 | | 11,733 | NS | NS | NS | NS | NS | NS |
| FRA1 | 11 | 5/27/14 | | 37,733 | NS | NS | NS | NS | NS | NS |
| FRA1 | 12 | 6/14/14 | | 48,069 | NS | NS | NS | NS | NS | NS |
| FRA1 | 13 | 12/24/14 | | 1,938,414 | 476 | 337 | 10.9 | 10.6 | 84.3 | 10.4 |
| FRA2 | 13 | 12/24/14 | | 1,549,984 | 416 | 344 | 15.0 | 15.0 | 32.3 | 19.7 |
| FRA1 | 14 | 1/4/15 | | 256,384 | NS | NS | NS | NS | NS | NS |
| FRA1 | 15 | 1/18/15 | | 460,184 | NS | NS | NS | NS | NS | NS |

| Station | Event | Start Date | Note | Discharge (L) | TP (µg/L) | TDP (µg/L) | TN (mg/L) | TDN (mg/L) | TSS (mg/L) | Cl (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| PAW1 | 1 | 10/29/14 | | 3,257 | NS | NS | NS | NS | NS | NS |
| PAW1 | 2 | 11/6/14 | | 4,118 | NS | NS | NS | NS | NS | NS |
| PAW1 | 3 | 11/17/14 | | 106,249 | 500 | 336 | 1.87 | 1.54 | 60.3 | 11.6 |
| PAW2 | 3 | 11/17/14 | | 41,694 | 505 | 448 | 1.03 | 0.79 | 13.6 | 15.1 |
| PAW1 | 4 | 11/24/14 | | 22,927 | 208 | 163 | 2.20 | 2.36 | 7.27 | 16.3 |
| PAW2 | 4 | 11/24/14 | | 15,257 | 284 | 212 | 0.97 | 0.70 | 5.78 | 17.4 |
| PAW1 | 5 | 12/3/14 | | 101,143 | NS | NS | NS | NS | NS | NS |
| PAW2 | 5 | 12/3/14 | | 44,601 | NS | NS | NS | NS | NS | NS |
| PAW1 | 6 | 12/22/14 | | 1,510,347 | 101 | 75.6 | 2.10 | 1.98 | 12.1 | 5.31 |
| PAW2 | 6 | 12/22/14 | | 719,728 | 75.7 | 60.5 | 0.93 | 0.92 | 4.50 | 3.47 |
| PAW1 | 7 | 12/27/14 | | 131,462 | NS | NS | NS | NS | NS | NS |
| PAW2 | 7 | 12/27/14 | | 80,244 | NS | NS | NS | NS | NS | NS |
| SHE1 | 2 | 4/2/14 | | 432,943 | NS | NS | NS | NS | NS | NS |
| SHE1 | 3 | 4/8/14 | | 12,894 | NS | NS | NS | NS | NS | NS |
| SHE2 | 3 | 4/7/14 | | 58,531 | NS | NS | NS | NS | NS | NS |
| SHE2 | 4 | 4/13/14 | | 10,995 | NS | NS | NS | NS | NS | NS |
| SHE1 | 5 | 4/15/14 | | 241,976 | NS | NS | NS | NS | NS | NS |
| SHE2 | 5 | 4/14/14 | | 422,587 | NS | NS | NS | NS | NS | NS |
| SHE2 | 6 | 4/27/14 | | 10,809 | NS | NS | NS | NS | NS | NS |
| SHE1 | 7 | 5/1/14 | | 1,522 | NS | NS | NS | NS | NS | NS |
| SHE2 | 7 | 4/30/14 | | 23,190 | NS | NS | NS | NS | NS | NS |
| SHE1 | 8 | 5/4/14 | | 16,748 | NS | NS | NS | NS | NS | NS |
| SHE2 | 8 | 5/4/14 | | 41,518 | NS | NS | NS | NS | NS | NS |
| SHE1 | 9 | 5/17/14 | | 39,144 | NS | NS | NS | NS | NS | NS |
| SHE2 | 9 | 5/17/14 | | 86,655 | NS | NS | NS | NS | NS | NS |
| SHE1 | 10 | 6/13/14 | | 105,040 | 1890 | 1450 | 10.8 | 8.41 | 21.3 | 48.8 |
| SHE2 | 10 | 6/13/14 | | 69,632 | 806 | 628 | 3.84 | 3.18 | 10.2 | 36.9 |
| SHE1 | 11 | 6/25/14 | | 137,722 | 983 | 963 | 4.84 | 4.34 | 7.67 | 18.9 |
| SHE2 | 11 | 6/25/14 | | 43,485 | 1090 | 453 | 2.78 | 2.50 | 4.33 | 16.7 |
| SHE1 | 12 | 12/17/14 | | 161,468 | 318 | 303 | 1.10 | 1.09 | 2.40 | 11.5 |
| SHE2 | 12 | 12/16/14 | | 103,933 | 525 | 500 | 2.07 | 1.50 | 10.0 | 20.6 |
| SHE1 | 13 | 12/24/14 | | 751,635 | 214 | 194 | 0.89 | 0.81 | 2.25 | 5.24 |
| SHE2 | 13 | 12/23/14 | | 718,552 | 492 | 472 | 1.27 | 1.15 | 6.13 | 12.3 |
| SHO1 | 1 | 4/4/14 | Note 1 | 123,739 | 899 | 784 | 5.93 | 5.46 | 64.6 | 11.2 |
| SHO2 | 1 | 4/4/14 | | 62,644 | 878 | 851 | 4.18 | 3.76 | 13.0 | 6.32 |

| Station | Event | Start Date | Note | Discharge (L) | TP (µg/L) | TDP (µg/L) | TN (mg/L) | TDN (mg/L) | TSS (mg/L) | Cl (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| SHO1 | 2 | 4/15/14 | | 188,804 | 277 | 286 | 2.92 | 3.04 | 11.0 | 8.99 |
| SHO2 | 2 | 4/15/14 | | 3,867 | 491 | 499 | 3.48 | 3.38 | 33.5 | 7.06 |
| SHO1 | 3 | 5/1/14 | | 4,386 | NS | NS | NS | NS | NS | NS |
| SHO1 | 4 | 6/14/14 | | 19,723 | NS | NS | NS | NS | NS | NS |
| SHO1 | 5 | 12/24/14 | | 601,806 | 1120 | 1120 | 2.02 | 2.08 | 9.20 | 6.06 |
| SHO2 | 5 | 12/25/14 | | 880 | NS | NS | NS | NS | NS | NS |
| WIL2 | 1 | 4/2/14 | | 86,196 | NS | NS | NS | NS | NS | NS |
| WIL1 | 2 | 4/3/14 | | 422 | NS | NS | NS | NS | NS | NS |
| WIL2 | 2 | 4/3/14 | | 2,686 | NS | NS | NS | NS | NS | NS |
| WIL1 | 3 | 4/15/14 | | 135,145 | 670 | 139 | 9.07 | 7.91 | 141 | 6.65 |
| WIL2 | 3 | 4/15/14 | | 85,768 | 1695 | 472 | 5.34 | 2.57 | 562 | 3.23 |
| WIL2 | 4 | 12/24/14 | | 149,494 | 572 | 573 | 1.74 | 1.67 | 1.81 | 2.00 |
| WAS1 | 1 | 4/8/14 | | 676,058 | NS | NS | NS | NS | NS | NS |
| WAS2 | 1 | 4/8/14 | | 770,339 | NS | NS | NS | NS | NS | NS |
| WAS1 | 2 | 4/15/14 | | 1,289,827 | 1515 | 216 | 4.17 | 1.24 | 1697 | 7.34 |
| WAS2 | 2 | 4/15/14 | | 1,549,732 | 1555 | 110 | 4.25 | 0.98 | 1643 | 6.67 |
| WAS1 | 3 | 4/30/14 | | 243,180 | 1228 | 97 | 14.0 | 12.0 | 965 | 5.78 |
| WAS2 | 3 | 4/30/14 | | 447,452 | 1280 | 78.6 | 3.49 | 2.22 | 1020 | 6.77 |
| WAS1 | 4 | 5/4/14 | | 30,654 | 347 | 69.2 | 2.22 | 1.61 | 162 | 6.69 |
| WAS2 | 4 | 5/4/14 | | 276,793 | 338 | 47.2 | 2.10 | 1.52 | 123 | 5.53 |
| WAS1 | 5 | 5/27/14 | | 5,308 | NS | NS | NS | NS | NS | NS |
| WAS2 | 5 | 5/27/14 | | 55,403 | NS | NS | NS | NS | NS | NS |
| WAS1 | 6 | 6/14/14 | | 130,429 | 448 | 424 | 19.5 | 19.0 | 38.8 | 67.5 |
| WAS2 | 6 | 6/12/14 | | 209,964 | 391 | 157 | 16.4 | 15.4 | 36.0 | 53.5 |
| WAS1 | 7 | 12/24/14 | | 3,183,528 | 332 | 190 | 10.8 | 10.7 | 99.9 | 14.8 |
| WAS2 | 7 | 12/24/14 | | 7,621,514 | 338 | 179 | 9.39 | 9.40 | 117 | 14.3 |

NS = No sample collected

Note 1 = 50% of discharge effectively sampled

# APPENDIX H: DISCHARGE AND CONSTITUENT LOADING FOR 2014 EVENTS

| Station | Event | Start Date | Note | Discharge (L) | TP (g) | TDP (g) | TN (g) | TDN (g) | TSS (kg) | Cl (kg) |
|---|---|---|---|---|---|---|---|---|---|---|
| FER1 | 1 | 4/1/14 | | 354,271 | 583 | 573 | 2972 | 3532 | 9.4 | 4.36 |
| FER2 | 1 | 4/1/14 | | 340,536 | 470 | 443 | 2775 | 3334 | 7.4 | 3.78 |
| FER1 | 2 | 4/8/14 | | 3,300 | 1.6 | NS | 18 | NS | 0.12 | NS |
| FER2 | 2 | 4/7/14 | | 86,587 | 27 | 24 | 335 | 325 | 1.04 | 1.98 |
| FER2 | 3 | 4/13/14 | | 3,843 | NS | NS | NS | NS | NS | NS |
| FER1 | 4 | 4/15/14 | | 149,214 | 37 | 37 | 643 | 655 | 2.54 | 1.66 |
| FER2 | 4 | 4/15/14 | | 570,477 | 140 | 123 | 2191 | 2208 | 8.6 | 6.62 |
| FER2 | 5 | 5/1/14 | | 37,076 | NS | NS | NS | NS | NS | NS |
| FER1 | 6 | 5/4/14 | | 9,967 | 1.7 | 1.2 | 28 | 26 | 0.10 | 0.05 |
| FER2 | 6 | 5/3/14 | | 171,006 | 20 | 14 | 450 | 397 | 0.70 | 1.57 |
| FER1 | 7 | 12/24/14 | | 309,961 | 223 | 211 | 651 | 651 | 1.77 | 4.22 |
| FER2 | 7 | 12/24/14 | | Invalid | Invalid | Invalid | Invalid | Invalid | Invalid | Invalid |
| FER1 | 8 | 1/19/15 | | 37,457 | 127 | 113 | 342 | 312 | 0.8 | 1.07 |
| FER2 | 8 | 1/19/15 | | 39,219 | 117 | 111 | 390 | 377 | 0.8 | 0.87 |
| FRA2 | 1 | 3/11/14 | | 124,945 | NS | NS | NS | NS | NS | NS |
| FRA2 | 2 | 3/28/14 | | 1,182,468 | NS | NS | NS | NS | NS | NS |
| FRA1 | 3 | 3/30/14 | | 1,718,017 | NS | NS | NS | NS | NS | NS |
| FRA2 | 3 | 3/30/14 | | 1,975,469 | NS | NS | NS | NS | NS | NS |
| FRA2 | 4 | 3/31/14 | | 72,469 | NS | NS | NS | NS | NS | NS |
| FRA1 | 5 | 4/1/14 | | 754,827 | NS | NS | NS | NS | NS | NS |
| FRA2 | 5 | 4/1/14 | | 176,289 | NS | NS | NS | NS | NS | NS |
| FRA1 | 6 | 4/4/14 | | 247,227 | NS | NS | NS | NS | NS | NS |
| FRA1 | 7 | 4/8/14 | | 170,185 | 150 | 34 | 1686 | 1373 | 84.7 | 4.16 |
| FRA2 | 7 | 4/8/14 | | 34,346 | 22 | 6.4 | 362 | 307 | 9.14 | 0.74 |
| FRA1 | 8 | 4/15/14 | | 730,852 | 1153 | 175 | 7133 | 4787 | 811 | 11.4 |
| FRA2 | 8 | 4/15/14 | | 344,287 | 544 | 44 | 3281 | 2276 | 539 | 4.61 |
| FRA1 | 9 | 4/30/14 | | 104,738 | 164 | 11 | 591 | 335 | 109 | 0.86 |
| FRA1 | 10 | 5/4/14 | | 11,733 | NS | NS | NS | NS | NS | NS |
| FRA1 | 11 | 5/27/14 | | 37,733 | NS | NS | NS | NS | NS | NS |
| FRA1 | 12 | 6/14/14 | | 48,069 | NS | NS | NS | NS | NS | NS |
| FRA1 | 13 | 12/24/14 | | 1,938,414 | 923 | 654 | 21129 | 20547 | 163 | 20.2 |
| FRA2 | 13 | 12/24/14 | | 1,549,984 | 645 | 533 | 23250 | 23250 | 50.1 | 30.5 |
| FRA1 | 14 | 1/4/15 | | 256,384 | NS | NS | NS | NS | NS | NS |
| FRA1 | 15 | 1/18/15 | | 460,184 | NS | NS | NS | NS | NS | NS |
| PAW1 | 1 | 10/29/14 | | 3,257 | NS | NS | NS | NS | NS | NS |

| Station | Event | Start Date | Note | Discharge (L) | TP (g) | TDP (g) | TN (g) | TDN (g) | TSS (kg) | Cl (kg) |
|---|---|---|---|---|---|---|---|---|---|---|
| PAW1 | 2 | 11/6/14 | | 4,118 | NS | NS | NS | NS | NS | NS |
| PAW1 | 3 | 11/17/14 | | 106,249 | 53 | 36 | 199 | 164 | 6.40 | 1.23 |
| PAW2 | 3 | 11/17/14 | | 41,694 | 21 | 19 | 43 | 33 | 0.57 | 0.63 |
| PAW1 | 4 | 11/24/14 | | 22,927 | 4.8 | 3.7 | 50 | 54 | 0.17 | 0.37 |
| PAW2 | 4 | 11/24/14 | | 15,257 | 4.3 | 3.2 | 15 | 11 | 0.09 | 0.27 |
| PAW1 | 5 | 12/3/14 | | 101,143 | NS | NS | NS | NS | NS | NS |
| PAW2 | 5 | 12/3/14 | | 44,601 | NS | NS | NS | NS | NS | NS |
| PAW1 | 6 | 12/22/14 | | 1,510,347 | 153 | 114 | 3172 | 2990 | 18.3 | 8.02 |
| PAW2 | 6 | 12/22/14 | | 719,728 | 54 | 44 | 669 | 662 | 3.24 | 2.50 |
| PAW1 | 7 | 12/27/14 | | 131,462 | NS | NS | NS | NS | NS | NS |
| PAW2 | 7 | 12/27/14 | | 80,244 | NS | NS | NS | NS | NS | NS |
| SHE1 | 2 | 4/2/14 | | 432,943 | NS | NS | NS | NS | NS | NS |
| SHE1 | 3 | 4/8/14 | | 12,894 | NS | NS | NS | NS | NS | NS |
| SHE2 | 3 | 4/7/14 | | 58,531 | NS | NS | NS | NS | NS | NS |
| SHE2 | 4 | 4/13/14 | | 10,995 | NS | NS | NS | NS | NS | NS |
| SHE1 | 5 | 4/15/14 | | 241,976 | NS | NS | NS | NS | NS | NS |
| SHE2 | 5 | 4/14/14 | | 422,587 | NS | NS | NS | NS | NS | NS |
| SHE2 | 6 | 4/27/14 | | 10,809 | NS | NS | NS | NS | NS | NS |
| SHE1 | 7 | 5/1/14 | | 1,522 | NS | NS | NS | NS | NS | NS |
| SHE2 | 7 | 4/30/14 | | 23,190 | NS | NS | NS | NS | NS | NS |
| SHE1 | 8 | 5/4/14 | | 16,748 | NS | NS | NS | NS | NS | NS |
| SHE2 | 8 | 5/4/14 | | 41,518 | NS | NS | NS | NS | NS | NS |
| SHE1 | 9 | 5/17/14 | | 39,144 | NS | NS | NS | NS | NS | NS |
| SHE2 | 9 | 5/17/14 | | 86,655 | NS | NS | NS | NS | NS | NS |
| SHE1 | 10 | 6/13/14 | | 105,040 | 199 | 152 | 1137 | 883 | 2.24 | 5.12 |
| SHE2 | 10 | 6/13/14 | | 69,632 | 56 | 44 | 267 | 221 | 0.71 | 2.57 |
| SHE1 | 11 | 6/25/14 | | 137,722 | 135 | 133 | 667 | 598 | 1.06 | 2.60 |
| SHE2 | 11 | 6/25/14 | | 43,485 | 47 | 20 | 121 | 109 | 0.19 | 0.73 |
| SHE1 | 12 | 12/17/14 | | 161,468 | 51 | 49 | 178 | 176 | 0.39 | 1.86 |
| SHE2 | 12 | 12/16/14 | | 103,933 | 55 | 52 | 215 | 156 | 1.03 | 2.14 |
| SHE1 | 13 | 12/24/14 | | 751,635 | 161 | 146 | 669 | 609 | 1.69 | 3.94 |
| SHE2 | 13 | 12/23/14 | | 718,552 | 354 | 339 | 913 | 826 | 4.40 | 8.84 |
| SHO1 | 1 | 4/4/14 | Note 1 | 123,739 | 111 | 97 | 731 | 678 | 9.20 | 1.38 |
| SHO2 | 1 | 4/4/14 | | 62,644 | 55 | 53 | 262 | 236 | 0.80 | 0.40 |
| SHO1 | 2 | 4/15/14 | | 188,804 | 52 | 54 | 551 | 574 | 2.08 | 1.70 |

| Station | Event | Start Date | Note | Discharge (L) | TP (g) | TDP (g) | TN (g) | TDN (g) | TSS (kg) | Cl (kg) |
|---|---|---|---|---|---|---|---|---|---|---|
| SHO2 | 2 | 4/15/14 | | 3,867 | 1.9 | 1.9 | 13 | 13 | 0.13 | 0.03 |
| SHO1 | 3 | 5/1/14 | | 4,386 | NS | NS | NS | NS | NS | NS |
| SHO1 | 4 | 6/14/14 | | 19,723 | NS | NS | NS | NS | NS | NS |
| SHO1 | 5 | 12/24/14 | | 601,806 | 674 | 674 | 1216 | 1252 | 5.54 | 3.65 |
| SHO2 | 5 | 12/25/14 | | 880 | NS | NS | NS | NS | NS | NS |
| WIL2 | 1 | 4/2/14 | | 86,196 | NS | NS | NS | NS | NS | NS |
| WIL1 | 2 | 4/3/14 | | 422 | NS | NS | NS | NS | NS | NS |
| WIL2 | 2 | 4/3/14 | | 2,686 | NS | NS | NS | NS | NS | NS |
| WIL1 | 3 | 4/15/14 | | 135,145 | 91 | 19 | 1226 | 1069 | 19.1 | 0.90 |
| WIL2 | 3 | 4/15/14 | | 85,768 | 145 | 40 | 458 | 220 | 48.2 | 0.28 |
| WIL2 | 4 | 12/24/14 | | 149,494 | 85 | 86 | 261 | 250 | 0.27 | 0.30 |
| WAS1 | 1 | 4/8/14 | | 676,058 | NS | NS | NS | NS | NS | NS |
| WAS2 | 1 | 4/8/14 | | 770,339 | NS | NS | NS | NS | NS | NS |
| WAS1 | 2 | 4/15/14 | | 1,289,827 | 1954 | 279 | 5379 | 1599 | 2188 | 9.47 |
| WAS2 | 2 | 4/15/14 | | 1,549,732 | 2410 | 170 | 6586 | 1519 | 2547 | 10.3 |
| WAS1 | 3 | 4/30/14 | | 243,180 | 299 | 24 | 3396 | 2922 | 235 | 1.41 |
| WAS2 | 3 | 4/30/14 | | 447,452 | 573 | 35 | 1562 | 993 | 456 | 3.03 |
| WAS1 | 4 | 5/4/14 | | 30,654 | 11 | 2.1 | 68 | 49 | 4.97 | 0.21 |
| WAS2 | 4 | 5/4/14 | | 276,793 | 94 | 13 | 581 | 420 | 34.1 | 1.53 |
| WAS1 | 5 | 5/27/14 | | 5,308 | NS | NS | NS | NS | NS | NS |
| WAS2 | 5 | 5/27/14 | | 55,403 | NS | NS | NS | NS | NS | NS |
| WAS1 | 6 | 6/14/14 | | 130,429 | 58 | 55 | 2541 | 2476 | 5.06 | 8.80 |
| WAS2 | 6 | 6/12/14 | | 209,964 | 82 | 33 | 3443 | 3236 | 7.56 | 11.2 |
| WAS1 | 7 | 12/24/14 | | 3,183,528 | 1058 | 604 | 34342 | 34159 | 318 | 47.0 |
| WAS2 | 7 | 12/24/14 | | 7,621,514 | 2579 | 1365 | 71537 | 71644 | 894 | 109 |

NS = No sample collected

Note 1 = 50% of discharge effectively sampled

# APPENDIX I: CALIBRATION PERIOD REGRESSION ANALYSES

## I.1. Ferrisburgh Site Regressions

**Q**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.763821 |
| RSquare Adj | 0.749928 |
| Root Mean Square Error | 0.266167 |
| Mean of Response | 5.246338 |
| Observations (or Sum Wgts) | 19 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 3.8950045 | 3.89500 | 54.9792 |
| Error | 17 | 1.2043665 | 0.07085 | Prob > F |
| C. Total | 18 | 5.0993709 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 2.8145147 | 0.333605 | 8.44 | <.0001* |
| FER1 logQ | 0.536318 | 0.072331 | 7.41 | <.0001* |

**TP**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.876906 |
| RSquare Adj | 0.868114 |
| Root Mean Square Error | 0.099673 |
| Mean of Response | 2.804091 |
| Observations (or Sum Wgts) | 16 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 0.9908397 | 0.990840 | 99.7346 |
| Error | 14 | 0.1390867 | 0.009935 | Prob > F |
| C. Total | 15 | 1.1299264 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 1.1308655 | 0.169388 | 6.68 | <.0001* |
| FER1 logTP | 0.6044374 | 0.060524 | 9.99 | <.0001* |

**TDP**
CALIBRATION

## Summary of Fit

| | |
|---|---|
| RSquare | 0.792883 |
| RSquare Adj | 0.77695 |
| Root Mean Square Error | 0.14881 |
| Mean of Response | 2.732722 |
| Observations (or Sum Wgts) | 15 |

## Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 1.1020531 | 1.10205 | 49.7663 |
| Error | 13 | 0.2878793 | 0.02214 | Prob > F |
| C. Total | 14 | 1.3899324 | | <.0001* |

## Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 1.1375067 | 0.229368 | 4.96 | 0.0003* |
| FER1 logTDP | 0.5926267 | 0.084007 | 7.05 | <.0001* |

**TN**
CALIBRATION

## Summary of Fit

| | |
|---|---|
| RSquare | 0.828745 |
| RSquare Adj | 0.816512 |
| Root Mean Square Error | 0.113901 |
| Mean of Response | 0.479167 |
| Observations (or Sum Wgts) | 16 |

## Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 0.8789482 | 0.878948 | 67.7493 |
| Error | 14 | 0.1816297 | 0.012974 | Prob > F |
| C. Total | 15 | 1.0605778 | | <.0001* |

## Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.2299794 | 0.041562 | 5.53 | <.0001* |
| FER1 logTN | 0.5529276 | 0.067176 | 8.23 | <.0001* |

**TDN**
CALIBRATION

## Summary of Fit

| | |
|---|---|
| RSquare | 0.694748 |
| RSquare Adj | 0.671267 |
| Root Mean Square Error | 0.137277 |
| Mean of Response | 0.402103 |
| Observations (or Sum Wgts) | 15 |

## Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 0.55758478 | 0.557585 | 29.5878 |
| Error | 13 | 0.24498615 | 0.018845 | Prob > F |
| C. Total | 14 | 0.80257093 | | 0.0001* |

## Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.2052734 | 0.050653 | 4.05 | 0.0014* |
| FER1 logTDN | 0.5225722 | 0.09607 | 5.44 | 0.0001* |

**TSS**
CALIBRATION

## Summary of Fit

| | |
|---|---|
| RSquare | 0.633084 |
| RSquare Adj | 0.606876 |
| Root Mean Square Error | 0.207571 |
| Mean of Response | 1.682635 |
| Observations (or Sum Wgts) | 16 |

## Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 1.0407780 | 1.04078 | 24.1559 |
| Error | 14 | 0.6032025 | 0.04309 | Prob > F |
| C. Total | 15 | 1.6439805 | | 0.0002* |

## Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.512702 | 0.24363 | 2.10 | 0.0539 |
| FER1 logTSS | 0.5768633 | 0.117371 | 4.91 | 0.0002* |

**Cl**

CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.828806 |
| RSquare Adj | 0.815637 |
| Root Mean Square Error | 0.206403 |
| Mean of Response | 0.851947 |
| Observations (or Sum Wgts) | 15 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 2.6812628 | 2.68126 | 62.9372 |
| Error | 13 | 0.5538288 | 0.04260 | **Prob > F** |
| C. Total | 14 | 3.2350916 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.3719708 | 0.080626 | 4.61 | 0.0005* |
| FER1 logCl | 0.7643064 | 0.096342 | 7.93 | <.0001* |

**TPx**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.87224 |
| RSquare Adj | 0.863115 |
| Root Mean Square Error | 0.178585 |
| Mean of Response | 2.071229 |
| Observations (or Sum Wgts) | 16 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 3.0483036 | 3.04830 | 95.5806 |
| Error | 14 | 0.4464947 | 0.03189 | Prob > F |
| C. Total | 15 | 3.4947983 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 1.2657427 | 0.093709 | 13.51 | <.0001* |
| FER1 logTPx | 0.5701614 | 0.058319 | 9.78 | <.0001* |

**TDPx**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.847574 |
| RSquare Adj | 0.835849 |
| Root Mean Square Error | 0.182623 |
| Mean of Response | 2.041495 |
| Observations (or Sum Wgts) | 15 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 2.4108727 | 2.41087 | 72.2876 |
| Error | 13 | 0.4335648 | 0.03335 | Prob > F |
| C. Total | 14 | 2.8444375 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 1.1527926 | 0.11467 | 10.05 | <.0001* |
| FER1 logTDPx | 0.6212663 | 0.073071 | 8.50 | <.0001* |

**TNx**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.763732 |
| RSquare Adj | 0.746856 |
| Root Mean Square Error | 0.228333 |
| Mean of Response | 2.746458 |
| Observations (or Sum Wgts) | 16 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 2.3594087 | 2.35941 | 45.2547 |
| Error | 14 | 0.7299066 | 0.05214 | **Prob > F** |
| C. Total | 15 | 3.0893153 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 1.6584704 | 0.171509 | 9.67 | <.0001* |
| FER1 logTNx | 0.5184217 | 0.077064 | 6.73 | <.0001* |

**TDNx**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.623489 |
| RSquare Adj | 0.594526 |
| Root Mean Square Error | 0.253842 |
| Mean of Response | 2.710982 |
| Observations (or Sum Wgts) | 15 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 1.3871449 | 1.38714 | 21.5275 |
| Error | 13 | 0.8376668 | 0.06444 | **Prob > F** |
| C. Total | 14 | 2.2248117 | | 0.0005* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 1.6190413 | 0.244299 | 6.63 | <.0001* |
| FER1 logTDNx | 0.5164907 | 0.111318 | 4.64 | 0.0005* |

**TSSx**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.836469 |
| RSquare Adj | 0.824788 |
| Root Mean Square Error | 0.276864 |
| Mean of Response | 3.949827 |
| Observations (or Sum Wgts) | 16 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 5.4891895 | 5.48919 | 71.6105 |
| Error | 14 | 1.0731485 | 0.07665 | **Prob > F** |
| C. Total | 15 | 6.5623381 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 1.485207 | 0.299359 | 4.96 | 0.0002* |
| FER1 logTSSx | 0.6708838 | 0.079279 | 8.46 | <.0001* |

**Clx**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.461364 |
| RSquare Adj | 0.419931 |
| Root Mean Square Error | 0.348384 |
| Mean of Response | 3.160812 |
| Observations (or Sum Wgts) | 15 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 1.3514755 | 1.35148 | 11.1351 |
| Error | 13 | 1.5778264 | 0.12137 | **Prob > F** |
| C. Total | 14 | 2.9293019 | | 0.0054* |

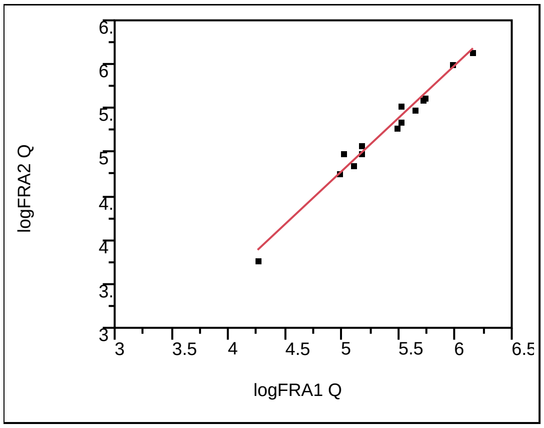
### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 1.8817987 | 0.393705 | 4.78 | 0.0004* |
| FER1 logClx | 0.5404921 | 0.161973 | 3.34 | 0.0054* |

## I.2. Franklin Site Regressions

**Q**

**CALIBRATION**




## Summary of Fit

| | |
|---|---|
| RSquare | 0.977816 |
| RSquare Adj | 0.975967 |
| Root Mean Square Error | 0.091285 |
| Mean of Response | 5.247257 |
| Observations (or Sum Wgts) | 14 |

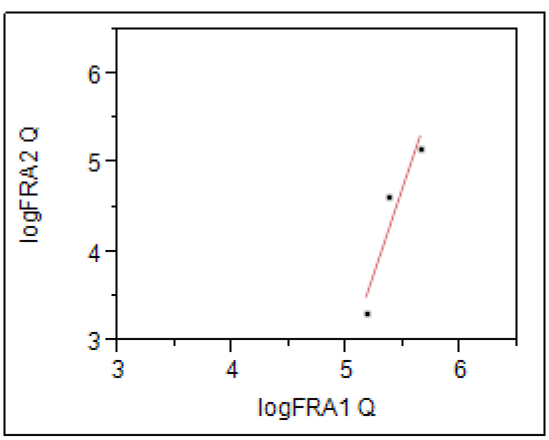
## Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 4.4075224 | 4.40752 | 528.9231 |
| Error | 12 | 0.0999961 | 0.00833 | **Prob > F** |
| C. Total | 13 | 4.5075186 | | <.0001* |

## Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | -1.263064 | 0.284127 | -4.45 | 0.0008* |
| logFRA1 Q | 1.2090302 | 0.05257 | 23.00 | <.0001* |

**TREATMENT**

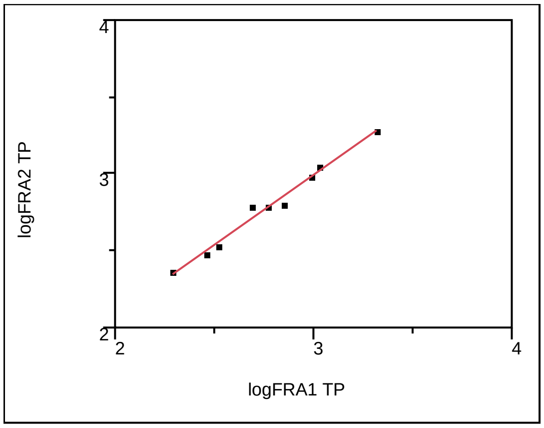



## Summary of Fit

| | |
|---|---|
| RSquare | 0.912291 |
| RSquare Adj | 0.824583 |
| Root Mean Square Error | 0.398353 |
| Mean of Response | 4.368589 |
| Observations (or Sum Wgts) | 3 |

**F Ratio**
10.4014
**Prob > F**
0.1914

**TP**
**CALIBRATION**
**Regression Plot**




**Summary of Fit**

| | |
|---|---|
| RSquare | 0.982776 |
| RSquare Adj | 0.980315 |
| Root Mean Square Error | 0.041274 |
| Mean of Response | 2.782941 |
| Observations (or Sum Wgts) | 9 |

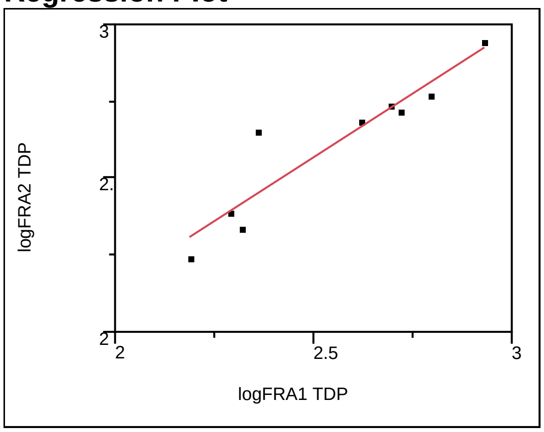
**Analysis of Variance**

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 0.68038510 | 0.680385 | 399.4000 |
| Error | 7 | 0.01192463 | 0.001704 | **Prob > F** |
| C. Total | 8 | 0.69230973 | | <.0001* |

**Parameter Estimates**

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.262408 | 0.126869 | 2.07 | 0.0774 |
| logFRA1 TP | 0.91015 | 0.045542 | 19.98 | <.0001* |

**TDP**
**CALIBRATION**
**Regression Plot**




**Summary of Fit**

| | |
|---|---|
| RSquare | 0.872537 |
| RSquare Adj | 0.854328 |
| Root Mean Square Error | 0.088655 |
| Mean of Response | 2.60622 |
| Observations (or Sum Wgts) | 9 |

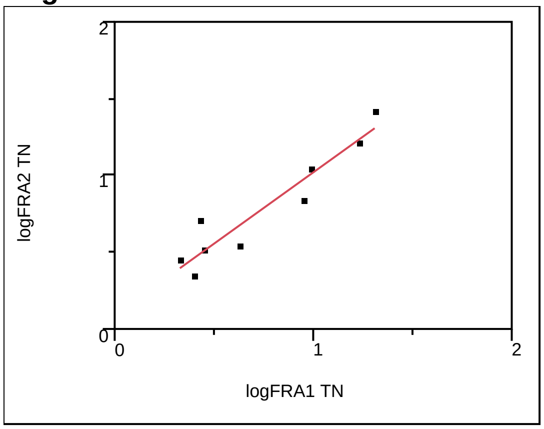
**Analysis of Variance**

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 0.37661902 | 0.376619 | 47.9181 |
| Error | 7 | 0.05501752 | 0.007860 | **Prob > F** |
| C. Total | 8 | 0.43163654 | | 0.0002* |

**Parameter Estimates**

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.4931839 | 0.306678 | 1.61 | 0.1518 |
| logFRA1 TDP | 0.8297112 | 0.119861 | 6.92 | 0.0002* |

**TN**
**CALIBRATION**
**Regression Plot**




## Summary of Fit

| | |
|---|---|
| RSquare | 0.894692 |
| RSquare Adj | 0.879648 |
| Root Mean Square Error | 0.129099 |
| Mean of Response | 0.784091 |
| Observations (or Sum Wgts) | 9 |

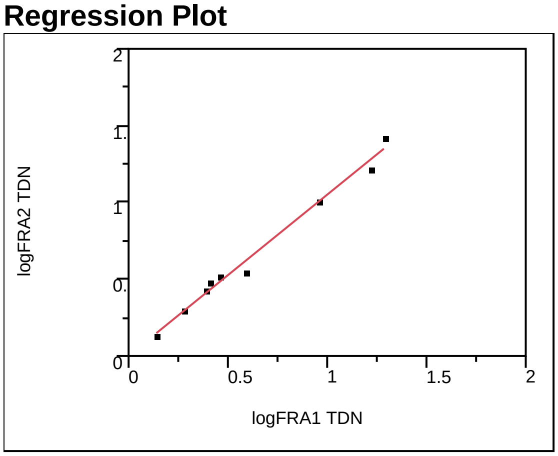
## Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 0.9911847 | 0.991185 | 59.4714 |
| Error | 7 | 0.1166660 | 0.016667 | **Prob > F** |
| C. Total | 8 | 1.1078507 | | 0.0001* |

## Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.0903689 | 0.099719 | 0.91 | 0.3949 |
| logFRA1 TN | 0.9291155 | 0.12048 | 7.71 | 0.0001* |

**TDN**
**CALIBRATION**
**Regression Plot**




## Summary of Fit

| | |
|---|---|
| RSquare | 0.987155 |
| RSquare Adj | 0.98532 |
| Root Mean Square Error | 0.053187 |
| Mean of Response | 0.671912 |
| Observations (or Sum Wgts) | 9 |

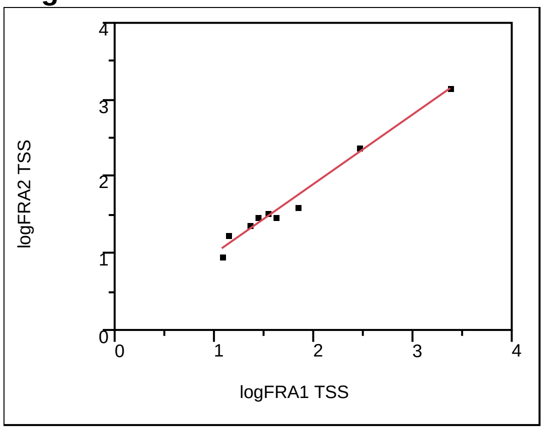
## Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 1.5218164 | 1.52182 | 537.9697 |
| Error | 7 | 0.0198017 | 0.00283 | **Prob > F** |
| C. Total | 8 | 1.5416181 | | <.0001* |

## Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.0019083 | 0.033893 | 0.06 | 0.9567 |
| logFRA1 TDN | 1.0484516 | 0.045203 | 23.19 | <.0001* |

**TSS**
**CALIBRATION**
## Regression Plot




## Summary of Fit

| | |
|---|---|
| RSquare | 0.98206 |
| RSquare Adj | 0.979497 |
| Root Mean Square Error | 0.096076 |
| Mean of Response | 1.683549 |
| Observations (or Sum Wgts) | 9 |

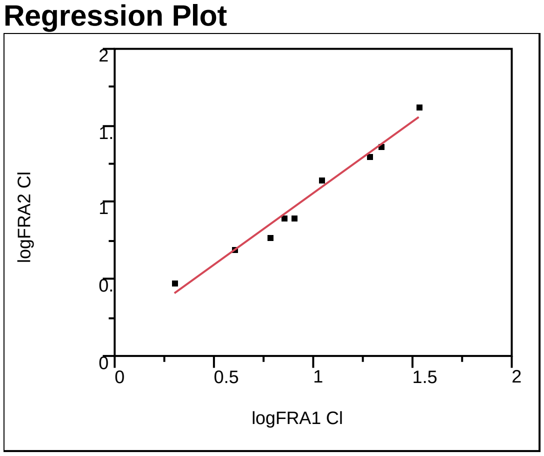
## Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 3.5370824 | 3.53708 | 383.1893 |
| Error | 7 | 0.0646145 | 0.00923 | **Prob > F** |
| C. Total | 8 | 3.6016969 | | <.0001* |

## Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.0861325 | 0.087663 | 0.98 | 0.3586 |
| logFRA1 TSS | 0.9064319 | 0.046305 | 19.58 | <.0001* |

**Cl**
**CALIBRATION**
## Regression Plot




## Summary of Fit

| | |
|---|---|
| RSquare | 0.978706 |
| RSquare Adj | 0.975664 |
| Root Mean Square Error | 0.056763 |
| Mean of Response | 1.021395 |
| Observations (or Sum Wgts) | 9 |

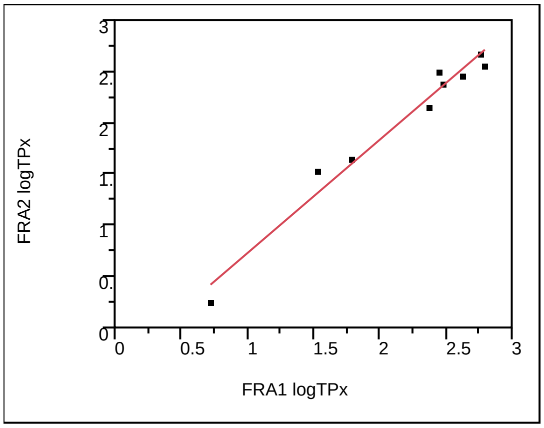
## Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 1.0366066 | 1.03661 | 321.7288 |
| Error | 7 | 0.0225539 | 0.00322 | **Prob > F** |
| C. Total | 8 | 1.0591605 | | <.0001* |

## Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.1282055 | 0.05327 | 2.41 | 0.0470* |
| logFRA1 Cl | 0.9321887 | 0.051971 | 17.94 | <.0001* |

## TPx
## CALIBRATION
### Regression Plot




### Summary of Fit

| | |
|---|---|
| RSquare | 0.971128 |
| RSquare Adj | 0.967003 |
| Root Mean Square Error | 0.140707 |
| Mean of Response | 2.015513 |
| Observations (or Sum Wgts) | 9 |

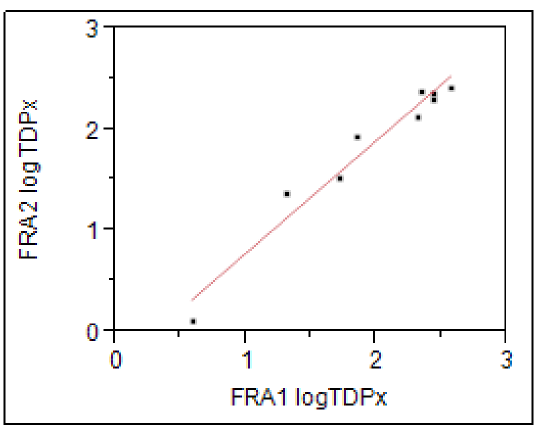
### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 4.6615073 | 4.66151 | 235.4489 |
| Error | 7 | 0.1385887 | 0.01980 | **Prob > F** |
| C. Total | 8 | 4.8000960 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | -0.383251 | 0.163213 | -2.35 | 0.0512 |
| FRA1 logTPx | 1.1063946 | 0.072104 | 15.34 | <.0001* |

## TDPx
## CALIBRATION




### Summary of Fit

| | |
|---|---|
| RSquare | 0.957535 |
| RSquare Adj | 0.951469 |
| Root Mean Square Error | 0.165159 |
| Mean of Response | 1.83885 |
| Observations (or Sum Wgts) | 9 |

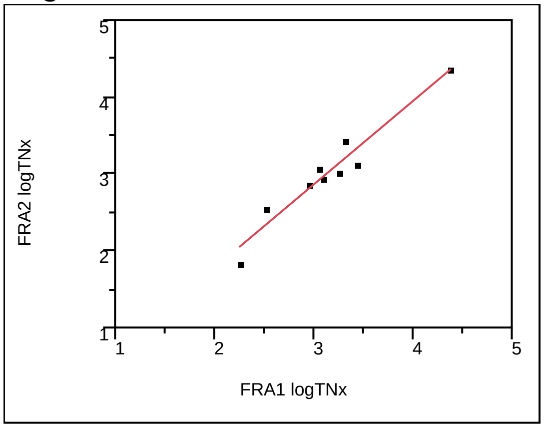
### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 4.3055459 | 4.30555 | 157.8417 |
| Error | 7 | 0.1909433 | 0.02728 | **Prob > F** |
| C. Total | 8 | 4.4964892 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | -0.326208 | 0.180909 | -1.80 | 0.1144 |
| FRA1 logTDPx | 1.1130056 | 0.08859 | 12.56 | <.0001* |

**TNx**
**CALIBRATION**
**Regression Plot**




**Summary of Fit**

| | |
|---|---|
| RSquare | 0.937296 |
| RSquare Adj | 0.928338 |
| Root Mean Square Error | 0.180493 |
| Mean of Response | 3.015905 |
| Observations (or Sum Wgts) | 9 |

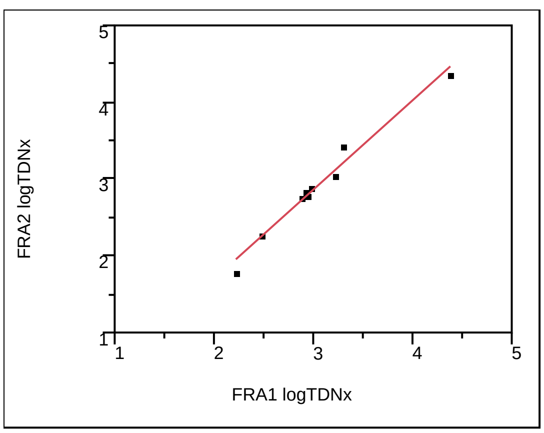
**Analysis of Variance**

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 3.4088001 | 3.40880 | 104.6358 |
| Error | 7 | 0.2280442 | 0.03258 | **Prob > F** |
| C. Total | 8 | 3.6368443 | | <.0001* |

**Parameter Estimates**

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | -0.397012 | 0.339027 | -1.17 | 0.2799 |
| FRA1 logTNx | 1.0850705 | 0.106076 | 10.23 | <.0001* |

**TDNx**
**CALIBRATION**
**Regression Plot**




**Summary of Fit**

| | |
|---|---|
| RSquare | 0.974287 |
| RSquare Adj | 0.970614 |
| Root Mean Square Error | 0.122301 |
| Mean of Response | 2.903747 |
| Observations (or Sum Wgts) | 9 |

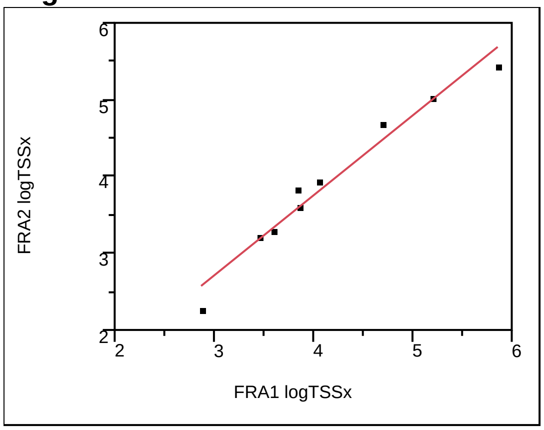
**Analysis of Variance**

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 3.9672769 | 3.96728 | 265.2379 |
| Error | 7 | 0.1047020 | 0.01496 | **Prob > F** |
| C. Total | 8 | 4.0719789 | | <.0001* |

**Parameter Estimates**

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | -0.630252 | 0.220791 | -2.85 | 0.0245* |
| FRA1 logTDNx | 1.1633294 | 0.071431 | 16.29 | <.0001* |

**TSSx**
**CALIBRATION**
**Regression Plot**




**Summary of Fit**

| | |
|---|---|
| RSquare | 0.963535 |
| RSquare Adj | 0.958326 |
| Root Mean Square Error | 0.201647 |
| Mean of Response | 3.916236 |
| Observations (or Sum Wgts) | 9 |

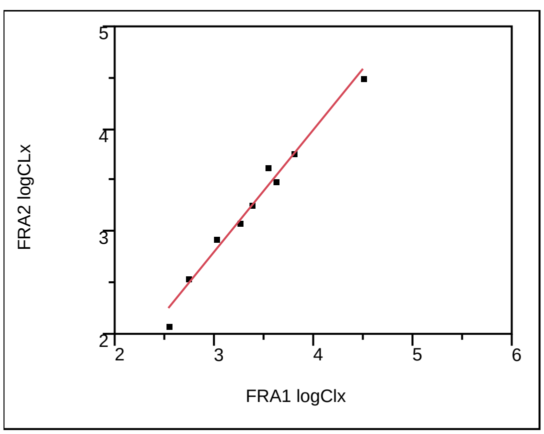
**Analysis of Variance**

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 7.5209360 | 7.52094 | 184.9646 |
| Error | 7 | 0.2846305 | 0.04066 | Prob > F |
| C. Total | 8 | 7.8055664 | | <.0001* |

**Parameter Estimates**

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | -0.417558 | 0.325669 | -1.28 | 0.2406 |
| FRA1 logTSSx | 1.0419299 | 0.076612 | 13.60 | <.0001* |

**Clx**
**CALIBRATION**
**Regression Plot**




**Summary of Fit**

| | |
|---|---|
| RSquare | 0.979403 |
| RSquare Adj | 0.976461 |
| Root Mean Square Error | 0.108697 |
| Mean of Response | 3.249268 |
| Observations (or Sum Wgts) | 9 |

**Analysis of Variance**

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 3.9327367 | 3.93274 | 332.8570 |
| Error | 7 | 0.0827057 | 0.01182 | Prob > F |
| C. Total | 8 | 4.0154424 | | <.0001* |

**Parameter Estimates**

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | -0.775119 | 0.223538 | -3.47 | 0.0104* |
| FRA1 logClx | 1.1911756 | 0.06529 | 18.24 | <.0001* |

## I.3. Pawlet Site Regressions

**Q**
CALIBRATION

## Summary of Fit

| | |
|---|---|
| RSquare | 0.731423 |
| RSquare Adj | 0.724355 |
| Root Mean Square Error | 0.336793 |
| Mean of Response | 4.605147 |
| Observations (or Sum Wgts) | 40 |

## Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 11.738384 | 11.7384 | 103.4864 |
| Error | 38 | 4.310311 | 0.1134 | **Prob > F** |
| C. Total | 39 | 16.048695 | | <.0001* |

## Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 1.0897034 | 0.349651 | 3.12 | 0.0035* |
| PAW1 logQ | 0.7198668 | 0.070764 | 10.17 | <.0001* |

**TP**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.623178 |
| RSquare Adj | 0.608685 |
| Root Mean Square Error | 0.231626 |
| Mean of Response | 2.451421 |
| Observations (or Sum Wgts) | 28 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 2.3068719 | 2.30687 | 42.9981 |
| Error | 26 | 1.3949151 | 0.05365 | **Prob > F** |
| C. Total | 27 | 3.7017869 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.7456649 | 0.263788 | 2.83 | 0.0089* |
| PAW1 logTP | 0.6673742 | 0.101776 | 6.56 | <.0001* |

**TDP**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.678941 |
| RSquare Adj | 0.666592 |
| Root Mean Square Error | 0.295091 |
| Mean of Response | 1.876669 |
| Observations (or Sum Wgts) | 28 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 4.7877501 | 4.78775 | 54.9819 |
| Error | 26 | 2.2640450 | 0.08708 | **Prob > F** |
| C. Total | 27 | 7.0517952 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.0759297 | 0.249172 | 0.30 | 0.7630 |
| PAW1 logTDP | 0.9229922 | 0.124477 | 7.41 | <.0001* |

**TN**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.753971 |
| RSquare Adj | 0.744508 |
| Root Mean Square Error | 0.182373 |
| Mean of Response | 0.301925 |
| Observations (or Sum Wgts) | 28 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 2.6500921 | 2.65009 | 79.6786 |
| Error | 26 | 0.8647546 | 0.03326 | **Prob > F** |
| C. Total | 27 | 3.5148467 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | -0.108206 | 0.057436 | -1.88 | 0.0708 |
| PAW1 logTN | 0.8288359 | 0.092853 | 8.93 | <.0001* |

**TDN**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.723228 |
| RSquare Adj | 0.712583 |
| Root Mean Square Error | 0.227457 |
| Mean of Response | 0.073679 |
| Observations (or Sum Wgts) | 28 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 3.5150047 | 3.51500 | 67.9402 |
| Error | 26 | 1.3451546 | 0.05174 | **Prob > F** |
| C. Total | 27 | 4.8601593 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | -0.168417 | 0.052062 | -3.23 | 0.0033* |
| PAW1 logTDN | 0.8385203 | 0.10173 | 8.24 | <.0001* |

**TSS**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.634616 |
| RSquare Adj | 0.620563 |
| Root Mean Square Error | 0.408985 |
| Mean of Response | 1.849622 |
| Observations (or Sum Wgts) | 28 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 7.553517 | 7.55352 | 45.1580 |
| Error | 26 | 4.348982 | 0.16727 | Prob > F |
| C. Total | 27 | 11.902499 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.4337914 | 0.22442 | 1.93 | 0.0642 |
| PAW1 logTSS | 0.6927936 | 0.103095 | 6.72 | <.0001* |

**Cl**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.834166 |
| RSquare Adj | 0.827533 |
| Root Mean Square Error | 0.140317 |
| Mean of Response | 0.893562 |
| Observations (or Sum Wgts) | 27 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 2.4759263 | 2.47593 | 125.7531 |
| Error | 25 | 0.4922198 | 0.01969 | Prob > F |
| C. Total | 26 | 2.9681462 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | -0.010808 | 0.085048 | -0.13 | 0.8999 |
| PAW1 logCl | 0.9197576 | 0.082019 | 11.21 | <.0001* |

**TPx**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.884486 |
| RSquare Adj | 0.880043 |
| Root Mean Square Error | 0.209955 |
| Mean of Response | 1.144749 |
| Observations (or Sum Wgts) | 28 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 8.7757566 | 8.77576 | 199.0814 |
| Error | 26 | 1.1461122 | 0.04408 | **Prob > F** |
| C. Total | 27 | 9.9218688 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.149082 | 0.080957 | 1.84 | 0.0770 |
| PAW1 logTPx | 0.6398049 | 0.045345 | 14.11 | <.0001* |

**TDPx**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.822655 |
| RSquare Adj | 0.815834 |
| Root Mean Square Error | 0.283559 |
| Mean of Response | 0.568077 |
| Observations (or Sum Wgts) | 28 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 9.697506 | 9.69751 | 120.6070 |
| Error | 26 | 2.090551 | 0.08041 | **Prob > F** |
| C. Total | 27 | 11.788057 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | -0.134607 | 0.08346 | -1.61 | 0.1189 |
| PAW1 logTDPx | 0.7370787 | 0.067116 | 10.98 | <.0001* |

**TNx**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.841308 |
| RSquare Adj | 0.835205 |
| Root Mean Square Error | 0.247166 |
| Mean of Response | 1.995942 |
| Observations (or Sum Wgts) | 28 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 8.420767 | 8.42077 | 137.8397 |
| Error | 26 | 1.588367 | 0.06109 | **Prob > F** |
| C. Total | 27 | 10.009134 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.1248599 | 0.166074 | 0.75 | 0.4589 |
| PAW1 logTNx | 0.7500833 | 0.063888 | 11.74 | <.0001* |

**TDNx**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.789597 |
| RSquare Adj | 0.781504 |
| Root Mean Square Error | 0.312173 |
| Mean of Response | 1.767497 |
| Observations (or Sum Wgts) | 28 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 9.508644 | 9.50864 | 97.5723 |
| Error | 26 | 2.533759 | 0.09745 | **Prob > F** |
| C. Total | 27 | 12.042403 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | -0.032601 | 0.191547 | -0.17 | 0.8662 |
| PAW1 logTDNx | 0.78604 | 0.079576 | 9.88 | <.0001* |

**TSSx**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.775833 |
| RSquare Adj | 0.767211 |
| Root Mean Square Error | 0.419323 |
| Mean of Response | 3.543002 |
| Observations (or Sum Wgts) | 28 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 15.822175 | 15.8222 | 89.9848 |
| Error | 26 | 4.571624 | 0.1758 | Prob > F |
| C. Total | 27 | 20.393800 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.8912854 | 0.290554 | 3.07 | 0.0050* |
| PAW1 logTSSx | 0.655692 | 0.069122 | 9.49 | <.0001* |

**Clx**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.812962 |
| RSquare Adj | 0.805481 |
| Root Mean Square Error | 0.229726 |
| Mean of Response | 2.575588 |
| Observations (or Sum Wgts) | 27 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 5.7345758 | 5.73458 | 108.6630 |
| Error | 25 | 1.3193489 | 0.05277 | Prob > F |
| C. Total | 26 | 7.0539247 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.4746726 | 0.206335 | 2.30 | 0.0300* |
| PAW1 logClx | 0.7054902 | 0.067678 | 10.42 | <.0001* |

## I.4. Shelburne Site Regressions

**Q**
CALIBRATION

## Summary of Fit

| | |
|---|---|
| RSquare | 0.834393 |
| RSquare Adj | 0.826866 |
| Root Mean Square Error | 0.237553 |
| Mean of Response | 5.14534 |
| Observations (or Sum Wgts) | 24 |

## Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 6.2551185 | 6.25512 | 110.8450 |
| Error | 22 | 1.2414870 | 0.05643 | **Prob > F** |
| C. Total | 23 | 7.4966055 | | <.0001* |

## Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 2.2140673 | 0.28261 | 7.83 | <.0001* |
| SHE1 logQ | 0.5960481 | 0.056614 | 10.53 | <.0001* |

**TP**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.830242 |
| RSquare Adj | 0.820811 |
| Root Mean Square Error | 0.080788 |
| Mean of Response | 2.45516 |
| Observations (or Sum Wgts) | 20 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 0.57456687 | 0.574567 | 88.0332 |
| Error | 18 | 0.11748068 | 0.006527 | **Prob > F** |
| C. Total | 19 | 0.69204755 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.6831815 | 0.18972 | 3.60 | 0.0020* |
| SHE1 logTP | 0.7397185 | 0.078839 | 9.38 | <.0001* |

**TDP**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.78139 |
| RSquare Adj | 0.769245 |
| Root Mean Square Error | 0.092186 |
| Mean of Response | 2.406122 |
| Observations (or Sum Wgts) | 20 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 0.54676487 | 0.546765 | 64.3382 |
| Error | 18 | 0.15296919 | 0.008498 | **Prob > F** |
| C. Total | 19 | 0.69973406 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 1.0069446 | 0.175651 | 5.73 | <.0001* |
| SHE1 logTDP | 0.6171981 | 0.076947 | 8.02 | <.0001* |

**TN**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.258788 |
| RSquare Adj | 0.217609 |
| Root Mean Square Error | 0.078013 |
| Mean of Response | 0.098361 |
| Observations (or Sum Wgts) | 20 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 0.03824787 | 0.038248 | 6.2845 |
| Error | 18 | 0.10954830 | 0.006086 | Prob > F |
| C. Total | 19 | 0.14779617 | | 0.0220* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.0677897 | 0.021284 | 3.18 | 0.0051* |
| SHE1 logTN | 0.1651464 | 0.065877 | 2.51 | 0.0220* |

**TDN**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.517563 |
| RSquare Adj | 0.490761 |
| Root Mean Square Error | 0.06578 |
| Mean of Response | 0.025054 |
| Observations (or Sum Wgts) | 20 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 0.08355768 | 0.083558 | 19.3106 |
| Error | 18 | 0.07788668 | 0.004327 | Prob > F |
| C. Total | 19 | 0.16144436 | | 0.0003* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.0163206 | 0.014843 | 1.10 | 0.2860 |
| SHE1 logTDN | 0.5030178 | 0.114468 | 4.39 | 0.0003* |

**TSS**
CALIBRATION - **CORRECTED**

### Summary of Fit

| | |
|---|---|
| RSquare | 0.201938 |
| RSquare Adj | 0.157602 |
| Root Mean Square Error | 0.219626 |
| Mean of Response | 0.775696 |
| Observations (or Sum Wgts) | 20 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 0.2196954 | 0.219695 | 4.5546 |
| Error | 18 | 0.8682375 | 0.048235 | **Prob > F** |
| C. Total | 19 | 1.0879329 | | 0.0468* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.4030023 | 0.181406 | 2.22 | 0.0394* |
| SHE1 logTSS | 0.3280155 | 0.153698 | 2.13 | 0.0468* |

**Cl**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.608859 |
| RSquare Adj | 0.587129 |
| Root Mean Square Error | 0.143182 |
| Mean of Response | 1.111041 |
| Observations (or Sum Wgts) | 20 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 0.57442420 | 0.574424 | 28.0192 |
| Error | 18 | 0.36901929 | 0.020501 | **Prob > F** |
| C. Total | 19 | 0.94344348 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.8799984 | 0.054131 | 16.26 | <.0001* |
| SHE1 logCl | 0.4658222 | 0.088002 | 5.29 | <.0001* |

**TPx**
CALIBRATION

## Summary of Fit

| | |
|---|---|
| RSquare | 0.753249 |
| RSquare Adj | 0.739541 |
| Root Mean Square Error | 0.293516 |
| Mean of Response | 1.652853 |
| Observations (or Sum Wgts) | 20 |

## Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 4.7338546 | 4.73385 | 54.9480 |
| Error | 18 | 1.5507271 | 0.08615 | **Prob > F** |
| C. Total | 19 | 6.2845817 | | <.0001* |

## Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.8357314 | 0.128292 | 6.51 | <.0001* |
| SHE1 logTPx | 0.5947013 | 0.080227 | 7.41 | <.0001* |

**TDPx**
CALIBRATION

## Summary of Fit

| | |
|---|---|
| RSquare | 0.762008 |
| RSquare Adj | 0.748786 |
| Root Mean Square Error | 0.289968 |
| Mean of Response | 1.603966 |
| Observations (or Sum Wgts) | 20 |

## Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 4.8458573 | 4.84586 | 57.6328 |
| Error | 18 | 1.5134684 | 0.08408 | **Prob > F** |
| C. Total | 19 | 6.3593257 | | <.0001* |

## Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.8386811 | 0.119858 | 7.00 | <.0001* |
| SHE1 logTDPx | 0.6142451 | 0.080911 | 7.59 | <.0001* |

**TNx**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.684573 |
| RSquare Adj | 0.667049 |
| Root Mean Square Error | 0.323129 |
| Mean of Response | 2.296337 |
| Observations (or Sum Wgts) | 20 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 4.0789082 | 4.07891 | 39.0655 |
| Error | 18 | 1.8794177 | 0.10441 | **Prob > F** |
| C. Total | 19 | 5.9583259 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 1.1318658 | 0.199828 | 5.66 | <.0001* |
| SHE1 logTNx | 0.5381472 | 0.0861 | 6.25 | <.0001* |

**TDNx**
CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.788689 |
| RSquare Adj | 0.77695 |
| Root Mean Square Error | 0.25578 |
| Mean of Response | 2.223311 |
| Observations (or Sum Wgts) | 20 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 4.3953008 | 4.39530 | 67.1825 |
| Error | 18 | 1.1776187 | 0.06542 | **Prob > F** |
| C. Total | 19 | 5.5729196 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 1.0468595 | 0.154507 | 6.78 | <.0001* |
| SHE1 logTDNx | 0.5892874 | 0.071895 | 8.20 | <.0001* |

**TSSx**

CALIBRATION - CORRECTED

## Summary of Fit

| | |
|---|---|
| RSquare | 0.685025 |
| RSquare Adj | 0.667526 |
| Root Mean Square Error | 0.412939 |
| Mean of Response | 2.973432 |
| Observations (or Sum Wgts) | 20 |

## Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 6.6753514 | 6.67535 | 39.1473 |
| Error | 18 | 3.0693352 | 0.17052 | **Prob > F** |
| C. Total | 19 | 9.7446865 | | <.0001* |

## Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 1.1786759 | 0.301345 | 3.91 | 0.0010* |
| SHE1 logTSSx | 0.5761835 | 0.092089 | 6.26 | <.0001* |

**Clx**

CALIBRATION

## Summary of Fit

| | |
|---|---|
| RSquare | 0.616901 |
| RSquare Adj | 0.595618 |
| Root Mean Square Error | 0.292932 |
| Mean of Response | 3.308289 |
| Observations (or Sum Wgts) | 20 |

## Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 2.4871972 | 2.48720 | 28.9853 |
| Error | 18 | 1.5445615 | 0.08581 | **Prob > F** |
| C. Total | 19 | 4.0317587 | | <.0001* |

## Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 2.120389 | 0.230161 | 9.21 | <.0001* |
| SHE1 logClx | 0.4796429 | 0.08909 | 5.38 | <.0001* |

## I.5. Shoreham Site Regressions

# Q
# CALIBRATION

## Summary of Fit

| | |
|---|---|
| RSquare | 0.414561 |
| RSquare Adj | 0.349512 |
| Root Mean Square Error | 0.70285 |
| Mean of Response | 4.09098 |
| Observations (or Sum Wgts) | 11 |

## Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 3.1482843 | 3.14828 | 6.3731 |
| Error | 9 | 4.4459850 | 0.49400 | **Prob > F** |
| C. Total | 10 | 7.5942694 | | 0.0325* |

## Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.8125039 | 1.315844 | 0.62 | 0.5522 |
| SHO1 logQ | 0.645529 | 0.255706 | 2.52 | 0.0325* |

**TP CALIBRATION**

## Summary of Fit

| | |
|---|---|
| RSquare | 0.910645 |
| RSquare Adj | 0.888307 |
| Root Mean Square Error | 0.075264 |
| Mean of Response | 2.464759 |
| Observations (or Sum Wgts) | 6 |

## Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 0.23092023 | 0.230920 | 40.7655 |
| Error | 4 | 0.02265841 | 0.005665 | **Prob > F** |
| C. Total | 5 | 0.25357864 | | 0.0031* |

## Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.7394381 | 0.271965 | 2.72 | 0.0530 |
| SHO1 logTP | 0.7025041 | 0.110028 | 6.38 | 0.0031* |

**TDP CALIBRATION**

## Summary of Fit

| | |
|---|---|
| RSquare | 0.942293 |
| RSquare Adj | 0.927867 |
| Root Mean Square Error | 0.054534 |
| Mean of Response | 2.435774 |
| Observations (or Sum Wgts) | 6 |

## Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 0.19424460 | 0.194245 | 65.3161 |
| Error | 4 | 0.01189567 | 0.002974 | **Prob > F** |
| C. Total | 5 | 0.20614028 | | 0.0013* |

## Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.8417217 | 0.198491 | 4.24 | 0.0133* |
| SHO1 logTDP | 0.6557909 | 0.081144 | 8.08 | 0.0013* |

## TN CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.934115 |
| RSquare Adj | 0.917643 |
| Root Mean Square Error | 0.029911 |
| Mean of Response | 0.278685 |
| Observations (or Sum Wgts) | 6 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 0.05073760 | 0.050738 | 56.7116 |
| Error | 4 | 0.00357864 | 0.000895 | **Prob > F** |
| C. Total | 5 | 0.05431624 | | 0.0017* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | -0.029856 | 0.042752 | -0.70 | 0.5234 |
| SHO1 logTN | 0.8582844 | 0.113971 | 7.53 | 0.0017* |

## TDN CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.981912 |
| RSquare Adj | 0.97739 |
| Root Mean Square Error | 0.030942 |
| Mean of Response | 0.216816 |
| Observations (or Sum Wgts) | 6 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 0.20789008 | 0.207890 | 217.1383 |
| Error | 4 | 0.00382963 | 0.000957 | **Prob > F** |
| C. Total | 5 | 0.21171972 | | 0.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | -0.092259 | 0.024485 | -3.77 | 0.0196* |
| SHO1 logTDN | 0.9917989 | 0.067306 | 14.74 | 0.0001* |

**TSS**
**CALIBRATION**

### Summary of Fit

| | |
|---|---|
| RSquare | 0.601351 |
| RSquare Adj | 0.501688 |
| Root Mean Square Error | 0.030878 |
| Mean of Response | 1.387598 |
| Observations (or Sum Wgts) | 6 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 0.00575314 | 0.005753 | 6.0339 |
| Error | 4 | 0.00381389 | 0.000953 | **Prob > F** |
| C. Total | 5 | 0.00956703 | | 0.0700 |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 1.1925407 | 0.080402 | 14.83 | 0.0001* |
| SHO1 logTSS | 0.1723502 | 0.070164 | 2.46 | 0.0700 |

**Cl**
**CALIBRATION**

### Summary of Fit

| | |
|---|---|
| RSquare | 0.695724 |
| RSquare Adj | 0.619655 |
| Root Mean Square Error | 0.128822 |
| Mean of Response | 0.336413 |
| Observations (or Sum Wgts) | 6 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 0.15177855 | 0.151779 | 9.1460 |
| Error | 4 | 0.06638056 | 0.016595 | **Prob > F** |
| C. Total | 5 | 0.21815911 | | 0.0390* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.0222147 | 0.116446 | 0.19 | 0.8580 |
| SHO1 logCl | 0.6527968 | 0.215856 | 3.02 | 0.0390* |

**TPx CALIBRATION**

### Summary of Fit

| | |
|---|---|
| RSquare | 0.727192 |
| RSquare Adj | 0.658991 |
| Root Mean Square Error | 0.318708 |
| Mean of Response | 0.906304 |
| Observations (or Sum Wgts) | 6 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 1.0830239 | 1.08302 | 10.6624 |
| Error | 4 | 0.4062984 | 0.10157 | **Prob > F** |
| C. Total | 5 | 1.4893222 | | 0.0309* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | -0.527858 | 0.458077 | -1.15 | 0.3134 |
| SHO1 logTPx | 0.8101392 | 0.248104 | 3.27 | 0.0309* |

**TDPx CALIBRATION**

### Summary of Fit

| | |
|---|---|
| RSquare | 0.689907 |
| RSquare Adj | 0.612384 |
| Root Mean Square Error | 0.336489 |
| Mean of Response | 0.877406 |
| Observations (or Sum Wgts) | 6 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 1.0076250 | 1.00763 | 8.8993 |
| Error | 4 | 0.4528983 | 0.11322 | **Prob > F** |
| C. Total | 5 | 1.4605234 | | 0.0406* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | -0.52958 | 0.491238 | -1.08 | 0.3417 |
| SHO1 logTDPx | 0.806463 | 0.270337 | 2.98 | 0.0406* |

**TNx**
**CALIBRATION**

### Summary of Fit

| | |
|---|---|
| RSquare | 0.589031 |
| RSquare Adj | 0.486289 |
| Root Mean Square Error | 0.332415 |
| Mean of Response | 1.720448 |
| Observations (or Sum Wgts) | 6 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 0.6335070 | 0.633507 | 5.7331 |
| Error | 4 | 0.4419994 | 0.110500 | **Prob > F** |
| C. Total | 5 | 1.0755063 | | 0.0748 |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | -1.554292 | 1.374388 | -1.13 | 0.3213 |
| SHO1 logTNx | 1.2248333 | 0.511543 | 2.39 | 0.0748 |

**TDNx**
**CALIBRATION**

### Summary of Fit

| | |
|---|---|
| RSquare | 0.669482 |
| RSquare Adj | 0.586852 |
| Root Mean Square Error | 0.318609 |
| Mean of Response | 1.658144 |
| Observations (or Sum Wgts) | 6 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 0.8224704 | 0.822470 | 8.1022 |
| Error | 4 | 0.4060480 | 0.101512 | **Prob > F** |
| C. Total | 5 | 1.2285184 | | 0.0466* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | -2.094783 | 1.324866 | -1.58 | 0.1890 |
| SHO1 logTDNx | 1.4291347 | 0.502079 | 2.85 | 0.0466* |

**TSSx**
**CALIBRATION**

### Summary of Fit

| | |
|---|---|
| RSquare | 0.695803 |
| RSquare Adj | 0.619754 |
| Root Mean Square Error | 0.331714 |
| Mean of Response | 2.829462 |
| Observations (or Sum Wgts) | 6 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 1.0067429 | 1.00674 | 9.1494 |
| Error | 4 | 0.4401365 | 0.11003 | Prob > F |
| C. Total | 5 | 1.4468793 | | 0.0390* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | -0.064385 | 0.966246 | -0.07 | 0.9501 |
| SHO1 logTSSx | 0.8397675 | 0.277628 | 3.02 | 0.0390* |

**Clx**
**CALIBRATION**

### Summary of Fit

| | |
|---|---|
| RSquare | 0.674702 |
| RSquare Adj | 0.593377 |
| Root Mean Square Error | 0.402021 |
| Mean of Response | 1.778156 |
| Observations (or Sum Wgts) | 6 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 1.3408740 | 1.34087 | 8.2964 |
| Error | 4 | 0.6464840 | 0.16162 | Prob > F |
| C. Total | 5 | 1.9873580 | | 0.0450* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | -0.808093 | 0.912771 | -0.89 | 0.4260 |
| SHO1 logClx | 0.9251832 | 0.321205 | 2.88 | 0.0450* |

## I.6. Williston Site Regressions

**Q**
**CALIBRATION**

## Summary of Fit

| | |
|---|---|
| RSquare | 0.609647 |
| RSquare Adj | 0.58525 |
| Root Mean Square Error | 0.536569 |
| Mean of Response | 4.238618 |
| Observations (or Sum Wgts) | 18 |

## Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 7.194341 | 7.19434 | 24.9885 |
| Error | 16 | 4.606495 | 0.28791 | **Prob > F** |
| C. Total | 17 | 11.800837 | | 0.0001* |

## Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | -0.34484 | 0.925583 | -0.37 | 0.7144 |
| WIL2 logQ | 1.0808286 | 0.216215 | 5.00 | 0.0001* |

**TP CALIBRATION**

### Summary of Fit

| | |
|---|---|
| RSquare | 0.5195 |
| RSquare Adj | 0.482539 |
| Root Mean Square Error | 0.130741 |
| Mean of Response | 2.795267 |
| Observations (or Sum Wgts) | 15 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 0.24024638 | 0.240246 | 14.0552 |
| Error | 13 | 0.22221031 | 0.017093 | **Prob > F** |
| C. Total | 14 | 0.46245670 | | 0.0024* |

Data Table=WIL_Jan_2014_conc_regression

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 1.4496872 | 0.360499 | 4.02 | 0.0015* |
| WIL2 logTP | 0.4442778 | 0.118505 | 3.75 | 0.0024* |

**TDP CALIBRATION**

### Summary of Fit

| | |
|---|---|
| RSquare | 0.073172 |
| RSquare Adj | 0.001878 |
| Root Mean Square Error | 107.4264 |
| Mean of Response | 310 |
| Observations (or Sum Wgts) | 15 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 11844.37 | 11844.4 | 1.0263 |
| Error | 13 | 150025.63 | 11540.4 | **Prob > F** |
| C. Total | 14 | 161870.00 | | 0.3295 |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 278.81523 | 41.43546 | 6.73 | <.0001* |
| WIL2 TDP | 0.0425634 | 0.042014 | 1.01 | 0.3295 |

## TN CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.520982 |
| RSquare Adj | 0.484135 |
| Root Mean Square Error | 0.136059 |
| Mean of Response | 0.378485 |
| Observations (or Sum Wgts) | 15 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 0.26174058 | 0.261741 | 14.1389 |
| Error | 13 | 0.24065784 | 0.018512 | Prob > F |
| C. Total | 14 | 0.50239842 | | 0.0024* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.160997 | 0.067673 | 2.38 | 0.0334* |
| WIL2 logTN | 0.5919137 | 0.157417 | 3.76 | 0.0024* |

## TDN CALIBRATION

### Summary of Fit

| | |
|---|---|
| RSquare | 0.145302 |
| RSquare Adj | 0.079557 |
| Root Mean Square Error | 0.264338 |
| Mean of Response | 0.257885 |
| Observations (or Sum Wgts) | 15 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 0.1544273 | 0.154427 | 2.2101 |
| Error | 13 | 0.9083715 | 0.069875 | Prob > F |
| C. Total | 14 | 1.0627988 | | 0.1610 |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.2247782 | 0.071793 | 3.13 | 0.0080* |
| WIL2 logTDN | 0.3397197 | 0.228517 | 1.49 | 0.1610 |

**TSS**
**CALIBRATION - CORRECTED**

### Summary of Fit

| | |
|---|---|
| RSquare | 0.904455 |
| RSquare Adj | 0.897105 |
| Root Mean Square Error | 0.198169 |
| Mean of Response | 2.130817 |
| Observations (or Sum Wgts) | 15 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 4.8327585 | 4.83276 | 123.0615 |
| Error | 13 | 0.5105239 | 0.03927 | **Prob > F** |
| C. Total | 14 | 5.3432824 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.1848883 | 0.182725 | 1.01 | 0.3301 |
| WIL logTSS | 1.0561484 | 0.095206 | 11.09 | <.0001* |

**Cl**
**CALIBRATION**

### Summary of Fit

| | |
|---|---|
| RSquare | 0.473382 |
| RSquare Adj | 0.432873 |
| Root Mean Square Error | 0.152633 |
| Mean of Response | 0.259214 |
| Observations (or Sum Wgts) | 15 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 0.27224276 | 0.272243 | 11.6858 |
| Error | 13 | 0.30285837 | 0.023297 | **Prob > F** |
| C. Total | 14 | 0.57510113 | | 0.0046* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.1681283 | 0.047572 | 3.53 | 0.0037* |
| WIL2 logCl | 0.534801 | 0.156445 | 3.42 | 0.0046* |

**TPx**
**CALIBRATION**

### Summary of Fit

| | |
|---|---|
| RSquare | 0.712263 |
| RSquare Adj | 0.69013 |
| Root Mean Square Error | 0.446831 |
| Mean of Response | 1.168544 |
| Observations (or Sum Wgts) | 15 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 6.4250306 | 6.42503 | 32.1802 |
| Error | 13 | 2.5955544 | 0.19966 | **Prob > F** |
| C. Total | 14 | 9.0205850 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.0877785 | 0.222728 | 0.39 | 0.6999 |
| WIL2 logTPx | 0.8349057 | 0.147178 | 5.67 | <.0001* |

**TDPx**
**CALIBRATION**

### Summary of Fit

| | |
|---|---|
| RSquare | 0.536182 |
| RSquare Adj | 0.500503 |
| Root Mean Square Error | 0.484464 |
| Mean of Response | 0.842376 |
| Observations (or Sum Wgts) | 15 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 3.5272075 | 3.52721 | 15.0282 |
| Error | 13 | 3.0511741 | 0.23471 | **Prob > F** |
| C. Total | 14 | 6.5783815 | | 0.0019* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.1675422 | 0.21436 | 0.78 | 0.4485 |
| WIL2 logTDPx | 0.6757963 | 0.174326 | 3.88 | 0.0019* |

**TNx**
**CALIBRATION**

### Summary of Fit

| | |
|---|---|
| RSquare | 0.704901 |
| RSquare Adj | 0.682202 |
| Root Mean Square Error | 0.456237 |
| Mean of Response | 1.751222 |
| Observations (or Sum Wgts) | 15 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 6.4637718 | 6.46377 | 31.0531 |
| Error | 13 | 2.7059806 | 0.20815 | **Prob > F** |
| C. Total | 14 | 9.1697524 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.2925303 | 0.28705 | 1.02 | 0.3268 |
| WIL2 logTNx | 0.8938831 | 0.160409 | 5.57 | <.0001* |

**TDNx**
**CALIBRATION**

### Summary of Fit

| | |
|---|---|
| RSquare | 0.435833 |
| RSquare Adj | 0.392435 |
| Root Mean Square Error | 0.608386 |
| Mean of Response | 1.63141 |
| Observations (or Sum Wgts) | 15 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 3.7171770 | 3.71718 | 10.0428 |
| Error | 13 | 4.8117306 | 0.37013 | **Prob > F** |
| C. Total | 14 | 8.5289076 | | 0.0074* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.5499087 | 0.375688 | 1.46 | 0.1670 |
| WIL2 logTDNx | 0.7939386 | 0.25053 | 3.17 | 0.0074* |

**TSSx**
**CALIBRATION - CORRECTED**

### Summary of Fit

| | |
|---|---|
| RSquare | 0.905049 |
| RSquare Adj | 0.897745 |
| Root Mean Square Error | 0.366784 |
| Mean of Response | 3.395403 |
| Observations (or Sum Wgts) | 15 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 16.670050 | 16.6701 | 123.9129 |
| Error | 13 | 1.748895 | 0.1345 | **Prob > F** |
| C. Total | 14 | 18.418946 | | <.0001* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.3822359 | 0.286774 | 1.33 | 0.2055 |
| WIL1 logTSSx | 0.9372916 | 0.084201 | 11.13 | <.0001* |

**Clx**
**CALIBRATION**

### Summary of Fit

| | |
|---|---|
| RSquare | 0.489428 |
| RSquare Adj | 0.450154 |
| Root Mean Square Error | 0.510682 |
| Mean of Response | 1.63226 |
| Observations (or Sum Wgts) | 15 |

### Analysis of Variance

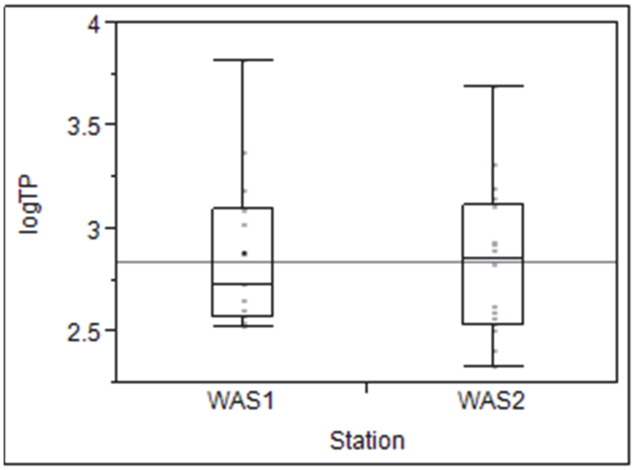
| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 3.2499579 | 3.24996 | 12.4617 |
| Error | 13 | 3.3903550 | 0.26080 | **Prob > F** |
| C. Total | 14 | 6.6403129 | | 0.0037* |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 0.3698807 | 0.381139 | 0.97 | 0.3495 |
| WIL2 logClx | 0.879301 | 0.249086 | 3.53 | 0.0037* |

# APPENDIX J: WASCOB CONCENTRATION STATISTICAL ANALYSIS

[TP]

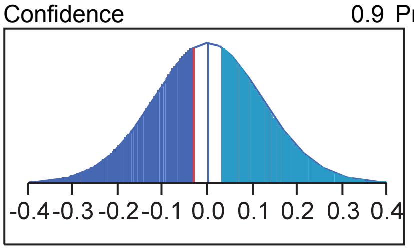



**Means and Std Deviations**

| Level | Number | Mean | Std Dev | Std Err Mean | Lower 90% | Upper 90% |
|---|---|---|---|---|---|---|
| WAS1 | 17 | 2.86434 | 0.359489 | 0.08719 | 2.7121 | 3.0166 |
| WAS2 | 18 | 2.83198 | 0.357915 | 0.08436 | 2.6852 | 2.9787 |

**t Test**
WAS2-WAS1
Assuming unequal variances

| | | | |
|---|---|---|---|
| Difference | -0.03237 | t Ratio | -0.26677 |
| Std Err Dif | 0.12132 | DF | 32.86834 |
| Upper CL Dif | 0.17298 | Prob > \|t\| | 0.7913 |
| Lower CL Dif | -0.23771 | Prob > t | 0.6043 |
| Confidence | 0.9 | Prob < t | 0.3957 |




Non-parametric test of group means on raw data:

**Wilcoxon / Kruskal-Wallis Tests (Rank Sums)**

| Level | Count | Score Sum | Expected Score | Score Mean | (Mean-Mean0)/Std0 |
|---|---|---|---|---|---|
| WAS1 | 17 | 316.000 | 306.000 | 18.5882 | 0.314 |
| WAS2 | 18 | 314.000 | 324.000 | 17.4444 | -0.314 |

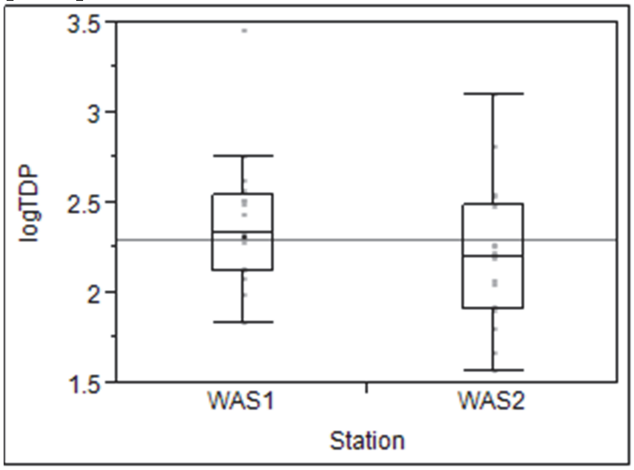
**2-Sample Test, Normal Approximation**

| S | Z | Prob>\|Z\| |
|---|---|---|
| 316 | 0.31363 | 0.7538 |

**1-way Test, ChiSquare Approximation**

| ChiSquare | DF | Prob>ChiSq |
|---|---|---|
| 0.1090 | 1 | 0.7413 |

[TDP]




**Means and Std Deviations**

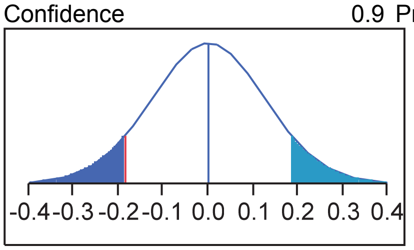
| Level | Number | Mean | Std Dev | Std Err Mean | Lower 90% | Upper 90% |
|---|---|---|---|---|---|---|
| WAS1 | 17 | 2.39613 | 0.363448 | 0.08815 | 2.2422 | 2.5500 |
| WAS2 | 18 | 2.21046 | 0.387733 | 0.09139 | 2.0515 | 2.3694 |

**t Test**

WAS2-WAS1

Assuming unequal variances

| | | | |
|---|---|---|---|
| Difference | -0.18568 | t Ratio | -1.46233 |
| Std Err Dif | 0.12697 | DF | 32.9989 |
| Upper CL Dif | 0.02921 | Prob > \|t\| | 0.1531 |
| Lower CL Dif | -0.40056 | Prob > t | 0.9234 |
| Confidence | 0.9 | Prob < t | 0.0766 |




Non-parametric test of group means on raw data:

**Wilcoxon / Kruskal-Wallis Tests (Rank Sums)**

| Level | Count | Score Sum | Expected Score | Score Mean | (Mean-Mean0)/Std0 |
|---|---|---|---|---|---|
| WAS1 | 17 | 355.000 | 306.000 | 20.8824 | 1.601 |
| WAS2 | 18 | 275.000 | 324.000 | 15.2778 | -1.601 |

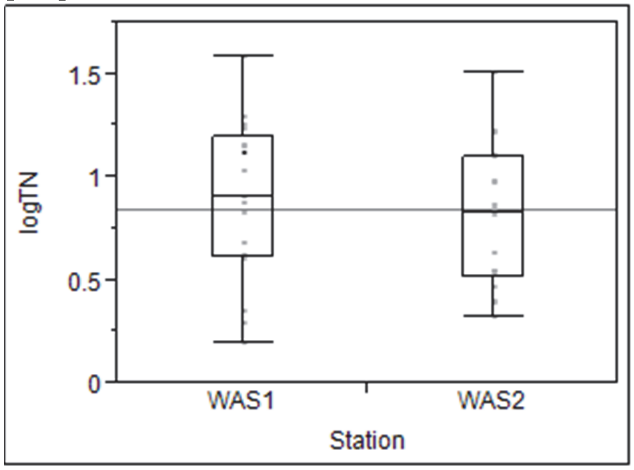
**2-Sample Test, Normal Approximation**

| S | Z | Prob>\|Z\| |
|---|---|---|
| 355 | 1.60074 | 0.1094 |

**1-way Test, ChiSquare Approximation**

| ChiSquare | DF | Prob>ChiSq |
|---|---|---|
| 2.6155 | 1 | 0.1058 |

[TN]




**Means and Std Deviations**

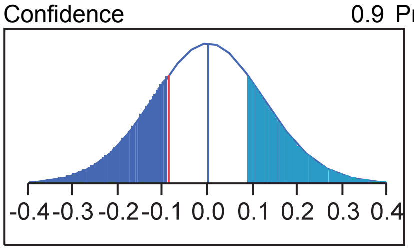
| Level | Number | Mean | Std Dev | Std Err Mean | Lower 90% | Upper 90% |
|---|---|---|---|---|---|---|
| WAS1 | 17 | 0.892620 | 0.390697 | 0.09476 | 0.72718 | 1.0581 |
| WAS2 | 18 | 0.804429 | 0.343157 | 0.08088 | 0.66372 | 0.9451 |

**t Test**

WAS2-WAS1

Assuming unequal variances

| | | | |
|---|---|---|---|
| Difference | -0.08819 | t Ratio | -0.70789 |
| Std Err Dif | 0.12458 | DF | 31.88038 |
| Upper CL Dif | 0.12286 | Prob > \|t\| | 0.4842 |
| Lower CL Dif | -0.29925 | Prob > t | 0.7579 |
| Confidence | 0.9 | Prob < t | 0.2421 |




Non-parametric test of group means on raw data:

**Wilcoxon / Kruskal-Wallis Tests (Rank Sums)**

| Level | Count | Score Sum | Expected Score | Score Mean | (Mean-Mean0)/Std0 |
|---|---|---|---|---|---|
| WAS1 | 17 | 334.000 | 306.000 | 19.6471 | 0.908 |
| WAS2 | 18 | 296.000 | 324.000 | 16.4444 | -0.908 |

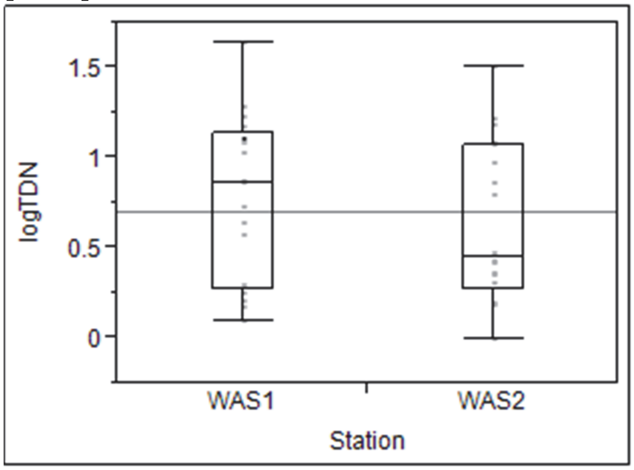
**2-Sample Test, Normal Approximation**

| S | Z | Prob>\|Z\| |
|---|---|---|
| 334 | 0.90764 | 0.3641 |

**1-way Test, ChiSquare Approximation**

| ChiSquare | DF | Prob>ChiSq |
|---|---|---|
| 0.8540 | 1 | 0.3554 |

[TDN]

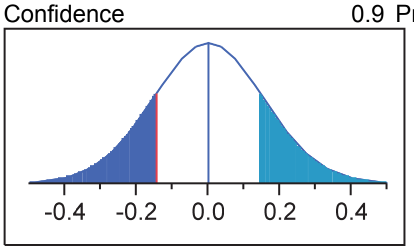



**Means and Std Deviations**

| Level | Number | Mean | Std Dev | Std Err Mean | Lower 90% | Upper 90% |
|---|---|---|---|---|---|---|
| WAS1 | 17 | 0.776581 | 0.458170 | 0.11112 | 0.58257 | 0.9706 |
| WAS2 | 18 | 0.631923 | 0.460576 | 0.10856 | 0.44307 | 0.8208 |

**t Test**
WAS2-WAS1
Assuming unequal variances

| | | | |
|---|---|---|---|
| Difference | -0.14466 | t Ratio | -0.93118 |
| Std Err Dif | 0.15535 | DF | 32.90523 |
| Upper CL Dif | 0.11827 | Prob > \|t\| | 0.3585 |
| Lower CL Dif | -0.40759 | Prob > t | 0.8207 |
| Confidence | 0.9 | Prob < t | 0.1793 |




Non-parametric test of group means on raw data:
**Wilcoxon / Kruskal-Wallis Tests (Rank Sums)**

| Level | Count | Score Sum | Expected Score | Score Mean | (Mean-Mean0)/Std0 |
|---|---|---|---|---|---|
| WAS1 | 17 | 332.000 | 306.000 | 19.5294 | 0.842 |
| WAS2 | 18 | 298.000 | 324.000 | 16.5556 | -0.842 |

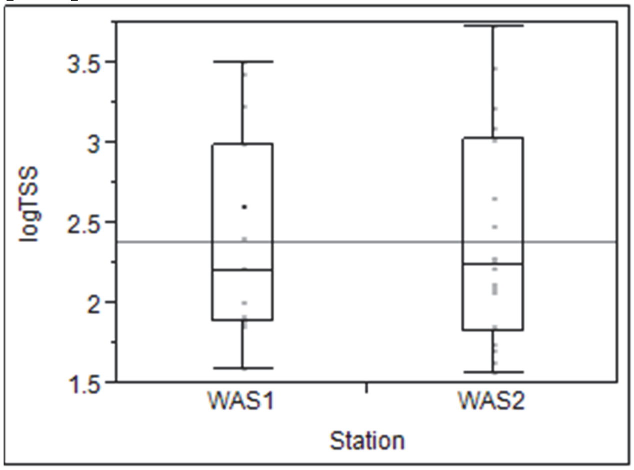
**2-Sample Test, Normal Approximation**

| S | Z | Prob>\|Z\| |
|---|---|---|
| 332 | 0.84168 | 0.4000 |

**1-way Test, ChiSquare Approximation**

| ChiSquare | DF | Prob>ChiSq |
|---|---|---|
| 0.7365 | 1 | 0.3908 |

[TSS]



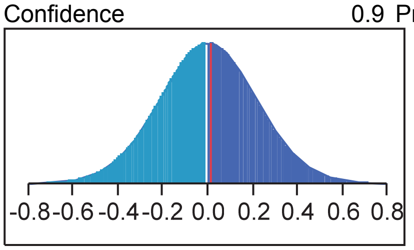

### Means and Std Deviations

| Level | Number | Mean | Std Dev | Std Err Mean | Lower 90% | Upper 90% |
|---|---|---|---|---|---|---|
| WAS1 | 17 | 2.38346 | 0.615891 | 0.14938 | 2.1227 | 2.6443 |
| WAS2 | 18 | 2.39404 | 0.657632 | 0.15501 | 2.1244 | 2.6637 |

### t Test

WAS2-WAS1
Assuming unequal variances

| | | | |
|---|---|---|---|
| Difference | 0.01058 | t Ratio | 0.049157 |
| Std Err Dif | 0.21527 | DF | 32.99853 |
| Upper CL Dif | 0.37489 | Prob > \|t\| | 0.9611 |
| Lower CL Dif | -0.35373 | Prob > t | 0.4805 |
| Confidence | 0.9 | Prob < t | 0.5195 |




Non-parametric test of group means on raw data:

### Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

| Level | Count | Score Sum | Expected Score | Score Mean | (Mean-Mean0)/Std0 |
|---|---|---|---|---|---|
| WAS1 | 17 | 302.500 | 306.000 | 17.7941 | -0.099 |
| WAS2 | 18 | 327.500 | 324.000 | 18.1944 | 0.099 |

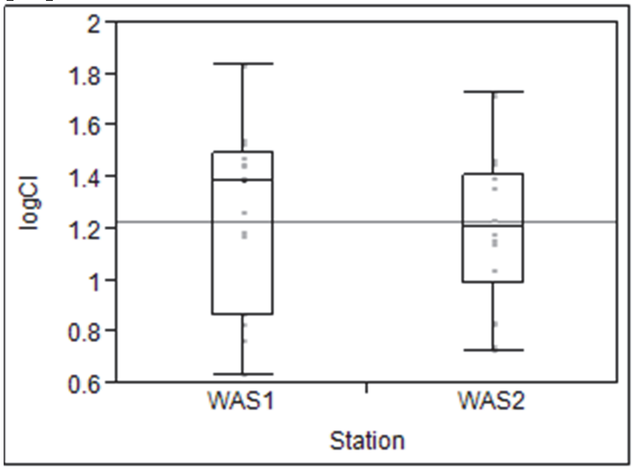
### 2-Sample Test, Normal Approximation

| S | Z | Prob>\|Z\| |
|---|---|---|
| 302.5 | -0.09903 | 0.9211 |

### 1-way Test, ChiSquare Approximation

| ChiSquare | DF | Prob>ChiSq |
|---|---|---|
| 0.0133 | 1 | 0.9080 |

[Cl]




**Means and Std Deviations**

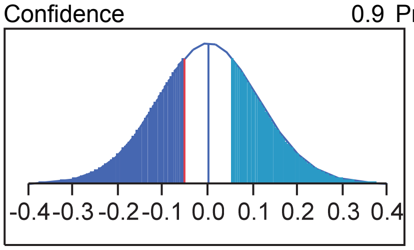
| Level | Number | Mean | Std Dev | Std Err Mean | Lower 90% | Upper 90% |
|---|---|---|---|---|---|---|
| WAS1 | 17 | 1.26011 | 0.362386 | 0.08789 | 1.1067 | 1.4136 |
| WAS2 | 18 | 1.20632 | 0.298747 | 0.07042 | 1.0838 | 1.3288 |

**t Test**

WAS2-WAS1

Assuming unequal variances

| | | | |
|---|---|---|---|
| Difference | -0.05379 | t Ratio | -0.47762 |
| Std Err Dif | 0.11262 | DF | 31.08001 |
| Upper CL Dif | 0.13714 | Prob > \|t\| | 0.6363 |
| Lower CL Dif | -0.24472 | Prob > t | 0.6819 |
| Confidence | 0.9 | Prob < t | 0.3181 |




Non-parametric test of group means on raw data:

**Wilcoxon / Kruskal-Wallis Tests (Rank Sums)**

| Level | Count | Score Sum | Expected Score | Score Mean | (Mean-Mean0)/Std0 |
|---|---|---|---|---|---|
| WAS1 | 17 | 331.000 | 306.000 | 19.4706 | 0.809 |
| WAS2 | 18 | 299.000 | 324.000 | 16.6111 | -0.809 |

**2-Sample Test, Normal Approximation**

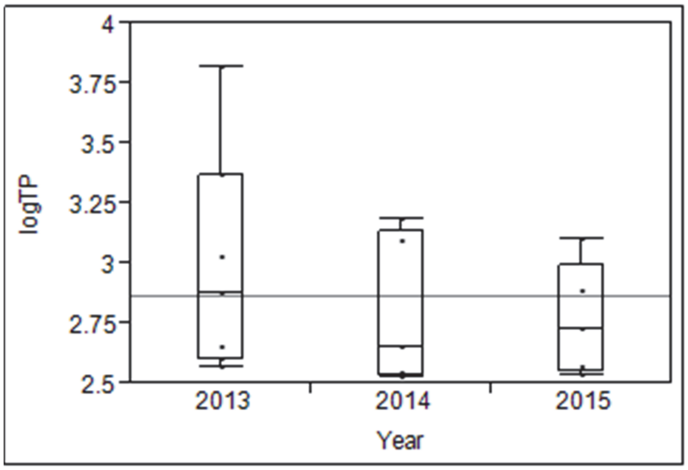
| S | Z | Prob>\|Z\| |
|---|---|---|
| 331 | 0.80885 | 0.4186 |

**1-way Test, ChiSquare Approximation**

| ChiSquare | DF | Prob>ChiSq |
|---|---|---|
| 0.6812 | 1 | 0.4092 |

[TP]

WAS1



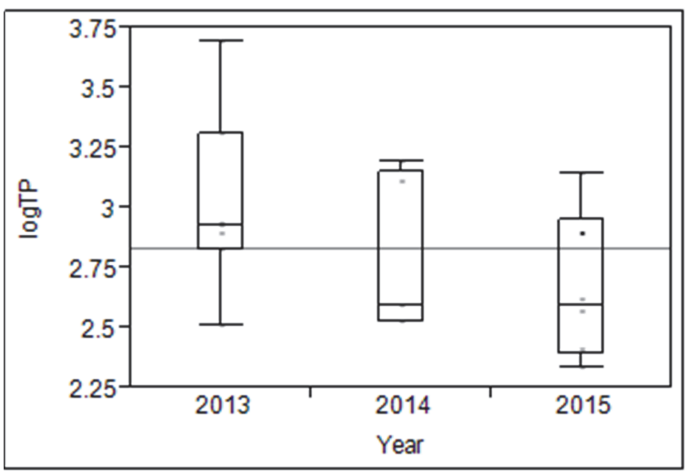

**Analysis of Variance**

| Source | DF | Sum of Squares | Mean Square | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Year | 2 | 0.1786014 | 0.089301 | 0.6618 | 0.5313 |
| Error | 14 | 1.8891202 | 0.134937 | | |
| C. Total | 16 | 2.0677216 | | | |

**Means for Oneway Anova**

| Level | Number | Mean | Std Error | Lower 90% | Upper 90% |
|---|---|---|---|---|---|
| 2013 | 7 | 2.98583 | 0.13884 | 2.7413 | 3.2304 |
| 2014 | 5 | 2.79647 | 0.16428 | 2.5071 | 3.0858 |
| 2015 | 5 | 2.76212 | 0.16428 | 2.4728 | 3.0515 |

WAS2



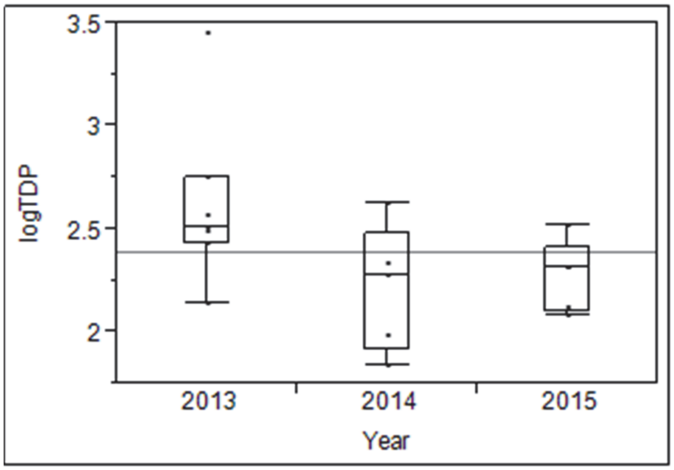

**Analysis of Variance**

| Source | DF | Sum of Squares | Mean Square | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Year | 2 | 0.4102013 | 0.205101 | 1.7406 | 0.2090 |
| Error | 15 | 1.7675483 | 0.117837 | | |
| C. Total | 17 | 2.1777496 | | | |

**Means for Oneway Anova**

| Level | Number | Mean | Std Error | Lower 90% | Upper 90% |
|---|---|---|---|---|---|
| 2013 | 7 | 3.01017 | 0.12975 | 2.7827 | 3.2376 |
| 2014 | 5 | 2.78979 | 0.15352 | 2.5207 | 3.0589 |
| 2015 | 6 | 2.65924 | 0.14014 | 2.4136 | 2.9049 |

[TDP]
WAS1



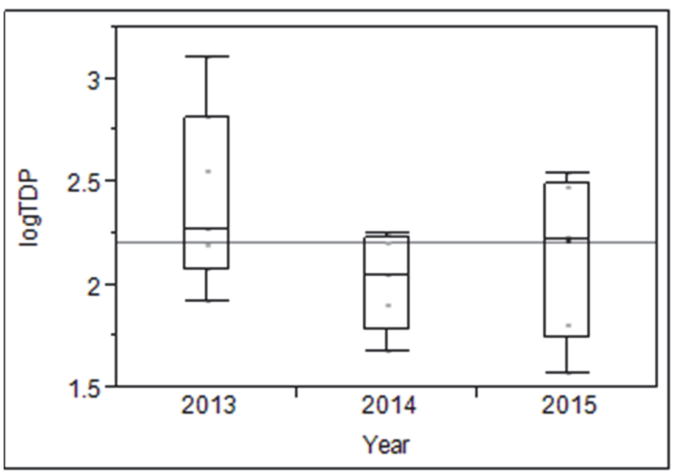

**Analysis of Variance**

| Source | DF | Sum of Squares | Mean Square | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Year | 2 | 0.5987034 | 0.299352 | 2.7666 | 0.0972 |
| Error | 14 | 1.5148039 | 0.108200 | | |
| C. Total | 16 | 2.1135073 | | | |

**Means for Oneway Anova**

| Level | Number | Mean | Std Error | Lower 90% | Upper 90% |
|---|---|---|---|---|---|
| 2013 | 7 | 2.61908 | 0.12433 | 2.4001 | 2.8381 |
| 2014 | 5 | 2.21324 | 0.14711 | 1.9541 | 2.4723 |
| 2015 | 5 | 2.26690 | 0.14711 | 2.0078 | 2.5260 |

WAS2




**Analysis of Variance**

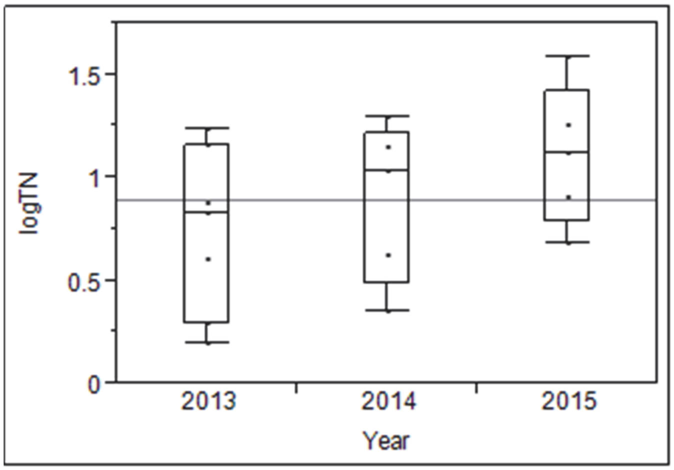
| Source | DF | Sum of Squares | Mean Square | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Year | 2 | 0.5261933 | 0.263097 | 1.9445 | 0.1775 |
| Error | 15 | 2.0295279 | 0.135302 | | |
| C. Total | 17 | 2.5557212 | | | |

**Means for Oneway Anova**

| Level | Number | Mean | Std Error | Lower 90% | Upper 90% |
|---|---|---|---|---|---|
| 2013 | 7 | 2.41607 | 0.13903 | 2.1723 | 2.6598 |
| 2014 | 5 | 2.01197 | 0.16450 | 1.7236 | 2.3004 |
| 2015 | 6 | 2.13598 | 0.15017 | 1.8727 | 2.3992 |

[TN]

WAS1



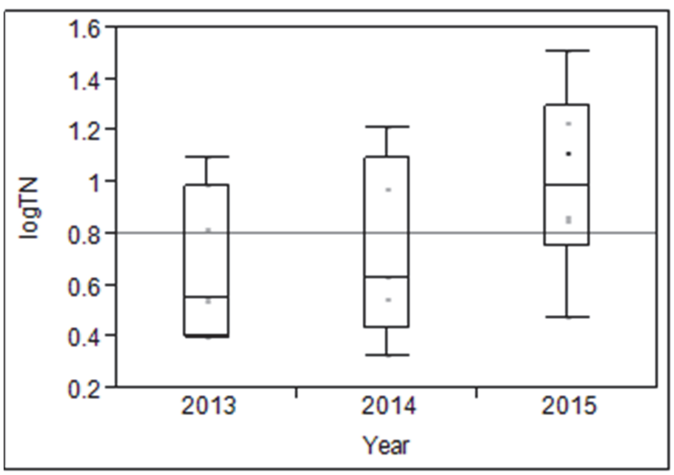

**Analysis of Variance**

| Source | DF | Sum of Squares | Mean Square | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Year | 2 | 0.3870282 | 0.193514 | 1.3182 | 0.2989 |
| Error | 14 | 2.0552737 | 0.146805 | | |
| C. Total | 16 | 2.4423019 | | | |

**Means for Oneway Anova**

| Level | Number | Mean | Std Error | Lower 90% | Upper 90% |
|---|---|---|---|---|---|
| 2013 | 7 | 0.74329 | 0.14482 | 0.48822 | 0.9984 |
| 2014 | 5 | 0.88686 | 0.17135 | 0.58506 | 1.1887 |
| 2015 | 5 | 1.10745 | 0.17135 | 0.80565 | 1.4093 |

WAS2



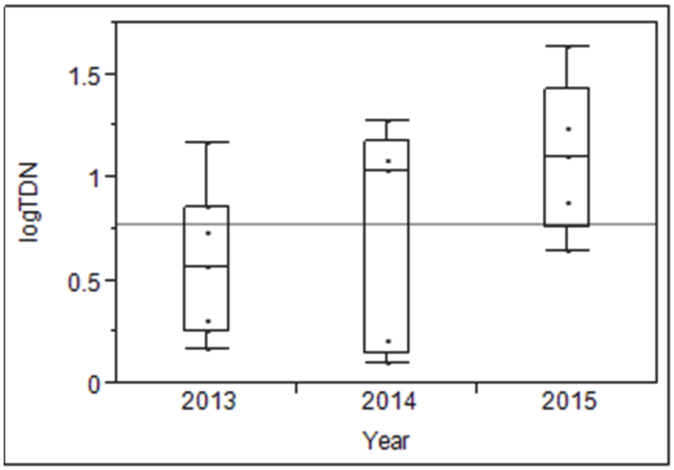

**Analysis of Variance**

| Source | DF | Sum of Squares | Mean Square | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Year | 2 | 0.3698784 | 0.184939 | 1.6998 | 0.2161 |
| Error | 15 | 1.6319867 | 0.108799 | | |
| C. Total | 17 | 2.0018652 | | | |

**Means for Oneway Anova**

| Level | Number | Mean | Std Error | Lower 90% | Upper 90% |
|---|---|---|---|---|---|
| 2013 | 7 | 0.68147 | 0.12467 | 0.46292 | 0.9000 |
| 2014 | 5 | 0.73619 | 0.14751 | 0.47759 | 0.9948 |
| 2015 | 6 | 1.00475 | 0.13466 | 0.76868 | 1.2408 |

[TDN]
WAS1



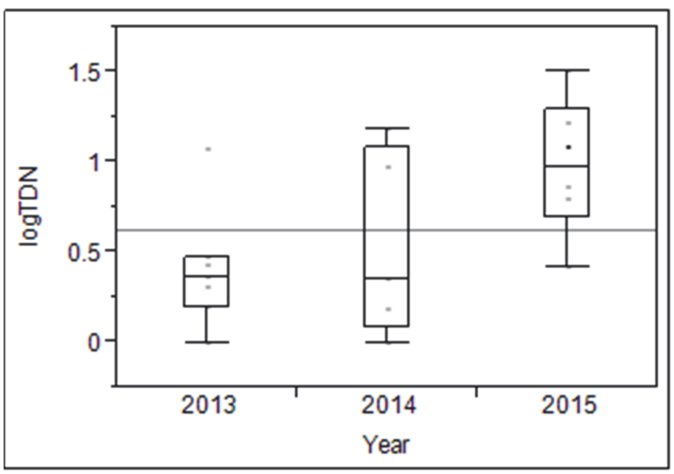

**Analysis of Variance**

| Source | DF | Sum of Squares | Mean Square | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Year | 2 | 0.7994416 | 0.399721 | 2.1866 | 0.1491 |
| Error | 14 | 2.5592778 | 0.182806 | | |
| C. Total | 16 | 3.3587193 | | | |

**Means for Oneway Anova**

| Level | Number | Mean | Std Error | Lower 90% | Upper 90% |
|---|---|---|---|---|---|
| 2013 | 7 | 0.57605 | 0.16160 | 0.29142 | 0.8607 |
| 2014 | 5 | 0.73781 | 0.19121 | 0.40103 | 1.0746 |
| 2015 | 5 | 1.09609 | 0.19121 | 0.75931 | 1.4329 |

WAS2



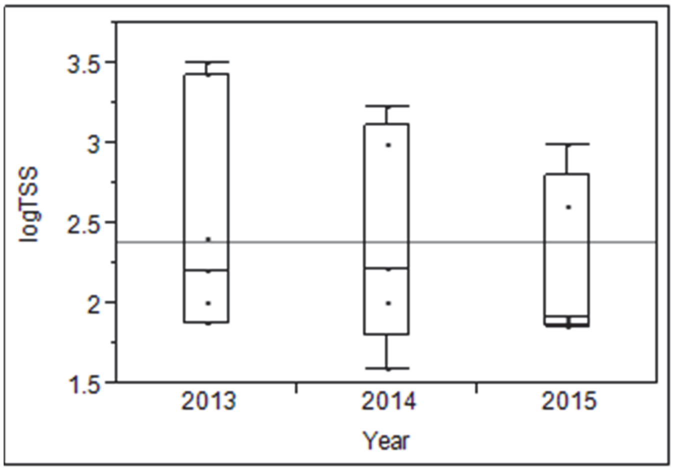

**Analysis of Variance**

| Source | DF | Sum of Squares | Mean Square | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Year | 2 | 1.1336995 | 0.566850 | 3.4389 | 0.0590 |
| Error | 15 | 2.4725138 | 0.164834 | | |
| C. Total | 17 | 3.6062133 | | | |

**Means for Oneway Anova**

| Level | Number | Mean | Std Error | Lower 90% | Upper 90% |
|---|---|---|---|---|---|
| 2013 | 7 | 0.403167 | 0.15345 | 0.13416 | 0.6722 |
| 2014 | 5 | 0.536071 | 0.18157 | 0.21777 | 0.8544 |
| 2015 | 6 | 0.978683 | 0.16575 | 0.68812 | 1.2692 |

[TSS]
WAS1



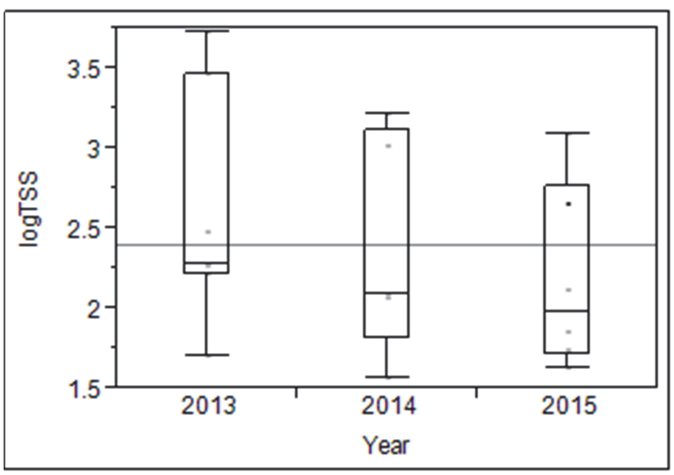

**Analysis of Variance**

| Source | DF | Sum of Squares | Mean Square | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Year | 2 | 0.1459202 | 0.072960 | 0.1724 | 0.8434 |
| Error | 14 | 5.9232262 | 0.423088 | | |
| C. Total | 16 | 6.0691464 | | | |

**Means for Oneway Anova**

| Level | Number | Mean | Std Error | Lower 90% | Upper 90% |
|---|---|---|---|---|---|
| 2013 | 7 | 2.46767 | 0.24585 | 2.0347 | 2.9007 |
| 2014 | 5 | 2.40296 | 0.29089 | 1.8906 | 2.9153 |
| 2015 | 5 | 2.24607 | 0.29089 | 1.7337 | 2.7584 |

WAS2




**Analysis of Variance**

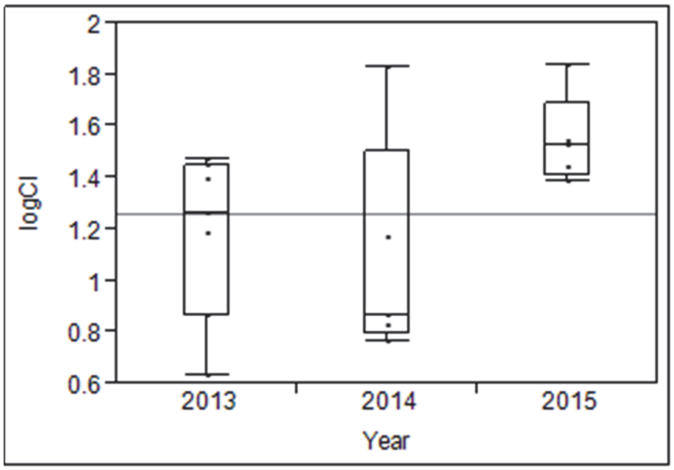
| Source | DF | Sum of Squares | Mean Square | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Year | 2 | 0.5470613 | 0.273531 | 0.6029 | 0.5599 |
| Error | 15 | 6.8050948 | 0.453673 | | |
| C. Total | 17 | 7.3521561 | | | |

**Means for Oneway Anova**

| Level | Number | Mean | Std Error | Lower 90% | Upper 90% |
|---|---|---|---|---|---|
| 2013 | 7 | 2.58635 | 0.25458 | 2.1401 | 3.0326 |
| 2014 | 5 | 2.38773 | 0.30122 | 1.8597 | 2.9158 |
| 2015 | 6 | 2.17495 | 0.27498 | 1.6929 | 2.6570 |

[Cl]

WAS1



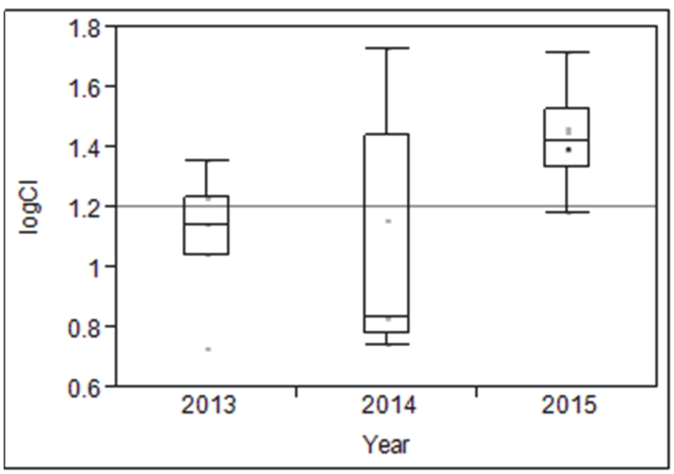

**Analysis of Variance**

| Source | DF | Sum of Squares | Mean Square | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Year | 2 | 0.5954443 | 0.297722 | 2.7682 | 0.0971 |
| Error | 14 | 1.5057351 | 0.107553 | | |
| C. Total | 16 | 2.1011794 | | | |

**Means for Oneway Anova**

| Level | Number | Mean | Std Error | Lower 90% | Upper 90% |
|---|---|---|---|---|---|
| 2013 | 7 | 1.17811 | 0.12395 | 0.9598 | 1.3964 |
| 2014 | 5 | 1.09048 | 0.14666 | 0.8322 | 1.3488 |
| 2015 | 5 | 1.54454 | 0.14666 | 1.2862 | 1.8029 |

WAS2




**Analysis of Variance**

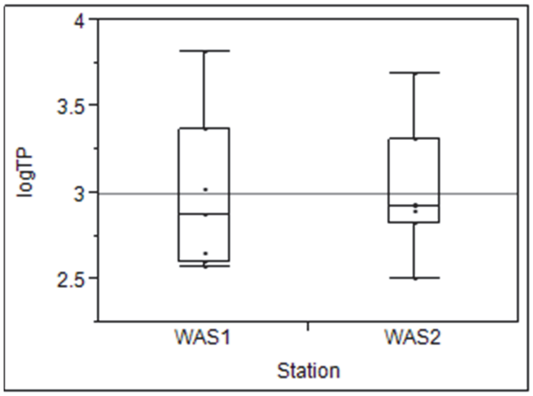
| Source | DF | Sum of Squares | Mean Square | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Year | 2 | 0.4620769 | 0.231038 | 3.2844 | 0.0656 |
| Error | 15 | 1.0551704 | 0.070345 | | |
| C. Total | 17 | 1.5172474 | | | |

**Means for Oneway Anova**

| Level | Number | Mean | Std Error | Lower 90% | Upper 90% |
|---|---|---|---|---|---|
| 2013 | 7 | 1.12172 | 0.10025 | 0.9460 | 1.2975 |
| 2014 | 5 | 1.05653 | 0.11861 | 0.8486 | 1.2645 |
| 2015 | 6 | 1.42985 | 0.10828 | 1.2400 | 1.6197 |

[TP]

2013

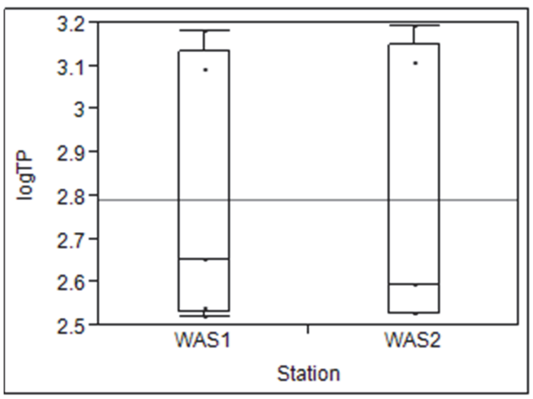



**t Test**

WAS2-WAS1

| | | | |
|---|---|---|---|
| Difference | 0.02434 | t Ratio | 0.107838 |
| Std Err Dif | 0.22567 | DF | 12 |
| Upper CL Dif | 0.42654 | Prob > \|t\| | 0.9159 |
| Lower CL Dif | -0.37787 | Prob > t | 0.4580 |
| Confidence | 0.9 | Prob < t | 0.5420 |

2014

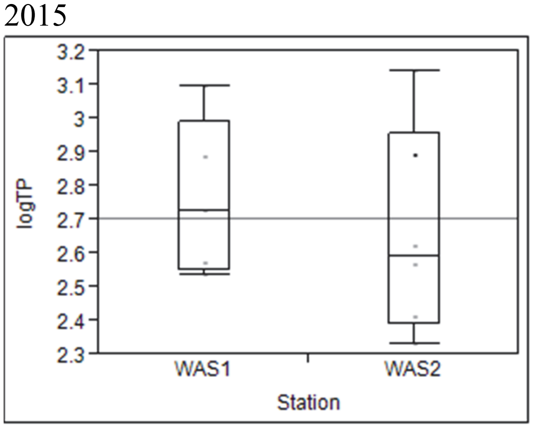



**t Test**

WAS2-WAS1

| | | | |
|---|---|---|---|
| Difference | -0.00668 | t Ratio | -0.03274 |
| Std Err Dif | 0.20409 | DF | 8 |
| Upper CL Dif | 0.37284 | Prob > \|t\| | 0.9747 |
| Lower CL Dif | -0.38620 | Prob > t | 0.5127 |
| Confidence | 0.9 | Prob < t | 0.4873 |

2015

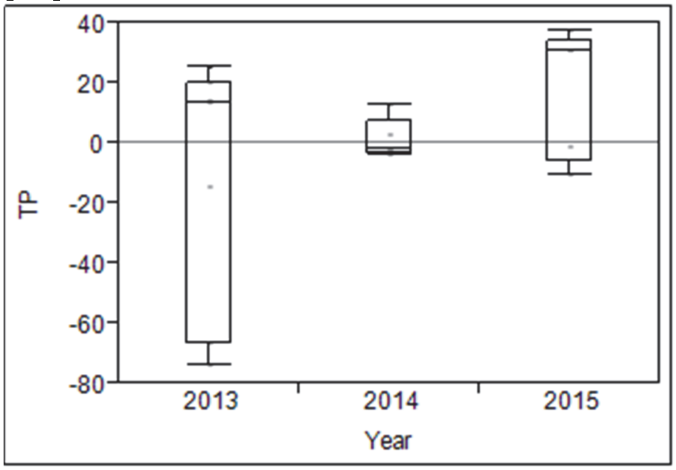



**t Test**

WAS2-WAS1

| | | | |
|---|---|---|---|
| Difference | -0.10288 | t Ratio | -0.61601 |
| Std Err Dif | 0.16702 | DF | 9 |
| Upper CL Dif | 0.20328 | Prob > \|t\| | 0.5531 |
| Lower CL Dif | -0.40904 | Prob > t | 0.7234 |
| Confidence | 0.9 | Prob < t | 0.2766 |

[TP] % reduction



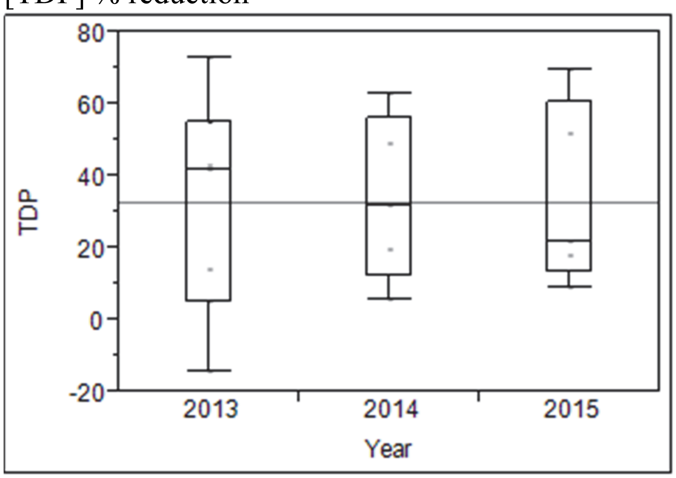

**Analysis of Variance**

| Source | DF | Sum of Squares | Mean Square | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Year | 2 | 2498.411 | 1249.21 | 1.3803 | 0.2837 |
| Error | 14 | 12670.210 | 905.02 | | |
| C. Total | 16 | 15168.621 | | | |

**Means for Oneway Anova**

| Level | Number | Mean | Std Error | Lower 90% | Upper 90% |
|---|---|---|---|---|---|
| 2013 | 7 | -11.829 | 11.370 | -31.86 | 8.198 |
| 2014 | 5 | 1.320 | 13.454 | -22.38 | 25.016 |
| 2015 | 5 | 17.420 | 13.454 | -6.28 | 41.116 |

[TDP] % reduction



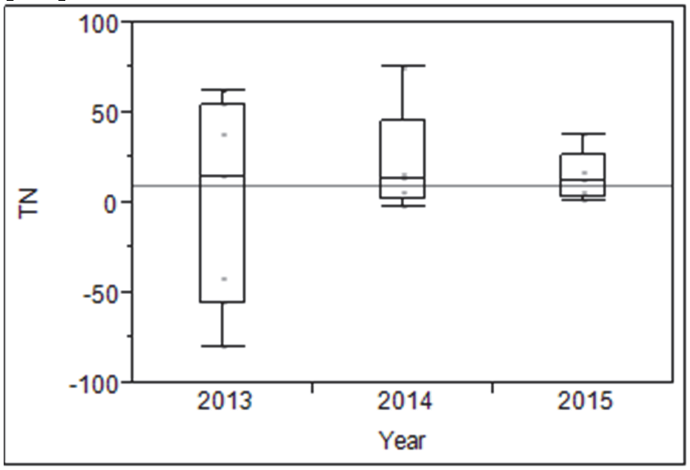

**Analysis of Variance**

| Source | DF | Sum of Squares | Mean Square | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Year | 2 | 31.696 | 15.848 | 0.0214 | 0.9788 |
| Error | 14 | 10363.249 | 740.232 | | |
| C. Total | 16 | 10394.945 | | | |

**Means for Oneway Anova**

| Level | Number | Mean | Std Error | Lower 90% | Upper 90% |
|---|---|---|---|---|---|
| 2013 | 7 | 30.9857 | 10.283 | 12.8735 | 49.098 |
| 2014 | 5 | 33.7400 | 12.167 | 12.3094 | 55.171 |
| 2015 | 5 | 33.7800 | 12.167 | 12.3494 | 55.211 |

[TN] % reduction



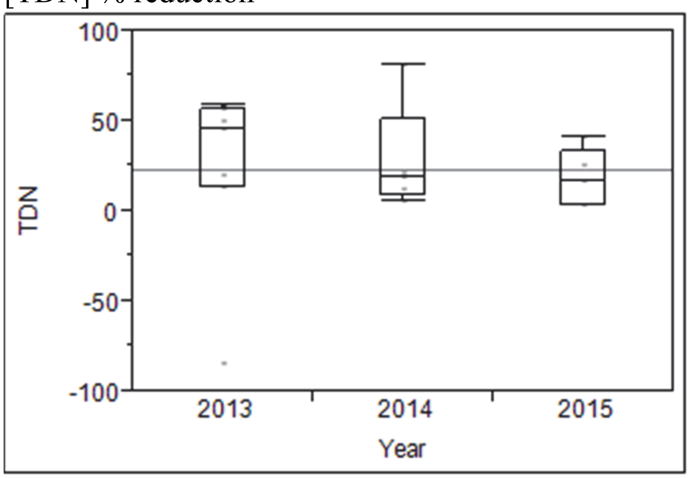

## Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Year | 2 | 1681.320 | 840.66 | 0.4827 | 0.6270 |
| Error | 14 | 24382.705 | 1741.62 | | |
| C. Total | 16 | 26064.025 | | | |

## Means for Oneway Anova

| Level | Number | Mean | Std Error | Lower 90% | Upper 90% |
|---|---|---|---|---|---|
| 2013 | 7 | -1.443 | 15.773 | -29.22 | 26.339 |
| 2014 | 5 | 21.480 | 18.663 | -11.39 | 54.352 |
| 2015 | 5 | 14.600 | 18.663 | -18.27 | 47.472 |

[TDN] % reduction



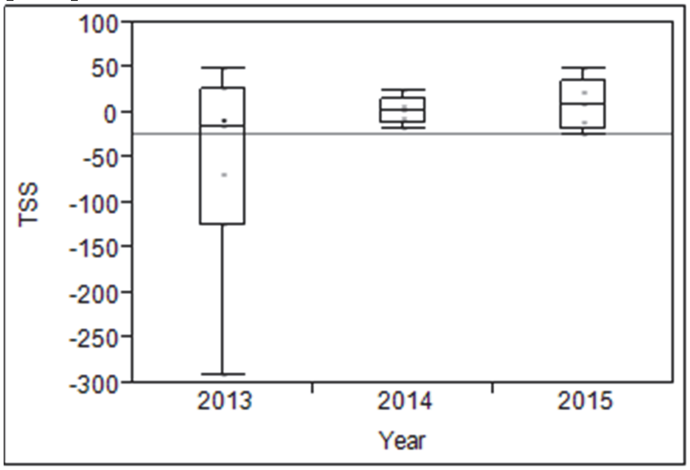

## Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Year | 2 | 246.050 | 123.03 | 0.0857 | 0.9184 |
| Error | 14 | 20106.474 | 1436.18 | | |
| C. Total | 16 | 20352.525 | | | |

## Means for Oneway Anova

| Level | Number | Mean | Std Error | Lower 90% | Upper 90% |
|---|---|---|---|---|---|
| 2013 | 7 | 22.8286 | 14.324 | -2.40 | 48.057 |
| 2014 | 5 | 27.8800 | 16.948 | -1.97 | 57.731 |
| 2015 | 5 | 17.9600 | 16.948 | -11.89 | 47.811 |

[TSS] % reduction



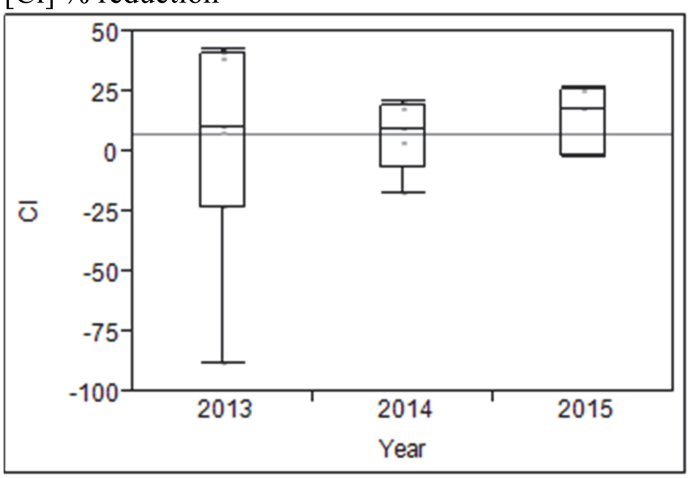

**Analysis of Variance**

| Source | DF | Sum of Squares | Mean Square | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Year | 2 | 18828.27 | 9414.13 | 1.5238 | 0.2519 |
| Error | 14 | 86491.01 | 6177.93 | | |
| C. Total | 16 | 105319.28 | | | |

**Means for Oneway Anova**

| Level | Number | Mean | Std Error | Lower 90% | Upper 90% |
|---|---|---|---|---|---|
| 2013 | 7 | -61.871 | 29.708 | -114.2 | -9.547 |
| 2014 | 5 | 2.220 | 35.151 | -59.7 | 64.132 |
| 2015 | 5 | 8.880 | 35.151 | -53.0 | 70.792 |

[Cl] % reduction



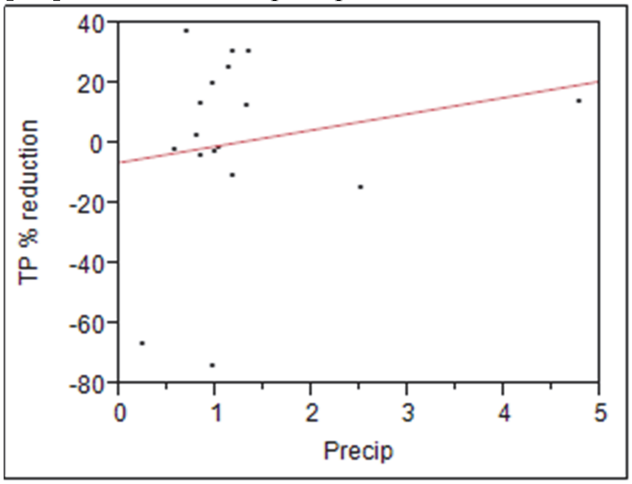

**Analysis of Variance**

| Source | DF | Sum of Squares | Mean Square | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Year | 2 | 238.189 | 119.09 | 0.1104 | 0.8963 |
| Error | 14 | 15103.993 | 1078.86 | | |
| C. Total | 16 | 15342.181 | | | |

**Means for Oneway Anova**

| Level | Number | Mean | Std Error | Lower 90% | Upper 90% |
|---|---|---|---|---|---|
| 2013 | 7 | 3.8857 | 12.415 | -17.98 | 25.752 |
| 2014 | 5 | 6.6600 | 14.689 | -19.21 | 32.532 |
| 2015 | 5 | 12.8600 | 14.689 | -13.01 | 38.732 |

[TP] % reduction vs precip




### Linear Fit

TP = -6.102533 + 5.4000496*Precip

### Summary of Fit

| | |
|---|---|
| RSquare | 0.032168 |
| RSquare Adj | -0.03235 |
| Root Mean Square Error | 31.28438 |
| Mean of Response | 0.641176 |
| Observations (or Sum Wgts) | 17 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 1 | 487.937 | 487.937 | 0.4985 |
| Error | 15 | 14680.684 | 978.712 | **Prob > F** |
| C. Total | 16 | 15168.621 | | 0.4910 |

### Parameter Estimates

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | -6.102533 | 12.198 | -0.50 | 0.6241 |
| Precip | 5.4000496 | 7.647923 | 0.71 | 0.4910 |