TOWN OF WILLISTON

TOWN-WIDE WATERSHED IMPROVEMENT PLAN - PHASE 2

ALLEN BROOK

MUDDY BROOK

SUCKER BROOK

WINOOSKI RIVER

DRAFT REPORT

Stone Project ID 12-055

September 10, 2013

Prepared for:

Town of Williston
Department of Planning & Zoning
7900 Williston Road
Williston, VT 05495
Tel. / 802.878.6704
E-Mail / jandreoletti@willistontown.com

Prepared by:

Stone Environmental, Inc.

535 Stone Cutters Way
Montpelier, VT 05602
Tel. / 802.229.4541
E-Mail / sei@stone-env.com

STONE ENVIRONMENTAL INC

ACKNOWLEDGEMENTS

This project was performed by Stone Environmental, Inc. for the Town of Williston with funding provided by Vermont Department of Environmental Conservation - Ecosystem Restoration Program.

Table of Contents

List of Tables

1. INTRODUCTION

The Town of Williston is a vibrant community located in Chittenden County, Vermont. Since the construction of I-89 in the late 1960's, Williston has slowly transformed from a small village surrounded by working farms to a multi-faceted community with dynamic residential, commercial, and industrial activity as well as valuable open space, rural areas, and plentiful natural resources. The Town has taken a proactive approach to community planning that includes both utilization and protection of land and water resources. As noted in the 2011 Town Plan, "the town has a strong history of using the planning process to moderate the impacts of population growth and land use change on the environment, public facilities and services, and the character of the community."

As development has increased within the Town of Williston, so has the complexity of managing the Town's water resources. The Town of Williston faces a range of regulatory and non-regulatory issues related to surface water protection and stormwater management. Two of the Town's major streams, Allen Brook and Muddy Brook, are considered impaired by contaminants primarily from storm runoff (see sidebar). Lake Champlain, which is the ultimate receiving water for streams and rivers leaving the Town, is also considered to be impaired. Areas of Williston are experiencing increased stormwater runoff volumes as a result of development; localized stream channel and land erosion concerns are problematic in their own right, but also contribute phosphorus to Lake Champlain.

Impaired Waters

Allen Brook
Pollutants of Concern: *E. Coli*
Stormwater Volume

Muddy Brook
Pollutants of Concern: Toxics
Nutrients
Temperature

Lake Champlain
Pollutants of Concern: Mercury & PCBs (in fish tissue)
Phosphorus

Stormwater runoff is commonly transported through Municipal Separate Storm Sewer Systems (MS4s), from which it is often discharged untreated into local receiving waters. The most effective strategy for reducing pollutant loads in stormwater is to prevent harmful pollutants from being washed or dumped into the storm sewer system in the first place. MS4 permit holders, including the Town of Williston, must develop and implement a stormwater management program. Vermont issued a revised MS4 in late 2012 which, in addition to the stormwater management program, requires the development and implementation of flow restoration plans (FRP) for streams designated as being impaired by stormwater runoff, including Allen Brook in Williston. These "big-picture" issues, along with an assortment of localized stormwater problems, ranging from the flooding that occurred in the spring of 2011 to on-going erosion along several town roads, together represent a need for significant investment in stormwater management by the Town.

This Town-wide Watershed Improvement Plan was developed to provide a strategic approach that allows the Town to meet stormwater regulatory requirements while also addressing other pressing water resource concerns throughout the Town in an efficient and targeted manner.

1.1. Project Background

As precipitation falls on an undisturbed, natural landscape and moves through the hydrologic cycle, it flows through a complex system of vegetation, soil, groundwater, and surface waters. Natural events have shaped these components over time to create a system that can efficiently handle stormwater through evaporation, transpiration, infiltration, and runoff. Alterations to the landscape change the way it responds to precipitation events. Management of land use, rainfall, stormwater management, and surface water (i.e. stream and lakes) are interrelated, and the management practices chosen all influence water quality and stream health.

Watersheds are interconnected networks of streams and watercourses in which a change at any location can carry throughout the system. Many factors influence exactly how stormwater runoff from a particular site will affect the other parts of the watershed, but this impact can be significant relative to other sources of pollution. Stormwater runoff affects water quality, water quantity, habitat and biological resources, public health, and the aesthetic appearance of the receiving water. Stormwater controls, in contrast, are typically conceived and implemented on a project-by-project basis. These projects are analyzed for their individual stormwater impacts, and not in the context of their impact on an interconnected hydrologic and hydraulic system. It is well documented, however, that the cumulative effects of individual land surface changes dramatically influence flooding conditions and contribute to degradation of water quality (NRC, 2009).

What is a watershed?

A **watershed** is any area of land in which all water runoff from its surface flows to the same drainage point. Watersheds are sometimes referred to as drainage areas.

Watersheds are important because they are the basic unit of analysis for all surface water management. They come in all shapes and sizes, and are defined based on the intended study area.

Watershed management practices have direct impacts on water quality in local creeks and streams (e.g., Allen Brook, Muddy Brook), as well as downstream waterbodies (e.g., Winooski River, Lake Champlain). Any decisions that affect land use have stormwater management ramifications and, in turn, impact all downstream water resources. The findings of one recent study (Troy et al., 2007) suggest that "land-use changes in the Basin have increased phosphorus levels in Lake Champlain, especially conversion of agricultural areas and forests to developed uses."

Vermont's streams, rivers, and Lake Champlain are vital economic resources. As such, the quality of local receiving waters affects both economic interests and quality of life in the surrounding areas. In Chittenden County, the local economy depends, in part, on the revenue gained from outdoor activities enjoyed in and on the water. Protecting the quality of surface waters is one of the most important commitments communities can make to protect the economic interests of residents.

Taken together, these elements emphasize the need for a holistic planning effort that considers the interconnected nature of land use, stormwater management, and river management in order to achieve overall watershed goals.

1.2. Goals of this Plan

The Town of Williston has three over-arching goals with regard to its surface water resources:

- Restoring the health of Allen Brook and Muddy Brook, to the point where these waters can be removed from the state's 303(d) list of impaired waters;
- Preventing the addition of other local streams to the list of impaired waters; and
- Promoting healthy populations of fish and other aquatic organisms in all of the Town's waters (Town of Williston, 2010, Chapter 29).

Although there are numerous stressors in any watershed – ranging from bacterial contamination to the presence of toxics to excess nutrients – the focus of this Town-Wide Watershed Improvement Plan is identifying locations adversely impacted by stormwater runoff. This plan focuses specifically on identifying places where there is active, on-going erosion, often caused by excess stormwater flows, and developing appropriate priorities and recommendations for addressing these concerns.

While the town will continue to explore and implement a variety of approaches to achieve all of the goals described above, such as improving development standards and addressing MS4 permit requirements, the town will use this plan to identify stormwater treatment practices and retrofits that, if implemented, will reduce sediment loads delivered to Williston's streams and result in improved stream quality.

1.3. Project Overview

In order to achieve the most effective and efficient solutions, issues related to land use, surface water quality, and stormwater management should not be viewed independently. Rather, localized stormwater problems need to be examined in a regional context to determine their relative contribution to the overall condition of the watershed. This Town-Wide Watershed Improvement Plan is responsive to the existing characteristics of the watershed, connecting land use, stormwater management, floodplain management, river corridor management, and public infrastructure needs to more effectively address all of the issues which contribute to water quality. This will enable the Town to more efficiently plan for and implement watershed management activities.

The overall objective of this project and resulting report is to provide the Town of Williston with a strategic approach for meeting stormwater regulatory requirements while addressing pressing water resource concerns in an efficient and targeted manner. Specific project goals include:

- Incorporating information from existing plans and datasets to create a single, town-specific resource to guide future stormwater management activities;
- Providing a means for comparing information about different watersheds and the anticipated benefits of individual stormwater improvements projects, both within a particular watershed and across watersheds;
- Developing recommendations to address stormwater problems, including:
    - A prioritized list of problem areas that can assist stakeholders in directing resources to high priority projects; and
    - A list of potential revisions to town regulations or ordinances needed to encourage location-specific management activities.
- Presenting conceptual solutions for stormwater management measures to address high priority problem areas, specifically reviewing the following attributes of each site:
    - Contributing drainage area, to compare the space available with the size of the practice that would be required to address the issue;
    - Water table elevation and soil conditions, to identify areas where the soils appear suitable for infiltration-based practices; and,
    - Existing infrastructure, along with traffic and pedestrian flow, to flag potential conflicts that might arise with the installation of new stormwater management measures.

2. GENERAL DESCRIPTION OF THE STUDY AREAS

The Town of Williston, located in Chittenden County, had a population of 8,698 at the 2010 Census, an increase of over 1,000 people since the 2000 census (U.S. Census Bureau, 2011). The Town covers a total area of more than 30 square miles, although most of the residential and commercial development is concentrated along Vermont Routes 2 and 2A. Since this document is focused on water resource concerns, watersheds, rather than political boundaries or transportation corridors, are the basic unit of analysis for planning. The Town of Williston lies wholly within the Lake Champlain basin. Runoff from the town eventually finds its way to the lake by one of several paths, most notably the Winooski River, which are shown on Map 1 in Appendix A. Each of the Town's watersheds is described in more detail below.

2.1. Allen Brook

Allen Brook originates above Mud Pond and flows northwest to join Muddy Brook just before that stream's confluence with the Winooski River. The Allen Brook watershed is Williston's largest, encompassing roughly 10.8 square miles (6,900 acres), or about one-third of the town (Town of Williston, 2011). The main stem of Allen Brook is approximately 11 miles long from its headwaters in the Sunset Hill area of Williston to its confluence with Muddy Brook along River Cove Rd.

Allen Brook is designated as a Class B waterway by the State of Vermont, meaning that the brook is suitable for "aquatic habitat, boating, swimming and public water supply with filtration and disinfection." Since 1992, the section of the Allen Brook upstream of Industrial Avenue has been included on the *Vermont 303(d) List of Waters* as impaired for *E. coli* and stormwater (Vermont DEC, 2012); the impaired reaches are highlighted on Map 8 in Appendix A.

The bacteria impairment has been identified in a 4.6-mile segment of Allen Brook from River Cove Road upstream to Route 2. As part of a Statewide Bacteria Total Maximum Daily Load (TMDL), Vermont DEC identified the following as potential sources of bacterial contamination in Allen Brook: illicit sewer connections; sewer line leaks; septic systems; urban stormwater runoff; and animal waste including wildlife, agriculture, and pets (Vermont DEC, 2011a). The TMDL also provides a broad framework for addressing bacterial pollution in the streams and rivers of Vermont, predicated mainly on improved stormwater management.

A hydrologically-based TMDL was developed in 2008 to address the impacts of the stormwater runoff in Allen Brook, with a particular focus on biological impairments in the stream (Vermont DEC, 2008). Although the major goal of the TMDL is to address stormwater runoff, the report describes how mitigation of this runoff will help reduce the impacts of other pollutants of concern in the watershed, including sediments, nutrients, heavy metals, and fecal bacteria.

In response to the TMDL, and as required by the Town's MS4 permit, the Town has drafted a Flow Restoration Plan (FRP) for Allen Brook. The purpose of a FRP is to identify stormwater treatment practices (including retrofits to existing practices) that will be recommended for implementation in an effort to achieve established TMDL flow targets, and eventually to allow the impacted stream to be removed from the state's list of impaired waters. Because the "pollutant of concern" in waters designated as stormwater-impaired is stormwater runoff volume, the practices identified in the FRP are specifically targeted towards reducing the large volumes of runoff that enter a stream during rainfall events.

2.2. Muddy Brook

Muddy Brook runs along Williston's western border, forming the town's boundary with South Burlington. Approximately 9.8 square miles (6,300 acres) of this 20.8-square mile watershed is in Williston. The headwaters of Muddy Brook are found upslope of Shelburne Pond in the towns of Shelburne and South Burlington. Shelburne Pond is the dominant surface water feature in the upper watershed. It has an area of 452 acres and is fed by the mainstem of Muddy Brook, as well as other smaller tributaries. The Muddy Brook watershed also includes the Sucker Brook watershed (Section 2.3). In addition, the watershed includes the commercial and retail development in Taft Corners and Maple Tree Place. Muddy Brook is listed on the *Vermont 303(d) List of Waters* as impaired for toxins, nutrients, and temperature; the impaired reaches are highlighted on Map 8 in Appendix A.

2.3. Sucker Brook

Sucker Brook is the major tributary to Muddy Brook and spans portions of the towns of Williston and St. George. The brook drains an area of approximately 7.4 square miles, 3 square miles (1,920 acres) of which is in Williston. Land cover in the watershed is predominantly second-growth forest and agriculture with some areas of low density residential development.

In the 1980s, a severe rainstorm forced a tributary of the Sucker Brook to change its course, abandoning a 30-foot waterfall and flowing instead into a nearby gravel pit located on town land just off Route 2A. Over time, the gravel pit eroded, forming a large unstable canyon and sending substantial volumes of sediment downstream. From 2003-2007, the Town conducted a multi-phase stream stabilization and restoration project along the eroded canyon to successfully address the erosion.

In 2011, elevated levels of lead were measured in the headwaters of Sucker Brook and were determined to have been caused by shooting practices at the North Country Sportsman's Club, which has been in operation since 1962 on a parcel located off Old Creamery Road. The Club has since developed and implemented an Environmental Stewardship Plan for management of lead shot that relocated parts of the shooting range and increased maintenance activities to remove shot fall in order to minimize the impacts of the shooting range on Sucker Brook.

Periodic monitoring by the State of Vermont has found that the water quality in along the mainstem of Sucker Brook meets standards and is able to fully support aquatic life.

2.4. Winooski River

The Winooski River has its source in the northeast corner of Washington County in the town of Cabot, then courses northwesterly for approximately 90 miles before flowing into Lake Champlain just north of Burlington. Its drainage area of about 1,080 square miles covers 11.9 percent of Vermont. The basin occupies all of Washington County, a little less than half of Chittenden County and small parts of Lamoille and Orange Counties (Vermont ANR, 2012). In Williston, several small tributaries flow directly into the Winooski River. Cumulatively, the watersheds of these streams cover about 8.4 square miles (5,400 acres) of the town (Town of Williston, 2011). Although upstream segments of the Winooski River, near Montpelier, are listed as on the *Vermont 303(d) List of Waters* as impaired for *E. coli*, assessments by the State of Vermont have found that water quality in the river as it passes through Williston meets standards (Vermont DEC, 2012).

2.5. Lake Iroquois

Lake Iroquois is a 229-acre reservoir in the southeast corner of Williston. Approximately half the lake is located within the town boundaries; the Lake Iroquois watershed also includes parts of the towns of St. George, Richmond, and Hinesburg. A dam built on the outlet at the south end of the lake was used historically to control the water supply to mills downstream in Hinesburg. During the 1960s the dam was intentionally cemented in its top position, keeping the pond at an artificially high level throughout the year.

The Vermont Agency of Natural Resources has classified Lake Iroquois as eutrophic, and the elevated nutrient levels in the Lake have contributed to the spread of the invasive aquatic plant Eurasian Watermilfoil (Myriophyllum spicatum) (Town of Williston, 2011).

2.6. Other Watersheds in Williston

Watersheds that are located partially within the Town of Williston, but which were not within the scope or focus of this project, include Patrick Brook and Johnnie Brook. Each of these watersheds is described briefly below.

2.6.1. Patrick Brook

Lake Iroquois and the surrounding lands are part of the LaPlatte River watershed. The lake drains into Patrick Brook, which joins the LaPlatte River in Hinesburg. The river then flows into Shelburne Bay. This watershed includes about 1.7 square miles (1,100 acres) in Williston (Town of Williston, 2011).

2.6.2. Johnnie Brook

The Town of Williston also includes less than one hundred acres of the Johnnie Brook watershed (Town of Williston, 2011). The portion of the Johnnie Brook watershed in Williston, along the town's eastern border south of I-89, is mostly wooded with low-density residential development.

3. EXISTING PLANS AND DATA

Numerous and varied groups and individuals have invested considerable effort in evaluating different components of Williston's water resources, and the important interface between water resources and local land use decisions. Some evaluations have followed watershed boundaries, while others have followed political boundaries. The following sections identify evaluations completed to date, with emphasis on work most relevant to the Town of Williston, and most relevant to future efforts to develop a list of strategic, prioritized projects that could be undertaken to improve water quality in and around Williston.

3.1. Allen Brook

A substantial number of assessments, including all four of the types of assessments described above, have been completed or are in progress for Allen Brook and its watershed. The work products resulting from these efforts are briefly summarized below from past to present.

3.1.1. Watershed Improvement Plan and Recommendations for a TMDL for Sediment (2003)

Prior to the development of the stormwater TMDL for Allen Brook, which was approved by EPA in 2008, VTDEC sponsored an effort to develop a watershed restoration plan for Allen Brook and to make recommendations for the development of a sediment-based TMDL (Barg et al., 2003). The objective of the plan was to develop an alternative approach to restore Allen Brook, and more generally determine a cost-effective means of restoring waters impaired by non-point sources.

The authors of the plan collected substantial scientific data and completed a variety of assessments on the Allen Brook watershed. These datasets included fluvial geomorphology characteristics, stream biology indicators, and water quality parameters. The team also performed watershed analyses including calculations of watershed impervious coverage and modeling of sediment loads in the watershed.

The information collected and compiled for this report was analyzed and used to provide specific recommendations for management activities that should be implemented to address existing impairments and prevent future degradation of the watershed. The report provides recommendations on areas that may be addressed through the development of ordinances and incentives to prevent further degradation of Allen Brook. Groups of recommendations in the report include:

- Stormwater Management and Retrofit Opportunities
- Prediction of stream adjustment based on land use
- Adopting Management and Maintenance Suggestions
- Changes to local ordinances
- Pollution prevention
- Developing a stormwater utility
- Best Management Practices During Construction
- Better Site Design
- Road Management
- Best Management Practices (BMPs)
- Prevention (via application of non-structural stormwater credits for new projects)

Detailed recommendations for retrofit opportunities are included with priority rankings for over 100 stormwater management systems in the watershed. At the time this report was finalized, the highest-priority retrofit opportunities included the following areas and issues, which are quoted directly from the report:

1. Meadow Ridge subdivision. Uncontrolled runoff from the subdivision overtops South Road and has washed manure from the Siple farm manure pit into Allen Brook. This has contributed to high nutrient loading to Allen Brook that is evident by the presence of long strands of attached filamentous algae in Reach 9. A stormwater detention pond was never built as required by the VTDEC Stormwater Discharge Permit. Swales were not dimensioned as shown in the permit and are conveyance ditches instead that are a source of sediment. **Elements of this need are also documented Problem Area Data Sheets AB-50 and AB-52, presented in Appendix C.1.**
2. South Ridge subdivision. The stream inventory of Allen Brook showed it to be in poor condition immediately downstream of this subdivision. While there are two other subdivisions in the general area, South Ridge is the largest, closest to the brook, and contains the most impervious area. Existing stormwater ponds need maintenance and retrofitting. **Elements of this need are also documented Problem Area Data Sheet AB-48, presented in Appendix C.1.**
3. Taft's Farm subdivision. This subdivision straddles Allen Brook with very little buffer left along the stream corridor. Significant erosion from some storm drain outfalls exists, treatment at certain discharge points to Allen Brook is insufficient or nonexistent, and basins are in need of maintenance and retrofitting. **Various elements of this need are also documented Problem Area Data Sheets AB-16, AB-17, AB-18, AB-19, AB-20 and AB-21, presented in Appendix C.1.**
4. Williston Hills subdivision. There was extensive gully erosion below the culvert outfall for the storm drain collection system serving this area.
   - In 2006, the Winooski Natural Resources Conservation District began efforts to stabilize the gullies. Construction for Gullies A and B occurred in the fall of 2007. Construction for the largest of the three gullies, Gully C, was completed in the fall of 2008. In November 2008, the site was re-vegetated with 185 trees and more than 400 shrubs from local nurseries.
5. Avenue D (Whitcomb Industrial Park). Most lots were not required to have a stormwater discharge permit since provisions to infiltrate stormwater on-site were included in construction plans. Many of the proposed infiltration STPs were never built or are not functioning as intended. There is gully erosion from both permitted and non-permitted discharge points. Groundwater impacts are a concern since this site was once a sand pit and has soils with high infiltration rates. **This need is also documented Problem Area Data Sheets AB-26 and AB-29, presented in Appendix C.1.**

3.1.2. Stream Geomorphic Assessment (2005)

Stream geomorphic assessment data specific to Allen Brook was collected in 2005. This work confirmed the significance of in-stream sediment generation, as opposed to production zone sediment inputs, and its resultant negative impact on aquatic biota and habitat (Fitzgerald, 2005). Results from the geomorphic assessment indicate that the stream channel is highly unstable and that the potential for more degradation is high. Of 15 reaches assessed in the Allen Brook watershed, one was rated as being in "poor" geomorphic condition, 11 were rated as being in "fair" condition and 3 were rated as "good". In the same 15 reaches, sensitivity to further channel instability was rated as "very high" in 11 reaches, "high" in three reaches and "moderate" in the remaining reach. These conditions reflect a generally degraded aquatic habitat, where 10 reaches were rated as having "fair" habitat conditions with the remaining five were rated as "good".

Building on this work, since 2001 the Town has collected cross-section data and conducted pebble counts at 13 sites in the Allen Brook watershed. The locations of completed transects are shown in Map 9 in Appendix A.

3.1.3. USGS Stream Gage (2007-present)

Since October 2007, the U.S. Geologic Survey (USGS) has operated a flow monitoring station in cooperation with the Vermont Agency of Transportation and the Town of Williston on Allen Brook where it passes under Route 2A. The data are available on-line at: http://waterdata.usgs.gov/vt/nwis/uv?04290335.

3.1.4. Water Quality Monitoring (2007-present)

The Williston Conservation Commission (WCC) has collected water quality samples along the Allen Brook since 2007 (no samples were taken in 2009 and not all parameters were sampled every year). The parameters sampled include Total Nitrogen (TN), Total Phosphorus (TP), E. coli, Chloride (Cl), Turbidity (NTU), and temperature. Key findings from the sampling effort include:

- TN and TP concentrations were greatest in the upstream reach of the Allen Brook and lowest in the downstream reach. These results were somewhat expected because agricultural land is concentrated in the upstream reach.
  - TP levels ranged from 0.021 to 0.157 mg/L
  - TN levels ranged from 0.31 to 1.05 mg/L
- Concentrations of *E. coli* were highly variable over the sampling period. There appeared to be no strong correlation between *E. coli* spikes and rain events.
- Turbidity levels were generally greater downstream than upstream, though no trends or explanations were apparent.
  - Turbidity levels ranged from 0.79 to 17.20 NTU
- Chloride concentrations generally increased as samples were taken further downstream.
  - Chloride levels ranged from 20.5 to 150.4 mg/L
- Allen Brook exceeded the water quality standards for *E. coli* and turbidity in the majority of samples collected; Allen Brook did not exceed the federal standards for Cl. Numerical standards do not yet exist for TN and TP levels in streams and rivers, but TP concentrations observed are generally above the in-lake standard (0.010 mg/L) established for phosphorus in segment of Lake Champlain to which Allen Brook ultimately discharges.

The locations where samples are collected are shown on Map 11 in Appendix A; tabular summaries of water quality data trends are also included in Appendix A (Tables A.1 through A.5).

3.1.5. Chloride Assessment of Select Urban Streams in Chittenden County (2007)

Chloride concentrations were measured in six locations in the greater Burlington area, including two locations in Williston – one on Allen Brook and a second on a tributary to Muddy Brook. The data were used to evaluate the extent to which chloride levels in the streams could be contributing to observed impacts to aquatic life

(Vermont DEC, 2007). During the study period, Allen Brook never exceeded the EPA's chronic criterion for chloride. The study concluded that it is unlikely chloride is significantly contributing to the biological impacts observed in Allen Brook. Results for the Muddy Brook are provided in Section 3.2.1.

3.1.6. Allen Brook Stream Bank Restoration Project (2008 - Present)

Stream geomorphic studies of Allen Brook (see Section 3.1.2, above, and 3.1.8, below) found that a number of reaches of Allen Brook lack forested riparian buffers. Inadequate buffers have led to stream bank failure and incision, which in turn has caused devastating habitat loss for fish and aquatic insects. The Town is committed to acquiring conservation easements and reforesting riparian buffer corridors along impaired portions of the Allen Brook and its tributaries, but needed a systematic approach for prioritizing the planning, design, coordination, and implementation of permanently conserved vegetated riparian buffer areas along segments of the Allen Brook and its tributaries.

The *Allen Brook Restoration Project* (KAS, 2011) identified 158 parcels that contain property within a 150' buffer corridor along the impaired portion of the Allen Brook and its tributaries. Each parcel was ranked based on suitability, need, and feasibility for restoration within the 2011 calendar year; a "short list" of 30 parcels was identified and cross-checked against the list of project sites contained within the Allen Brook Watershed Departure Analysis and Project Identification Summary (see section 3.1.8, below). In general, parcels on the short list tended to have larger riparian buffer areas (over an acre), incised stream banks, poor riparian buffer quality, and erodible soils. The Town has used the short list of parcels from this report to guide its conservation efforts in the Allen Brook watershed.

To date, the Town has permanently conserved approximately 25 acres of stream buffer (ranging in width from 50 to 150 feet) and re-vegetated 18 acres along the banks of the Allen Brook (Town of Williston, 2011).

3.1.7. TMDL to Address Biological Impairment (2008)

Allen Brook is listed as impaired because of diminished biological integrity due to "excessive stormwater flows." A TMDL for excess stormwater in Allen Brook has been developed by VT DEC and subsequently approved by EPA Region 1 (Vermont DEC, 2008). Because the "pollutant of concern" is stormwater runoff volume, the loading capacity is the greatest volume of stormwater runoff Allen Brook can receive without violating the stream's aquatic life criteria. Background and reasoning behind the impaired designation is discussed as well as TMDL development.

3.1.8. Watershed Departure Analysis and Project Identification Summary (2008)

The watershed departure analysis presents the findings of a study of the sediment source and transport characteristics in Allen Brook (Fitzgerald, 2008). Results indicated that impervious cover, man-made drainage infrastructure, and loss of wetlands have impacted the geomorphology of the Allen Brook, leading to increased erosion rates and sediment transport capacity. A prioritized list of 21 watershed improvement projects was provided as part of the report, with 12 restoration projects identified as high or medium priority. These projects were further characterized as "passive" (generally conservation based and do not require further study to pursue implementation) or "active" (projects which will require further study prior to implementation).

A stream reach map for Allen Brook is included as Map 3 in Appendix A. Projects ready to pursue implementation (passive restoration), by stream reach and project number, included:

6. M01-1: Develop conservation easements for parcels on lower and middle reach. Ideally completed in conjunction with buffer planting project described in project M01-2 (high priority).
7. M02-1: Develop conservation easements for parcels on lower section of reach where lower sloped land adjacent stream channel could face development pressure in future (medium priority).
8. M03-A-1: Develop conservation easements for parcels on west bank parcels in middle and upper segment where adjacent land could face development pressure in future (medium priority).
9. M03-C-1: Develop conservation easements for parcels on lower and middle segment, on the left bank. Ideally completed in conjunction with buffer planting project described in project M03-C-2 (high priority).
10. M05-B-1: In areas where corridor is not developed, pursue conservation easements for parcels in upper reach in between Route 2 and I-89 (high priority).

Projects requiring further study (active restoration), by stream reach and project number, included:

1. M01-2: Plant buffer with native woody vegetation in the middle and lower reach (high priority).
2. M01-3: Replace bridges with appropriately sized structures. Follow new River Management Program guidelines to accommodate 100% of equilibrium channel width (medium priority). **Additional information is provided on Problem Area Data Sheet AB-03, presented in Appendix C.1.**
3. M03-C-2: Plant buffers in middle-lower segment where no woody vegetation exists on either side, and in upper segment on left bank where there is limited woody vegetation. Other active restoration approaches for this segment, such as restoration of channel geometry, are discouraged in the short term due to the current state of channel adjustment (high incision; stage II CEM; medium priority).
4. M04-A-1: Plant stream buffer in areas above Old Stage Rd where bank vegetation is lacking (medium priority). **Additional information on this need is provided on Problem Area Data Sheet AB-46, presented in Appendix C.1.**
5. M04-A-2: Investigate feasibility of active channel restoration of bedforms and floodplain features in upper segment (medium priority). **Additional information is provided on Problem Area Data Sheet AB-47, presented in Appendix C.1.**
6. M05-B-2: Plant stream buffers in vicinity of Route 2 crossing. Stream boundaries lack native woody vegetation above and below crossing for ~300’ on both sides (medium priority).
7. M07-1: Plant stream buffer, and install fencing to exclude grazing animals from stream channel in lower reach (high priority). **Additional information is provided on Problem Area Data Sheet AB-50, presented in Appendix C.1.**

3.1.9. Biological and Aquatic Life Use Attainment Assessment of Allen Brook (2011)

Vermont DEC uses standard protocols for periodically assessing the biological condition of stream sites across Vermont, including segments of Allen Brook, Muddy Brook, and Sucker Brook. An in-depth evaluation of the biological data was completed for Allen Brook following the 2010 monitoring season (Vermont DEC 2011). In addition to observations related to the biological condition of Allen Brook, the report summarizes habitat observations and water quality measures collected simultaneously with the biomonitoring data, including canopy cover, silt rating, pH, and nutrient and chloride concentrations.

The report includes a number of interesting findings, such as:

- Macroinvertebrate assessments in Allen Brook are higher (more favorable) than for the fish communities. In fact, the macroinvertebrate community has consistently met water quality standards for aquatic life use support at all locations on Allen Brook since 2005.
- Habitat observations show a slight trend in decreased canopy cover, moving from upstream to downstream;
- A number of freshwater mussel species, including two uncommon species, are present in Allen Brook;
- It is likely, given the level of activity in the watershed, as well as the complexity and diversity of the landscape in the Allen Brook watershed, that factors other than “sediment” (e.g., nutrients and hydrology) contribute to the impacts observed within the biological community.

3.1.10. Winooski River Basin Water Quality Management Plan (2012)

The Vermont ANR published the water quality management plan for the Winooski River basin in 2012. This report provides an overview of the Winooski River Basin’s surface waters, including Allen Brook, and a description of ongoing and future steps to restore and protect those waters. The plan presents the recommendations of local watershed residents, stakeholders with varying interests, Vermont ANR, and professionals from other State and federal agencies that will guide efforts to improve both water quality and aquatic habitat, in the basin over the next five years. It includes several statements specific to Allen Brook, including:

- Identifying the implementation of efforts to address the Bacteria TMDL for Allen Brook is one of the top ten priority strategies in the management plan. Specific measures that are likely to be incorporated in Vermont ANR’s implementation plan to meet the Bacteria TMDL include:
  - Identifying agricultural operations in the watershed and working with agricultural resource staff to identify and address pathogen sources;
  - Identifying and implementing stormwater management opportunities that reduce bacterial loads to receiving streams; and
  - Developing and implementing a pet waste management plan with the Town and other landowners.
- Increasing the establishment and enhancement of woody riparian corridors on stable reaches of Allen Brook as a priority strategy for enhancing stream stability; and
- Supporting the implementation of this Town-Wide Watershed Improvement Plan, once complete.

3.1.11. Flow Restoration Plan (2012)

A draft flow restoration plan (FRP) was recently completed as part of an effort to implement the stormwater TMDL for Allen Brook (DuBois and King, 2012). The goal of the FRP was to identify best management practices (BMPs) that will achieve flow targets set forth in the 2008 TMDL. The plan identifies expired stormwater discharge permits and opportunities for implementation of BMPs within town boundaries. The two specific opportunities for BMP implementation on town-owned land that were identified in the FRP are:

- A parcel south of and behind the Town offices located off of U.S. Route 2. A majority of the parcel is wetland and the uplands are occupied by 25 pole mounted solar trackers, which were installed in 2013. The BMP could be installed near the south side of the parcel where it abuts I-89, and thus capture drainage from the wooded areas to the south of the highway.
- A parcel between U.S Route 2 and Interstate I-89. This parcel is currently undeveloped; portions are utilized as farmland. The BMP could be installed near the south side of the parcel where it abuts I-89, and thus capture drainage from Hurricane Lane and the wooded areas to the south of the interstate.

The FRP also identified three opportunities within VTrans right-of-way for additional stormwater management. In addition to identifying these opportunities, a construction schedule is generally discussed, and construction cost estimates are provided for individual BMP projects. The municipal separate storm sewer system (MS4 permit), issued on December 5, 2012, requires the development and implementation of a FRP for each of Vermont's stormwater impaired watersheds (Vermont DEC, 2012a).

3.2. Muddy Brook

Geomorphic assessments and water quality monitoring efforts have been completed or are underway in the Muddy Brook watershed. The work products resulting from these efforts are briefly summarized below from past to present.

3.2.1. Chloride Assessment of Select Urban Streams in Chittenden County (2007)

Chloride concentrations were measured in six locations in the greater Burlington area, including two locations in Williston – one on Allen Brook (see Section 3.1.5, above) and a second on a tributary to Muddy Brook. The data were used to evaluate the extent to which chloride levels in the streams could be contributing to observed impacts to aquatic life (Vermont DEC, 2007). During the study period, chloride concentrations at the study site in Muddy Brook exceeded the criterion 66% of the time. The study concluded that chloride is likely contributing to stormwater-driven impacts in the tributary to Muddy Brook. Results for Allen Brook are provided in Section 3.1.5.

3.2.2. Phase 1 and 2 Stream Geomorphic Assessment Summary (2009)

This report provides the results from Phase 1 and 2 stream geomorphic assessments of Muddy Brook (Fitzgerald and Parker, 2009). The two goals of the report are:

- Assessing the current geomorphic stability and habitat conditions in the watershed to compliment Vermont DEC biological sampling data, and
- Establishing baseline data for long-term monitoring purposes.

The nature of the watershed was characterized. The extent of departure from reference conditions was reported, along with suspected causative factors; 16 bridges and culverts were specifically assessed for their impact on channel equilibrium conditions. A stream reach map for Muddy Brook is provided as Map 4 in Appendix A. Reach-specific recommendations for restoration activities from this work are presented below without modification:

- Arrest Headcuts: The two headcuts noted on Tributary 3 are causing the export of large amounts of sediment to the downstream reaches. The headcut located downstream of Harvest Lane on T3.01-E has the potential to impact the road crossing in the near future (5-10 years), and will need to be addressed with an active channel management approach.
- Continuous monitoring of both headcut sites is recommended to determine the rates of migration and the immediacy of restoration needs.
- Corridor Protection: Protecting the stream corridor through conservation easements is recommended along reaches of the lower and middle watershed that are susceptible to future development. This approach is especially important in reaches or segments that are in vertical adjustment: M02, M10, T3.01-E.
- Undersized Stream Crossings: Severely undersized culverts are causing channel adjustments in the following reaches: M02, M08, M13, T2.01-A, T3.02-A. As noted in the structures summary, these structures should be considered high priority for replacement by town and state agencies.
- Derelict Stream Crossing: There is an inactive stream crossing in Reach M09. The abutments act as a channel constriction and are causing erosion and bifurcation of the channel. Given that the stream crossing is no longer in use, removal of the abutments is recommended.

The Problem Area Data Sheets for Muddy Brook, presented in Appendix C.2, indicate which problem areas were initially identified by reviewing the Phase 1 and 2 SGAs. **In total, nine of the 19 stormwater problem areas documented in the Muddy Brook watershed were drawn from the SGAs; these are: MB-02, MB-06, MB-07, MB-08, MB-09, MB-11, MB-14, MB-15, and MB-25.**

3.2.3. Water Quality Monitoring (2012-present)

The Chittenden County Stream Team (CCST) initiated a volunteer-led water quality monitoring effort in six Chittenden County streams in the summer of 2012, including Muddy Brook. Samples were collected twice monthly at three sites along Muddy Brook (one in Williston and two in South Burlington), and analyzed for phosphorus, nitrogen, turbidity and chloride levels. This data is being made available on-line on the Stream Team website (CCST, 2013), and shows:

- Total phosphorus levels ranging from 0.043 to 0.266 mg/L
- Total nitrogen levels ranging from 0.70 to 2.75 mg/L
- Turbidity levels ranging from 4.81 to 53.7 NTU
- Chloride levels ranging from 21.3 to 143 mg/L

Although it is impossible to make direct comparisons between sediment and nutrient loads in Allen and Muddy Brooks based on this data, the data do suggest that nutrient concentrations and turbidity levels are generally higher in Muddy Brook than in Allen Brook (see Section 3.1.1.4); chloride levels are comparable in both brooks.

3.3. Sucker Brook

Only Phase 1 and 2 Stream Geomorphic Assessments have been completed for Sucker Brook.

3.3.1. Phase 1 and 2 Stream Geomorphic Assessment Summary (2007)

This report provides the results from Phase 1 and 2 stream geomorphic assessments of Sucker Brook (Fitzgerald, 2007). The intent of the document is to:

- Concisely summarize Sucker Brook watershed zones and geomorphic processes; and
- Highlight important or extraordinary information for those using the data.

The nature of each section of the watershed is characterized and each reach described. The report concluded that the Sucker Brook watershed supports many sections in good to reference conditions – especially in steeper terrain. The lower reaches are more impacted due to a lack of riparian buffers and channel straightening associated with agricultural use. Stream reach maps for Sucker Brook are presented in Maps 5-7 in Appendix A. Potential restoration projects identified during this work are listed and briefly described below by stream reach:

- Route 2A Valley (M04 to M07; T1.01):
  - Protection of the corridor from future encroachment
  - Replacement or retrofit of several undersized culverts to accommodate the large volume of sediment working its way through the reach, and the resulting vertical (aggradation followed by incision) and lateral (planform change) adjustments that will continue to occur over the next 10 to 20 years. The severe aggradation of coarse material in reach T1.01 has been problematic for the Town of Williston and the landowners whose driveways and roads cross the channel. **This need is also documented Problem Area Data Sheet SB-01, presented in Appendix C.3.**
- North Branch Middle Zone (T1.02 to T1.04-A):
  - An incised tributary entering from the north was noted in Segment T1.04-A. This tributary enters the north branch channel west of Lyman Road and originates from an area of recent residential development on the north side of Old Creamery Road. Recently built housing on Highlands Drive and Overlake View, and an increase in upslope impervious cover, may be resulting in excess hydraulic loading and channel incision. **This need is also documented Problem Area Data Sheet SB-09, presented in Appendix C.3.**
- Old Creamery Road Zone (T1.04-B to T1.05-C)
  - In-stream structures (e.g., weirs) in reaches T1.04-B and T1.05-A are permanent enough to remain in place during moderate flow events (below bankfull) when fine sediment is being transported through the channel. This is resulting in aggradation upstream of the structures that is degrading the habitat. It is recommended that these structures be removed to reduce further habitat impacts.
  - Additional projects in this densely residential zone would include the re-vegetation of the buffers with native woody vegetation.
  - Future efforts to identify specific projects in this watershed zone would involve extensive public outreach, given the large number of residential properties found along the channel, especially in segment T1.05-A.

3.4. Winooski River

A substantial number of assessments have been completed for the Winooski River watershed. The work products resulting from these efforts are briefly summarized below from past to present.

3.4.1. Fluvial Geomorphology Assessment of the Lower Winooski River, Vermont (2006)

This report provides a geomorphological assessment of six identified reaches of the lower 21.7 miles of the Winooski River—from the confluence of Alder Brook to Lake Champlain (Field Geology Services, 2006). The report cites the natural constrictive effect of the Winooski Gorge, reduced sediment loads (due to dams and 20th century reforestation of the watershed), and minor channel straightening as being the primary factors inhibiting sediment-transport equilibrium. Recommendations for restoring channel stability and aquatic habitat are provided, though all of the substantial project identification in this report is for the reaches of the Winooski River downstream of Winooski Falls, well outside of the Town of Williston.

3.4.2. Mid-Winooski Watershed Phase I Stream Geomorphic Assessment (2007)

This report provides a broad assessment of geomorphic conditions in the Winooski River from Montpelier downstream to Alder Brook (Bear Creek Environmental, 2007). The goal of the report is to provide a stream-impact ranking to each reach to help direct the focus of more detailed Phase 2 Geomorphic Assessments. Significant channel alterations and development within the watershed are cited as the major influences on the geomorphic conditions of this stretch of the Winooski River. Specific reaches of the Winooski and major tributaries are identified in fair to poor condition and are recommended for more detailed, Phase 2 Assessments. Due to high levels of observed impact and reach condition, all of the main stem reaches are recommended for a Phase 2 assessment, including Reach R07 on the Winooski River, located on Williston's northern border between Alder Brook and the I-89 and Route 2 bridges in Richmond.

3.4.3. Winooski River Basin Water Quality Management Plan (2012)

As discussed in Section 3.1.1.1, this report gives an overview of the waters of Winooski River watershed, and describes present and future measures for restoration and protection of these water resources (Vermont ANR, 2012). The ten highest-priority strategies for improvement initiatives are presented and discussed. High-priority strategies that are generally relevant to the Town of Williston include:

- Identify culvert replacement projects in the basin that will improve geomorphic stability of the stream as well as improve fish passage.
- Promote agricultural programs in targeted areas that incentivize fencing, buffers, grassed waterways, barnyard treatments, conservation tillage practices, and cover cropping.
- Work with towns to protect river corridors and promote flood resiliency by establishing Fluvial Erosion Hazard zones and buffer zones in local zoning.
- Identify wetlands on agricultural lands for phosphorus retention, and in the river corridor for sediment attenuation, prioritize and conserve and/or restore.
- Hold an annual Vermont Invasive Patrollers (VIP) training to support the establishment of VIP programs for lakes and ponds in the basin.
- Encourage use of rivers and lakes in the basin to increase people's appreciation.

3.5. Lake Iroquois

The Town's 2011 Comprehensive Plan, Chapter 11.4, contains two key goals and actions concerning Lake Iroquois:

- Support the efforts of the Lake Iroquois Association, through direct funding and in-kind contributions, to help them achieve their mission to restore the lake.
- Develop a Lake Iroquois District Overlay to protect water quality, particularly with regard to the potential conversion of seasonal camps to year-round use where the existing camps do not conform to Williston's current watershed protection buffer regulations.

Several studies have been completed on Lake Iroquois since the summer of 2007 when the Lake Iroquois Association was formed. Of particular interest:

- In 2010, volunteers for the Lake Iroquois Association, with assistance from Vermont DEC, completed a three-phase survey (in-lake, shoreland, and watershed) to identify and prioritize required actions that make the biggest impact on improving the lake, though this plan has not yet been published (Lake Iroquois Association, 2012). This survey resulted in the identification of several stormwater mitigation projects.
- In 2010, the organization received a Better Backroads grant from Vermont ANR to study an ongoing storm runoff issue at Pine Shore Drive in Hinesburg and design solutions to mitigate flow of storm water into the lake, resulting in the construction of improvements in the summer of 2012 (Handler, 2012).
- In 2011, LIA received a Vermont ANR Ecosystem Restoration Grant to develop a stormwater runoff mitigation solution for the area of Shadow Lane, also in Hinesburg (Lake Iroquois Association, 2012). A similar Ecosystem Restoration grant that will enable the Lake Iroquois Association (LIA) and the Lake Iroquois Recreation District (LIRD) to stop gullying on the Lake Iroquois public beach and the resulting erosion of sediments into the lake was awarded in the 2012 funding cycle, with completion of a final design expected in the late summer of 2013.
- LIA participates actively in both the Lay Monitoring and Vermont Invasive Patroller (VIP) programs, both of which are implemented state-wide by the Vermont DEC. Volunteers measure water clarity and nutrient levels, and regularly traverse the lake looking for new invasive aquatic plants and animals. This effort is supported by a grant to cover the cost of chemical analysis at the state's LaRosa Lab.

Recent work by volunteers of the Lake Iroquois Association and staff of Vermont DEC identified areas along the lakeshore as potential input points for nutrients and stormwater. In 2012, LIA volunteers collected water samples at ten sites in the watershed, as shown on Map 10 in Appendix A. The following observations were made following the testing:

- Significant spikes are observed in phosphorus levels resulting from heavy precipitation.
- Much of the water entering the lake exceeds 15 ug P/L in phosphorus and thus contributes to the eutrophication of the lake.
- Chloride levels are notably higher along the west side of the lake.

- Instances of relatively low turbidity but high phosphorus levels may indicate sources other than erosion as a source for phosphorus pollution.

A graphical summary of the monitoring results is also included in Appendix A (Figures A.1 through A.4).

3.6. Other Watershed Assessments

An evaluation of potential stormwater problem areas in the Patrick Brook and Johnnie Brook watersheds was not undertaken as part of this project. The geomorphic assessments of Patrick Brook that have been completed are described below, as is the on-going effort by EPA to revise the Lake Champlain Phosphorus TMDL.

3.6.1. Patrick Brook

Phase 1 and 2 geomorphic assessments have been completed for the LaPlatte River and its major tributaries including Patrick Brook (LaPlatte Watershed Partnership, 2006). Each of three main reaches in Williston was characterized as follows:

- Habitat and geomorphic conditions were assessed;
- Channel alterations, obstructions, and constructions were noted;
- Extraneous influences were documented; and
- Channel evolution stage was documented.

Channel alteration and channel constrictions were found to be major factors affecting the geomorphology of the reaches studied. Reaches that were altered are expected to be the most sensitive to future development. Guidance for future work is provided, though no potential restoration projects were identified in the Patrick Brook watershed up-stream of Lake Iroquois.

3.6.2. Lake Champlain

In early 2011, EPA withdrew their 2002 approval of the Vermont portion of the Lake Champlain TMDL for phosphorus. In reversing their decision, EPA noted that two elements of the TMDL did not comply with EPA regulations and guidance. Specifically, EPA found that the TMDL did not provide an adequate “margin of safety” to account for uncertainty in the true capacity of the lake to accommodate phosphorus pollution, and did not offer “reasonable assurances” that the called-for reductions in non-point source pollution would actually be achieved.

EPA has specifically noted that the 2002 TMDL allowed most of Vermont’s wastewater treatment facilities to have effluent phosphorus concentrations “well above levels that would otherwise be required in the absence of nonpoint source load reductions”. This statement suggests that additional phosphorus removal requirements for wastewater treatment facilities are likely under consideration. In addition, EPA has indicated their intention to treat MS4s as “point sources” in the revised TMDL. Other changes that EPA may be contemplating are less clear, but could involve:

- Requiring more communities to obtain MS4 (municipal separate storm sewer system) permit coverage. Currently, MS4 designations are confined to the more densely populated areas of Chittenden County, with Rutland City and Town and St. Albans City and Town being added with the new MS4 permit signed in December 2012.
- Expanding the use of “residual designation authority” to require larger developed tracts to install stormwater management systems and obtain permit coverage.

- Requiring agricultural operations to obtain additional permit coverage beyond the medium-farm or large-farm operation (MFO or LFO) permits currently issued by the Agency of Agriculture.

3.7. Town-Wide Assessments and Programs

The Town of Williston's existing plans, resources, and data related to this Watershed Improvement Plan include policy documents, municipal ordinances, implementation documents related to the Town's MS4 permit, and a detailed Stormwater Management Practices Study. Each of these resources is described in more detail below.

3.7.1. Municipal Ordinances and Regulations

Chapter 11 of the Williston Town Plan provides a policy basis for the Town's efforts to maintain and restore the health of its watersheds. It specifically highlights the following objectives related to this Watershed Improvement Plan:

- Improving stormwater management;
- Expanding stream restoration efforts;
- Monitoring in-stream water quality;
- Identifying and alleviating problem areas affecting Lake Iroquois; and
- Promoting land stewardship opportunities.

Chapter 29 of the Williston Unified Development Bylaw is dedicated to the protection of water quality and watershed health. Chapter 29 regulates construction site erosion and stormwater management in new developments and on redevelopment sites. This chapter also establishes standards for riparian buffers along streams and around wetlands and lakes.

Town regulations require runoff and erosion control plans for development in which the cumulative land disturbance is greater than two acres, and for projects greater than ¼ acre that will disturb land within watershed protection buffers or on slopes greater than eight percent (Town of Williston 2010, Chapter 29, Sections 29.2-29.4). Projects that disturb more than ¼-acre but less than two acres are required to follow the *Low Risk Site Handbook for Erosion Prevention and Sediment Control*, published by Vermont DEC. In addition, Section 29.5.7 requires that runoff be retained on-site to be "infiltrated and/or released at a rate not exceeding the pre-development rate of release".

Town regulations also include "watershed protection buffers" for all streams, ponds, lakes and for certain wetlands. These are:

- A buffer of at least 150 feet above the ordinary high water mark of all ponds or lakes that have more than a half-acre of water surface and along Allen Brook, Muddy Brook, Sucker Brook and the Winooski River; and,
- A buffer of at least 50 feet above the ordinary high water mark of all unnamed streams – perennial or intermittent – identified on the 7.5' U.S. Geological Survey quadrangle maps covering the town, as well as above the delineated boundary of any Class II wetland or Class III wetland upon the recommendation of the Conservation Commission.

Although Chapter 29 explicitly ensures that erosion prevention measures are used during construction in projects that disturb more than ¼-acre and that riparian areas and wetland buffers are protected, the bylaws are less explicit in prescribing strategies to help limit the impacts of post-construction stormwater runoff associated with development. Chapter 29 states only in general terms that runoff needs to be retained on-site and infiltrated and/or released at a rate not exceeding the pre-development rate of release, thoughtful site planning to minimize impervious surfaces is encouraged, and porous pavements should be employed where site conditions permit. Recommendations for additional stormwater management measures that could be incorporated into the Town's Unified Development Bylaw and/or the *Town of Williston Public Works Standards* are presented in Section 5.

3.7.2. NPDES MS4 Program and Minimum Control Measures

Williston is designated as an MS4 under the National Pollutant Discharge Elimination System (NPDES) Phase II stormwater requirements of the Clean Water Act (Vermont DEC, 2012a). This MS4 designation requires Williston to file a five year Stormwater Management Program (SWMP) which responds to six "Minimum Control Measures" (or "MCM"):

- Public Education and Outreach on Stormwater Impacts (MCM 1)
- Public Involvement/Participation (MCM 2)
- Illicit Discharge Detection & Elimination (MCM 3)
- Construction Site Stormwater Runoff Control (MCM 4)
- Post-Construction Stormwater Management for New Development and Redevelopment (MCM 5)
- Pollution Prevention/Good Housekeeping for Municipal Operations (MCM 6)

In addition, the Town is obligated to file an annual report describing stormwater management activities completed during the preceding planning year.

3.7.3. Stormwater Management Practices Study

In 2004, Hoyle, Tanner & Associates (HTA) completed a study intended to assist the Town of Williston in identifying appropriate stormwater treatments practices that could be used within the planned densely developed "downtown" area that are consistent with current State stormwater treatment requirements (HTA 2004). The report includes an extensive literature review and a detailed discussion of nine specific stormwater treatment technologies. The technologies are: infiltration trenches and basins; porous pavement; open channel systems; underground and perimeter sand filter systems; manufactured underground filtering systems; detention ponds; underground storage systems; chambered separation treatment practices; and, swirl concentration treatment practices.

4. STORMWATER PROBLEM AREAS

One of the goals of this Plan is to "develop a comprehensive list of stormwater problems." To achieve this goal, a thorough effort was made to identify existing problem areas, and then to evaluate the existing conditions and potential solutions.

4.1. Identification of Problem Areas

The first task was to identify the location and nature of existing drainage problems, and where appropriate, to gather field data for further analysis. A variety of strategies were employed to identify potential problem areas, including:

- Holding a public meeting to describe the project and solicit suggestions of potential problem areas;
- Distributing a "Citizen Questionnaire" via the Town's website to gather additional public input on problem areas (see Appendix C);
- Performing windshield surveys of strategic areas throughout Town during, or immediately following, rain events;
- Meeting with representatives from the Lake Iroquois Association to gather input on problem areas within the lake's watershed; and,
- Meeting with Town staff to review the draft list of stormwater problem areas and solicit input.

In total, 76 problem areas were identified and geo-located. The geographical location data were used to plot all of the problem areas on a single map (see Appendix A, Map 2). Mapping problem area locations in this manner allows the viewer to identify isolated problems, and make a visual assessment of which problems may be part of a larger systemic issue. Systemic problems may warrant consideration of additional stormwater management regulations, in addition to efforts to correct the existing problems.

4.2. Evaluation of Problem Areas

Working from the list of potential problem areas, the Consultant Team visited each potential problem area location to directly observe the site. When no stormwater problems were evident and/or it was obvious that a solution had been implemented, the site was not evaluated further. Where an unresolved problem was found, photos were taken of any areas of active erosion, and observations about the source or cause were documented. Each problem area was also evaluated with respect to:

- Relative environmental impact on receiving water (e.g., proximity, location, amount of sediment being mobilized), with 1 being least impact and 3 being greatest impact;
- Frequency of occurrence, with 1 = rarely/extreme rain events, 2 = occasional/moderate rain events, and 3 = frequent/ nearly every rain event;
- Current condition of existing facilities and related infrastructure, with 1 = good to excellent; 2 = fair to good; 3 = poor;
- Urgency of the need to fix the problem, with 1 = problem is unlikely to get worse if left untreated; 2 = problem may get worse, but immediate action not necessary; 3 = problem is getting worse, immediate action is necessary.
- Whether the problem is impacting public infrastructure
- How realistic it is to fix the problem
- Whether there were impacts beyond water quality (e.g., aquatic organism passage inhibited)
- Whether the problem was part of a larger or more systemic problem

Each problem area was then given a score, with the intent of generally assessing the severity of existing problems, and providing general guidance on the relative order in which the problems should be addressed when considered town-wide. Scores were assigned as follows:

The complete set of problem area data sheets developed as part of this project are provided as Appendix C of this report, and summaries of evaluation results are presented in Tables 1-4 below. Only sites that scored priority 5 or above were listed in the tables, and the sites are listed in order of priority.

All problem areas that received an evaluation score of 8 or higher – generally indicative of an on-going or significant erosion and/or drainage problem – were advanced to Phase 2 of the *Williston Town-Wide Watershed Improvement Plan* project where a preliminary engineering analysis was conducted. As part of this analysis, a site-specific feasibility assessment was completed that defined contributing drainage area, water table elevation, soil conditions, existing infrastructure, and traffic and pedestrian flow in order to more fully evaluate anticipated water quality benefits and constructability at each priority problem area.

Table 1: Allen Brook Watershed Problem Area Evaluation

	Site ID	Relative Impact	Frequency	Current Conditions	Urgency	Priority[1]
High Priority	AB-53	3	3	3	3	12
	AB-19	3	2	3	2	10
	AB-09	2	2	3	2	9
	AB-11	3	2	2	2	9
	AB-13	2	3	2	2	9
	AB-18	2	2	3	2	9
	AB-20	2	2	3	2	9
	AB-43	2	2	3	2	9
	AB-44	2	2	3	2	9
	AB-45	3	2	2	2	9
	AB-01	3	2	1	2	8
	AB-05	1	3	2	2	8
	AB-07	2	2	2	2	8
	AB-17	2	2	2	2	8
	AB-24	2	2	2	2	8
	AB-26	1	2	3	2	8
	AB-29	2	2	2	2	8
	AB-30	2	2	3	1	8
	AB-32	1	3	2	2	8
	AB-34	3	1	2	2	8
	AB-39	2	2	2	2	8
	AB-46	2	2	2	2	8
	AB-49	2	2	2	2	8
	AB-50	2	3	2	1	10

	Site ID	Relative Impact	Frequency	Current Conditions	Urgency	Priority[1]
Lower Priority	AB-02	2	1	2	2	7
	AB-14	2	2	2	1	7
	AB-16	2	1	2	2	7
	AB-35	1	2	2	2	7
	AB-36	2	1	2	2	7
	AB-40	2	2	1	2	7
	AB-41	1	2	2	2	7
	AB-47	2	1	2	2	7
	AB-48	2	2	2	1	7
	AB-04	2	1	2	1	6
	AB-21	1	2	2	1	6
	AB-38	1	2	2	1	6
	AB-42	1	2	1	2	6
	AB-52	2	1	2	1	6
	AB-03	1	1	2	1	5
	AB-10	1	2	1	1	5
	AB-33	1	1	2	1	5

1 Only sites that scored priority 5 or above are listed. Sites are listed in order of priority, with the highest priority first.

Table 2: Muddy Brook Watershed Problem Area Evaluation

	Site ID	Relative Impact	Frequency	Current Conditions	Urgency	Priority[1]
High Priority	MB-14	3	2	3	3	11
	MB-28	3	2	3	2	10
	MB-11	3	2	2	2	9
	MB-18	2	2	2	3	9
	MB-26	2	2	2	3	9
	MB-02	2	2	2	2	8
	MB-08	2	2	2	2	8
	MB-20	2	2	2	2	8
	MB-23	2	2	2	2	8
Lower Priority	MB-10	2	2	1	2	7
	MB-12	1	2	2	2	7
	MB-13	2	2	1	2	7
	MB-15	2	2	2	1	7
	MB-19	1	2	2	2	7
	MB-27	2	1	2	2	7
	MB-07	1	1	2	2	6
	MB-09	1	1	2	2	7
	MB-03	2	1	1	1	5
	MB-25	1	1	2	1	5

1 Only sites that scored priority 5 or above are listed. Sites are listed in order of priority, with the highest priority first.

Table 3: Sucker Brook Watershed Problem Area Evaluation

		Relative Impact	Frequency	Current Conditions	Urgency	Priority
High Priority	SB-01	3	2	2	1	8
	SB-09	2	2	2	2	8
	SB-12	2	2	2	2	8
	SB-13	1	2	3	1	7

Table 4: Winooski Direct Drainage Problem Area Evaluation

		Relative Impact	Frequency	Current Conditions	Urgency	Priority[1]
High Priority	WR-01	3	3	3	3	12
High Priority	WR-04	3	3	3	2	11
High Priority	WR-10	2	3	2	3	11
High Priority	WR-03	3	2	2	2	9
High Priority	WR-05	2	2	2	2	8
	WR-06	2	2	2	1	7
	WR-08	1	2	2	2	7
	WR-02	1	2	1	1	5

1 Only sites that scored priority 5 or above are listed. Sites are listed in order of priority, with the highest priority first.

Table 5: Lake Iroquois Watershed Problem Area Evaluation

		Relative Impact	Frequency	Current Conditions	Urgency	Priority
High Priority	LI-04	3	3	3	3	12
High Priority	LI-01	3	2	3	3	11
High Priority	LI-03	3	3	3	2	11
	LI-02	3	2	1	1	7

5. EVALUATING POSSIBLE FUTURE CONDITIONS

The data collection and field observation approach described above is well-suited for identifying existing stormwater problem areas, but is not designed to anticipate impacts from future projected land uses within the Town. The ability to proactively identify areas of the landscape that may be particularly susceptible to changes in hydrology resulting from land use changes will enable the Town to develop strategies to avoid such impacts as opposed to being relegated to remediating problems only after they occur.

This sort of "future condition" analysis was completed for Allen Brook as part of the process used to develop the stormwater TMDL and draft Flow Restoration Plan (see Sections 3.1.7 and 3.1.11). Prior to this report, however, a similar evaluation had not been made in other watersheds of Williston. Given development patterns in Williston and the lower sensitivity of larger rivers (such as the Winooski River) to modest increases in stormwater flows, effort future conditions analysis was focused on the Muddy Brook/Sucker Brook watershed. As a part of this effort, GIS-based approach was employed to estimate how stormwater flows may increase as a result of projected future land use and build-out changes within the watershed.

Before considering a build-out scenario, it is important to understand baseline environmental and development conditions and how those conditions relate to the mapped or total impervious area (TIA) and effective impervious area (EIA), in order to predict changes in stormwater runoff in the target watersheds. The distinction between TIA and EIA is that EIA recognizes that some impervious areas are completely surrounded by pervious areas and therefore have less of an impact on aquatic ecosystems. EIA is the impervious cover that provides stormwater flows fairly directly and quickly to streams.

As part of the current condition GIS-based design flow analysis, sub-watersheds were classified based on the type and amount of stormwater management infrastructure to estimate EIA. The Consultant Team combined parcel-specific information – linking spatial GIS datasets such as parcel boundaries, land cover, and soil properties with database information such as property use – with the estimated EIA to predict current flows.

The Consultant Team then incorporated results from the current condition analysis and the build-out analysis previously completed by the Chittenden County Regional Planning Commission (CCRPC) to determine areas of current and future development and the underlying soil, slope, and land cover conditions. This analysis was further modified based on the number of new buildings from the build-out analysis, and associated assumptions regarding residential building footprint size, land cover, and impervious surface. Estimated stormwater runoff volumes were determined based on the soil properties of the parcel, and the amount of impervious surface and land cover as a result of current and future development. The results were then used to rank estimated increases in stormwater flows at build-out in different subwatersheds within the Muddy Brook/Sucker Brook watershed (see Appendix D, Figure 1). The approach is further detailed in Appendix D.

Currently, Chapter 29 of Williston's *Unified Development Bylaw* requires that developments that are not exempted (projects < ¼ acre) or defined as 'low risk' (more than ¼ acre but less than 2 acres of disturbance and located outside watershed protection buffers) be accompanied by a runoff and erosion control plan, with runoff retained on-site to be "infiltrated and/or released at a rate not exceeding the pre-development rate of release" (Section 29.5.7).

More could be done to explicitly incentivize or require developers to employ low impact design (LID) approaches and other green stormwater infrastructure (GSI) practices to further manage stormwater runoff – particularly on parcels that do not trigger state-led regulatory oversight (projects > 1 acre). Additional incentives and/or requirements for LID and GSI could be implemented in a targeted manner, using an overlay district, in areas of town expected to see the most growth as new, sub-jurisdictional development. The build-out analysis suggests that in the Muddy Brook watershed this will be the area north of I-89. Options for expanding stormwater management could include:

- Completing an in-depth evaluation of current parking requirements contained in Chapter 14 against regional "smart growth" guidelines and/or modifying parking requirements to be consistent with suggested parking maximums and minimums from the state of Massachusetts' Smart Growth / Smart Energy Toolkit (http://www.mass.gov/envir/smart_growth_toolkit/bylaws/SP-Bylaw.pdf) or other regional guidance for low-impact development specifically related to parking requirements. Requirements for off-street parking and loading spaces could be stated as a maximum only; currently both minimum and maximum requirements are provided.
- Revising Chapter 25 of the bylaws, which currently states "wherever feasible, parking lot landscaping should be designed to function as part of the stormwater management system…", to explicitly require parking lots be graded to drain to "landscaped islands" or to the medians that are already required to occupy a minimum of 5% of the parking area.
- Reworking Chapter 29 to create incentives to disconnect impervious surfaces from drainage systems, and/or to use landscaping practices and soil amendments to capture stormwater runoff. Potential changes could include articulating a clear preference for practices that seek to infiltrate, as opposed to detain, stormwater runoff, and explicitly requiring a certain amount of rainfall be managed on-site (e.g., the first inch of precipitation);
- Increasing the tree planting strip minimum width to 10 feet, or even 15 feet from the 8-foot minimum width currently proscribed in Chapter 26, and adding a requirement to protect planting strips from compaction during construction. These measures would improve the long-term health of street trees, and increase the runoff-reduction-related benefits the trees could provide over time. In cases where a wider planting strip cannot be accommodated, options such as structural soils or engineered support cells (such as the Silva Cell system recently applied on Cherry Street in Burlington) could be utilized to supply the needed uncompacted soil volume while also supporting streets, sidewalks, and traffic.
- Establishing a maximum front yard setback distance, especially in the Agricultural/Rural Residential Zoning District (Chapter 31), to avoid the construction of excessively long driveways. Currently, the maximum permissible driveway length is established at 1,320 feet in Chapter 13. A variance could be offered at the discretion of the DRB, but establishing maximum as well as minimum setback distances would give the Town an opportunity to request adequate stormwater management measures if an applicant wishes to set a structure an exceptional distance from the nearest public ROW.

6. DEVELOPMENT OF CONCEPTUAL SOLUTIONS

As was described in Section 4 of this report, the first phase of this work identified and geo-located 76 stormwater problem areas, 45 of which were identified as high priority. The Consultant Team revisited each of the high priority problem areas in order to consider each with respect to:

- ***Constructability*** –including whether the recommended practice(s) could be constructed on town-owned land, existing access to the site, and the amount of engineering design work that would be required to move the project to implementation. The maximum score a site could receive is 6 points, indicating a project that should move quickly and easily to implementation.
- ***Ease of operation*** – including the extent of maintenance likely to be required and whether it will be straightforward to complete. The maximum score a site could receive is 2 points, indicating a project with lesser maintenance needs.
- ***Anticipated pollutant abatement*** – including the ability of the recommended practice to reduce flow and/or address sediment and nutrient pollution. The maximum score a site could receive is 3 points, meaning the project both controls flow and should provide a significant reduction in the amount of sediment being delivered to a receiving water.

The scores for each of these criteria were combined with the "Environmental Priority" for each site tabulated in Section 4, which took into account relative environmental impact the site was having on the nearest receiving water, the frequency of events that would make the problem worse, the current condition of any attendant existing facilities or related infrastructure, and the stability of the site. The combined score establishes an Implementation Rank for each site.

The 30 sites with the highest Implementation Rank scores are shown in Table 6, a decision matrix that facilitates reviewing and comparing the conceptual solutions. The decision matrix identifies one or more solutions that could be implemented to address each of the high priority problem areas and allows for weighing the cost of constructing and operating each project against its anticipated water quality benefits and the role the Town may be able to fill in project implementation.

These same 30 sites were also advanced forward to the development of conceptual solutions. The conceptual solutions highlight areas that appear to be available and suitable for potential project implementation. Conceptual solutions for each of the 30 sites are included as Appendix E of this report.

In developing the conceptual solutions, the Consultant Team identified potential locations for stormwater management measures and specifically reviewed the following attributes for each site:

- Contributing drainage area, to compare the space available with the size of the practice that would be required to address the issue;
- Water table elevation and soil conditions, to identify areas where the soils appear suitable for infiltration-based practices; and,
- Existing infrastructure, along with traffic and pedestrian flow, to flag potential conflicts that might arise with the installation of new stormwater management measures.

Table 6: Decision Matrix for Reviewing Conceptual Solutions

Site ID	Site Name	Recommended Practice(s)	*Environmental Priority (scale 1-12)*	*Constructability (scale 1-6)*	*Ease of Operation (scale 1-2)*	*Anticipated Pollutant Abatement (scale 1-3)*	Implementation Rank	Cost	Ability to Phase Implementation?
LI-04	Martel Ln	bioswale w/ check dams	12	4	1	2	19	M	Y
MB-11 MB-14	Harvest Ln	bank stabilization culvert replacement	11	4	2	2	19	H	Y
WR-01	Shirley Circle	bioswale bioretention	12	3	1	2	18	M	Y
LI-03	Beebe Ln	culvert replacement	11	3	2	2	18	H	N
AB-50	South Rd	reinforced animal trail	10	4	2	2	18	L	N
WR-10	Route 2A (near Essex town line)	flow redirection (to existing swale)	10	4	2	2	18	L	N
WR-04	Chapman Ln	road grading/crowing bioswale	10	5	1	2	18	M	Y
AB-11	Pamela Ct	bioretention headcut stabilization	9	5	1	3	18	M	Y
LI-01	Oak Hill Rd	culvert replacement stone lining ditch	11	2	2	2	17	H	Y
MB-28	Williston Rd (near Miller Ln)	bioretention headcut stabilization	10	3	1	3	17	H	Y
AB-09	Horseshoe Dr	bioretention	9	4	1	3	17	M	Y
MB-08	South Brownell Rd	bank stabilization (tree planting)	8	6	2	1	17	L	Y
AB-43	Central School Dr	culvert replacement stone lining ditch	8	5	1	3	17	M	Y
AB-19 AB-20	Talcott Rd	bank stabilization culvert replacement	9	3	2	2	16	H	N
AB-44	Old Stage Rd	culvert replacement	9	3	2	1	15	H	N
SB-12	Lincoln Rd	bioswale w/ check dams	8	4	1	2	15	M	Y
WR-05	Fontaine Ln	bioswale w/ and w/out check dams	8	4	1	2	15	M	Y
MB-06	Marshall Ave (at Shunpike Rd)	culvert replacement headcut stabilization	8	3	2	2	15	H	Y
AB-05	Palmer Ct	bioretention	8	5	1	1	15	M	N
MB-20	Kirby Ln	improved conveyance	8	4	2	1	15	M	N
MB-23	Lamplite Ln	bioretention	8	5	1	1	15	H	Y
MB-26	Walker Hill Rd	headcut stabilization	9	3	1	1	14	M	N
SB-01	Route 2A (at Ridge Rd)	culvert reset/replace bank stabilization	8	2	2	2	14	H	Y
MB-02	SD Ireland haul road	culvert replacement	8	2	2	2	14	M	N
AB-14	O’Brien Ct	bioretention	7	4	1	2	14	M	Y
WR-06	Gov Chittenden Rd	road grading/crowning bioswale	7	4	1	2	14	M	Y
AB-40	Route 2 (Armory)	bioretention	7	4	1	2	14	M	Y
WR-08	Sunrise Circle	bioretention	7	5	1	1	14	M	Y
AB-52	East Hill Rd	stormwater system stone lining ditch	6	5	2	1	14	M	Y
MB-09	Route 116	bridge replacement	7	2	2	1	12	H	N

7. NEXT STEPS

This Plan represents an extensive effort to identify and evaluate potential stormwater problem areas throughout the Town of Williston, and has resulted in the identification of 30 potential stormwater improvement projects that the Town could pursue (see Table 6, above). This section describes the recommended approach for supporting the implementation of high priority stormwater improvement projects, while also taking steps to guard against potential future impacts.

7.1. Project Implementation

7.1.1. FY13 Ecosystem Restoration Program Grant

Since 2008, Vermont DEC has made available competitive grant funding thru its Ecosystem Restoration Program (ERP). The Town of Williston has applied for and received grants from Vermont DEC to implement measures to address two of the high priority problem areas from the list presented in Table 6. At the writing of this report, the Town is in the process of selecting the two problem areas for design and implementation of a solution. Vermont DEC has also indicated that it plans to make additional funding available in early 2014. The ERP grant application indicates that a prioritized plan, such as the Town-Wide Watershed Implementation Plan, is a prerequisite for projects to be eligible for implementation funding. Thus, the Town should be well-positioned with regard to obtaining additional ERP funding to support implementation. That said, discharges that are or could be regulated as point source discharges (e.g., projects within areas of Town considered “stormwater impaired” and that could be required as part of a Flow Restoration Plan) are not eligible for ERP funding.

7.1.2. LCBP Grants

Since 1992, the Lake Champlain Basin Program has awarded nearly $3.6 million in local grants. While the Basin Program offers a number of different local grant programs in most years, the two that are most pertinent to the implementation of this plan are:

- Pollution Prevention – to support technical projects which address LCBP’s pollution prevention priorities, including urban stormwater management; and,
- Education & Outreach – for projects that increase awareness, knowledge, skills, and commitments to Lake Champlain issues.

Information on current grant opportunities available through the Basin Program is available at http://www.lcbp.org/about-us/grants-rfps/available-grants/.

7.1.3. Town Capital Funds

For several years, the Town of Williston has included line items within its Capital & Equipment Projects Budget related to water quality improvements. Included in the FY2014 budget is $6,000 in town funds for continued restoration work along Allen Brook (see Section 7.1.4 for more information). In addition, the six-year capital budget and program for the period 2014-2019 includes more than $3 million in capital project needs for stormwater management and water quality improvements (Town of Williston, 2012a). The budget indicates that the Town anticipates addressing the majority of the funding need via bonding and grants.

7.1.4. Stream Bank Restoration and Conservation Easements

The Allen Brook Restoration Project is an ongoing effort that began in 2007 and culminated in 2011, as described in Section 3.1.6, with the release of the *Allen Brook Restoration Project* report (KAS, 2011). To date, the Town has permanently conserved approximately 25 acres of stream buffer (ranging in width from 50 to 150 feet) and re-vegetated 18 acres along the banks of the Allen Brook (Town of Williston, 2011). As noted in Section 7.1.3, the Town continues to make a modest annual allocation to support conservation efforts in the Allen Brook watershed.

7.2. Town Bylaw Revisions

As was discussed in Section 5, above, the Town's Unified Development Bylaw could more explicitly incentivize or require developers to employ low-impact design measures. This report offers several broad recommendations for areas where stormwater BMPs could be incorporated into the bylaws. The next step in this effort will be to undertake a comprehensive review of the bylaws that looks not only for places where stormwater management requirements could be made more explicit, but also places where the bylaws may, often unintentionally, present barriers or disincentives to the implementation of low-impact development strategies and infiltration-based stormwater management practices. This analysis would make suggestions for improvements or modifications to the bylaws, and include an analysis of the impact that changes will have on development and development patterns, incorporating the results of the future condition analysis described in Section 5. In addition, an evaluation could be completed to understand whether it would be most appropriate and practical to target changes to the bylaws to specific areas of town, or to apply them town-wide.

7.3. Continued Monitoring and Assessment

As described in Section 4, there are a significant number of monitoring efforts, both completed and ongoing, to assess the quality of surface waters within the Town of Williston. These efforts employ a range of different techniques designed to assess the physical, chemical, and biological health of the surface waters. Monitoring is important not only for identifying problems, but also for tracking change and progress over time in order to make informed decisions about which approaches yield the most significant water quality benefits, and where resources might be effectively invested to yield desired results.

For example, biological assessment data for Allen Brook shows that the macroinvertebrate community has consistently met water quality standards for aquatic life use support at all locations on Allen Brook since 2005, and the fish community has shown some improvement in recent surveys. When Allen Brook is able to support both macroinvertebrate and fish communities, it will be removed from the State's list of impaired waters. It is important for the Town and the State to continue to track progress toward meeting this important goal.

7.4. MS4 Permit Requirements

Vermont's latest MS4 Permit was issued on December 5, 2012. This is the second MS4 General Permit issued by the State of Vermont. The first MS4 permit was issued in 2003 and amended in 2004. The most significant change in the 2012 MS4 permit is the requirement for municipalities to develop FRPs to implement TMDLs developed for stormwater-impaired watersheds. The FRPs must be developed for each impaired watershed within three years, and must include the following elements:

- Identification of the required controls,
- Design and construction schedule,

- A financial plan,
- A regulatory analysis,
- Identification of regulatory assistance, and
- Identification of any third party implementation.

The schedule needs to provide for implementation of the required BMPs as soon as possible, but within 20 years of the effective date of the permit.

The issuance of the MS4 permit has direct implications for stormwater management in Williston, in particular with regard to the implementation of the Allen Brook FRP. As was noted in Section 3.1.11 above, a draft FRP has been prepared that addresses the elements identified here. The narrative for the Town's 2014 capital budget anticipates that nearly $600,000 will be required to implement the two stormwater management practices on Town-owned land identified in the FRP between 2014 and 2019 (Town of Williston, 2012a).

In June 2013, the Town delivered its updated Stormwater Management Program (Town of Williston, 2013) to VT DEC. The SWMP specifically addresses how the Town has responded to each of the six minimum measures required by the MS4 permit. The SWMP makes specific reference to this watershed improvement plan as a tool for helping address the nutrient and temperature impairments in Muddy Brook, for which there currently are no TMDLs.

8. REFERENCES

Barg, Lori, Kari Dolan, Cully Hession, Chris Cianfrani, and Bob Kort. 2003. Watershed Improvement Plan and Recommendations for a Total Maximum Daily Load (TMDL) for Sediment, Allen Brook, Williston, Vermont, Waterbody ID 08-02. Final report dated March 30, 2003. Accessed at http://willistonvt.govoffice3.com/vertical/sites/%7BF506B13C-605B-4878-8062-87E5927E49F0%7D/uploads/%7B07774046-70FF-41F6-85F4-574A14F6ADA3%7D.PDF on December 13, 2012.

Bear Creek Environmental. 2007. Mid-Winooski Watershed, Phase 1 Stream Geomorphic Assessment. Report dated June 30, 2007. Accessed at http://www.anr.state.vt.us/dec//waterq/rivers/docs/FinalReports/rv_P1_MidWinooski.pdf on December 11, 2012.

Chittenden County Stream Team (CCST). 2013. Accessed at http://www.ccstreamteam.org/index.php/volunteer/stream-monitoring/muddy on January 17, 2013.

DuBois and King, Inc. 2012. Town of Williston, Allen Brook Flow Restoration Plan, Draft Report. Report dated February 1, 2012, prepared for the Town of Williston and the Vermont Agency of Transportation. Accessed at http://willistonvt.govoffice3.com/vertical/sites/%7BF506B13C-605B-4878-8062-87E5927E49F0%7D/uploads/Allen_Broook_FRP_Report_Draft_02-01-12_(2).pdf on December 13, 2012.

Field Geology Services. 2006. Fluvial Geomorphology Assessment of the Lower Winooski River, Vermont. Report dated August 2006, prepared for the Winooski Valley Park District. Accessed at http://www.vtwaterquality.org/rivers/docs/FinalReports/rv_P2_WinooskiRiver.pdf on December 14, 2012.

Fitzgerald, E., 2005, Allen Brook Phase 2 Documentation and QA/QC Notes, Burlington, VT, University of Vermont.

Fitzgerald Environmental Associates, LLC. 2007. Sucker Brook Watershed Report: Phase 1 and 2 Stream Geomorphic Assessment Summary. Report dated October 11, 2007. Accessed at http://willistonvt.govoffice3.com/vertical/sites/%7BF506B13C-605B-4878-8062-87E5927E49F0%7D/uploads/%7B21E8C16F-5C23-4147-9643-5B0E054ECDCC%7D.PDF on December 14, 2012.

Fitzgerald, E. 2008. Allen Brook Watershed Departure Analysis and Project Identification Summary. Report dated April 11, 2008, prepared by Fitzgerald Environmental Associates, LLC for the Vermont River Management Program. Accessed at http://willistonvt.govoffice3.com/vertical/sites/%7BF506B13C-605B-4878-8062-87E5927E49F0%7D/uploads/%7BF542235C-9BF4-4515-A44B-B979EAB25581%7D.PDF on December 13, 2012.

Fitzgerald, Evan, and Samuel P. Parker. 2009. Muddy Brook Phase 1 and 2 Stream Geomorphic Assessment Summary, Muddy Brook below Van Sicklen Road. Report dated February 2, 2009, prepared for the Vermont River Management Program. Accessed at http://willistonvt.govoffice3.com/vertical/sites/%7BF506B13C-605B-4878-8062-87E5927E49F0%7D/uploads/%7B922450B7-536D-4114-A65A-AE44AF7AE55D%7D.PDF on December 14, 2012.

Handler, Meg. 2012. After Irene: Storming into action at Lake Iroquois. Burlington Free Press, August 24, 2012. Accessed at http://www.burlingtonfreepress.com/apps/pbcs.dll/article?AID=2012308260006&nclick_check=1 on December 14, 2012.

Hoyle, Tanner & Associates (HTA). 2004. Stormwater Management Practices Study. Prepared for the Town of Williston. Report dated May, 2004.

KAS, Inc. 2011. Allen Brook Restoration Project – Final Report. Prepared for the Town of Williston. Report dated December, 2011. Accessed at http://town.williston.vt.us/vertical/Sites/%7BF506B13C-605B-4878-8062-87E5927E49F0%7D/uploads/Final_Report_Complete_Reduced.pdf on February 15, 2013.

Lake Iroquois Association. 2012. Lake Iroquois Association webpage. Accessed at http://www.lakeiroquois.org/home on December 14, 2012.

LaPlatte River Watershed Partnership. 2006. LaPlatte River Phase 2 Stream Geomorphic Assessment: Hinesburg Reaches. Report dated February, 2006. Accessed at http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCIQFjAA&url=http%3A%2F%2Fwww.uvm.edu%2Fenvnr%2Fensc201%2FProject%2FLaPlatte%2520Phase%2520II%2520SGA%2520report%25202-23-06.doc&ei=GP5tUI69AaT40gH5zYDYDQ&usg=AFQjCNHx73W93Zujo8io6L1Rq4WmTTyuCw on December 14, 2012.

National Research Council (NRC), 2009. *Urban Stormwater Management in the United States.* Committee on Reducing Stormwater Discharge Contributions to Water Pollution, Water Science Technology Board, Division on Earth and Live Studies. Accessed at http://www.nap.edu/openbook.php?record_id=12465&page=R1 on December 14, 2012.

Town of Williston. 2010. Unified Development Bylaw for the Town of Williston, Vermont. Adopted June 1, 2009, effective June 22, 2009, as amended July 19, 2010. Accessed at http://willistonvt.govoffice3.com/vertical/Sites/%7BF506B13C-605B-4878-8062-87E5927E49F0%7D/uploads/%7B2920AC61-60E4-483B-8A02-015028396045%7D.PDF on December 13, 2012.

Town of Williston, Vermont, 2011. Town of Williston Comprehensive Plan. Last accessed: December 2012. http://town.williston.vt.us/index.asp?Type=B_BASIC&SEC=%7B26EA4BDF-4482-4523-B051-394E7ACEDA5C%7D&DE=%7B477C40BA-9AF8-4D5D-B17B-DD3145A6B53B%7D

Town of Williston, Vermont. 2012. Stormwater web page. Page updated December 2012. Accessed at http://town.williston.vt.us/index.asp?Type=B_BASIC&SEC={ACC6B21E-0FDB-497F-8A5A-62CDFF871272} on December 14, 2012.

Town of Williston, Vermont. 2012a. Capital Budget and Program – Fiscal Years 2014 through 2019. Accessed at http://www.town.williston.vt.us/vertical/sites/%7BF506B13C-605B-4878-8062-87E5927E49F0%7D/uploads/2014_Capital_Budget_Complete(1).pdf on September 3, 2013.

Town of Williston, Vermont. 2013. 2013 Williston Stormwater Management Program. Accessed at http://www.vtwaterquality.org/stormwater/docs/ms4/sw_Williston_MS4_SWMP.pdf on August 27, 2013.

Troy, et al. 2007. *Technical Report No. 54 - Updating the Lake Champlain Basin Land Use Data to Improve Prediction of Phosphorus Loading.* Lake Champlain Basin Program. Last accessed: December 2012. http://www.uvm.edu/giee/pubpdfs/Troy_2007_Lake_Champlain_Basin_Program.pdf

U.S. Census Bureau. 2011. U.S. Census Bureau American FactFinder web page. Accessed at http://factfinder2.census.gov on December 13, 2012.

http://www.vtwaterquality.org/mapp/docs/mp_bacteriatmdl.pdf on February 15, 2013.

VT ANR. 2012. *Winooski River Basin Water Quality Management Plan*. May 2012. Accessed at http://www.vtwaterquality.org/mapp/docs/mp_basin8final.pdf on December 14, 2012.

Vermont Department of Environmental Conservation (VT DEC). 2007. *A Chloride Assessment of Select Urban Streams in Chittenden County, Vermont.* Prepared by the Biomonitoring and Aquatic Studies Section. July, 2007.

VT DEC, Water Quality Division. 2008. Total Maximum Daily Load to Address Biological Impairment in Allen Brook (VT08-02), Chittenden County, Vermont. Approved by U.S. EPA on August 21, 2008. Accessed at http://www.vtwaterquality.org/stormwater/docs/sw_all_tmdl_approved.pdf on December 13, 2012.

VT DEC, Water Quality Division. 2011. *Biological and Aquatic Life Use Attainment Assessment of Allen Brook – 2011.* Prepared by the Biomonitoring and Aquatic Studies Section.

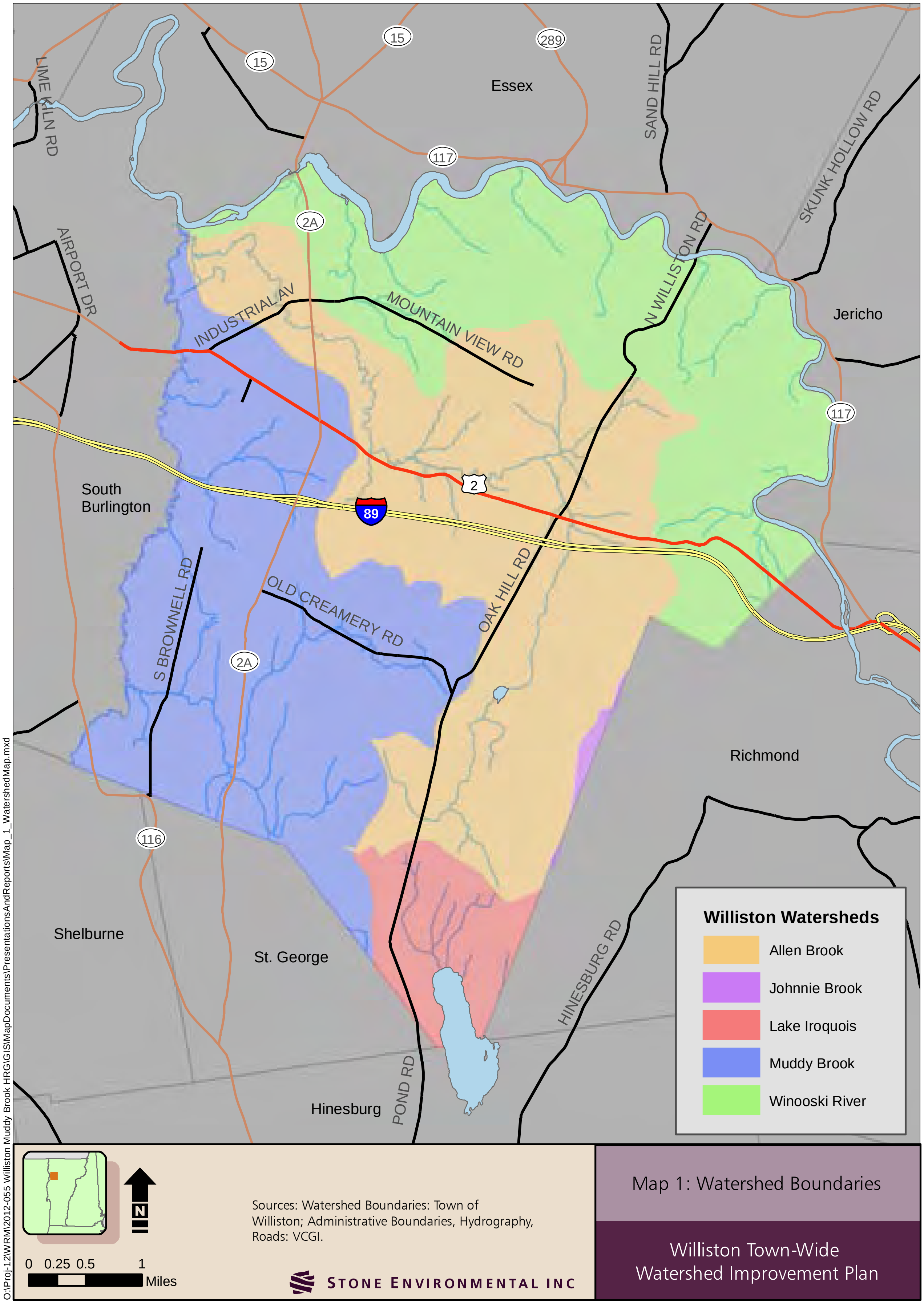
VT DEC, Water Quality Division. 2011a. *Vermont Statewide Total Maximum Daily Load (TMDL) for Bacteria-Impaired Waters – September 2011.* Prepared by F.B. Environmental Associates, Inc. Accessed at http://www.vtwaterquality.org/mapp/docs/mp_bacteriatmdl.pdf on August 30, 2013.

VT DEC, Watershed Management Division. 2012. State of Vermont 2012 303(d) List of Waters, Part A: Impaired Surface Waters in Need of TMDL. Approved by USEPA Region 1 on June 13, 2012. Accessed at http://www.vtwaterquality.org/mapp/docs/mp_2012_303d_Final.pdf on December 13, 2012.

VT DEC, Watershed Management Division. 2012a. General Permit for Small Municipal Separate Storm Sewer Systems (MS4). Page updated December 5, 2012. Accessed at http://www.vtwaterquality.org/stormwater/htm/sw_ms4.htm on December 13, 2012.

APPENDICES

APPENDIX A: MAPS & FIGURES

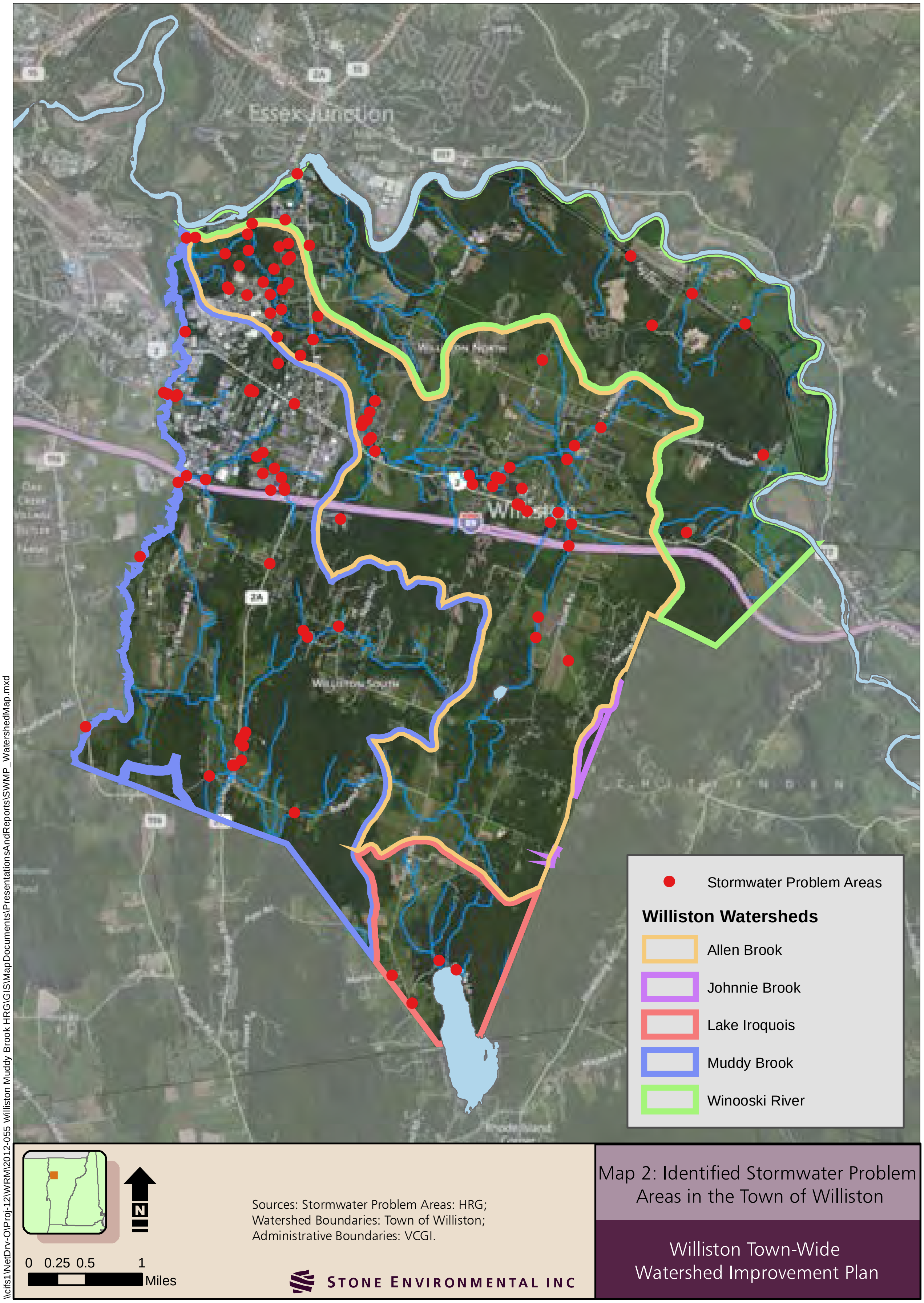


Sources: Watershed Boundaries: Town of Williston; Administrative Boundaries, Hydrography, Roads: VCGI.

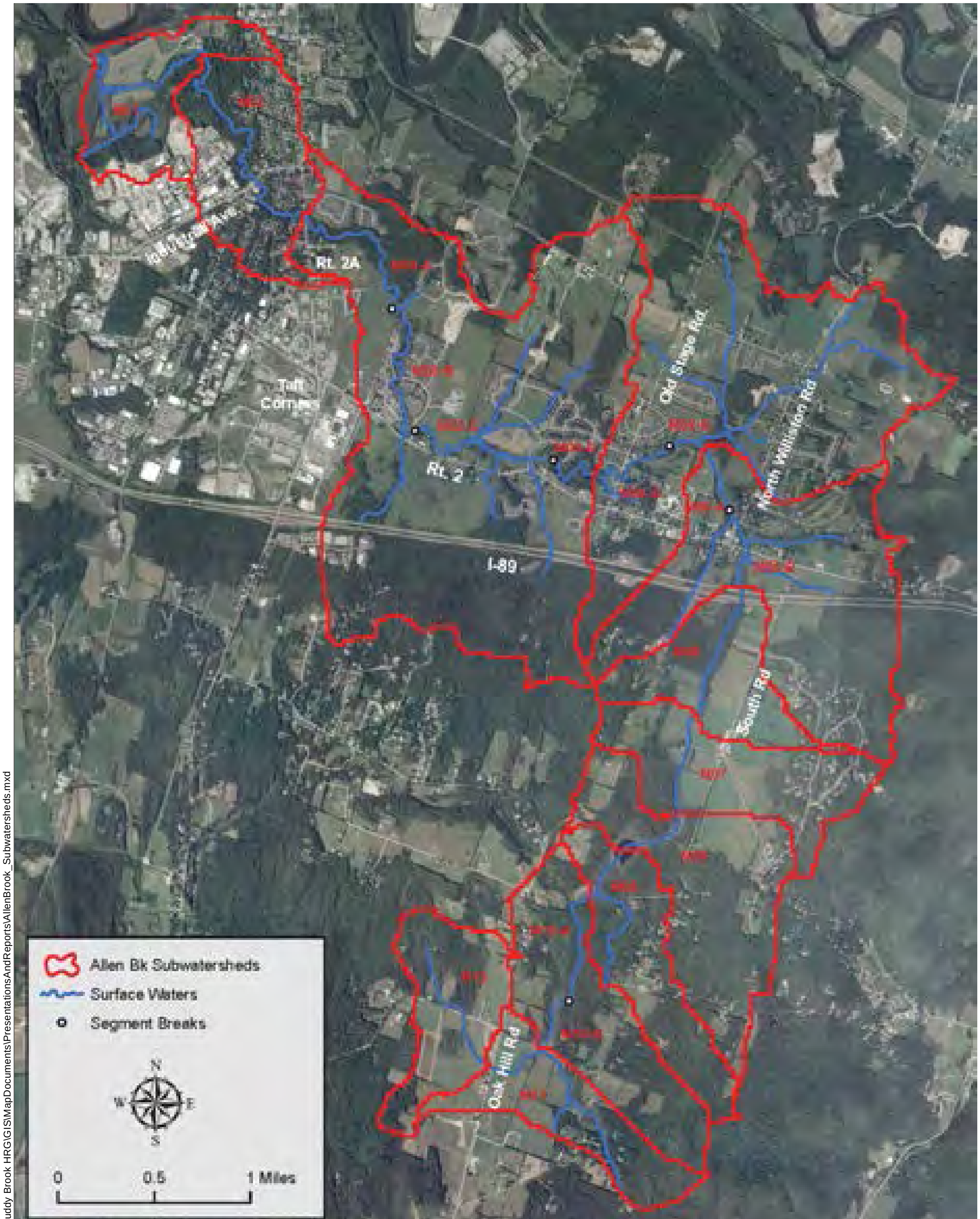
STONE ENVIRONMENTAL INC

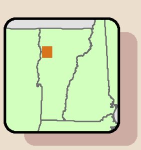
Map 1: Watershed Boundaries

Williston Town-Wide Watershed Improvement Plan



\\cifs1\NetDrv-O\Proj-12\WRM\2012-055 Williston Muddy Brook HRG\GIS\MapDocuments\PresentationsAndReports\SWMP_WatershedMap.mxd





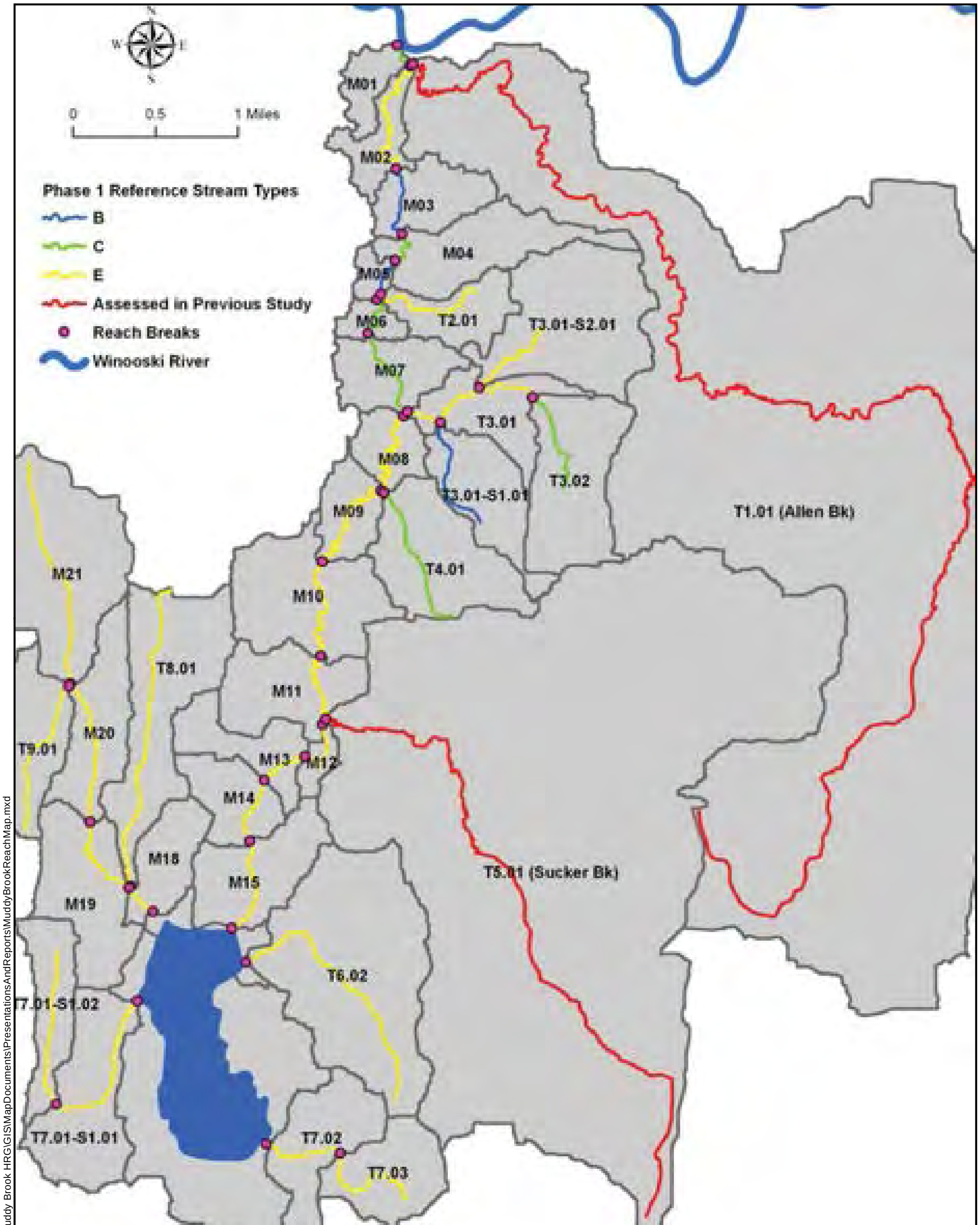
Sources: Watershed Boundaries: Fitzgerald Environmental Associates.

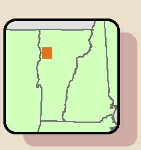
STONE ENVIRONMENTAL INC

Map 3: Allen Brook Subwatersheds and Stream Reaches

Williston Town-Wide Watershed Improvement Plan

O:\Proj-12\WRM\2012-055 Williston Muddy Brook HRG\GIS\MapDocuments\PresentationsAndReports\AllenBrook_Subwatersheds.mxd





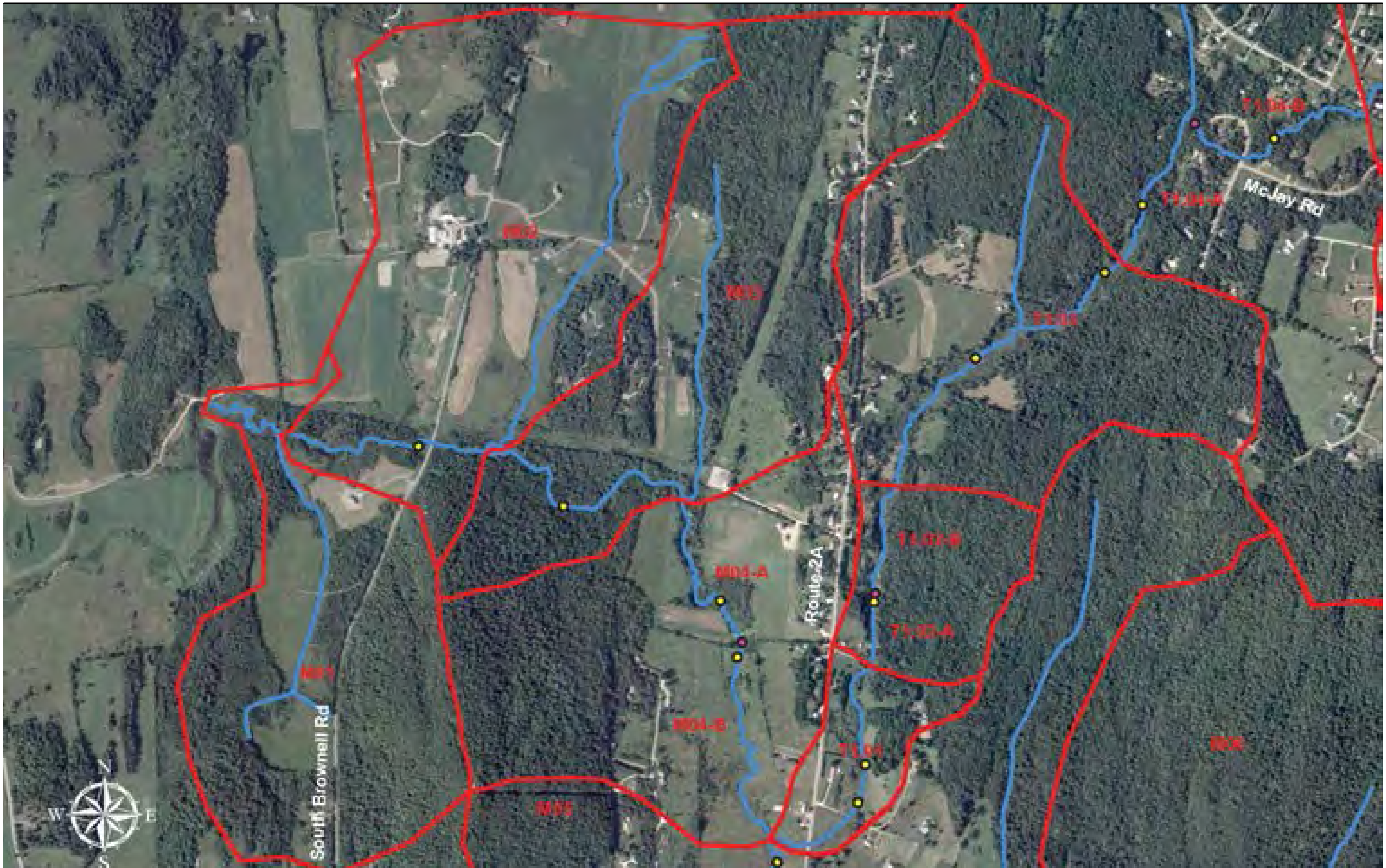
Sources: Watershed Boundaries:
Fitzgerald Environmental Associates

STONE ENVIRONMENTAL INC

Map 4: Muddy Brook Subwatersheds and Stream Reaches

Williston Town-Wide Watershed Improvement Plan

O:\Proj-12\WRM\2012-055 Williston Muddy Brook HRG\GIS\MapDocuments\PresentationsAndReports\MuddyBrookReachMap.mxd



Sucker Brook Cross Sections

Sucker Brook Segment Breaks

Sucker Brook Surface Waters

Sucker Brook Subwatershed Boundaries

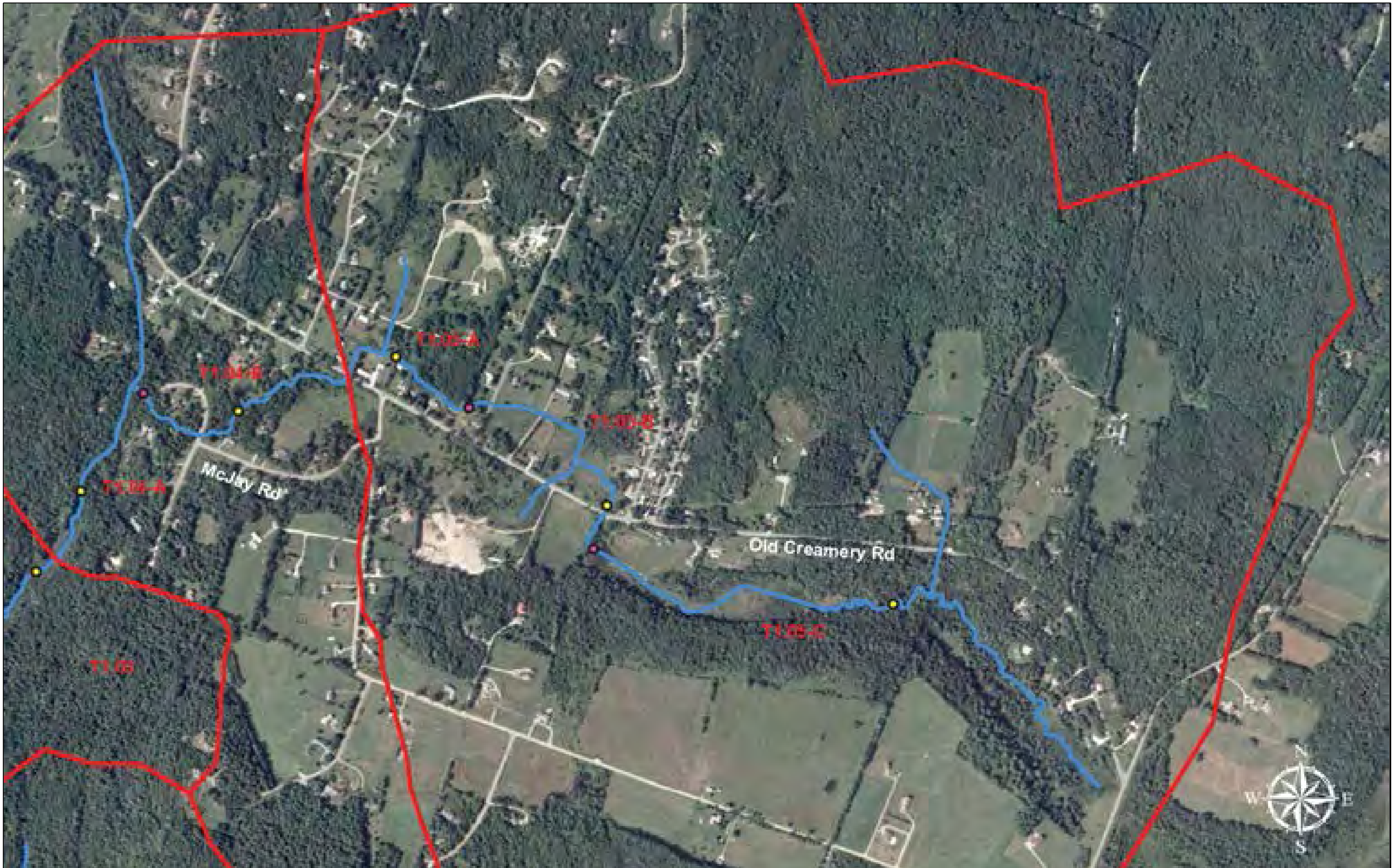
STONE ENVIRONMENTAL INC

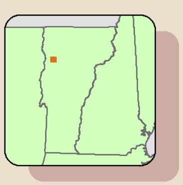
Sources: Sucker Brook Subwatershed data: Fitzgerald Environmental Associates

0 375 750 1,500 Feet

Map 5: Sucker Brook Subwatersheds and Stream Reaches

Williston Town-Wide Watershed Improvement Plan





- Sucker Brook Cross Sections
- Sucker Brook Segment Breaks
- Sucker Brook Surface Waters
- Sucker Brook Subwatershed Boundaries

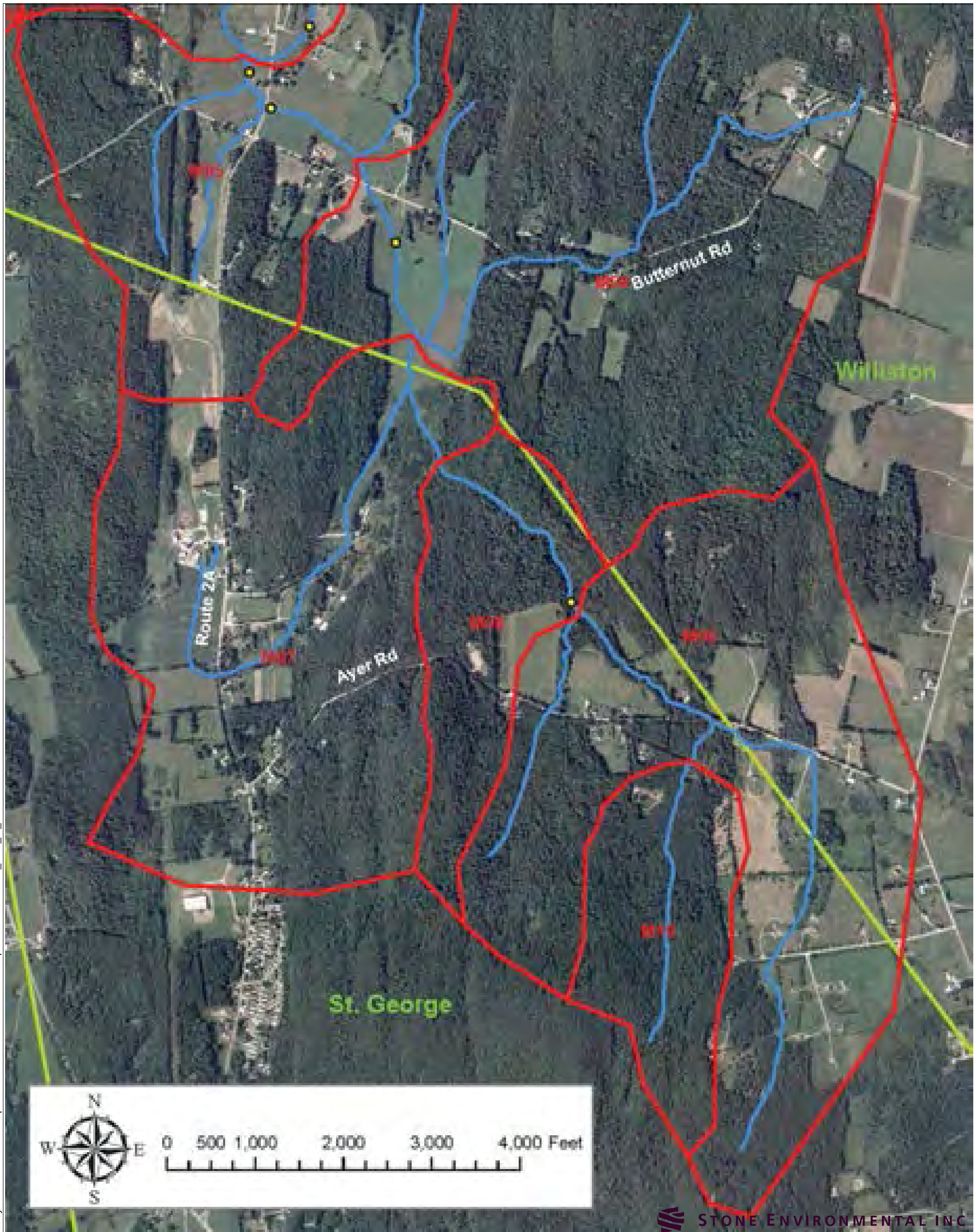
STONE ENVIRONMENTAL INC

Sources: Watershed Boundaries:
Fitzgerald Environmental Associates

0 250 500 1,000
Feet

Map 6: Sucker Brook Subwatersheds and Stream Reaches

Williston Town-Wide Watershed Improvement Plan



Sucker Brook Cross Sections

Sucker Brook Segment Breaks

Sucker Brook Surface Waters

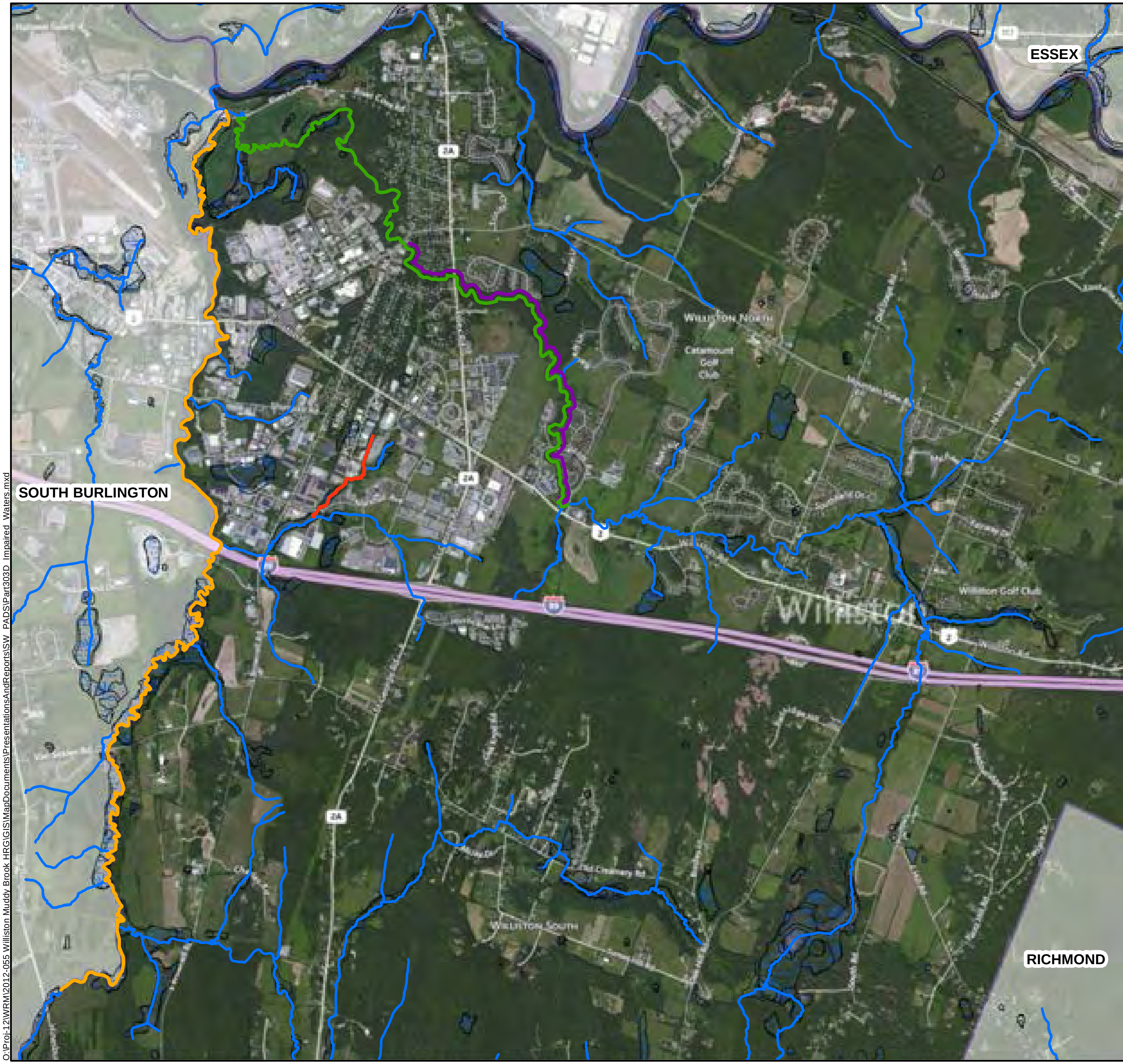
Sucker Brook Subwatershed Boundaries

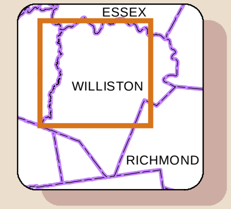
Sources: Watershed Boundaries: Fitzgerald Environmental Associates

Map 7: Sucker Brook Subwatersheds and Stream Reaches

Williston Town-Wide Watershed Improvement Plan

O:\Proj-12\WRM\2012-055 Williston Muddy Brook HRG\GIS\MapDocuments\PresentationsAndReports\SuckerBrook_M05_to_M10.mxd





0 1,000 2,000 4,000
Feet

Pollutant

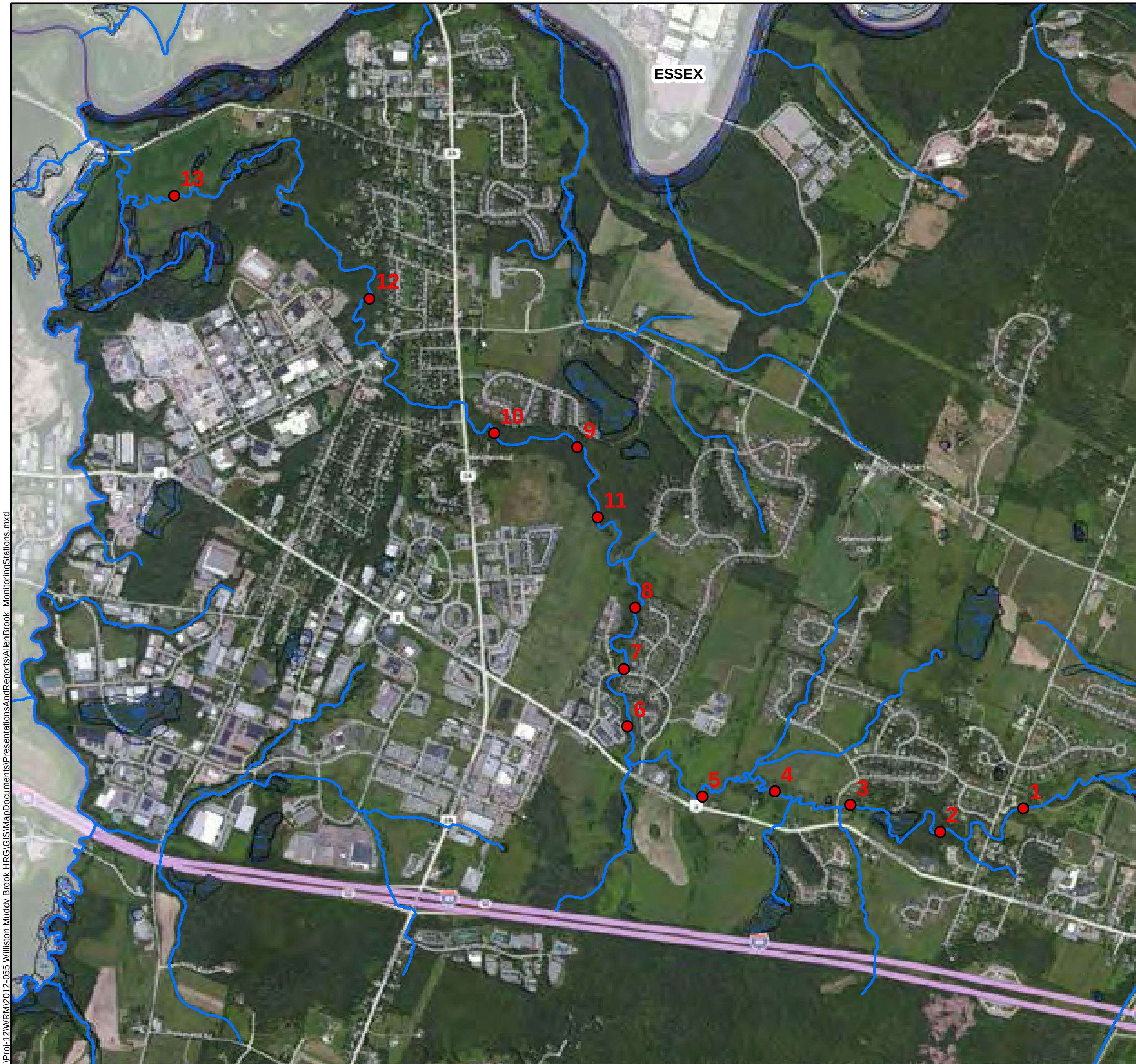
- E. coli
- Stormwater
- Nutrients, Temperature
- Toxics
- River or Stream
- Wetlands

Sources:Hydrography, Wetlands, Impaired Waters: VCGI; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Map 8: 303D Impaired Waters

Williston Town-Wide Stormwater Master Plan



N

0 5001,000 2,000
Feet

- Monitoring Stations
- River or Stream
- Wetlands

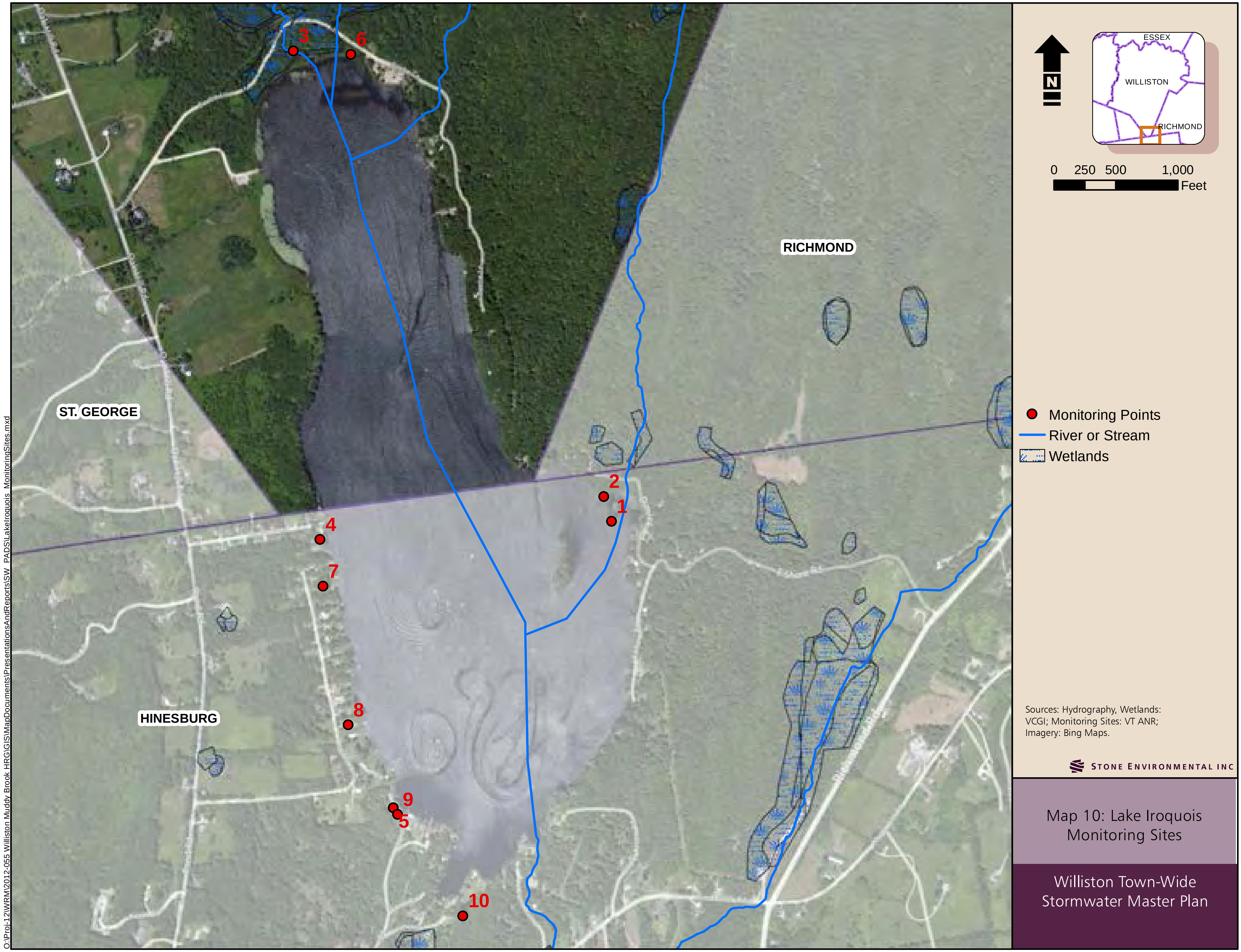
Sources: Hydrography, Wetlands: VCGI; Monitoring Sites: VT ANR; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Map 9: Town of Williston Allen Brook Stream Cross-Section Monitoring Stations

Williston Town-Wide Stormwater Master Plan

O:\Proj-12\WRM\2012-055 Williston Muddy Brook HRG\GIS\MapDocuments\PresentationsAndReports\AllenBrook_MonitoringStations.mxd

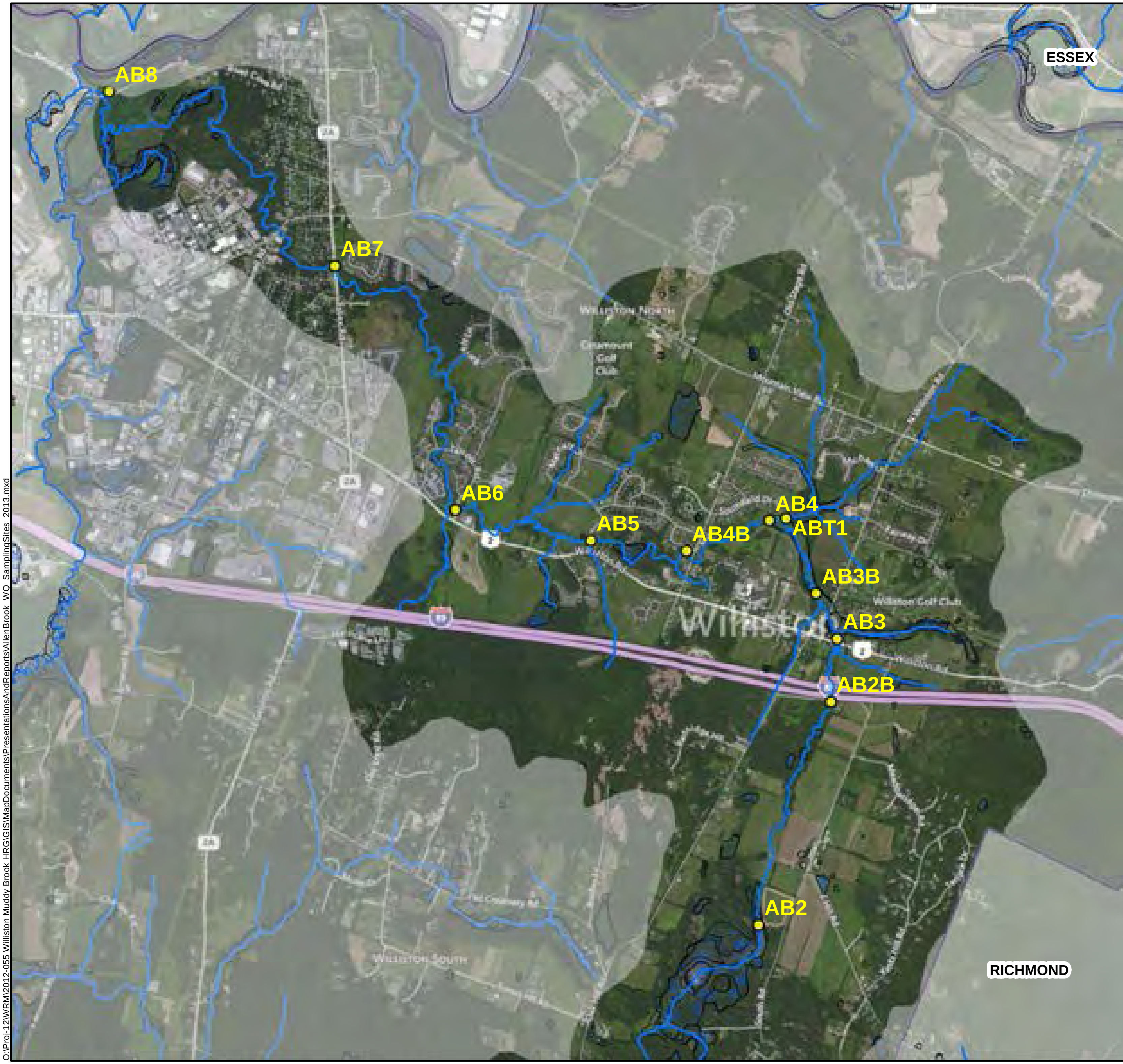


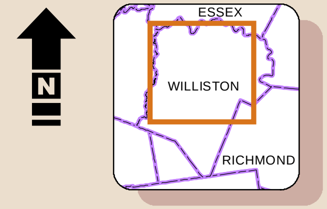
Sources: Hydrography, Wetlands: VCGI; Monitoring Sites: VT ANR; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Map 10: Lake Iroquois Monitoring Sites

Williston Town-Wide Stormwater Master Plan





0 1,000 2,000 4,000 Feet

Water Quality Sampling Sites
River or Stream
Wetlands

Sources: Hydrography, Wetlands: VCGI; Monitoring Sites: VT ANR; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Map 11: Allen Brook Water Quality Sampling Sites 2013

Williston Town-Wide Stormwater Master Plan

O:\Proj-12\WRM\2012-055 Williston Muddy Brook HRG\GIS\MapDocuments\PresentationsAndReports\AllenBrook_WQ_SamplingSites_2013.mxd

Tables A.1 through A.5. Allen Brook Water Quality Monitoring Trends, 2007 - 2012.

Table A.1. Total Nitrogen (mg/L)

Site ID	2007	2008	2010	2012
AB2	0.62	0.54	1.05	0.54
AB2B		0.51	0.62	
AB3	0.37	0.49	0.44	
AB3B		0.48	0.55	
ABT1		0.57	0.5	
AB4	0.6	0.49	0.53	
AB4B		0.47	0.52	
AB5	0.43	0.47	0.40	
AB6	0.46	0.44	0.45	0.44
AB7	0.41	0.45	0.46	
AB8	0.34	0.41	0.31	0.34

Table A.2. Total Phosphorus (mg/L)

Site ID	2007	2008	2010	2011	2012
AB2	60.8	30.4	139.0	70.0	47.0
AB2B		46.3	58.9		51.9
AB3	33.4	43.0	44.9	67.6	45.0
AB3B		39.1	38.8		48.7
ABT1		40.2	53.5		41.9
AB4	74.3	39.3	54.9	67.6	44.7
AB4B		37.1	46.7	68.2	37.4
AB5	21	32.8	36.4	91.9	27.6
AB6	32	34.7	42.5	80.8	42.5
AB7	28.5	30.7	40.5	110.5	40.9
AB8	21.5	25.2	26.7	156.5	27.6

Table A.3. *E. Coli* (MPN/100 mL)

Site ID	2007	2008	2010	2011	2012
AB2	29	48	42	48	156
AB2B		145			
AB3	119	138	286.5	144	231
AB3B		144			
ABT1		148			
AB4	162	249	176.5	378	204
AB4B		152			
AB5	201	152			
AB6	303.5	236	106	239	78
AB7	39	172			
AB8	139	137	133		

Table A.4. Chloride (mg/L)

Site ID	2010	2012
AB2		20.5
AB2B		
AB3		
AB3B		
ABT1		
AB4	67.6	
AB4B	68.2	
AB5	91.9	
AB6	76.75	63.7
AB7	110.5	
AB8	150.4	130

Table A.5. Turbidity (NTU)

Site ID	2010	2011	2012
AB2	3.56	1.24	1.75
AB2B	0.79	1.85	1.84
AB3	2.25	2.22	2.14
AB3B	3.17	3.20	4.26
ABT1	5.55	8.37	6.64
AB4	6.76	5.14	3.95
AB4B	3.89	3.62	2.55
AB5	1.90	1.84	1.37
AB6	3.45	4.54	4.91
AB7	2.86	3.33	4.64
AB8	17.2	5.88	10.7

Notes: Sampling of each parameter did not occur at every site each year. No data were collected in 2009.

Color Key for Median Concentration at each Sampling Site:

Red = High Concentration (top 33% of the median)

White = Moderate Concentration (middle 33% of the median)

Green = Low Concentration (lowest 33% of the median)

Figure A.1: Mean Chloride

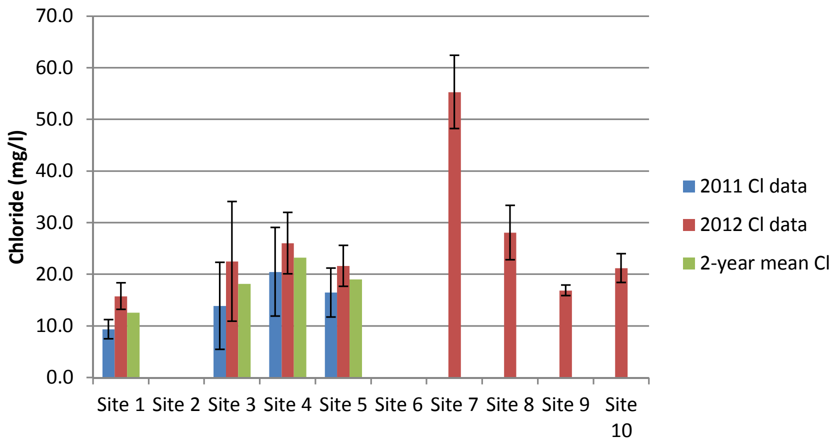


Figure A.2: Mean Total Nitrogen

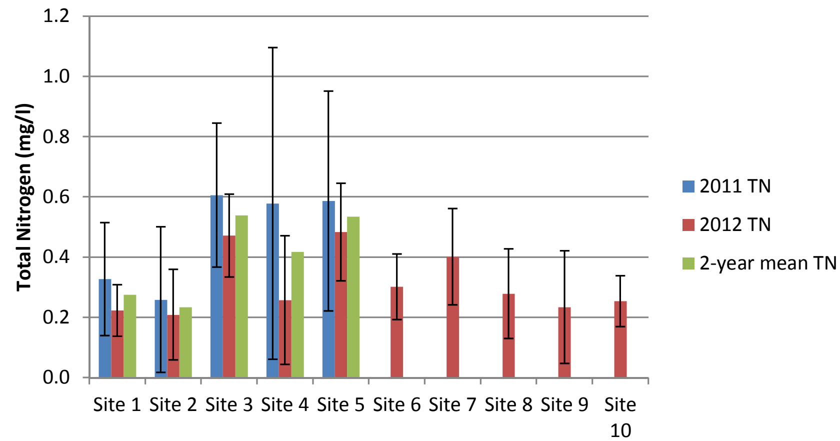


Figure A.3: Mean Total Phosphorus

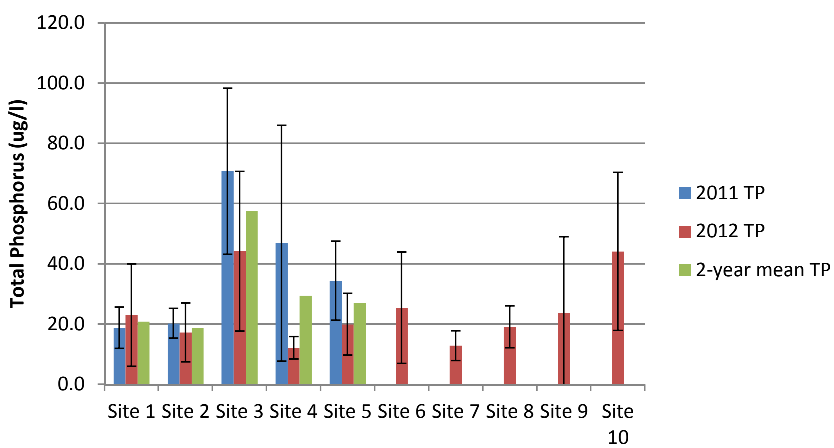
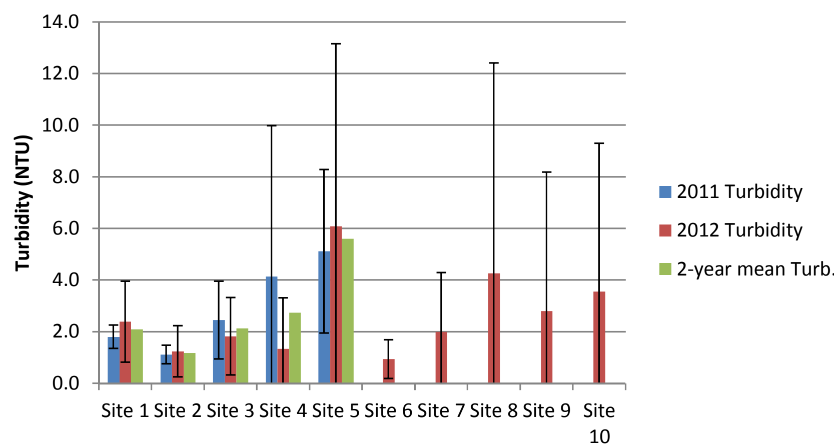


Figure A.4: Mean Turbidity



Figures A.1 through A.4. Mean concentrations of chloride, total nitrogen, total phosphorus, and turbidity at the ten tributary monitoring sites for the 2011-2012 Lake Iroquois Tributary Monitoring Program. Error bars are 1 SD.

APPENDIX B: SWMP CITIZEN QUESTIONNAIRE

Citizen Questionnaire

Town of Williston Town-Wide Stormwater Master Plan

The Town is seeking information from residents about stormwater problems on your property and other locations throughout town. This information will be used to develop a stormwater study that is currently being completed to help shape the Town's strategy for how stormwater can be managed more effectively throughout Williston. Please take a few minutes to check the appropriate answer and write comments where needed.

Thank you in advance for your input.

PLEASE COMPLETE THE FOLLOWING QUESTIONNAIRE AND RETURN BY OCTOBER 31, 2011 TO:	
Adam R. Zahniser, PE Herbert, Rowland & Grubic, Inc. 3755 East State Street Hermitage, PA 16148	Or, send by email to: azahniser@hrg-inc.com

PERSON COMPLETING QUESTIONNAIRE (OPTIONAL; May be used if needed to contact you for additional information)	
Name:	
Owner Address:	
Property Address: (If different from above)	
Phone:	
e-mail:	
How long have you owned or lived at this location?	☐ Less than 1 year ☐ 1 - 5 years ☐ 5 - 15 years ☐ More than 15 years

Local Drainage Problems			
1. Have you experienced flooding or other drainage problems caused by stormwater?	☐ Yes ☐ No		
1.1. If yes, describe the location:			
1.2. If yes, how frequently does the stormwater problem occur at this location?	☐ Less than once per year ☐ Once per year ☐ More than once per year		
1.3. If yes, does it:			
1.3.1. Flood yards or other open space with little or no damage?	☐ Yes	☐ No	☐ N/A
1.3.2. Damage public infrastructure such as roads or utility lines?	☐ Yes	☐ No	☐ N/A
1.3.3. Damage the basement of your primary structure?	☐ Yes	☐ No	☐ N/A
1.3.4. Damage other private property such as landscaping, or accessory structures?	☐ Yes	☐ No	☐ N/A
1.4. If water enters your home (primary structure) does it enter through the (please check all that apply): ☐ Floor ☐ Walls ☐ Drains ☐ Bathtub ☐ Toilet ☐ Windows ☐ Window-Wells ☐ N/A			
2. Where does the excess stormwater that causes this problem come from?			
Street or Road (name)			
Creek or Stream (name)			
Adjacent Property (describe)			
Other Sources (list)			
3. Are you aware of any other problems with the storm drainage system (i.e., ditches, pipes, drains, or streams)?	☐ Yes ☐ No		
3.1 If yes, check all situations that apply. ☐ Corroded pipes ☐ Pipe blockage ☐ Drains in need of repair ☐ Stream or ditch blockage ☐ Other ___________________________			

Stream Flooding Problems	
4. Do you know of flooding that occurs as a result of streams / rivers overflowing their banks?	☐ Yes ☐ No
4.1. If yes, describe the location:	
4.2. If yes, how frequently does flooding occur at this location?	☐ Less than once per year ☐ Once per year ☐ More than once per year
4.3. If yes, does it:	
4.3.1. Flood yards or other open space with little or no damage?	☐ Yes ☐ No ☐ N/A
4.3.2. Damage private property such as landscaping, accessory structures, or homes?	☐ Yes ☐ No ☐ N/A
4.3.3. Damage public infrastructure such as roads or utility lines?	☐ Yes ☐ No ☐ N/A

Erosion Problems	
5. Do you know of any soil erosion problems from a storm drainage system (i.e. ditches, pipes, drains, or streams)?	☐ Yes ☐ No
5.1. If yes, please indicate the location and severity of the problem(s):	
Location:	☐ Minor ☐ Moderate ☐ Severe
Location:	☐ Minor ☐ Moderate ☐ Severe
Location:	☐ Minor ☐ Moderate ☐ Severe

Water Quality Problems	
6. Are you aware any sources of pollution such as trash, sediment, fertilizer, or other chemicals entering a storm drainage system (i.e. ditches, pipes, drains, or streams)?	☐ Yes ☐ No
6.1. If yes, please indicate the location and describe the nature of problem(s):	
Location:	Description:
Location:	Description:
Location:	Description:

Please describe in detail any flood-related or stormwater-related problems that have not already been described above:	
Do you have any photographs, videotape, or other records of flooding problems that occurred on your property or in your neighborhood? If so, please send to the address listed above on this questionnaire. Any documentation or media that you provide will be used to help complete this study.	
☐ No	☐ Video
☐ Written	☐ Other ______________________________
☐ Photos	