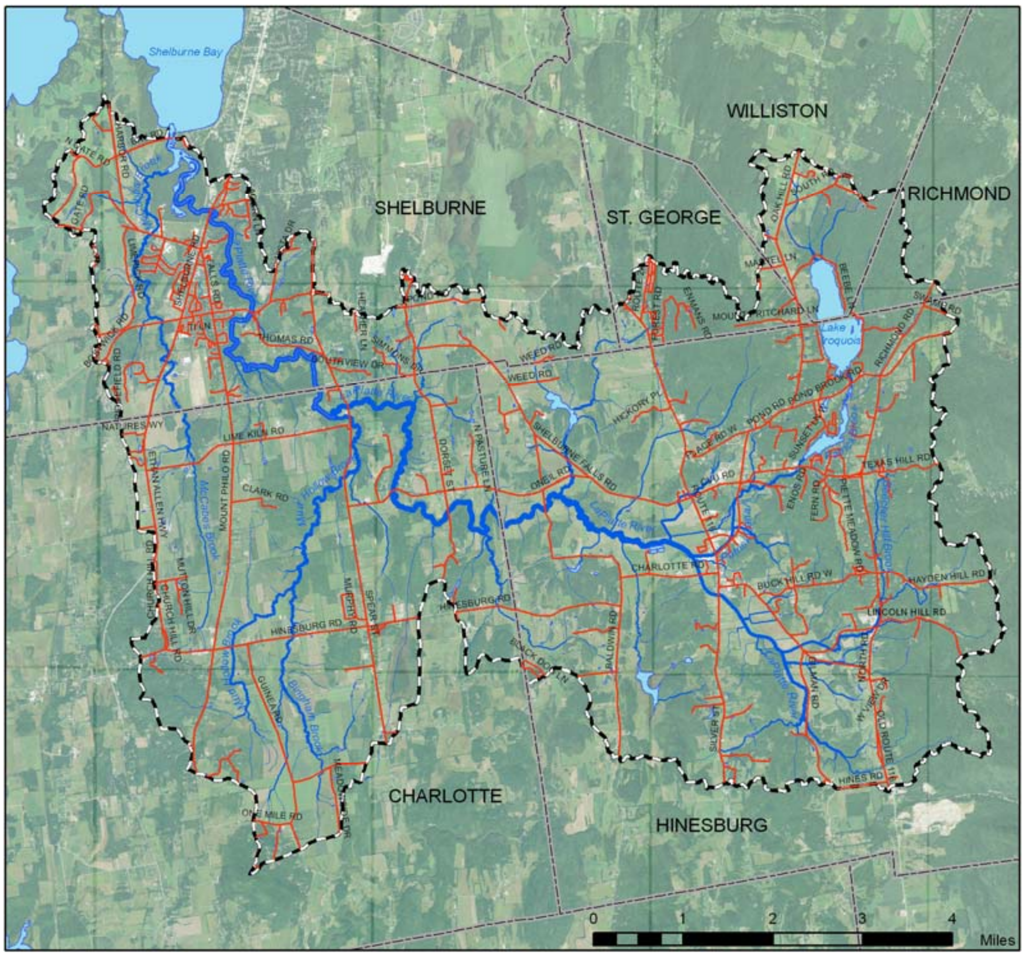
LaPlatte River Watershed
Stormwater Infrastructure Study
Chittenden County, VT

June 25, 2010



Prepared for:
LaPlatte Watershed Partnership
Hinesburg, VT

Prepared by:
Milone & MacBroom, Inc.
South Burlington, VT

Table of Contents

Acknowledgements

This project was funded by a Vermont Clean and Clear Grant to the Lewis Creek Association (CC 2009-RCG-3-04). Andrea Morgante of the LaPlatte Watershed Partnership, in conjunction with Marty Illick of the Lewis Creek Association, coordinated this project. Mark Suozzo, a student at the University of Vermont, provided GIS analysis through a service learning component of the NR-243 course under direction of Jarlath O'Neil-Dunne of the Spatial Analysis Lab and professors in the College of Engineering and Mathematical Science. James Pease and Collin Smythe of the Vermont Department of Environmental Conservation Stormwater Section provided project guidance and technical support for stormwater infrastructure mapping. Pam Brangan of the Chittenden County Regional Planning Commission provided GIS data and project guidance. Bernie Gagnon, Public Works Director for the Town of Shelburne, contributed firsthand knowledge of the stormwater infrastructure in Shelburne. Bill Hoadley added knowledge of stormwater outfalls in Shelburne and regional water quality conditions.

Executive Summary

Milone & MacBroom, Inc was retained by the LaPlatte Watershed Partnership to analyze stormwater impacts on the LaPlatte River and tributaries in Shelburne, Charlotte, and Hinesburg, Vermont. The work here includes both GIS analysis and field verification to identify primary stormwater impacts to water quality and stream geomorphology within the LaPlatte watershed.

Subwatersheds corresponding to stream geomorphic assessment reaches were refined with high resolution topography and field verification of drainage patterns and stormwater infrastructure. These subwatersheds served as a basis for the stormwater analysis.

Stormwater infrastructure mapping was compiled for regions of the LaPlatte River watershed in Shelburne, Charlotte, and Hinesburg. This mapping included collection systems, treatment areas, and outfalls. Data was collected using plans submitted for use with VT DEC stormwater permits, a windshield survey, and collection of GPS information on foot in developed village centers.

A GIS study was performed by a University of Vermont student by subwatershed to estimate relative stormwater risks based on impervious cover, soils, landuse, and runoff volume to target specific subwatersheds for mitigation.

Subwatersheds were ranked based on percent impervious cover and estimated runoff volumes. Ranking confirmed that the priority subwatersheds for focused stormwater mitigation are within the village centers where the most land use conversion has taken place. Priority subwatersheds identified include areas draining to reaches of the LaPlatte River (M04, M06, and M16 village areas), McCabe's Brook (T1.03 in Shelburne Village), the Canal (T4.01, T4.04), and Patrick Brook (M15.S2 in Hinesburg Village).

Results of past stream geomorphic assessment and corridor planning were compared to identified stormwater risks. Several of the subwatersheds that ranked high in terms of impervious surface and runoff volume also had Poor to Fair geomorphic condition (M06, M16, T1.03, T4.01, and T4.04). Many of these subwatersheds, and subwatersheds downstream of priority stormwater subwatersheds, had excessive bank erosion. It appears that stormwater inputs may be contributing to local stream channel adjustment and channel instability.

Stream Habitat condition is Fair to Poor at or downstream of primary stormwater inputs. For example, on the LaPlatte River habitat condition is fair upstream of reach M16 that receives the majority of stormwater from the village center of Hinesburg, yet the condition reduces to Poor downstream of the stormwater inputs. In Patrick Brook, upper reaches were found to have Good habitat while conditions reduced further downstream (T4.02 and T4.01) to Fair to Poor where stormwater inputs occur. In Shelburne, habitat conditions were found to be Fair where the majority of stormwater inputs occur (T3.01, M06).

Water quality monitoring completed in the LaPlatte River and McCabe's Brook by the LaPlatte Watershed Partnership as part of its Volunteer Monitoring Program starting in 2004 (LWP 2008) was reviewed and compared to the stormwater mapping analysis. Water quality data have shown that storm events tend to increase concentrations of nitrogen, phosphorus, and suspended solids. Water quality results indicate that the LaPlatte River may be impacted from runoff from the Shelburne Village area, corresponding to priority subwatersheds identified in the impervious cover and runoff volume ranking. Increases in suspended sediments, phosphorus, and bank erosion downstream of Hinesburg Village are possibly a product of increased local flows from stormwater runoff that are typically untreated at the current time. The water quality report notes, "Phosphorus concentrations in McCabe's Brook are significantly impacted by storm runoff from agricultural land and large impervious surfaces, as well as by stormwater runoff from urban/semi-urban areas in downstream stations." Sampling on Patrick Brook showed increases in turbidity and Total Phosphorus between the Mechanicsville Road and Route 116 crossings, suggesting that runoff from the commercial development may be influencing water quality. Water quality data on Mud Hollow and Bingham Brook tributaries show increased suspended solids and phosphorus concentrations during high flows where large road and field ditch networks are the primary stormwater conveyance mechanisms such as in headwater locations in Charlotte and other rural locations in the watershed.

Stormwater accumulation areas and collection systems discharging within priority subwatersheds without treatment were identified for future stormwater mitigation projects. Projects were identified primarily in the village centers. Contributing drainage area and amount of impervious surface were calculated to guide project implementation.

General recommendations for stormwater management are provided based on the results of this study. These include requirements of smaller scale development to mitigate stormwater and recommendation of a growth center / town village plan for stormwater.

Low Impact Development (LID) techniques are summarized and suggested for local implementation. These practices are small, relatively low cost, and applicable on a property by property basis. Cumulatively, small changes to the amount of impervious surface connected to a drainage system have a large impact. Two specific village neighborhoods are identified for possible implementation. Specific popular LID methods are suggested as possible ways to meet to following stormwater treatment goals.

- Limit the amount of impervious surface and preserve open space
- Disconnect impervious surfaces from collection systems and receiving waters
- Preserve river corridor natural stormwater functions
- Improve stormwater treatment function of roadside ditches

The sources of unregulated and unmitigated stormwater are substantial in the LaPlatte River watershed and the state. The Laplatte River watershed is not designated as a stormwater impaired watershed according the EPA 303(d) list and steps should be taken to improve stream health and avoid a future impaired designation. Stormwater has a cumulative effect on receiving waters and should therefore be examined on a watershed basis, as is done for Total Maximum Daily Load allocations in impaired waterways. This project takes a proactive approach to examine stormwater risks in the LaPlatte River watershed to improve the condition of receiving waters and guide future growth.

1.0 Project Introduction

1.1 Project Overview

Lewis Creek Association and LaPlatte Watershed Partnership (LCA- LWP) have completed water quality and geomorphic assessments (VTANR 2009) for the LaPlatte River that suggest significant erosion and phosphorus mobilization impacts due to stormwater runoff. Likely stormwater stressors include direct connections to river channels from impervious and compacted surfaces, and large-scale tilled agricultural areas directly draining to stream channels.

Examination of stormwater outfalls and impacts to the river channels was identified as a priority project in the Stream Corridor Plan for the LaPlatte River and Tributaries in Town of Hinesburg (LWP 2007) and Reaches M6-M11 in Towns of Charlotte and Shelburne (LWP 2008). LCA-LWP retained Milone & MacBroom Inc. (MMI) to study stormwater infrastructure and inputs to the LaPlatte River in Shelburne, Hinesburg, and Charlotte. The objectives of the project follow.

- Update and expand existing stormwater infrastructure mapping with available plans and field verification to provide tool for future stormwater management.
- Identify likely stormwater impact locations in the LaPlatte River Watershed using available GIS resources and updated stormwater infrastructure mapping, and land use regulations.
- Relate stormwater runoff and infrastructure to previously collected geomorphic, habitat, and water quality data.
- Identify potential stormwater design projects for implementation.
- Provide recommendations for further river protection planning strategies.
- Share revised GIS mapping with project stakeholders. GIS files will reside with LCA-LWP, DEC, CCRPC, and the Towns.

Many project partners have worked with LCA-LWP and MMI to contribute data, analysis, methods, and interest in project outcomes.

- University of Vermont, Spatial Analysis Laboratory
- Chittenden County Regional Planning Commission (CCRPC)
- Vermont Department of Environmental Conservation (DEC) Stormwater Section
- DEC River Management Program
- Town of Shelburne

- Town of Hinesburg
- Town of Charlotte

1.2 Project Need / History of Stormwater Management

As land becomes increasingly compacted, cleared, and covered with impervious surface a larger volume of stormwater will run off the land rather than infiltrate. Land use conversion away from naturally vegetated condition tends to shorten the amount of time it takes for water to travel to the receiving body. The increased volume and shortened time for water to reach the stream contribute to increasing peak flood discharges, volumes, and water surface elevations in the river.

As the flow changes, the channel adjusts to attempt to regain the balance between water and sediment (Lane 1955). Erosion of bed and banks, and downstream sediment deposition is often associated with channel adjustment. Thresholds of impervious cover below which water quality and stream conditions deteriorate have been found (e.g., Brabec, Schulte et al. 2002; CWP 2003; Fitzgerald 2007; Schiff and Benoit 2007).

Stormwater is regulated by both federal and state laws, and municipalities may choose to implement further rules. The Vermont Department of Environmental Conservation (DEC) Stormwater Section issues permits for stormwater runoff from impervious surfaces, construction sites, and industrial properties. Vermont began regulating developments that created impervious surfaces in the 1970's.

Impervious surfaces are regulated to comply with Vermont Statute 10 V.S. A. 1264. These "operational" stormwater permits are required if a new or redevelopment project creates more than 1 acre of impervious surface or expands by more than 5,000 square feet. If a project with more than 1 acre of impervious is located within a stormwater impaired watershed it is held to a higher standard and must apply for an Individual permit, otherwise projects apply for coverage under General Permit 3-9015. To meet General Permit standards, the site must follow criteria outlined in the 2002 Vermont Stormwater Manual (VTDEC 2002) for protection of water quality, groundwater recharge, and channel health. Developments that add 1 to 10 acres of impervious cover must detain the 1-year storm (i.e., channel protection) and the 10-year storm (i.e., overbank flood protection). Projects creating more than 10 acres of impervious cover require detention of the 100-year storm (i.e., extreme flood control.

Some watersheds have been designated as stormwater impaired as listed on the State of Vermont 303(d) List (VTDEC 2008). Stormwater impairment requires creation of a Total Maximum Daily Load (TMDL) to set standards for discharge in the watershed. Stormwater discharges within watersheds designated as impaired are required to meet higher standards and required to obtain a

National Pollutant Discharge Elimination System (NPDES) General Permit 3-9030. These rules are in the process of changing, with an increase in standards set to take effect on October 15, 2010. Upcoming changes will include standards for properties with existing impervious surfaces less than one acre, as presented in a the *Small Sites Guide for Stormwater Management* (VTDEC 2009). Currently the LaPlatte River and its tributaries are not listed on the 303d list that designates impaired waterways. Shelburne will be affected by some of these more stringent rules due to the impairment of Munroe Brook.

Multiple municipalities in Vermont are subject to an additional standard based on the federal EPA's Phase II Stormwater Rule due to their size or other criteria such as containing an impaired waterway. The applicable National Pollutant Discharge Elimination System (NPDES) permit is called the General Permit for Small Municipal Separate Storm Sewer Systems (MS4). In the LaPlatte River watershed, Shelburne falls under MS4 jurisdiction. MS4 towns are required to plan for: Public Education and Outreach, Public Participation/Involvement, Illicit Discharge Detection and Elimination, Construction Site Runoff Control, Post-Construction Runoff Control, and Pollution Prevention/Good Housekeeping. Specific boundary areas for permit jurisdiction are drawn. MS4 permit area in the Town of Shelburne includes the Munroe Brook watershed (a stormwater impaired watershed) and a census-designated urbanized portion of the village center. Vermont Agency of Transportation is permitted under the MS4 program as a non-traditional system.

Construction sites often have large areas of exposed soil that can contribute large amounts of sediment to receiving water bodies during a storm event. The VTDEC Construction Stormwater Permit Program addresses stormwater discharge during construction. Construction General Permit 3-9020 is required for sites that disturb 1 or more acres of land. This permit was created by DEC to meet federal requirements of the Clean Water Act under NPDES. There are three levels of permitting requiring increasing levels of mitigation based on area disturbed, watershed impairment, disturbance time, slopes and soil erodibility.

New and existing industrial sites are required to obtain a Multi-Sector General Permit (MSGP). This permit is a NPDES permit, also a requirement of the federal Clean Water Act administered by DEC. The permit includes a long list of facilities required to be covered including many forms of manufacturing, mining, water and solid waste facilities, transportation, mills, among others.

There are stormwater systems that originally obtained a permit, but have let their permit lapse. These systems fall under a special Orphan Stormwater Program. This program is geared toward reviewing the stormwater treatment of a subdivision, bringing failing systems back into compliance, and issuing a permit. The permit obtained would be under General Permit 3-9010 "Previously Permitted Stormwater Discharges to Waters that are Not Principally Impaired," and would not be applicable to stormwater impaired watersheds. Systems in this program would be transferred to the municipality for control of the system and future responsibility and maintenance.

Many sources of runoff are not covered by a permit.

- Road systems contribute a significant amount of impervious surface and channelization of flow in roadside ditches. State Routes are covered under the VTRANS MS4 permit, but all local and private roads are uncovered and have no mitigation unless built recently enough to fall under the jurisdiction of one of the permits. Runoff from ditches is widespread component of rural stormwater runoff in the LaPlatte River watershed.

- Impervious surfaces created before the 1970's when permitting began.

- New and redeveloped areas with less than one acre of impervious surface (unless in stormwater impaired watershed, in MS4 area, or industrial facility).

The sources of non-permitted and unmitigated stormwater in the LaPlatte River watershed and Vermont are abundant and widespread. Stormwater has a cumulative effect on receiving waters and therefore should be examined on a watershed basis, such as TMDL allocations for impaired waterways.

In non-stormwater impaired watersheds, non-industrial projects creating less than 1 acre of impervious surface are not required to obtain a stormwater permit in Vermont (excluding MS4 towns). The federal and state permitting environment tends to leave most stormwater discharges that are established incrementally in small to moderate projects non-regulated and untreated. The responsibility for maintenance of stormwater infrastructure and level of treatment defaults to the municipalities.

Planning is needed to improve the current minimal level of treatment and inform the smart growth movement that is taking place across Vermont. Low-impact development should include green infrastructure to create the required treatment systems to facilitate growth while minimizing impacts to receiving waters, ecosystems, open space, and human health. Outreach is needed to increase public awareness of stormwater impacts and move beyond the traditional expectations to collect stormwater and pass it downstream as fast as possible, even without any level of treatment or consideration of downstream impacts. This project takes a proactive approach to understanding and improving stormwater conveyance and treatment in the LaPlatte River watershed.

2.0 Watershed and Subwatersheds

The LaPlatte River runs approximately southeast to northwest and drains into Shelburne Bay of Lake Champlain (Figure 1). The LaPlatte River watershed has an area of approximately 53 square miles with contributing areas in Hinesburg (46%), Charlotte (30%), Shelburne (17%), Williston (4%), St. George (2%), and Richmond (1%). This study focuses on areas within Shelburne, Hinesburg, and Charlotte because of their significant contributing areas, presence of village centers, and existing infrastructure.

The LaPlatte River is a 5th order stream when it flows into Lake Champlain. Stream order (Strahler 1952) is one indicator of the size of a stream. Headwater streams are 1st order, when two 1st order streams meet they form a 2nd order stream, when two 2nd order streams meet they form a 3rd order stream, and so on. If two streams of different orders join, they retain the higher order downstream of the confluence. Stormwater inputs occur at all stream sizes, and accumulate in the downstream direction. Typical inputs are from ditches in rural headwaters and ditch/pipe systems near village centers.

Stream geomorphic and habitat assessments (VTANR 2009) have been completed for the LaPlatte River Watershed and provide an understanding of current river form and processes and how these may have departed from reference conditions based on the LaPlatte River valley. The geomorphic data is useful to guide planning efforts for conservation and restoration.

Phase 1 and 2 assessments have been completed for the LaPlatte River reaches M03-M11 and McCabe's Brook tributary reaches T1.02-T1.05 (LWP 2007). Phase 2 was also completed for Hinesburg reaches including M12-M18 and sections of tributaries including Patrick Brook, Beecher Hill Brook, the Canal, and an unnamed tributary T3 (LWP 2006). Data were used to create a Stream Corridor Plan for the LaPlatte River and Tributaries in Town of Hinesburg (LWP 2007) and Reaches M6-M11 in Towns of Charlotte and Shelburne (LWP 2008). These prior studies, available for download at the LaPlatte Watershed Partnership website: (http://www.lewiscreek.org/LaPlatte), provided information for the current study.

Subwatersheds, reaches, and segments were originally delineated during the Phase 1 and 2 assessments. Watershed divides originally delineated using USGS topographic maps have been updated where new high resolution LIDR data area available (Figure 2). LIDAR data now exist for 76% of the watershed, mostly excluding Charlotte. Subwatershed delineations in Charlotte are not as precise due to lower resolution topography available.

Stormwater infrastructure was mapped based on plans of state-permitted systems and field observations in village centers (see Section 6.0 for more details). Subwatershed delineations were refined based on the stormwater infrastructure mapping (Figure 3). Field verification of drainage patterns resulted in adjustment of many subwatershed divides. Observations of the

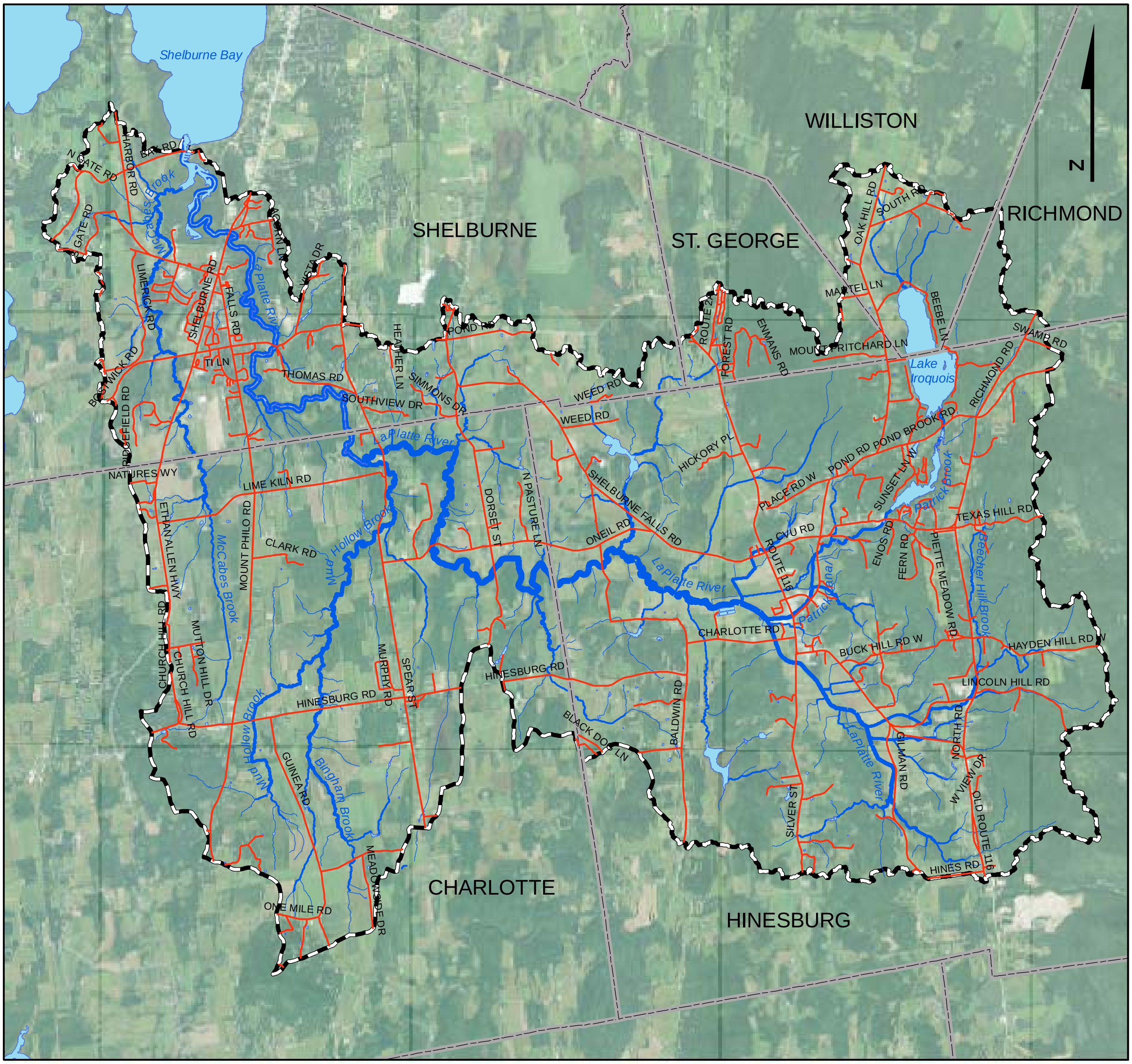


Figure 1: LaPlatte River Watershed

Roads

Towns

LaPlatte River Watershed

Lakes and Ponds

River (By Stream Order)

1 2 3 4 5

Background aerial imagery from 2008 National Agriculture Inventory Program. Roads from Emergency 911 database obtained from VCGI.org. Streams from Vermont Hydrography Dataset obtained from VCGI.org. Watershed based on HUC-12 outline, updated where high resolution topography was availiable by Mark Suozzo and by field verification by Milone & MacBroom, 2009.

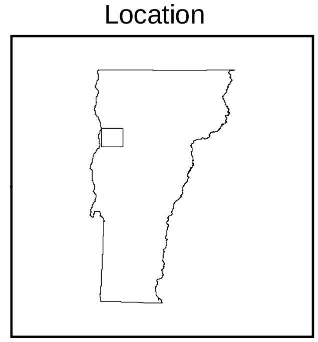
Created March 23, 2010

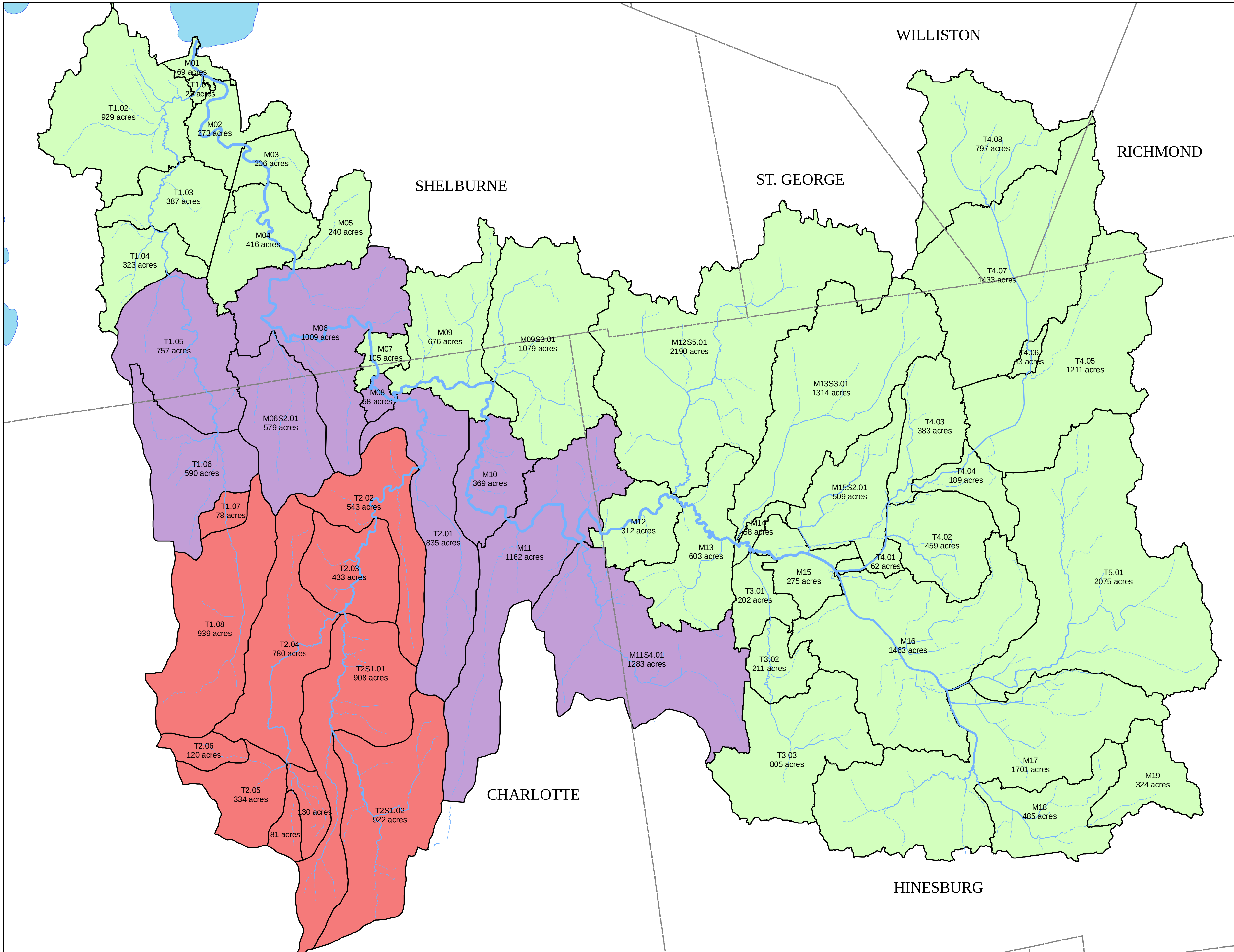
Engineering, Landscape Architecture and Environmental Science

MILONE & MACBROOM®

0 1 2 3 4 Miles

Location





N
W
E
S

Reach Subwatersheds (By Data Source)

- LIDAR
- Phase 1
- Spliced
- Town Boundary
- Lake Champlain

River (By Stream Order)

1 2 3 4 5

Reach Subwatersheds

LaPlatte River Watershed Stormwater Project

Map By: JSC

Date: January 2010

Scale: 1" = 4,500'

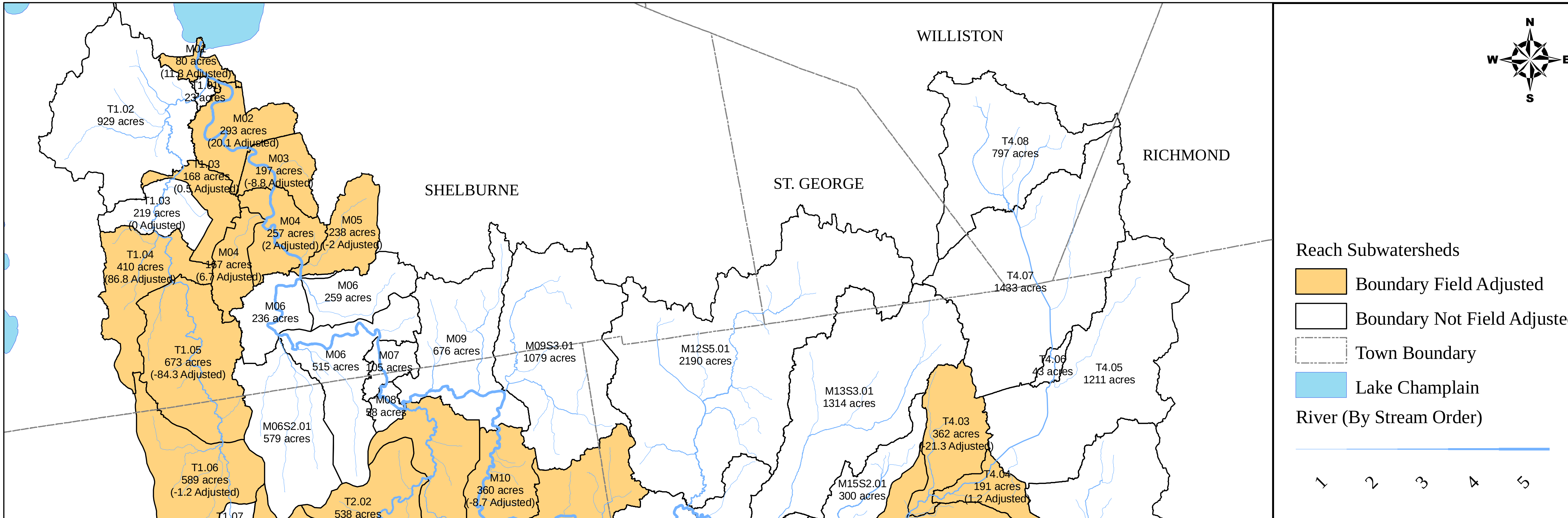
Sheet:

Figure 2

Engineering, Landscape Architecture and Environmental Science

MILONE & MACBROOM®

1233 Shelburne Road, Suite 150
South Burlington, VT 05403
Phone: 802.864.1600
Fax: 802.864.1601



Stormwater Corrected Reach Subwatersheds

LaPlatte River Watershed Stormwater Project

Map By: JSC

Date: January 2010

Scale: 1" = 4,500'

Sheet:

Figure 3

Engineering, Landscape Architecture and Environmental Science

MILONE & MACBROOM®

1233 Shelburne Road, Suite 150
South Burlington, VT 05403
Phone: 802.864.1600
Fax: 802.864.1601

rural road ditch network in Charlotte led to refinement of many of the previously mapped subwatersheds. Stormwater collection systems in the village centers of Shelburne and Hinesburg often did not follow ground topography and resulted in transferring collected runoff between previously delineated subwatersheds (see Section 6.0 for more details). Subwatershed divides were adjusted where these inter-basin transfers occurred to properly represent the runoff contributing to subwatershed and stormwater system outlets.

Some subwatersheds were divided to provide a more detailed picture of the stormwater contributions in village centers. For example, reach M16 in Hinesburg was split because the lower section is in the village center with dense development and multiple stormwater outfalls while the upper segment is relatively rural. The refined subwatershed delineations improve upon past delineations, are used as the basis for analysis for this study, and should be used for future studies in the LaPlatte River watershed. GIS shapefiles of these subwatersheds will be provided to project partners for future use.

3.0 Geology

3.1 Bedrock Geology

Watershed infiltration and aquifer storage characteristics are governed by the underlying bedrock geology. Bedrock is the parent material that makes up overlying layers. It dictates presence of aquifers versus impermeable layers and infiltration characteristics of soils. Bedrock formations in the watershed include dolostones, quartzites, marble, and shales (Figure 4) general descriptions of bedrock types are included in Table 1.

Table 1: Summary of Bedrock Geology in the LaPlatte River Watershed

Code	Name	Area (acres)	Percent Area (%)	Description
Ob	Bascom Formation	613	1.8	Interbedded dolostone, limestone and marble with horizons of calcareous sandstone.
Cch	Cheshire Quartzite	23	0.1	Feldspar-rich, thin to thick-bedded, white to buff quartzite with argillaceous horizons.
COcs	Clarendon Springs Formation	4,997	14.8	Massively bedded light gray dolomite with numerous vugs and quartz knots on weathered surfaces, in places disseminated quartz grains are present.
k	Cretaceous dikes	14	0.0	Leucophyres and lamprophyres variable in color from black to brick red.
Oc	Cutting Dolostone	1,489	4.4	Massively bedded gray dolostone.
Cda	Danby Formation	3,017	8.9	Interbedded sandstone and dolostone horizons.
Cdu	Dunham Dolostone	205	0.6	Cyclically bedded buff to pink colored dolostone and massively bedded structureless buff to white dolostone.

Code	Name	Area (acres)	Percent Area (%)	Description
CZfp	Fairfield Pond Formation	6,160	18.2	Light gray to light green quartz-sericite-chlorite phyllite magnetite biotite.
Oi	Iberville Shale	1,422	4.2	Black argillaceous shale weathers buff in color.
LAKE	Lake	4	0.0	
Cm	Monkton Quartzite	4,715	14.0	Lower unit a gray to white sandstone, often with quartz pebble horizons; upper unit interbedded red sandstone, red shale and buff colored dolostone.
CZp	Pinnacle Formation	1,929	5.7	Undifferentiated metagreywackes and schists.
Os	Shelburne Marble	2,997	8.9	Massively bedded white to gray pinstriped sucrosic marble. West of the Champlain Thrust the unit is a mottled gray and white limestone formerly termed the Ticonderoga Formation.
Osp	Stony Point Shale	30	0.1	Black calcareous fissile shale.
Cw	Winooski Dolostone	6,158	18.2	Buff to gray color, medium- to massively bedded dolostone.
	Totals:	33,773	100.0	

3.2 Landforms

The entire LaPlatte river watershed is located within the Champlain Valley biophysical region of Vermont (Thompson and Sorenson 2005). This area was glaciated and covered at times by both fresh and salt waterbodies. The LaPlatte River watershed is dominated by glaciolacustine deposits – deposits from glaciers that settled out in large water bodies. Sediments deposited after the melting of glaciers have been and continue to be transported and deposited by regional river systems (LWP 2007).

The volume and runoff rate within a watershed are largely a function of soil characteristics of the area that in turn directly related to the landforms that they are associated with. Sand and gravel allow more precipitation and runoff to infiltrate into the ground than silts and clays. In contrast, shallow bedrock, compact glacial till, clay, and saturated lowlands limit infiltration and leads to increased runoff.

Glaciolacustrine clay deposits with interspersed bedrock outcrops makes up the majority of the western two thirds of the watershed (Figure 5, Table 2). Compacted glacial till and bedrock make up most of the eastern third of the watershed. The presence of clay and bedrock over much of the LaPlatte River watershed indicates poor drainage and limited potential for stormwater treatment.

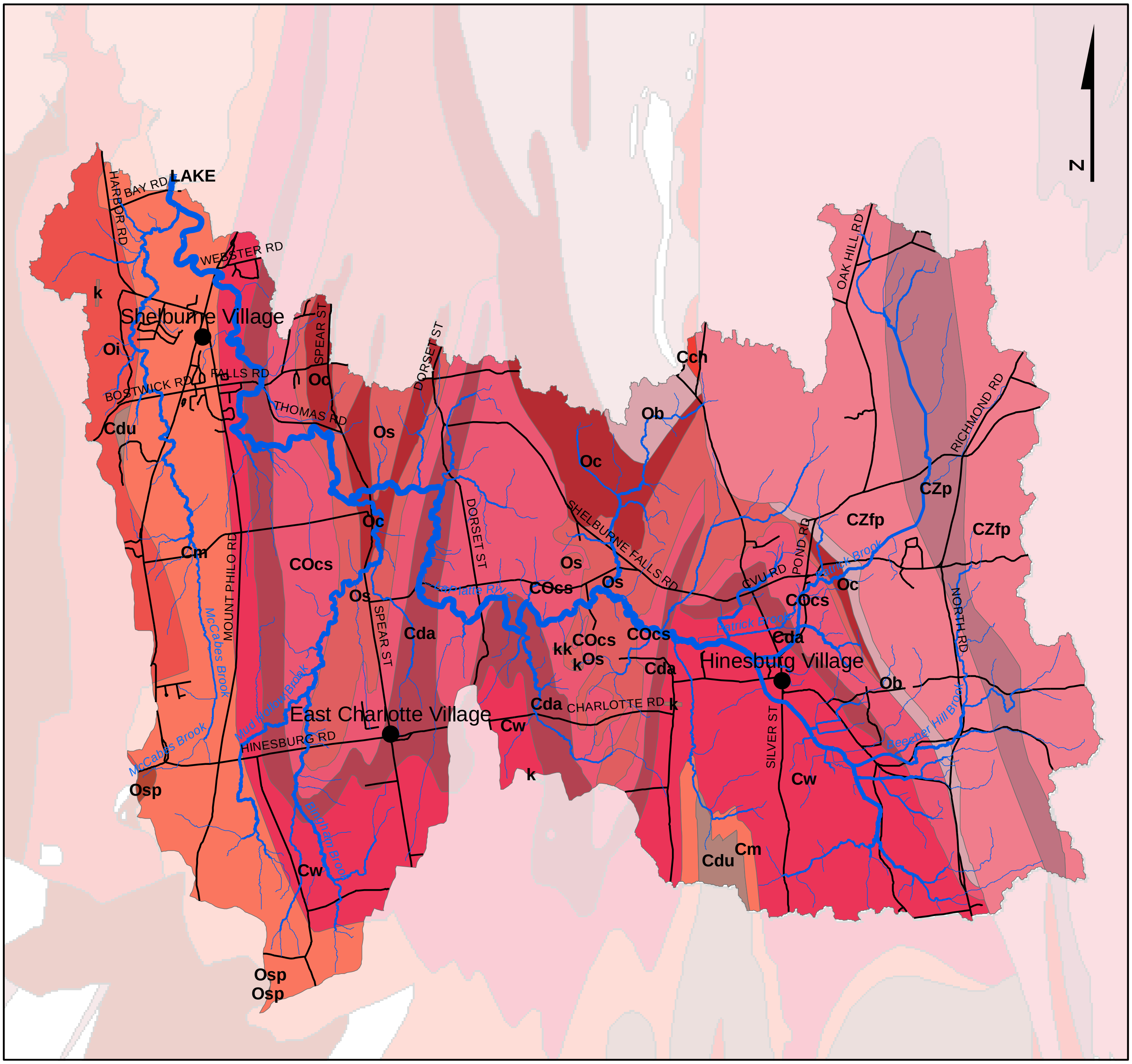


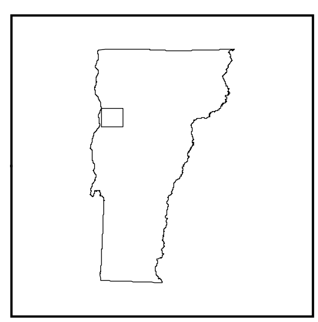
Figure 4: Bedrock Geology of LaPlatte Watershed

Bascom Formation , Ob	Danby Formation , Cda	Monkton Quartzite , Cm
Cheshire Quartzite , Cch	Dunham Dolostone , Cdu	Pinnacle Formation , CZp
Clarendon Springs Formation , COcs	Fairfield Pond Formation , CZfp	Shelburne Marble , Os
Cretaceous dikes, k	Iberville Shale , Oi	Stony Point Shale , Osp
Cutting Dolostone , Oc	Lake, LAKE	Winooski Dolostone , Cw

The bedrock geology dataset includes data that was compiled from RF 100,000 USGS base maps. The data was created under the auspices of the Vermont Geological Survey with the assistance of the Information Management Section of the Agency of Natural Resources.

Map originally created by Mark Suozzo as part of UVM course NR-243, December 18, 2009. Updated by Milone & MacBroom, Inc. March 23, 2010.

0 1 2 3 4 Miles



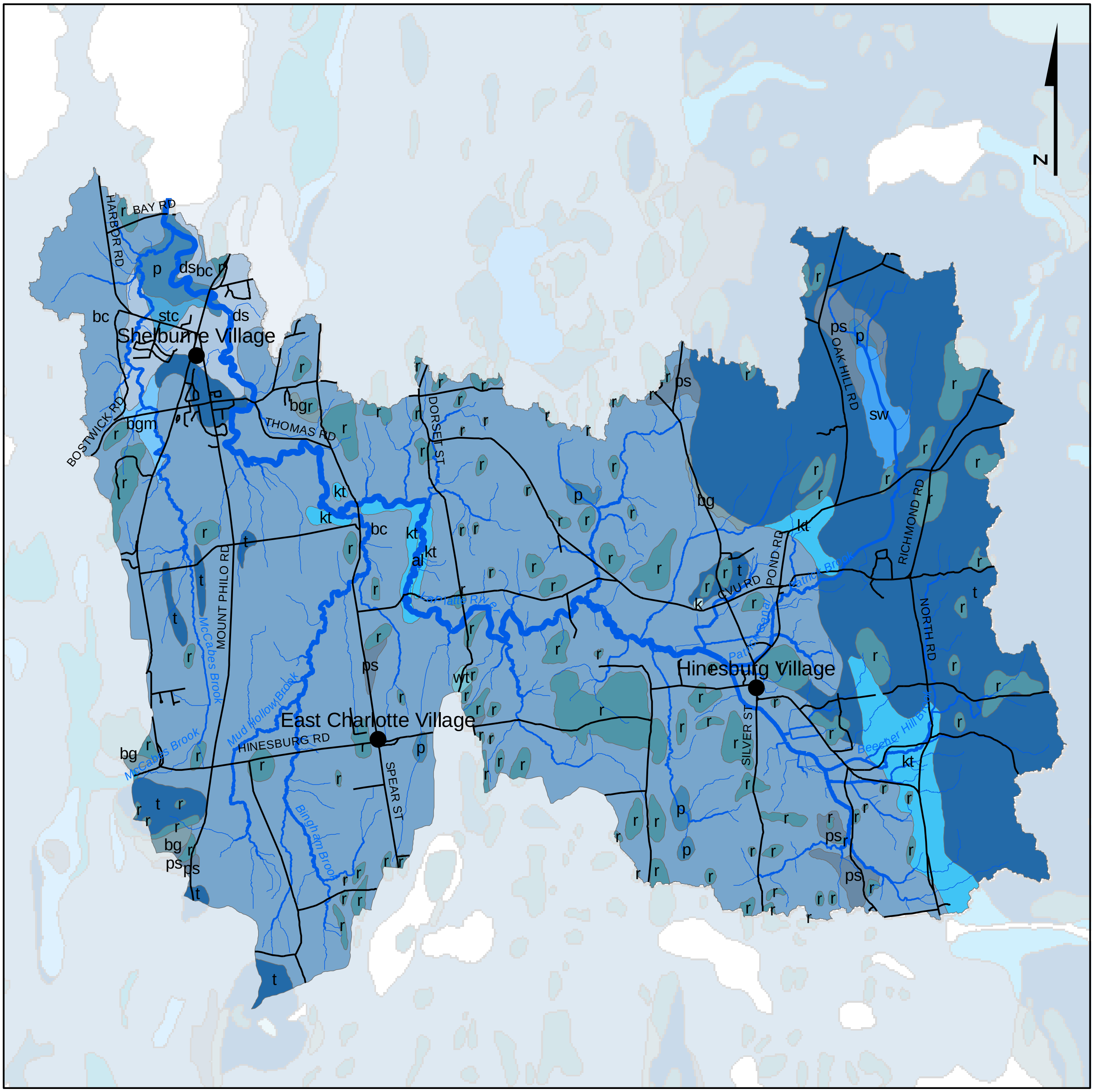


Figure 5: Suficial Geology of LaPlatte Watershed

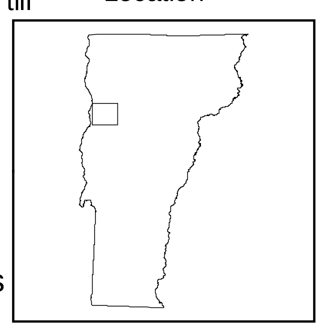
- al, alluvium
- bc, boulders in clay
- bg, beach gravel
- bgm, marine beach gravel
- ds, delta sand
- k, isolated kame
- kt, kame terrace
- p, swamp, peat and/or muck
- ps, pebbly sand
- psm, pebbly marine sand
- r, bedrock exposure
- stc, silt, silty clay, and clay
- sw, surface water
- wt, wave-washed till
- t, till

The surficial geology data consists of surficial geologic features as digitized from the 1:62,500 15 minute series USGS quadrangle map sheets, compiled by The Vermont Geological Survey 1956-1970.

Map originally created by Mark Suozzo as part of UVM course NR-243, December 18, 2009. Updated by Milone & MacBroom, Inc. March 23, 2010.

0 0.5 1 2 3 4 Miles

Location



Sands and gravels are mapped in approximately 8% of the watershed. This permeable material is important as it serves as groundwater infiltration areas. Permeable soils located near village centers are valuable assets for infiltration to support aquifer recharge and stream baseflow and for stormwater treatment. A green infrastructure overlay could be created to locate and appropriately value these areas to target them for land conservation for protection of the hydrologic cycle and to facilitate smart growth. Land use in this district could be anything that does not compact soils or install impervious cover. The treatment of stormwater should be evaluated for future development as is currently done for siting septic system leach fields.

Table 2: Summary of Surficial Materials in LaPlatte River Watershed

Code	**Feature**	**Description**	**Area (Acres)**	**Percent Area (%)**
r	Bedrock exposure	bedrock exposure	3,053	9.0
bgm	Champlain Sea deposit	marine beach gravel	128	0.4
psm	Champlain Sea deposit	pebbly marine sand	3	0.0
t	Glacial deposit	till	7,225	21.4
k	Glaciofluvial deposit	isolated kame gravel	6	0.0
kt	Glaciofluvial deposit	kame terrace gravel	1,092	3.2
bc	Glaciolacustrine deposit	boulders in clay	20,061	59.4
bg	Glaciolacustrine deposit	beach gravel	142	0.4
ds	Glaciolacustrine deposit	delta sand	746	2.2
ps	Glaciolacustrine deposit	pebbly sand	493	1.5
stc	Glaciolacustrine deposit	silt, silty clay, and clay	78	0.2
wt	Glaciolacustrine deposit	wave-washed till	24	0.1
p	Pluvial deposit	swamp, peat and/or muck	438	1.3
al	Postglacial fluvial deposit	Alluvium, sand and gravel	46	0.1
sw	Surface Water	surface water	235	0.7
		Totals:	33,769	100.0

3.3 Soils

Soil type strongly influences runoff characteristics throughout a watershed. Soil types in the watershed were determined from the NRCS soil survey for Chittenden County, Vermont that includes Hydrologic Soil Group (HSG) classifications of all soils (Figure 6). The NRCS divides soils into four hydrologic soil groups: A, B, C, or D, depending on their infiltration capacity – the maximum rate water can enter the soil. A soils are well-drained and have high infiltration capacity. D soils have the lowest infiltration capacity and generate the highest runoff rates.

Wetlands typically form in low-gradient areas with poorly drained soils. Wetlands serve important ecosystem functions such as unique habitats and food sources for fish and wildlife, and

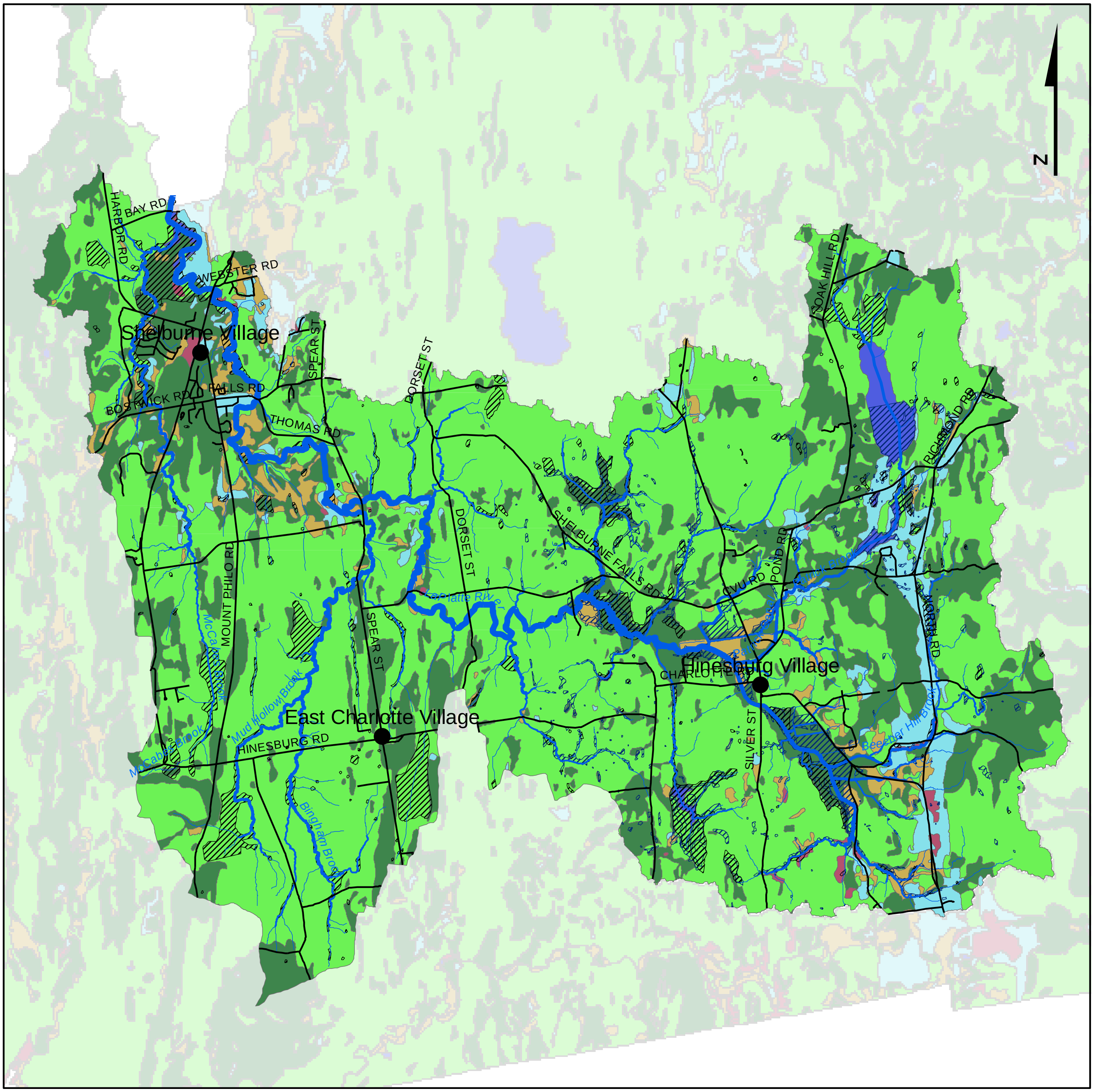


Figure 6: Hydrologic Soil Groups and Wetlands

Soil data were developed from materials used by the Natural Resource Conservation Service (NRCS) to prepare the Chittenden County soil survey. The soil data used were prepared by soil scientists as part of the National Cooperative Soil Survey. Hydrologic soil classifications conform to those used by the National Resource Conservation Service (NRCS) and to the Vermont Stormwater Manual.

Wetlands from Vermont Significant Wetlands Inventory (VSWI) updated February 2006. Additional wetlands shown are from multiple sources and should be used for planning purposes only. Included are delineations in Hinesburg from Arrowhead Environmental completed 2006 (southern parcel) and 2009 (village area) extending only to property bounds of selected parcels. Also included are generalized and potential wetlands identified by UMASS for the Town of Hinesburg based on 1993 aerial photography in 2006.

Map originally created by Mark Suozzo as part of UVM course NR-243, December 18, 2010. Updated by Milone & MacBroom, Inc. April 14, 2010.

A **C** **not rated**

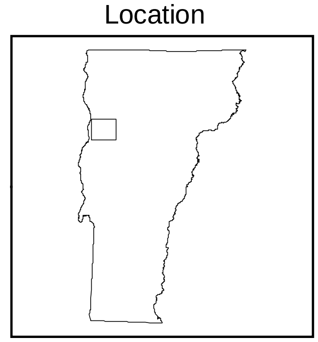
B **D** **water**

Vermont Significant Wetlands

Wetlands Additional Delineations

0 0.5 1 2 3 4 Miles

Location



important ecosystem services such as detainment of surface water. Wetlands identified in the Vermont Significant Wetlands Inventory have been overlaid on the soils map (Figure 6) to show relationship between their location and HSG. Large wetlands tend to be found in areas with C and D soils, and adjacent to stream channels. A higher resolution of wetland delineation is available in Hinesburg based on a past study of potential recreation areas and has been included in mapping (Figure 6).

A small part of the LaPlatte River watershed has soils that are suitable for infiltration (Table 3). The permeable soils are generally located on alluvial deposits in the LaPlatte River corridor in Hinesburg and Shelburne, and in a north-south band approximately following North Road and Beecher Hill Brook in Hinesburg, South of Lake Iroquois. Given the limited presence of areas with high infiltration rates, these locations should be prioritized for conservation for stormwater treatment as part of a green infrastructure system and for aquifer protection.

Table 3: Summary of Soils in LaPlatte River Watershed

Hydrologic Soil Group	Area (acres)	Percent Area (%)
A	1,536	5
B	1,210	4
C	8,097	24
D	22,384	66
Water	143	<1
Not Rated	397	1

4.0 Land use / Land cover

4.1 Watershed Landuse

The current use or cover of the land influences the hydrologic cycle. Land use conversion away from natural vegetative cover tends to compact soils and create impervious surfaces that leads to reduced infiltration, reduced evapotranspiration, and increased runoff. Vegetation removal leads to increased watershed export of sediment and nutrients. Land development is also typically associated with a reduction of watershed storage.

Landuse information compiled in 2001 as part of the National Landcover Dataset was corrected by the UVM Spatial Analysis Lab to better represent urban areas. The landuse in the LaPlatte River watershed is primarily agriculture and forest, with small areas of urban and residential uses (Table 4). The eastern third of the watershed is primarily forested with some roads, development, wetlands, and surface waters including Lake Iroquois and the impounded section of Patrick Brook (Figure 7). The western two thirds of the watershed have a significant amount of

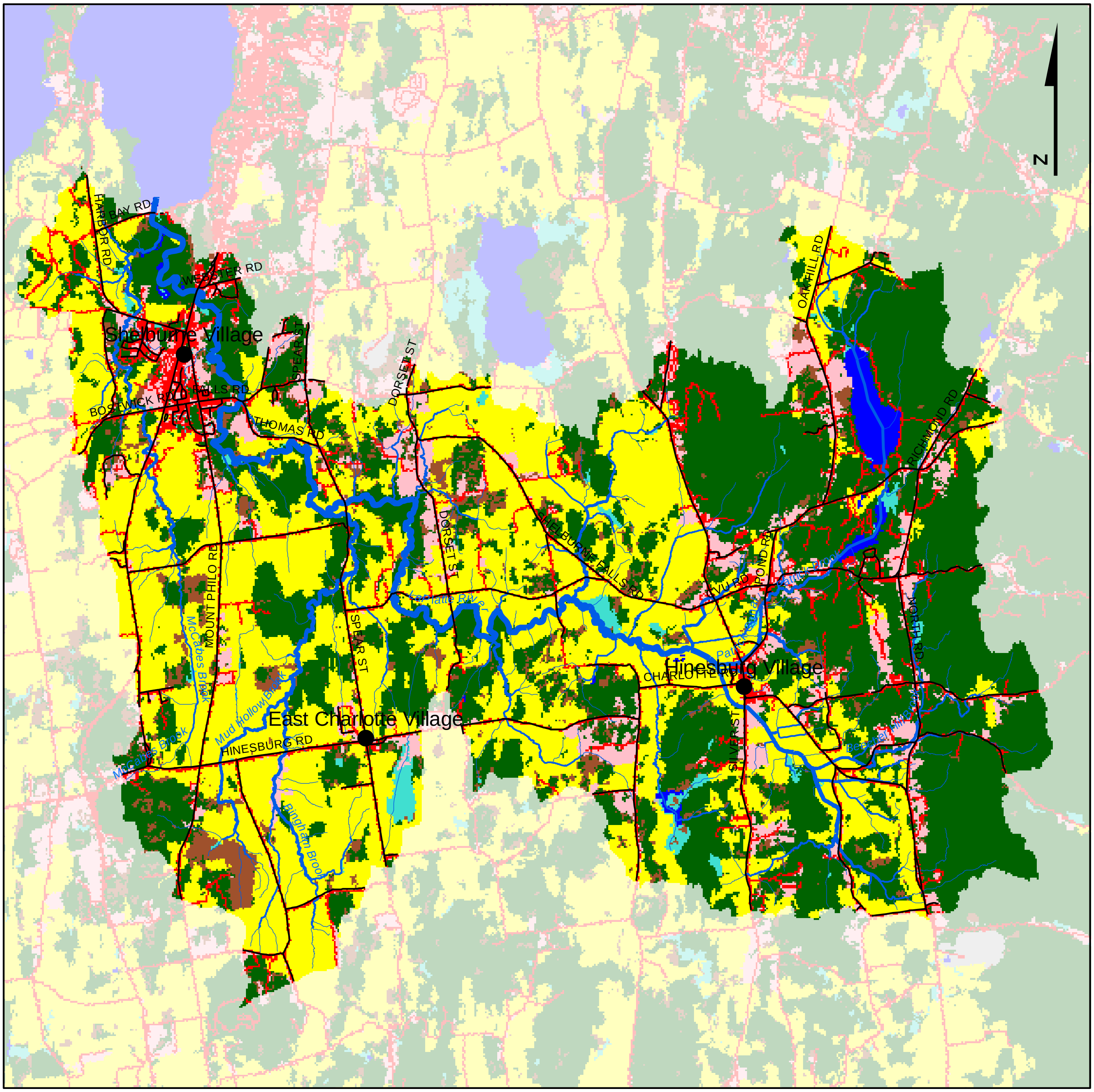
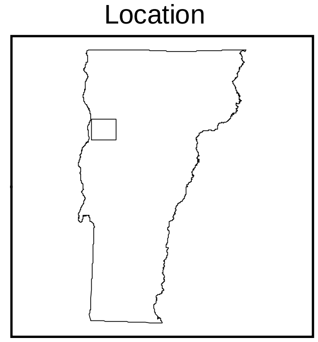


Figure 7: Land Use of Laplatte Watershed

Agriculture		Urban	
Barren		Urban-Open	
Brush		Water	
Forest		Wetland	

Location



Land use data is from an "improved" version of NLCD 2001 using ancillary GIS data and Landsat satellite imagery produced by UVM Spatial Analysis Lab.

Map originally created by Mark Suozzo as part of UVM course NR-243, December 18, 2010. Updated by Milone & MacBroom, Inc. March 24,

0 1 2 3 4

Miles

agricultural land with some areas of forest. The land use map illustrates the road network connecting the village centers in the watershed.

Stormwater contribution was estimated to be 38% from Agricultural/ Open Space and 62% from Urban/Developed Land. These contributions were estimated using a method outlined in the TMDL for Munroe Brook, an adjacent watershed (VTDEC 2008). Generally, Agriculture and Barren Land were lumped into the Agriculture/Open Space category and Urban and Urban-Open were combined in the Urban/Developed Land and other categories are assumed to be in their natural state with no unnatural impervious surfaces. Average values for impervious surface in each category are used to determine an estimation of runoff for each Landuse category.

Table 4: Summary of Landuse in LaPlatte River Watershed

Class	Area (acres)	Percent Area (%)
Agriculture	13,434	40
Barren	4	0
Brush	1,595	5
Forest	13,151	39
Urban	2,734	8
Urban-Open	2,075	6
Water	356	1
Wetland	421	1

4.2 Impervious Cover

As part of this study an improved GIS impervious cover layer was created at the UVM Spatial Analysis Laboratory (Appendix B). The impervious cover was calculated using 2008 National Agriculture Imagery Program (NAIP) imagery and GIS layers of roads and streams. The new impervious cover map is an improved combined representation of roads, buildings, driveways and other impervious areas in the watershed (Figure 8). The LaPlatte River watershed was calculated to be 3.6% impervious surface.

Impervious area was examined by subwatershed to provide an overview of the stream reaches that are receiving runoff from higher amounts of impervious area. Thresholds of impervious cover below which water quality and stream conditions deteriorate have been found to range between 5 and 10 % (e.g., Brabec, Schulte et al. 2002; CWP 2003; Schiff and Benoit 2007). LaPlatte River subwatersheds had low to moderate amounts of impervious cover except at the village centers of Shelburne (M04 = 19.7 %; T1.03 = 19.6 %) and Hinesburg (M16 = 14 %) that had the highest amount of impervious cover (Figure 9). McCabe's Brook subwatersheds in the western section of the watershed and Patrick Brook subwatersheds in the eastern part of the watershed had moderate amounts of impervious cover (4-5 %).

The level of connection between impervious cover and stream channel must be considered to fully understand the stormwater risks to streams. Impervious cover that conveys stormwater directly to channels via pipes and short swales rapidly following a storm event pose greater risks to stream health than when the flow is stored and delayed prior to discharging to the channel. Although impervious cover tends to be low to moderate in the LaPlatte River watershed, field observations indicate that the imperviousness is often located close to the stream channels and that treatment is typically limited or non-existent. Opportunities exist to mitigate existing untreated stormwater discharge at specific locations receiving the majority of runoff from village centers (see Section 8.0).

New stormwater treatment opportunities are identified by the proximity of high infiltration sites with permeable soils (HSG A and B) to areas having dense impervious cover. Impervious cover density was determined by identifying the number of impervious features (i.e., buildings, roads, and driveways from the Emergency 911 GIS database) per acre (Figure 10). The number of impervious feature point locations were averaged over an area to determine density, as described in Appendix B. Some areas in Shelburne and Hinesburg village centers indicate good stormwater treatment potential as high impervious cover density is located close to soils suitable for infiltration.

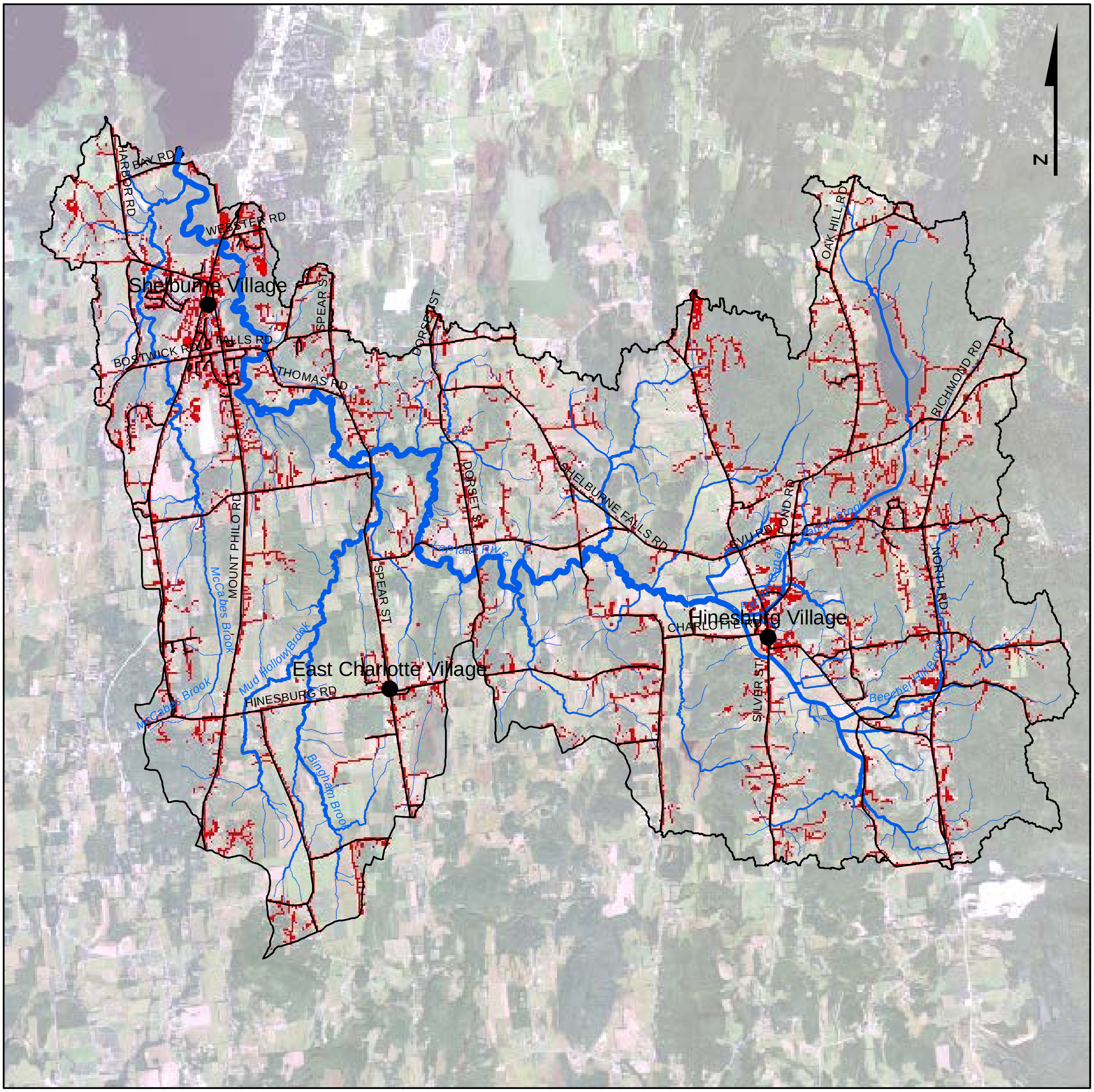


Figure 8: Impervious Cover from Imagery Data

LaPlatte River Watershed

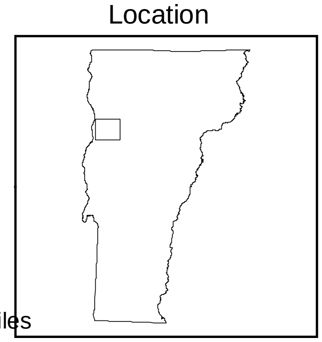
Impervious Cover

National Agriculture Imagery Program (NAIP) 2008 imagery data were used to produce the impervious cover presented on this map and visible as background images. Normalized Difference Vegetation Index (NDVI) values less than -0.22 were used to determine impervious area.

Map originally created by Mark Suozzo as part of UVM course NR-243, December 18, 2010. Updated by Milone & MacBroom, Inc. March 24, 2010.

0 1 2 3 4 Miles

Location



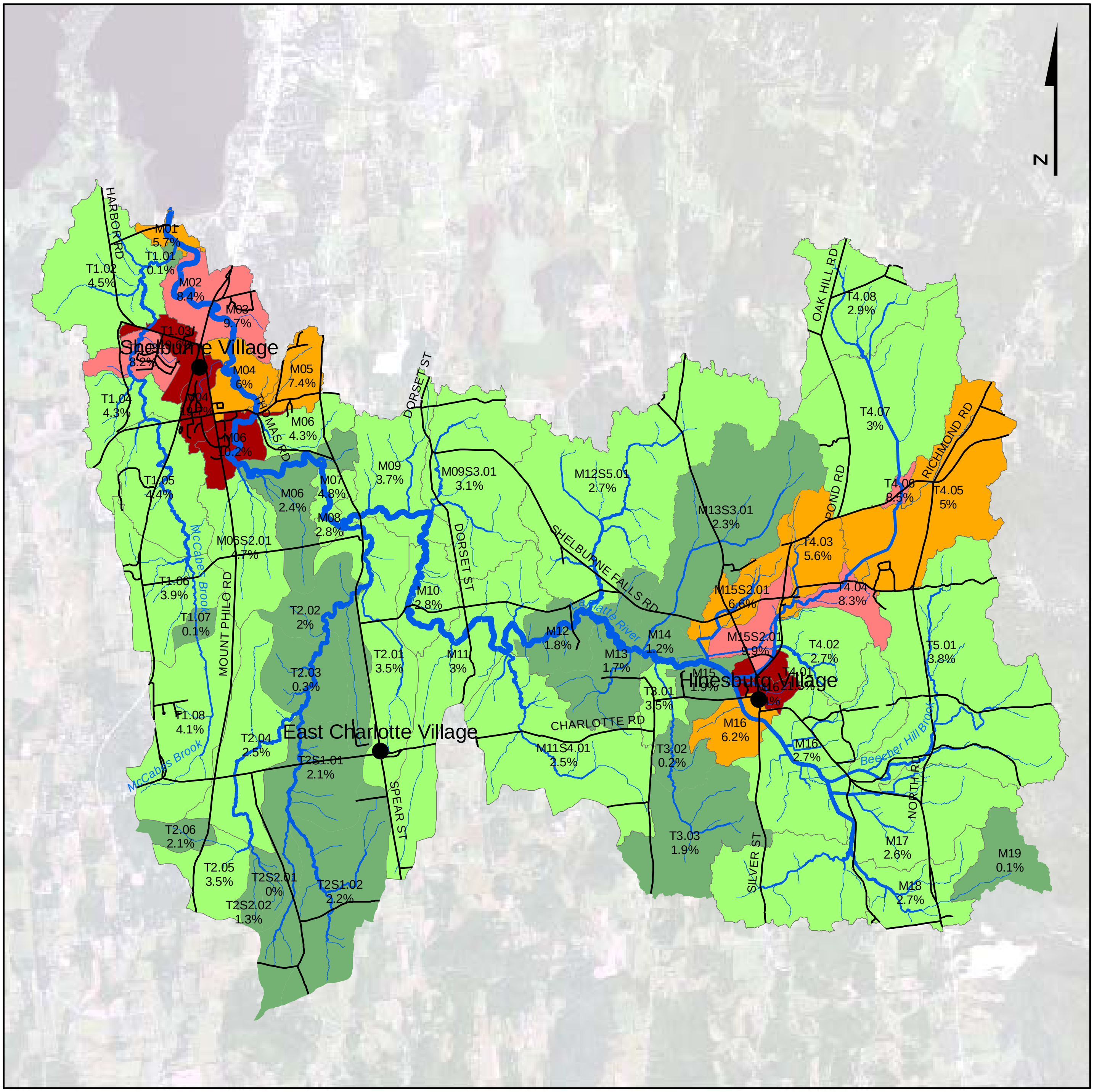


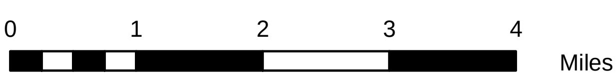
Figure 9: Percent Impervious by Subwatershed Area

Percent Impervious

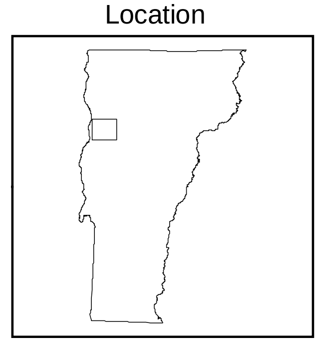
- 0.0 - 2.4
- 2.5 - 4.9
- 5.0 - 7.4
- 7.5 - 10.0
- > 10

Data was based on Interpretation of NAIP imagery as seen in Figure 8. Values shown on the map represent the percentage of total area covered by impervious cover for each subwatershed.

Map originally created by Mark Suozzo as part of UVM course NR-243, December 18, 2009. Updated by Milone & MacBroom, Inc. March 24, 2010.



Location



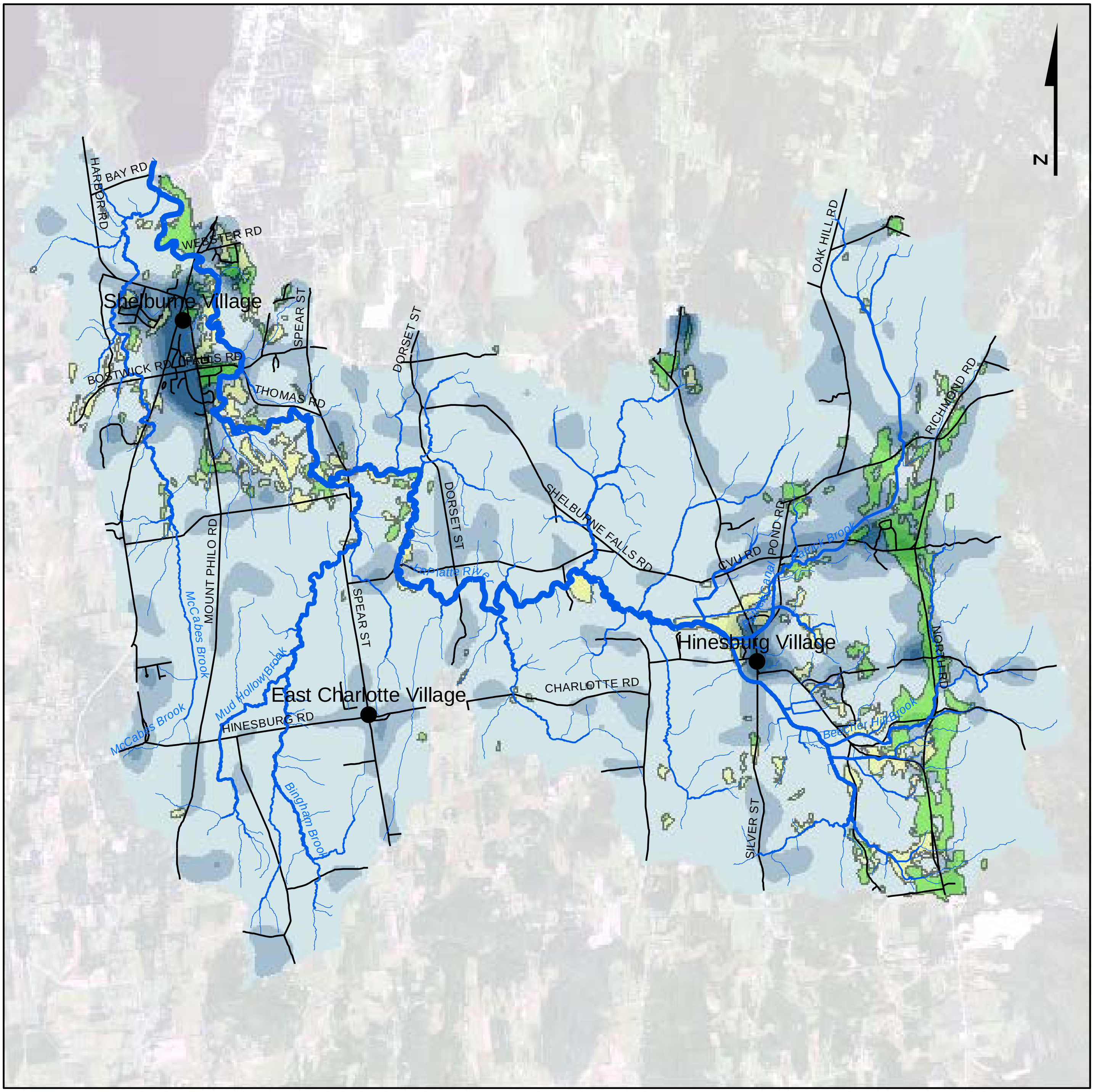


Figure 10: Density of Impervious Features

Possible Infiltration Site

Good (HSG A)

Average (HSG B)

Impervious Features per Acre

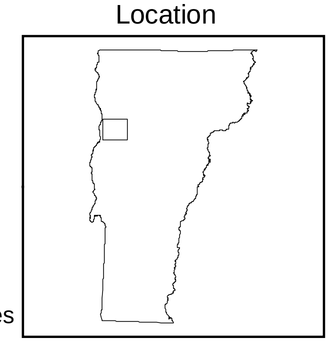
0 - 0.5 | 0.51 - 1 | 1.11 - 1.5 | 1.51 - 2 | > 2

Impervious density was determined by point density of features in the Emergency 911 GIS database including structures, roads, and driveways. Points to represent roads and driveways were created every 100 linear feet. Infiltration sites are based on soil classifications of A (Good) and B (Average) using NRCS hydrologic soils classificiaion.

Map originally created by Mark Suozzo as part of UVM course NR-243, December 18, 2009. Updated by Milone & MacBroom, Inc. March 24, 2010.

0 1 2 3 4 Miles

Location



5.0 Subwatershed Hydrology

5.1 Runoff Analysis

The amount of runoff generated from a precipitation event or thaw is primarily a function of watershed soil types and land cover. As land becomes increasingly compacted, cleared, and covered with impervious surface a larger volume of water will run off the land rather than infiltrate. Land use conversion also tends to shorten the amount of time it takes for water to travel to the receiving body. The increased volume and shortened time for water to reach the stream contribute to increasing peak flood discharges, volumes, and water surface elevations in the river. As the flow changes, the channel adjusts to attempt to regain the balance between water and sediment (Lane 1955). Erosion of bed and banks, and downstream sediment deposition is often associated with channel adjustment.

An estimation of the runoff volume (acre-feet) from each subwatershed was calculated using the Soil Conservation Service (SCS, now NRCS) runoff curve number method. A rainfall of 2.1 inches associated with the 1-year, 24-hour duration storm was used for runoff calculations (VTDEC 2002). LaPlatte River soils, land cover, and impervious cover maps were used to develop area-weighted, composite curve numbers for each subwatershed (SCS 1986). Curve number assignments were fine-tuned based on field observations. Estimated runoff volumes are normalized by watershed area, or presented as the 1-year runoff depth, in order to facilitate comparisons between the subwatersheds (Figure 11).

Subwatersheds in the village centers of both Shelburne and Hinesburg have the largest amount of runoff. High runoff volumes were calculated on the LaPlatte River (M04 village section) and McCabe's Brook (T1.03) in Shelburne Village and the Canal (T4.01) and LaPlatte River (M16 village sections) in Hinesburg Village. Increased runoff was anticipated in the village centers, yet the relatively high runoff volumes throughout the watershed based on low infiltration capacity associated with the dominance of poorly drained soils is not intuitive. These data suggest that rural stormwater runoff is more likely to flow to streams and rivers than infiltrate. The outcome of this analysis further illustrates the importance of protecting potential stormwater treatment locations.

Upstream stormwater runoff will influence downstream locations. Runoff volume estimates presented do not explicitly consider the timing of runoff or the cumulative effect of runoff from upstream watershed locations. More detailed hydrology models travel times and subwatershed position to generate hydrographs to show cumulative effects of runoff as it is collected and flows down a river. This level of modeling requires additional time and information and is needed for project design and implementation. The detailed influence of existing stormwater infrastructure was also not directly included in this initial analysis. Runoff curve numbers assume the presence of some collection systems in urban areas, but do not include specific storage and discharge associated with collection and detainment stormwater systems.

5.2 Prioritization from Runoff Analysis

A GIS analysis was performed to prioritize subwatersheds for stormwater mitigation based on existing conditions. A ranking was calculated from percent impervious cover and runoff volume. Each variable was normalized by the maximum value in the watershed, summed, and divided by two for a combined possible rank of zero to one. A value of one indicates the subwatershed with the highest stormwater threat where stormwater treatment projects should be prioritized.

The prioritization exercise confirmed that the village centers subwatersheds should be the focus for stormwater mitigation (Figure 12, Table 5). Priority subwatersheds include sections of the LaPlatte River (M04 and M06 villages), McCabe's Brook (T1.03) in Shelburne Village, and the Canal (T4.01, T4.04) and LaPlatte River (M16 village) in Hinesburg Village. The Patrick Brook (M15.S2) reaches were also identified as high priority.

Table 5: Subwatersheds ranked by Stormwater Runoff Risk

Phase 2 Reach	Stream	Area (acres)	Percent Impervious Area (%)	Runoff Depth (inches)	Runoff Rank
M04, Shelburne Village Section	LaPlatte River	167	19.7	1.18	0.96
T1.03, Village Green Section	McCabe Brook	168	19.6	0.93	0.85
T4.01	Patrick Brook Canal	71	21.5	0.82	0.85
M16, Lower, Saputo Section	LaPlatte River	96	14.0	0.72	0.63
M15.S2.01, Commerce Park Section	Patrick Brook	229	9.9	0.67	0.51
T1.03, School Street Section	McCabe Brook	219	8.2	0.72	0.49
M05	LaPlatte River	238	7.4	0.67	0.45
M06, Shelburne Village Section	LaPlatte River	236	10.2	0.47	0.44
M15S2.01, Ballards Corner Section	Patrick Brook	300	6.6	0.62	0.42
M16, Middle, Silver Street Section	LaPlatte River	259	6.2	0.62	0.41
T4.04	Patrick Brook	191	8.3	0.50	0.41

Possible infiltration sites were overlaid on the stormwater threat ranking to identify areas where soils would be suitable for infiltration. The potential exists for infiltration-based stormwater mitigation in select locations in most of the priority watersheds. These possible treatment sites should be investigated further for verification of infiltration capacity based on soil mapping, proximity to potential development sites, and identification of parcel information.

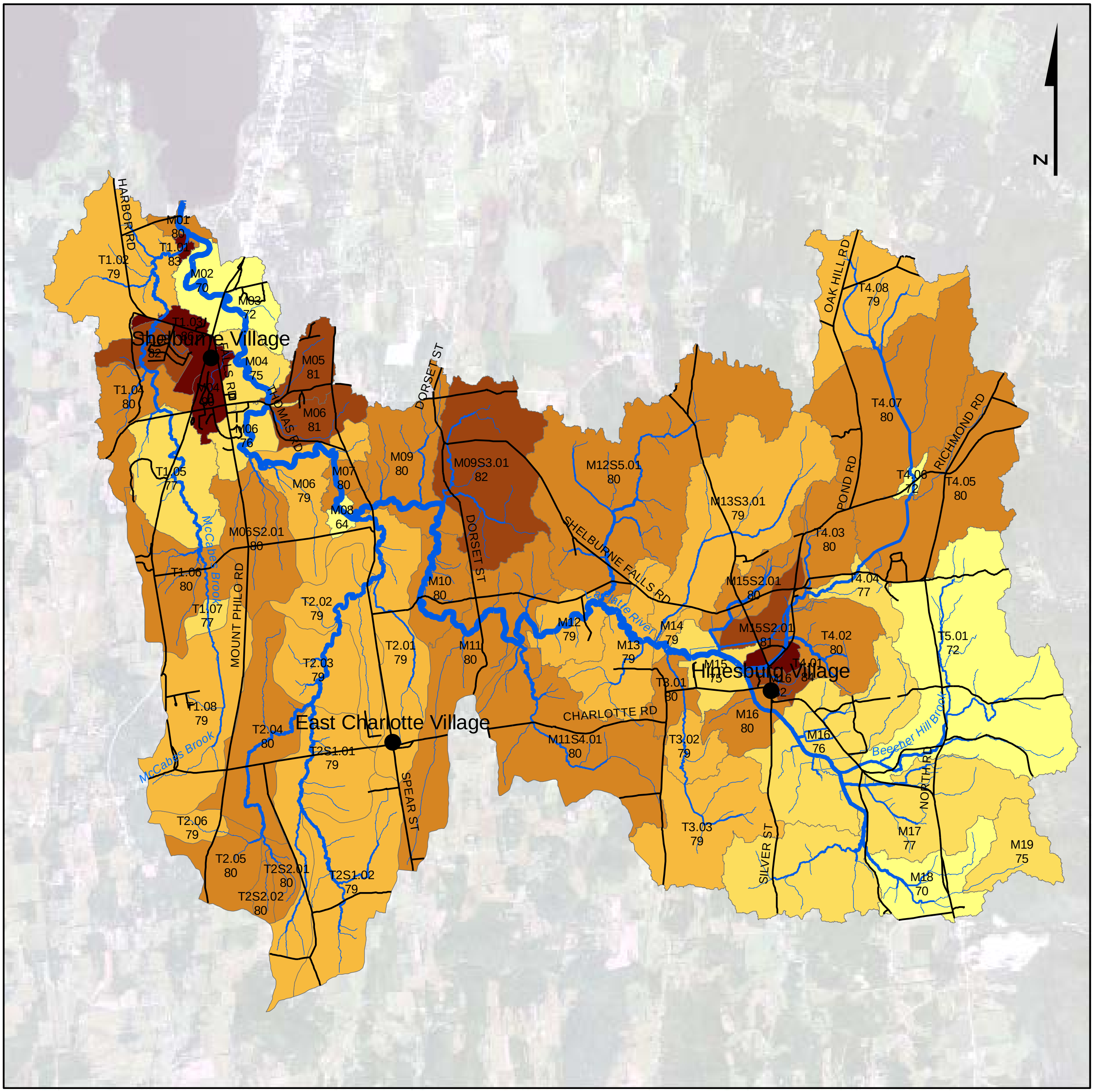


Figure 11: Runoff Volume

acre-feet / acre

- 0.012 - 0.030
- 0.031 - 0.045
- 0.046 - 0.050
- 0.051 - 0.055
- 0.056 - 0.060
- 0.061 - 1.000

0 1 2 3 4 Miles

Location

Total runoff volumes were determined according to standard SCS runoff calculations. Curve Numbers (CN) were determined from combination of HSG, landcover, impervious surface and averaging values over each subwatershed . Runoff Volume was calculated for the 1-year, 24-hour storm event for Chittenden County (2.1 inches). Subwatersheds are labeled with CN values used in calculation.

Map originally created by Mark Suozzo as part of UVM course NR-243, December 18, 2009. Updated by Milone & MacBroom, Inc. March 29, 2010.

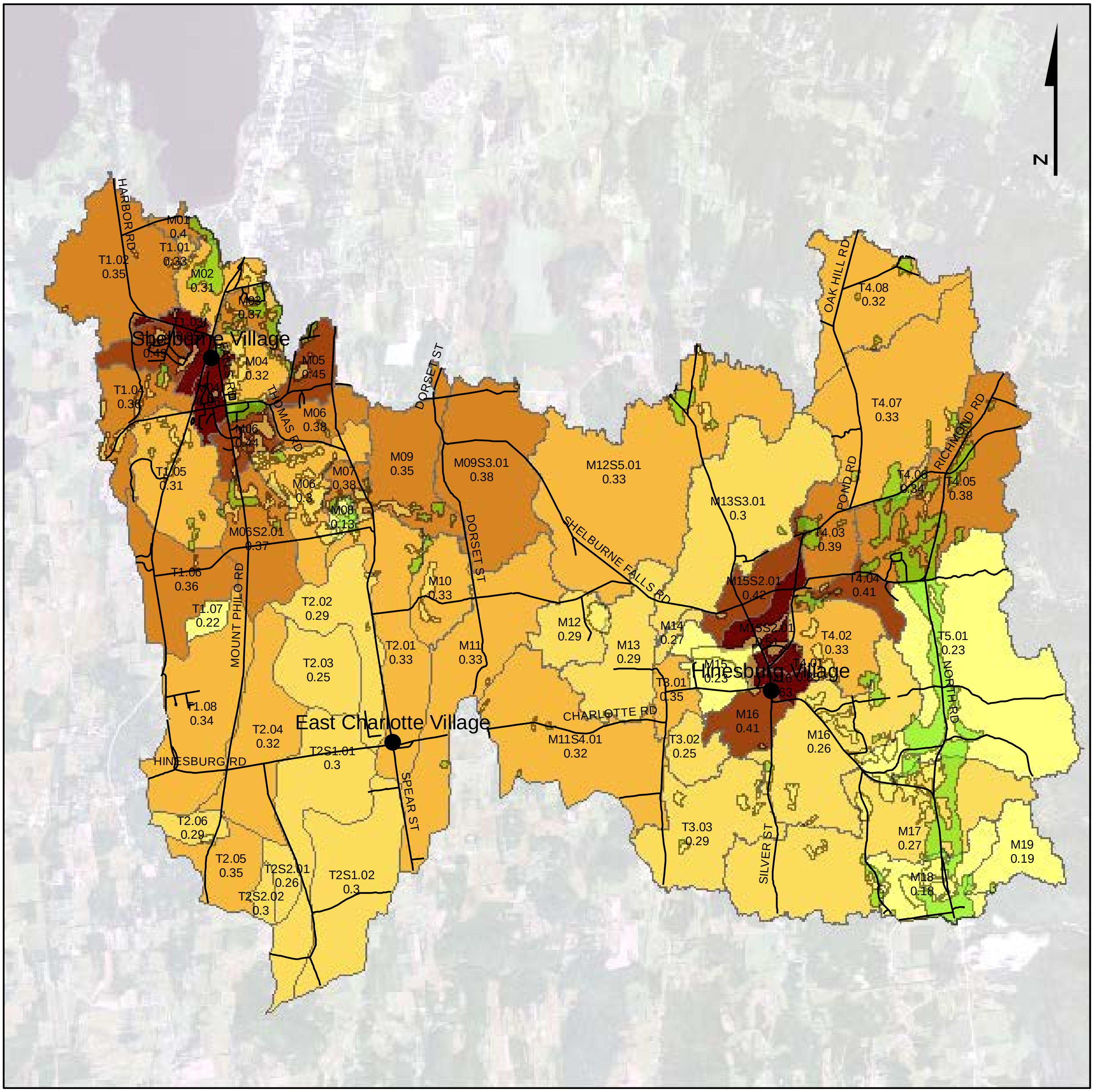


Figure 12: Ranking by Impervious Cover and Runoff Volume

Rank Value

- 0.13 - 0.25
- 0.26 - 0.30
- 0.31 - 0.35
- 0.36 - 0.40
- 0.41 - 0.50
- 0.51 - 1.00

Possible Infiltration Site

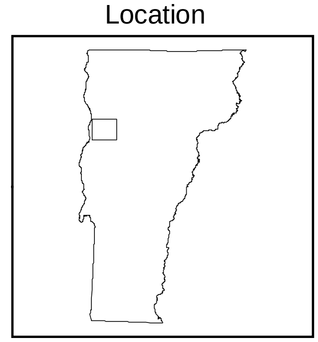
- Good (HSG A)
- Average (HSG B)

0 1 2 3 4 Miles

Ranking was based on percent impervious surface and runoff volume, both normalized by maximum values. A high values indicate high percent impervious and/or large runoff volumes. Infiltration sites are based on soil classification of A (Good) and B (Average) using NRCS hydrologic soils classification.

Map originally created by Mark Suozzo as part of UVM course NR-243, December 18, 2009. Updated by Milone & MacBroom, Inc. March 29, 2010.

Location



6.0 Stormwater Infrastructure

6.1 Mapping Procedures

Stormwater infrastructure shown on plans of stormwater permits on file with the DEC Stormwater Section was digitized into GIS to begin to develop stormwater infrastructure maps. Stormwater infrastructure includes linear features such as stormwater pipes, swales, and culverts. Point features such as catch basins, manholes, drop inlets, detention ponds, and outfalls were also digitized. Methods and map symbols (Figure 13) for the stormwater infrastructure mostly follows DEC Stormwater Section conventions.

Digitized stormwater information was added to existing stormwater mapping compiled by the CCRPC in 2006. The state-permitted stormwater systems in Shelburne in the CCRPC GIS database had been field checked by the Shelburne Director of Public Works. Corrections based on this field verification have been incorporated into the updated mapping. Newly installed stormwater systems were also included from plans available at DEC. Additional field verification was completed via a windshield survey of the watershed.

Hinesburg and Charlotte did not have stormwater infrastructure mapping in place prior to this project. Following digitization of DEC stormwater plans, the village centers and areas of dense development were explored on foot and stormwater infrastructure was located with GPS. A windshield survey of the rural areas of the watershed was completed to note general runoff patterns and confirm road ditch drainage directions. The current stormwater infrastructure maps are provided with this report in electronic format (Appendix A).

The stormwater infrastructure map shows that very little of the watershed area contains infrastructure that falls under the jurisdiction of the state. This even extends to limited regulatory oversight in more developed village centers as infrastructure was in place prior to the start of permitting in the 1970’s or some infrastructure does not meet permitting thresholds (greater than 1 acre of impervious surface, unless in a designated stormwater impaired watershed where stricter standards apply). State-permitted infrastructure conveys stormwater for approximately 25% of Shelburne Village (M04, M06, T1.03), 15% of Hinesburg Village (M16, M15S2, T4.01), and 0 % of East Charlotte Village (T2.01). This is an expected finding with so many rural locations, yet highlights the fact that management of stormwater is mostly an issue for Town’s to address in the LaPlatte River watershed.

A description of runoff in subwatersheds focusing on stormwater infrastructure follows. The presence of stormwater collection systems, description of drainage areas, and description of discharge locations are provided to highlight potential mitigation areas. Developed areas that have received an operational stormwater permit under the jurisdiction of the state are described as “permitted” or “regulated”, whereas areas with no record of an operational permit are described as “non-permitted” or “unregulated.”

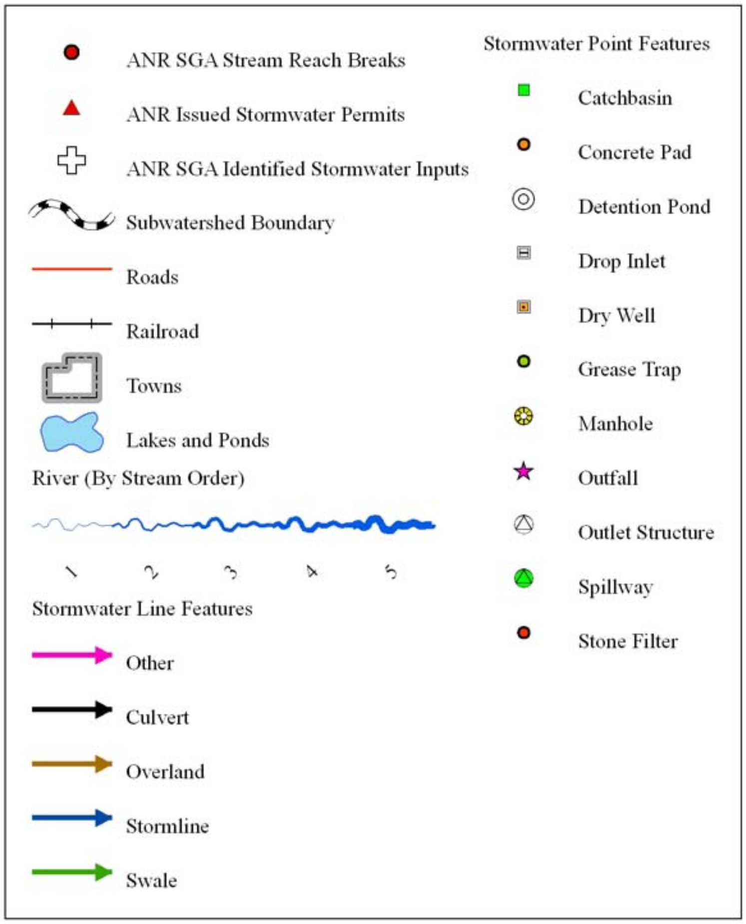
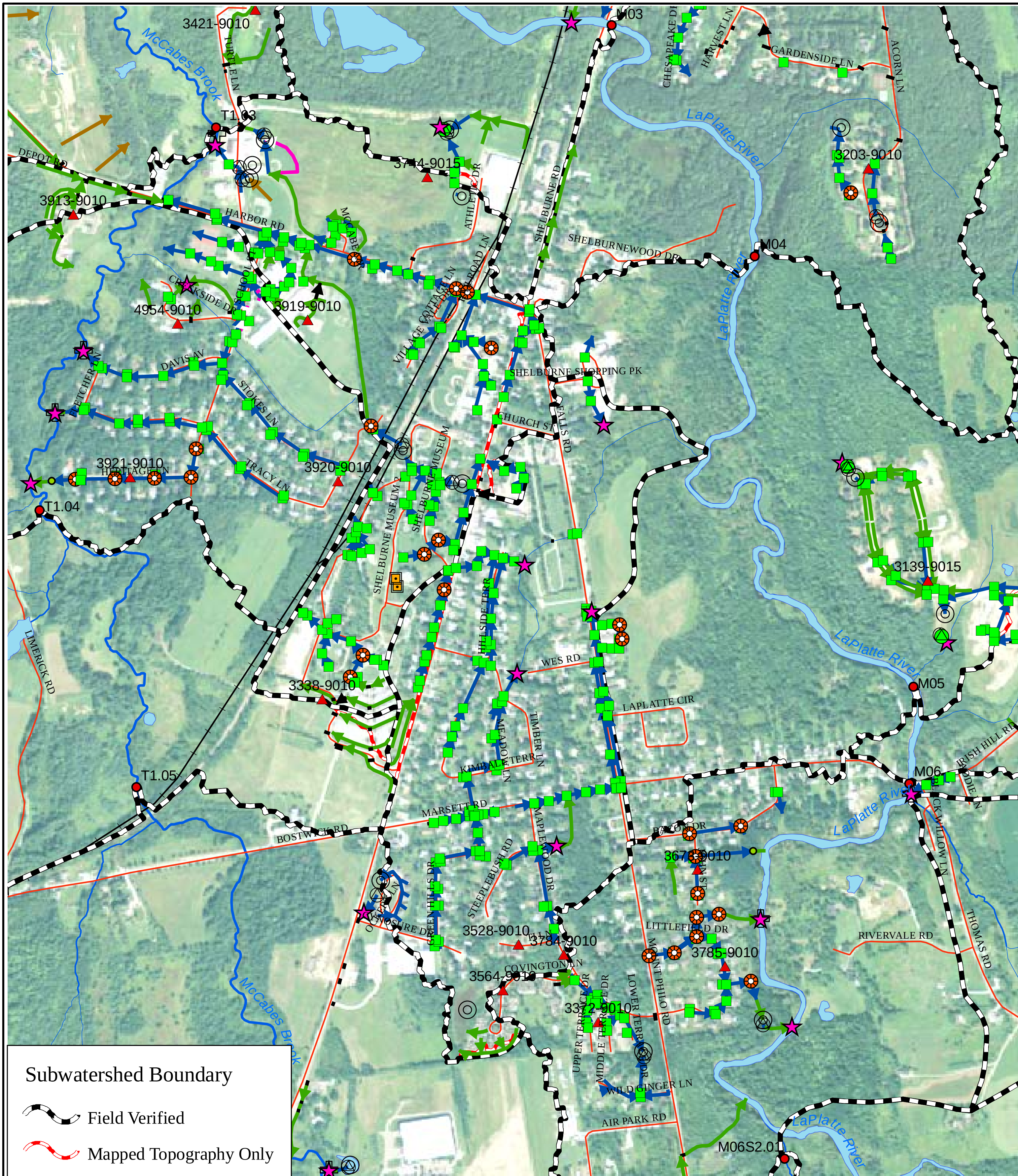


Figure 13: Legend showing symbols and stormwater infrastructure categories for Figures 14-22.

6.2 Shelburne Village

Shelburne has a developed central village surrounded by a network of residential neighborhoods interspersed with agriculture fields and tracts of forestland. Stormwater infrastructure is centralized along Route 7 and clustered around the village center (Figure 14). Some neighborhoods in the more rural sections of Shelburne have stormwater collection systems that can be seen on the full infrastructure map (Appendix A). Shelburne village drains to the lower sections of the LaPlatte River to the east (M4, M6) and McCabe’s Brook to the west (T1.3).

The LaPlatte River meets Lake Champlain north of Shelburne village. Reach M1 is small and rural, and receives runoff from Spinnaker Lane, a permitted system, and unregulated runoff from Bay Road. Moving upstream, the LaPlatte River receives collected stormwater from a section of Route 7 (reach M2), as well as permitted and treated runoff from Athletic Drive and the



Engineering, Landscape Architecture and Environmental Science

MILONE & MACBROOM®

1233 Shelburne Road, Suite 150
South Burlington, VT 05403
(802) 864-1600 Fax: (802) 864-1601
www.miloneandmacbroom.com

Shelburne Village Stormwater Infrastructure

LaPlatte River Watershed Stormwater Project

N W E S

0 250 500 1,000 Feet

DATE: March 2010

SCALE: 1" = 1,000'

SHEET: Figure 14

businesses off of Route 7 and a section of unregulated housing without a collection system in the vicinity of Webster Road. A ditch along a section of Route 7 and residential neighborhoods along Shelburnewood Drive, Gardenside Lane, and Acorn Lane carry stormwater to the river north of the village (M3). Of these collection systems, only Acorn Lane is permitted and includes treatment.

The village is roughly comprised of two subwatersheds with the area to the east of Route 7 draining to the LaPlatte River (M04) and the area to the west draining to McCabe's Brook (T1.03). The reach M04 subwatershed was divided into two areas based on varying land use and stormwater discharge locations.

A small tributary that collects the majority of the developed land in the subwatershed was split from the rest of M04. This subwatershed receives runoff from the village center including the area approximately between Route 7 and Falls Road from Church Street south to Covington Lane. The neighborhoods in this subwatershed are older and mainly constructed prior to state-mandated stormwater treatment. The Town holds a permit for the northern part of Maplewood Drive and Steeplebush Road, but no significant treatment is included in this system. Multiple collection systems comprised of catch basins and pipe outfalls without treatment exist in this area that should be targeted for improvement.

The mostly forested eastern portion of the M04 subwatershed draining directly to the LaPlatte Mainstem was isolated. This subwatershed contains one large development off of Thompson Road that has a recent stormwater treatment system and permit. This subwatershed does have some residential properties along Marsette Road and LaPlatte Circle that do not have treatment or state stormwater permits.

Upstream on the LaPlatte, reach M05 has a rural subwatershed to the east of the village with little existing stormwater infrastructure. Although rural with minimal infrastructure, this subwatershed was identified as having a high percent of impervious cover and runoff potential. Rural development off of Irish Hill Road and Thompson Road does not have stormwater permits or collection or treatment systems. A small development at the upper end of the subwatershed, Cedar Ridge Drive does have a permit held by the Town and treatment.

The M06 drainage was broken down to isolate three subwatersheds with different runoff characteristics. The western section contains a tributary with a rural watershed to the east of Thomas Road with little stormwater infrastructure. Another divide was made where the M06.S2.01 tributary enters the mainstem. This divide separates the rural southern section from the northwest section with dense residential development. The developed portion of M06 receives runoff from a few older neighborhoods in the vicinity of John Street, Littlefield Drive, and Wild Ginger Lane. Treatment ponds exist for several of these systems and a significant portion is under permits held by the Town. An outfall between John Street and Littlefield Drive collects overland and ditch flow from a section of Mt. Philo Road, as well as effluent from the treatment pond collecting from the southern section of Maplewood Drive, Lower Terrace and Wild Ginger Lane. Treatment should be explored at this outfall to treat the portion of runoff from Mt. Philo Road.

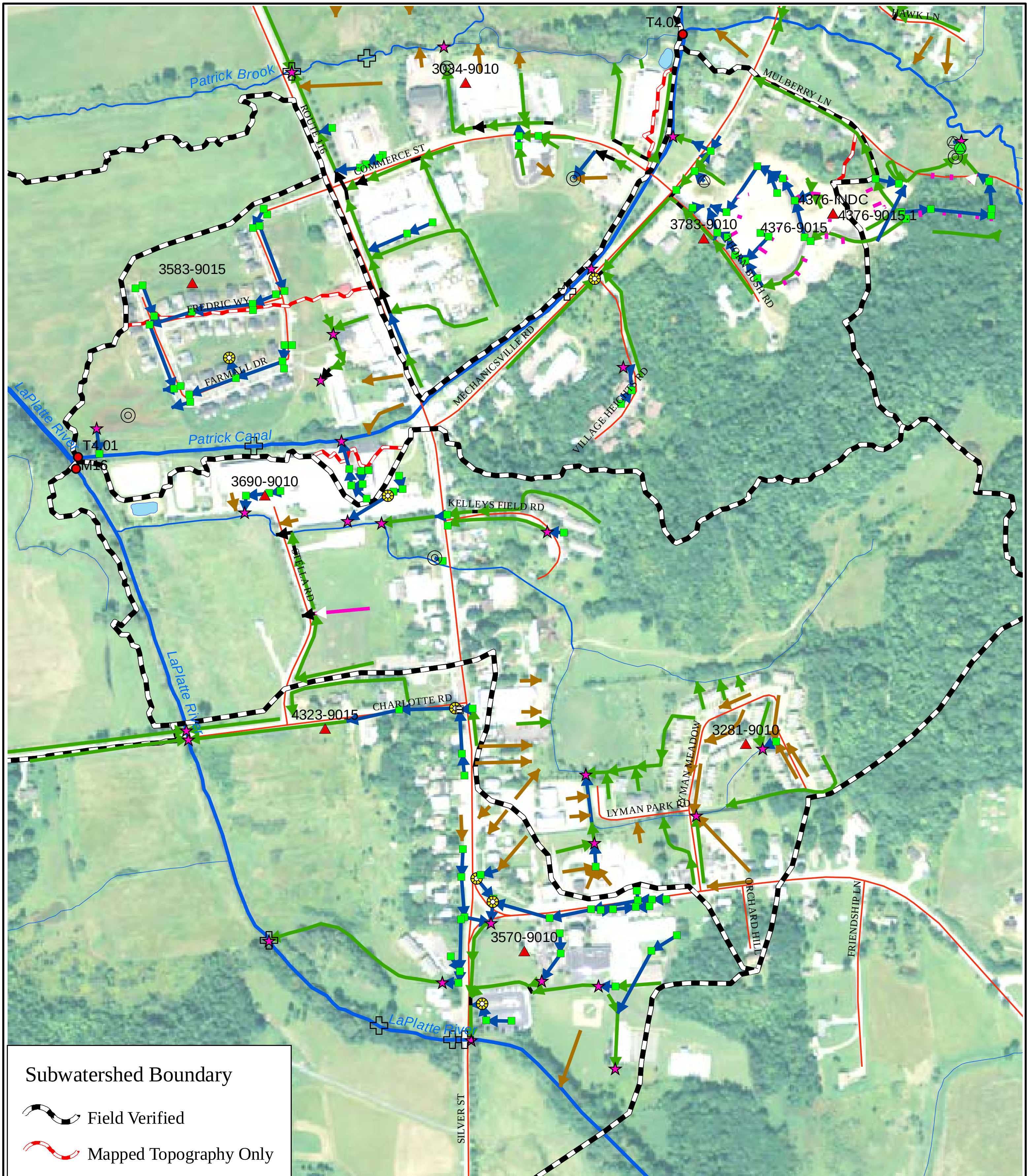
McCabe's Brook joins the LaPlatte River near Lake Champlain, and the McCabe's Brook watershed makes up the western edge of the LaPlatte River watershed. The lower reaches are rural with no stormwater infrastructure and include a backwatered section near the confluence and agricultural land mostly associated with Shelburne Farms. T1.03 extends from just downstream of the Town Garage to upstream of Heritage Lane. This reach was split at the Harbor Road crossing due to a large stormwater collection system entering on the downstream side. The collection system that runs down Harbor Road collects stormwater from Shelburne Museum, the Village Green, businesses on Route 7, part of the Shelburne Elementary School, and Harbor Road. This currently untreated large system may have opportunities for treatment before reaching the outfall. Only the Elementary School has a stormwater permit. The Town Garage also drains to this subwatershed and has a permit held by the Town and treatment in place.

Upstream of Harbor Road multiple outfalls exist along McCabe's Brook. Many of these are catch basin and pipe systems in older residential neighborhoods that do not appear to have stormwater treatment. They include Heritage Lane, Tracy Lane, Fletcher Lane, Stokes Lane, Creekside Drive, and School Street. Only Heritage Lane and a section of Tracy Lane have permits, both held by the Town. Non-permitted systems should be explored for specific improvements that could be made. These streets drain to the McCabe's Brook with little available non-wetland space for systems.

The remaining parts of the watershed in Shelburne include upper reaches of McCabe's Brook and drainage to small tributaries of the LaPlatte River. These areas are primarily rural with little existing development or stormwater infrastructure or stormwater permits. The Teddy Bear Factory does have a permit and is the only additional property with significant infrastructure.

6.3 Hinesburg Village

The portion of the LaPlatte River watershed in Hinesburg is mostly open space or rural residential. Some of the rural developed areas have dedicated stormwater collection and treatment systems, but most rely on ditches or overland flow for conveyance of surface runoff. The densest development in Hinesburg is in the village center along Route 116 from Commerce Street south to the Hinesburg Community School (Figure 15). LaPlatte River reaches M15



Engineering, Landscape Architecture and Environmental Science

MILONE & MACBROOM®

1233 Shelburne Road, Suite 150
South Burlington, VT 05403
(802) 864-1600 Fax: (802) 864-1601
www.miloneandmacbroom.com

Hinesburg Village
Stormwater Infrastructure

LaPlatte River Watershed
Stormwater Project

DATE: March 2010

SCALE: 1" = 500'

SHEET: **Figure 15**

(downstream/northern section) and M16 (upstream/southern section) receive runoff from this area.

At the northern end of the village, the LaPlatte River reach M15 remains mostly rural with little existing stormwater infrastructure. However, this reach receives flow from Patrick Brook and the Patrick Canal that both receive runoff from densely developed sections of the village. Patrick Brook (M15.S2.01) receives runoff from NRG, businesses on Commerce Street, a section of Route 116, and part of Champlain Valley Union High School (CVU). NRG has treatment in place and is permitted. CVU has multiple detention ponds in place and a state permit. Runoff from the eastern section of Commerce Street is permitted and follows a path either north or south to one of two detention ponds. A series of ditches along Route 116 collects runoff from the western section of Commerce Street and business along the eastern side of Route 116, including a significant amount of impervious area before discharging directly to Patrick Brook. This non-permitted collection system should be examined for treatment prior to outfall. Additional non-permitted impervious areas include development and road runoff along Shelburne Falls Road, CVU Road, Route 116, and Pond Road.

Patrick Brook has been altered in this area to include a bypass canal that is considered as a separate stream reach (T4.01) that runs parallel to Mechanicsville Road. The canal joins the LaPlatte River at the upstream end of M15. This subwatershed receives runoff from permitted systems in residential neighborhoods along Thorn Bush Road, Village Heights Road, Fredric Way, and part of the former Saputo property. The GIS topography mapped the edge of this subwatershed along the centerline of Fredric Way. Field verification of the stormwater systems showed that runoff from the entire Fredric Way neighborhood is collected and routed to the detention pond at the southwest corner of the watershed (Figure 15). Non-permitted or treated runoff includes multiple businesses and residences along Route 116 and Mechanicsville Road. Approximately half of the impervious surface in this subwatershed in non-permitted.

LaPlatte River reach M16 extends from the confluence with the Patrick Canal, just downstream of the former Saputo property, north to the confluence with Beecher Hill Brook near Beecher Hill Road. This large subwatershed was split into three areas for analysis based on varying land use and stormwater input locations. The downstream sub-reach extends to the Charlotte Road crossing. This area collects water through a ditched tributary that runs along the former Saputo property, under Route 116 and behind the grocery store, church, and Lyman Meadows neighborhood. A majority of the village drains to this tributary, including most of the eastern half of Route 116 through the village. There is a significant amount of impervious surface associated with the older development that was not required to install stormwater treatments that should be examined for treatment opportunities. Of the many impervious areas draining to this tributary, none include significant treatment and only the Saputo factory site, Kelley’s Field Drive, and Lyman Meadow neighborhood have stormwater permits. Areas with large impervious surfaces with no permits include businesses along Route 116, specifically the grocery store, church, gas station, diner/creemee stand, and many residences.

The middle section of M16 includes runoff from the remaining section of the village, from Charlotte Road upstream past Hinesburg Community School. Ditches along Charlotte Road collect water from a section of Route 116 with catch basins and pipes. Another series of catch basins and pipes run along the southwest part of the village and drains to a ditch leading to the LaPlatte River downstream of Silver Street. Catch basins along Route 116 in front of the Hinesburg Elementary school, and the area to the east side of Route 116, collect and discharge stormwater near the corner of Silver Street and Route 116. Erosion is taking place at this outfall that conveys untreated stormwater to the LaPlatte River in a ditch along Silver Street. This is a priority treatment location for Hinesburg Village. Hinesburg Community School has two additional direct discharge locations behind the school. None of the five networks described in M16 have significant treatment of the stormwater and each should be considered for mitigation. The only permitted system in this subwatershed is the small lower parking area on the Hinesburg Community School property. The western section of this subwatershed remains mostly in its natural forested state with a few homes and fields.

The upper area of M16 is rural and mostly comprised of agricultural fields and forest. Minimal stormwater infrastructure is in place. Runoff from roads, agricultural fields, and individual homes is conveyed either in ditches or overland.

6.4 Charlotte Stormwater Infrastructure

The portion of the LaPlatte River watershed within the town of Charlotte is rural with a mix of agriculture, forest, and rural residential land uses. Stormwater infrastructure is minimal consisting of only a few rurally located residential developments. Although hard infrastructure such as catch basins and pipes are limited, the town does have a significant number of roadside ditches that collect and convey stormwater runoff from paved and dirt roads, and agricultural fields. Improvement of these networks could have substantial impacts on the receiving waters and will be generally addressed in later sections of this report.

A study of rural road ditch networks in the region is being sponsored by the Lake Champlain Basin Program and is slated to begin in Spring of 2010. A key outcome of this study is to generate estimates of sediment and Phosphorus loading from the road ditch networks in all Vermont watersheds draining to Lake Champlain. This information will be directly applicable to understanding the primary stormwater threat from Charlotte, and other rural areas, in the LaPlatte River watershed.

7.0 Relating Stormwater Scenario to Existing SGA and Water Quality Data

7.1 SGA Data

Phase 1 and 2 assessments have been completed for the LaPlatte River reaches M03-M11 and McCabe's Brook tributary reaches T1.02-T1.05 (LWP 2007). Phase 2 was also completed for Hinesburg reaches including M12-M18 and sections of tributaries including Patrick Brook, Beecher Hill Brook, the Canal, and an unnamed tributary T3 (LWP 2006). Data were further analyzed into a Stream Corridor Plan for the LaPlatte River and Tributaries in Town of Hinesburg (LWP 2007) and Reaches M6-M11 in Towns of Charlotte and Shelburne (LWP 2008), both prepared by the LaPlatte Watershed Partnership. These studies collected information on stream channel condition that may be related to stormwater impacts.

The Shelburne and Charlotte Corridor plan (LWP 2008) identified multiple hydrologic stressors that contribute to high stormwater impacts to the channel. These include high road densities in Shelburne Village, M04, M05, and M06, that leads to large amounts of impervious cover that has been confirmed by mapping for this study. Bank erosion appears to be most abundant in subwatersheds with large amounts of impervious cover and the most identified stormwater outfalls (M06, T1.03, and T1.05). Indicators of stormwater impacts such as gullies and tributary rejuvenation were seen in M06, M09A, M10, and M11.

The Hinesburg Corridor Plan identified multiple stormwater inputs to the channels and made suggestions that much of the bank erosion may be related to stormwater runoff (LWP 2007). A preliminary suggestion was made to look at implementing a village-wide stormwater approach to address smaller properties that may not be subject to state stormwater permitting.

A few of the watersheds that had a high ranking for risks from stormwater were previously identified to have Poor and Fair geomorphic conditions including (M06, M16, T1.03, T4.01, and T4.04) (Table 6). Many of these and downstream subwatersheds had excessive bank erosion.

Stream habitat condition is shown to be Fair or Poor at or downstream of major stormwater inputs. In Hinesburg, habitat condition was found to be Fair where a portion of the village stormwater enters the system (M16), while a Poor habitat conditions was identified downstream of the village stormwater inputs. In Patrick Brook, upper reaches were found to have good habitat, and downstream reaches (T4.02 and T4.01) had Fair and Poor conditions where stormwater inputs occur. In Shelburne, habitat condition was Fair where the majority of stormwater inputs occur (T3.01, M06).

Table 6: Summary of Stream Geomorphic Assessment Data

Segment	Town	Stream Type		Departure	Geomorphic Condition	Evolution Stage	Sensitivity	Habitat Condition
LaPlatte River and Minor Tributaries								
M3,M4A	Shelburne	E5	Dune Ripple		Good	I	High	Good
M04B	Shelburne	C4	Riffle Pool		Good	I	High	Good
M06	Shelburne	B4c	Plane Bed	yes	Poor	IV	High	Fair
M07	Shelburne	B5	Plane Bed		Good	III	Moderate	Good
M08	Charlotte	C4	Riffle Pool		Fair	IV	Very High	Fair
M09A	Charlotte	B4c	Plane Bed		Fair	IV	High	Fair
M09B	Charlotte	C5	Riffle Pool		Fair	IV	Very High	Good
M10	Charlotte	C5	Riffle Pool		Fair	IV	Very High	Fair
M11	Charlotte	B4c	Dune Ripple		Good	I	Moderate	Good
M12	Hinesburg	E5	Dune Ripple		Good	I	High	Fair
M13	Hinesburg	E5	Dune Ripple		Good	I	High	Fair
M14	Hinesburg	E5	Dune Ripple		Good	III	High	Fair
M15A	Hinesburg	E5	Dune Ripple		Fair	III	Very High	Fair
M15B	Hinesburg	C5c	Dune Ripple		Fair	III	Very High	Poor
M16	Hinesburg	C5	Dune Ripple		Fair	III	Very High	Fair
M17	Hinesburg	B5c	Dune Ripple	yes	Poor	III	High	Fair
M18A	Hinesburg	C4	Riffle Pool		Fair	IIC	Very High	Good
M18B	Hinesburg	C4	Riffle Pool		Poor	II	Very High	Fair
T3.01	Hinesburg	E5	Dune Ripple		Good	III	High	Fair
T3.02	Hinesburg	C5	Dune Ripple		Good	IIc	High	Fair
McCabe's Brook								
T1.02	Shelburne	E5	Dune Ripple		Good	III	High	Good
T1.03	Shelburne	E5	Dune Ripple		Fair	IIc	Very High	Fair
T1.04A	Shelburne	N/A	N/A		N/A	N/A	N/A	N/A
T1.04B	Shelburne	C4	Riffle Pool		Fair	II	Very High	Fair
T1.05A	Shelburne	F4	Riffle Pool	yes	Poor	III	Extreme	Fair
T1.05B	Shelburne	C5	Dune Ripple		Good	IIc	High	Good
Patrick Brook								
M15S2.01	Hinesburg	E4	Dune Ripple		Good	III	High	Fair
T4.01	Hinesburg	C5	Plane Bed		Fair	II	Very High	Poor
T4.02	Hinesburg	F4	Plane Bed	yes	Poor	III	Extreme	Fair
T4.03	Hinesburg	C4	Riffle Pool		Fair	III	Very High	Good
T4.04	Hinesburg	B4a	Step Pool		Fair	IIc	High	Good
T4.06	Hinesburg	C4	Riffle Pool		Good	III	High	Good
Beecher Hill Brook								
T5.01A	Hinesburg	E5	Dune Ripple		Good	IIc	High	Fair
T5.01B	Hinesburg	E4	Riffle Pool		Fair	IIc	Very High	Fair
T5.01C	Hinesburg	B3	Step Pool		Good	I	Moderate	Good
T5.01D	Hinesburg	F4	Plane Bed	yes	Poor	II	Extreme	Fair

7.2 Water Quality Data

Water quality monitoring has been completed in the LaPlatte River and McCabe's Brook by the LaPlatte Watershed Partnership as part of its Volunteer Monitoring Program starting in 2004. Data have been compiled and analyzed up through the 2007 monitoring season (LWP 2008). Concentrations of nitrogen, phosphorus, and suspended solids increased with storm events, and concentrations of phosphorus were found to be correlated with concentrations of suspended solids. This report includes data for a relatively short monitoring period, but provides general suggestions on water quality that may be confirmed as additional data is collected.

Results along the mainstem of the LaPlatte River highlighted a few key areas influenced by storm flows. The suspended sediment concentrations increase rapidly between the Hinesburg wastewater treatment plant and Leavensworth Road that have been attributed to bank erosion. Suspended sediments are diluted down to the Falls Road and slowly increase again to the mouth of the river at Lake Champlain. Increased suspended sediment is thought to be from stormwater runoff, bank erosion, and channel scour.

The stormwater runoff in Shelburne Village is suggested by the LWP preliminary report to be a possible cause of increased total Nitrogen concentrations in the LaPlatte River, corresponding to the priority subwatersheds identified in the impervious cover and runoff volume ranking (LWP 2008).

Past water quality reporting indicates that "Phosphorus concentrations in McCabe's Brook are significantly impacted by storm runoff from agricultural land and large impervious surfaces, as well as by stormwater runoff from urban/semi-urban areas in downstream stations (LWP, 2008)." These trends generally apply to suspended sediment and nitrogen concentrations. There were increases in total Nitrogen, suspended solids, and Phosphorus between Bostwick Road and Harbor Road. Large increases in Phosphorus at the Teddy Bear access road were attributed to runoff from parking areas and buildings. These water quality results indicate that the identified stormwater outfalls at both the Teddy Bear Company and neighborhood upstream of Harbor Road in Shelburne Village should be targeted for stormwater mitigation.

Sampling on Patrick Brook showed increases in turbidity and total Phosphorus between the Mechanicsville Road and Route 116 crossings. Runoff from the commercial development may be influencing water quality. This sampling location is upstream of the outfall discharging water from Route 116 and the gas station on Commerce Road and thus local water quality may be further reduced than data suggest. Stormwater outfalls along Patrick Brook should be targeted for stormwater treatment.

Mud Hollow and Bingham Brook tributaries were sampled and showed that when flows are high the suspended solids and Phosphorus concentrations are high. These watersheds are rural and are primarily affected by agricultural field runoff.

8.0 Stormwater Treatment Projects and General Recommendations

8.1 Project Identification

Stormwater mitigation project locations have been identified based on the improved understanding of the existing conditions of the stormwater system. Subwatersheds with high percent impervious cover, large runoff volumes, and known water quality issues were targeted for possible mitigation projects. Access to soils with good infiltration capacity is also considered.

Stormwater discharge locations establish point sources of pollution on the landscape where treatment methods can be applied. Addressing point sources is often a more straight forward task than dealing with nonpoint source pollution distributed across the landscape. Potential mitigation projects are sited at or near existing systems and close to proposed growth center areas. In watersheds such as the LaPlatte with concentrated village center areas with a small amount of stormwater infrastructure in place, multiple landowners, and minimal access to permeable soils, stormwater treatment and conveyance should be a primary consideration for locating future development and designating growth centers.

Due to the dense nature of development in the village setting, stormwater cumulatively collects from many landowners and it is difficult or impossible for each individual to treat stormwater on site. In these densely populated areas community-based treatment should be planned, implemented, and funded by the town. Potential sources of funding for community stormwater treatment include creation of a Stormwater Utility such as in South Burlington, town taxes, or pursuing grant funding. Suggestions and additional information for implementation are included in Section 8.0.

Project implementation in the areas generally identified here would require landowner and town participation to site a project on a specific parcel. Further analysis and design would be necessary to develop each project associated with this study and stormwater treatment focused strategy of growth.

LaPlatte River M04, Shelburne Village

The M04 reach subwatershed was broken into two parts. The subwatershed draining the village center neighborhoods was identified as a priority watershed based on impervious surface and runoff volume. This subwatershed is almost entirely developed with older village neighborhoods with stormwater collection systems that lack treatment facilities. Examination of the stormwater infrastructure identifies two main collection systems, each collecting approximately half of the drainage area. The eastern system collects water from Maplewood Drive and Mt. Philo Road, before discharging into a field off of Mt. Philo Road and eventually flowing to the LaPlatte River. The discharge location is in a field adjacent to Mt. Philo Road, just north of Wes Road, where there is available space for stormwater detention and possibly infiltration (Figure 16). A possible treatment location was highlighted near the Mt. Philo Road for ease of access and maintenance, although there are permeable soils located in the field farther to the east near the woods in the field and in the southern section of the fields behind the homes to the south. This is a walking park and any treatment implemented would need to be designed to complement the existing recreational uses.

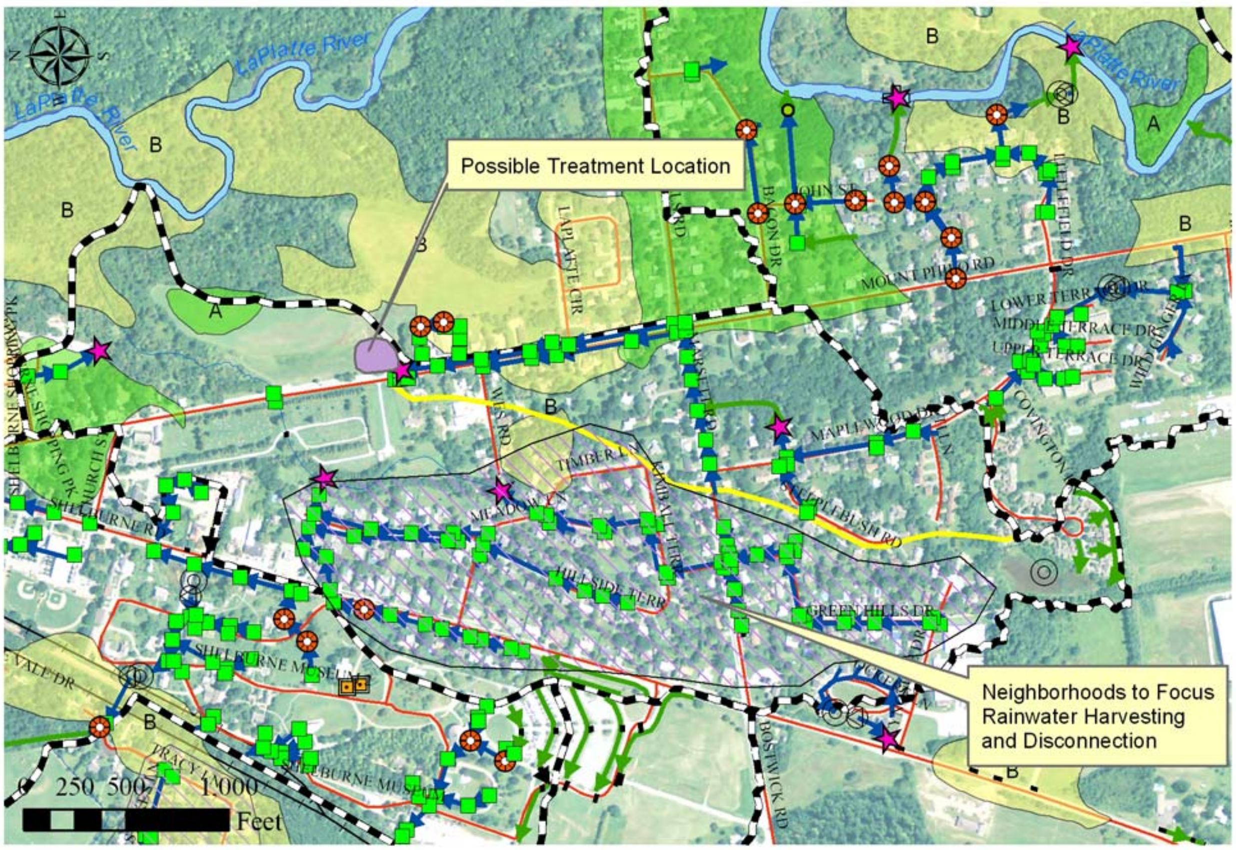


Figure 16: Potential Stormwater Treatment Options in Shelburne Village M04

The other half of the subwatershed collects through a series of catch basins and pipes to two discharge locations to a small tributary of the LaPlatte River. These outfall locations do not appear to have available space for end-of-pipe treatment. The potential for treatment near these outfalls needs to be explored further. It is recommended that this neighborhood be targeted for stormwater reduction methods such as disconnection of impervious cover, use of pervious pavement in the future, installation of rain gardens, and use of rain barrels. Low impact development approaches that amount to decentralized mitigation have been shown to reduce stormwater runoff volume and nutrient export (Bedan and Clausen 2009).

LaPlatte River M06, Shelburne Village

The M06 reach subwatershed was broken into three parts, the western section including part of the village was found to have water quality, geomorphic condition, and impervious cover indicators of stormwater problems. Multiple neighborhoods exist in this subwatershed, some of which have treatment in place. A system that collects water on Mt. Philo Road and discharges between John Street and Littlefield Drive is a location where improved treatment is suggested (Figure 17). This system collects some stormwater treatment pond effluent and part of the ditches along Mt. Philo Road and leads to a manhole between the neighborhoods. This area is sloped so a surface detention system would need to be a terraced system to provide multiple storage cells and adequate residence times. Other options include infiltration techniques or improvement of the ditch network along Mt. Philo Road to provide treatment before entering the stormpipes.

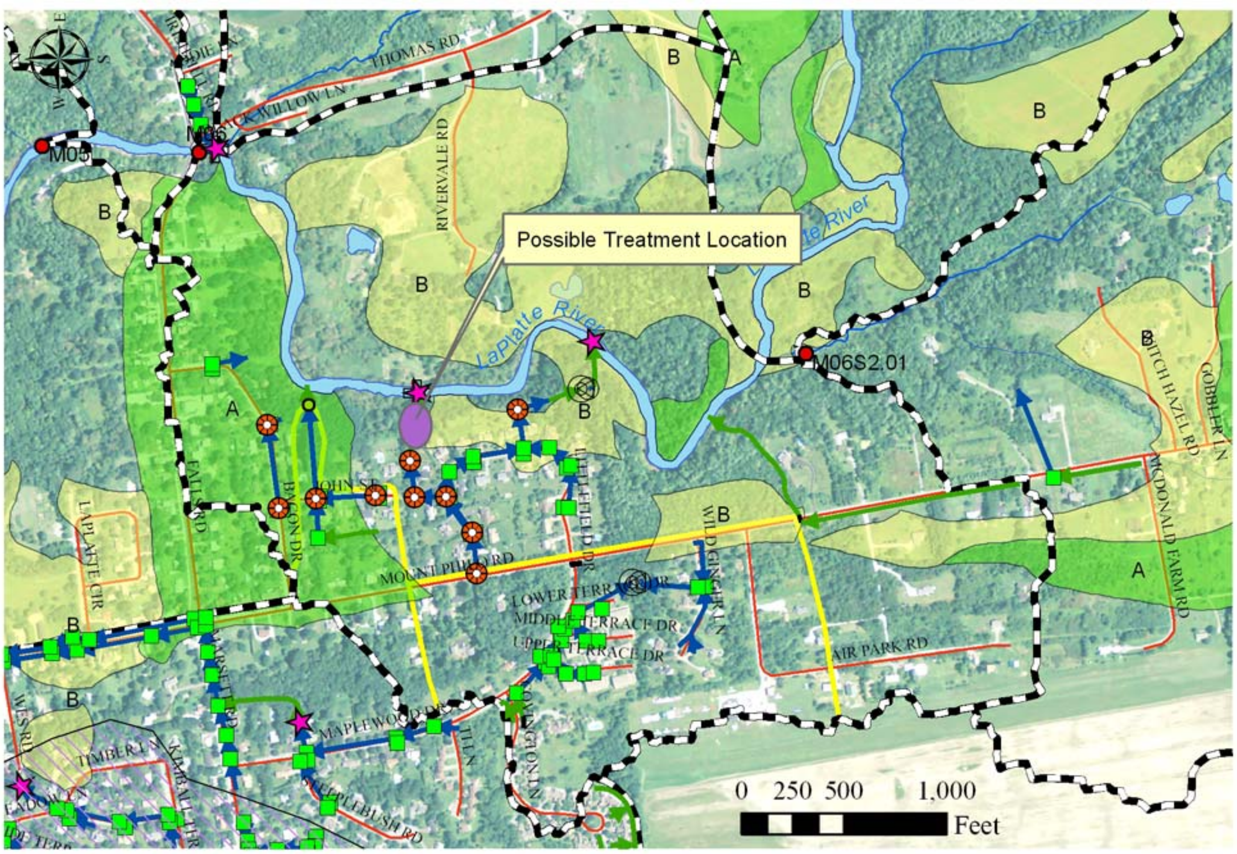


Figure 17: Potential Stormwater Treatment Options in Shelburne Village M06

The collection system on John Street currently has a grease trap that stormwater passes through before discharge to the LaPlatte River. This system could be upgraded for improved stormwater treatment as a future project. Infiltration practices such as installation of recharge galleys or establishment of a stormwater detention pond would be appropriate due to soil types in the area around this outfall.

McCabe’s Brook T1.03, Shelburne Village

McCabe’s Brook subwatershed T1.03 was identified as having high impervious cover, large runoff volumes, and reduced water quality. T1.03 extends from just downstream of the Town Garage to upstream of Heritage Lane. The system that runs down Harbor Road collects stormwater from Shelburne Museum, the village green, businesses on Route 7, part of the Shelburne Elementary School, and Harbor Road. This large system appears to have opportunities for treatment before reaching McCabe’s Brook. Two potential detention areas are identified – off Harbor Road near Athletic Drive and expanding the existing pond behind the Town Garage (Figure 18). These locations are in the vicinity of wetlands and may not have available space for a large pond-type treatment option. There may be smaller, decentralized treatment alternatives for stormwater disconnection such as rain gardens at the school.

Upstream of Harbor Road, there are multiple outfalls along McCabe’s Brook originating from Heritage Lane, Tracy Lane, Fletcher Lane, Stokes Lane, Creekside Drive, and School Street. Many of these older stormwater conveyance systems consist of catch basins and pipes, and do not appear to have treatment facilities. Improvements are recommended at any of these outfalls, although the close proximity of outfalls to the river corridor may not allow space for detention. Low impact development techniques should be applied in this neighborhood to reduce stormwater runoff and increase infiltration. A collection system discharging behind the tennis courts off of School Street has been targeted for treatment due to available space at the outfall and the large contributing area. This area is within a Town Park and any treatment would need to be designed to complement the existing recreational uses. Subsurface treatment options may be appropriate in this location.

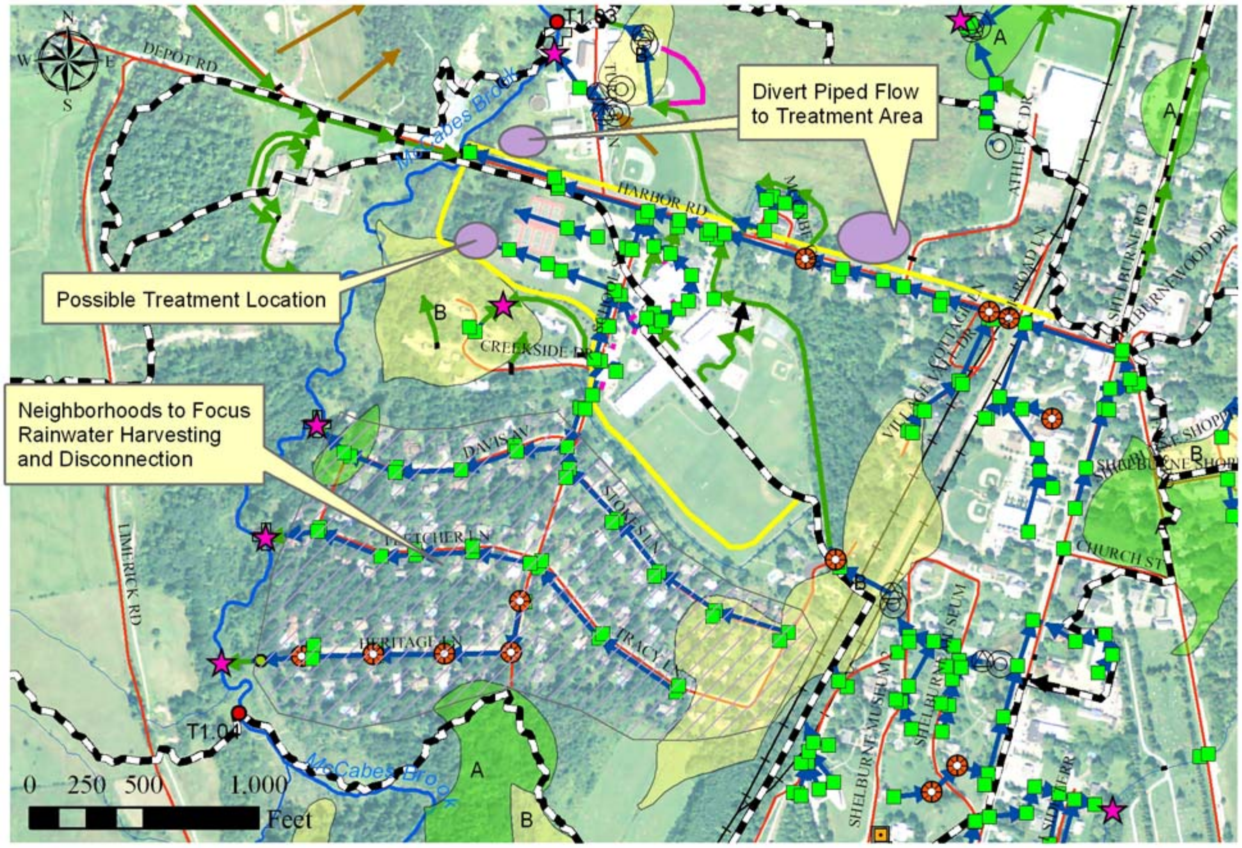


Figure 18: Potential Stormwater Treatment Options in Shelburne Village T3.01

McCabe's Brook T1.05, Teddy Bear Factory, Shelburne

The Teddy Bear Factory property includes a high percentage of impervious surface from buildings, parking lots, and the access road. This location was identified by the watershed volunteer water quality testing as a possible contributor to lower water quality (LWP, 2008). A stormwater treatment pond does exist on this property and has a state stormwater permit. Further investigation is needed to confirm water quality results and identify possible improvement at the site such as re-routing runoff or increasing the amount of runoff volume stored and the duration of storage.

LaPlatte River M16, Hinesburg Village

LaPlatte River reach M16 extends from the confluence with the Patrick Canal, just downstream of the former Saputo property, north to the confluence with Beecher Hill Brook. This large subwatershed was split into three sections for analysis based on stormwater type and input locations. The lower two subwatersheds have been targeted for stormwater improvement.

A majority of village drains to the tributary in the downstream section of this reach, including most of the eastern half of Route 116 through the village. Treatment potential exists in this area. Stormwater could be diverted from the ditched tributary into the existing treatment pond that was formerly used by the Saputo factory (Figure 19). If this pond will not be used for future plant operations it would serve as ready-made stormwater detention. Space for other detention areas exists around the factory site that could be reserved for planned future uses in the area and village expansion. Permeable soils are mapped in the LaPlatte River corridor in this area including the western half of the factory site and portions of the fields both to the north and south of the site which could present opportunities for infiltration based mitigation.

Additional opportunities for stormwater interception are possible in the collection system upstream including expanding the current ditch in Lyman Park to enhance stormwater treatment by establishing wider detention areas. Stormwater enters the ditch systems behind the gas station, church, and the grocery store at multiple locations and thus small decentralized treatment methods such as rain gardens or infiltration practices may be appropriate. Minimal, if any, mowing should be performed in the swales so thicker vegetation increases hydraulic resistance slowing flow rate and increasing retention times.

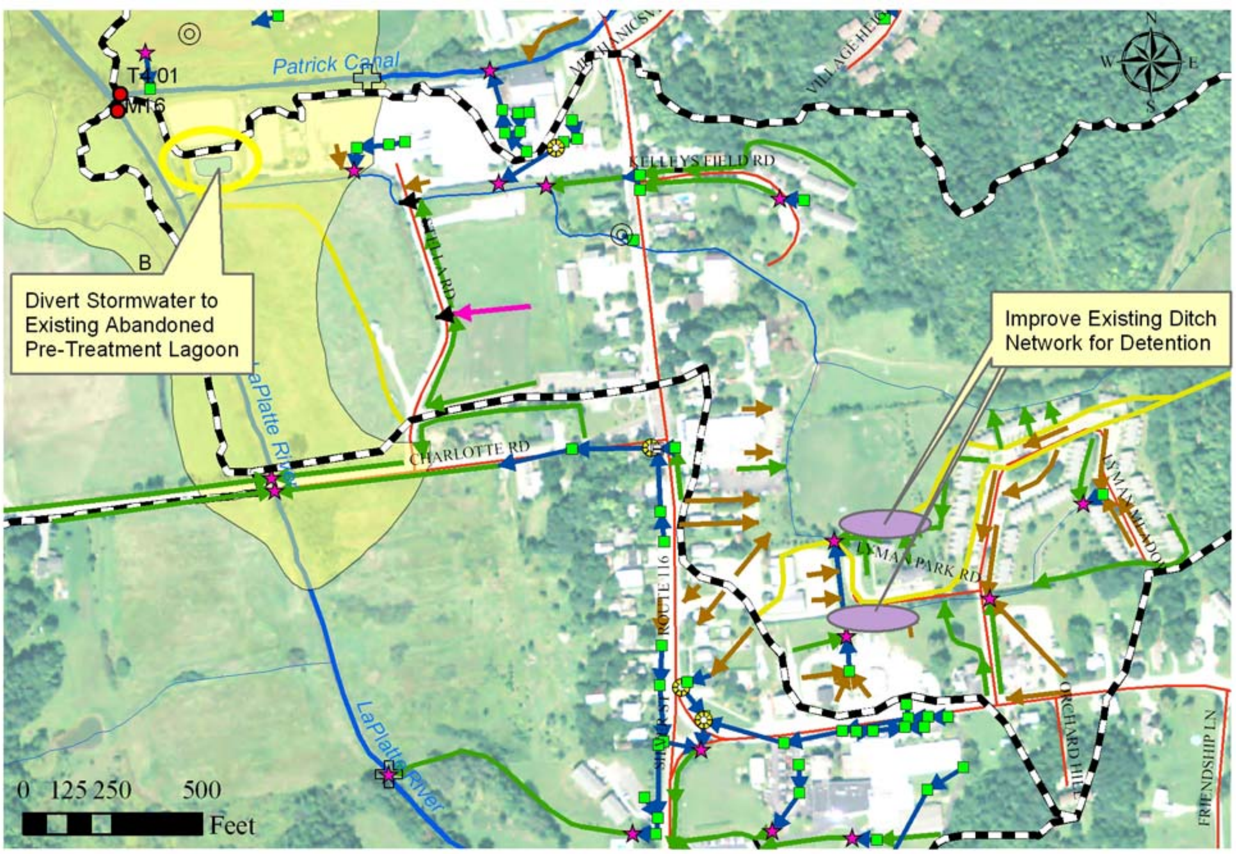


Figure 19: Potential Stormwater Treatment Options in Hinesburg Village Lower M16

The middle section of M16 includes runoff from the remaining section of Hinesburg village, from Charlotte Road upstream past Hinesburg Community School. This subwatershed was targeted for treatment due to high percentage of impervious surface, water quality problems downstream, and local erosion. A multi-celled, terraced detention system is recommended where the piped system meets the ditch at the corner of Silver Street (Figure 20). Multiple detention cells would allow for increased retention times on the sloping corner of land. Water currently rushes out of the pipe and down the existing steep ditch to the LaPlatte River.

Ditches along Charlotte Road collect water from a section of Route 116 with catch basins and stormwater pipes. The ditch that this system discharges to is a grass swale along the road that could be improved into a higher functioning linear rain garden system. Soils located in the area indicate that infiltration could be possible in this location.

Another series of catch basins along the southwest part of the village collects runoff along Route 116 in front of the Hinesburg Elementary school and discharges near the corner of Silver Street and Route 116. Erosion is taking place at this outfall indicating high stormwater flows. Runoff eventually flows through the ditches along Silver Street. The terraced rain garden recommended in this area will thus need to be size for the volume of runoff coming from this and the previously mentioned pipe systems.

Hinesburg Community School has two discharge points behind the school. Multiple opportunities exist for stormwater treatment such as rain gardens or constructed wetlands at the school site (Figure 20). These projects could benefit local stream health and present a hands-on educational opportunity for the students at the Hinesburg Community School to learn about stormwater. The targeted outfall collects runoff from compacted areas of the lawn and discharges behind the play area. Roof runoff should be diverted to the recommended treatment area. Other smaller stormwater projects could be implemented around the school such as inclusion of rain water collection barrels at the roof downspouts and building of small rain gardens in the median strip in front of the school that are now drained by catch basins. Disconnection of impervious surfaces or install of infiltration methods are recommended for the parking areas and the roof that are now discharging to the LaPlatte River near the Silver Street Bridge without treatment. Installation of stormwater treatments may be pursued as part of the reconstruction of the Silver Street Bridge, scheduled for 2011-2012.

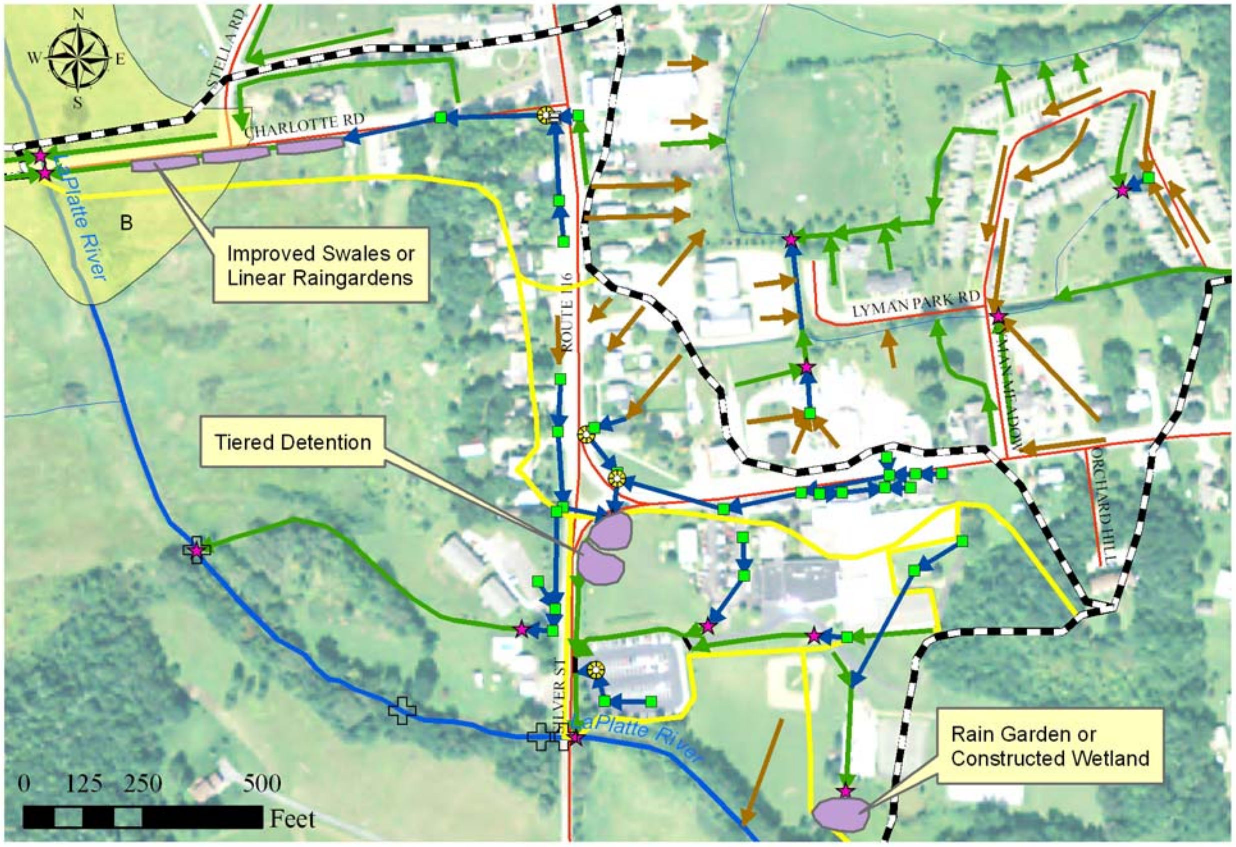


Figure 20: Potential Stormwater Treatment Options in Hinesburg Village Middle M16

Patrick Brook M15S02, Hinesburg Village

Patrick Brook (M15.S02.1) was identified as a priority watershed for stormwater treatment based on the ranking analysis and specifically percent impervious surface. Between the local gas station and Patrick Brook is a piece of open space that could serve as a location for a stormwater detention pond (Figure 21). A constructed wetland or traditional pond could be built and directly draining runoff from the area could be diverted to the pond via swales or curbing along the back of the parking areas.

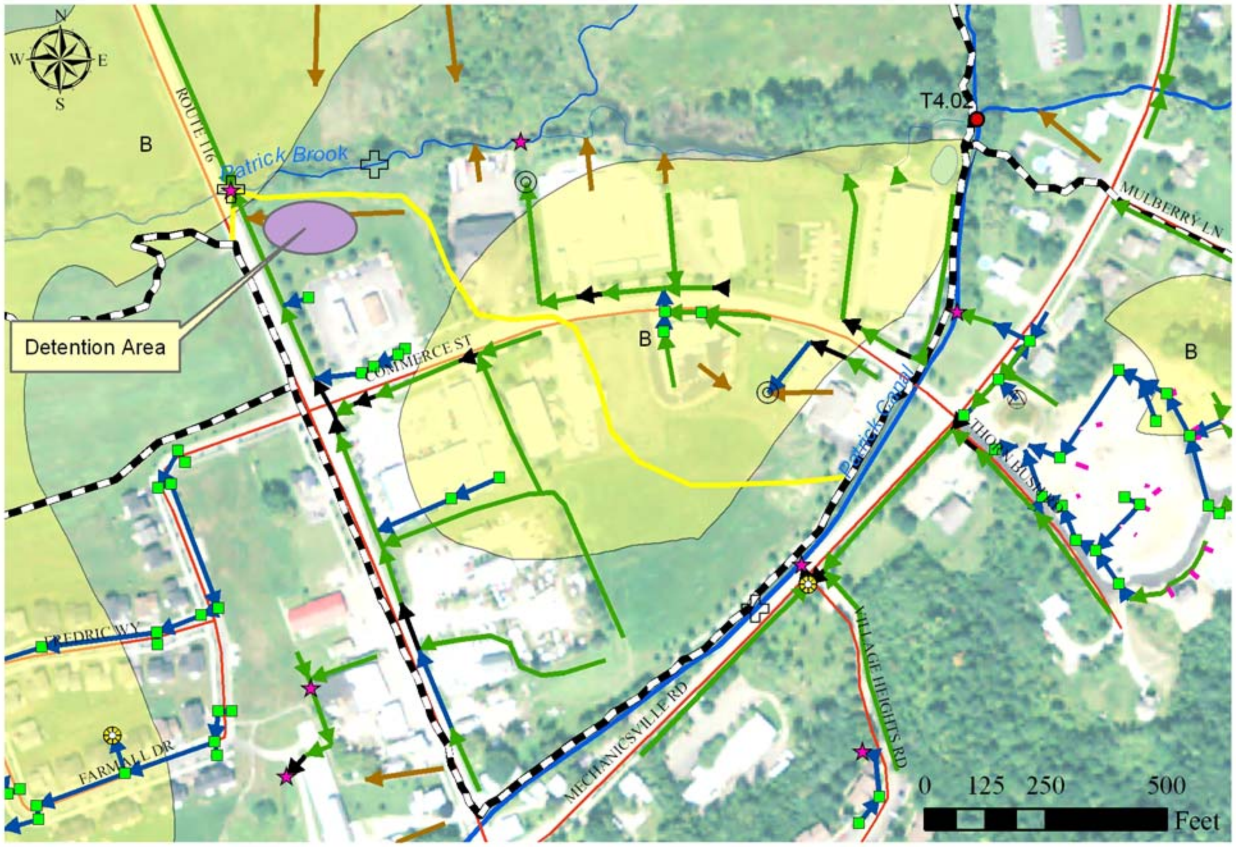


Figure 21: Potential Stormwater Treatment Option in Hinesburg Village Patrick Brook

Patrick Canal T4, Hinesburg

Several of the Patrick Canal subwatersheds have been identified as having degraded geomorphic condition and are high priority for stormwater mitigation. Much of the development in the lower reach (T4.01) is new and has adequate stormwater treatment. The close proximity of the canal to Mechanicsville Road limits opportunity for detention along this degraded reach (T4.02). The upper watersheds have some in-line detention in the form of ponds and dams. Residential development in the upper reaches is dispersed and does not have stormwater treatment. One potential treatment location was identified next to Mechanicsville Road at the base of the cemetery (Figure 22). A detention area at this location could serve as channel overflow during storm events and detain runoff from the cemetery hillside. The location of this detention area is upstream of T4.02 that has poor geomorphic condition and T4.01 which has significant impervious surface and is therefore vulnerable to stormwater runoff. This site was visited in the field and appears to be a good location for a constructed wetland.

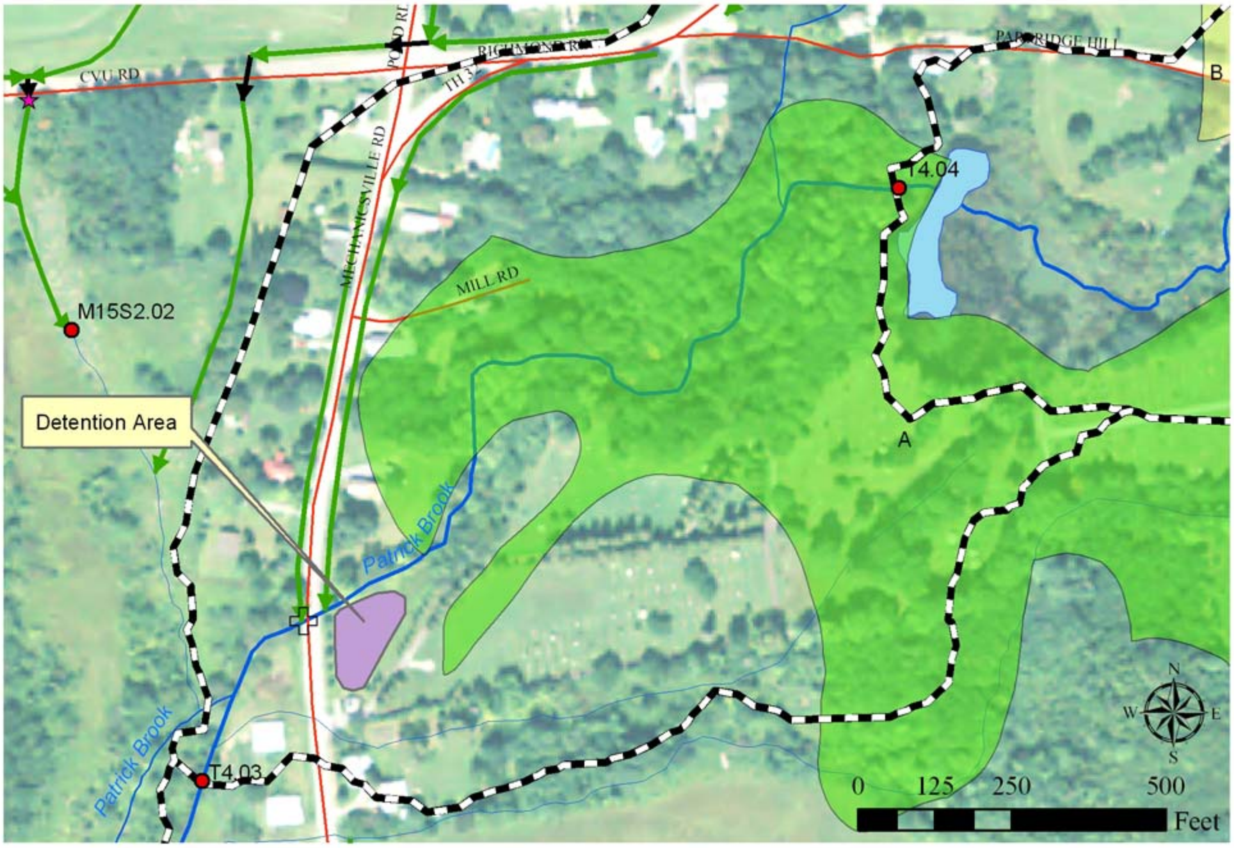


Figure 22: Potential Stormwater Treatment Option in Hinesburg Patrick Canal

8.2 Summary of Recommended Projects

The recommended stormwater treatment projects presented here have been tabulated along with relevant stormwater information to aid in project prioritization and further project development (Table 7 and Table 8). Drainage area and amount of impervious area draining to each outlet or project location was identified. An approximate runoff volume was calculated based on the subwatershed runoff depth and the drainage area to the outfall.

Table 7: Summary of Suggested Projects in Shelburne

Project Location	Recommendations	Property Owner	Parcel ID	Stream Reach ID	Subwatershed Runoff Ranking	Approximate Drainage Area to Outlet (acres)	Approximate Impervious Area to Outlet (acres)	Subwatershed Runoff Depth (inches)
Mt. Philo Road north of Wes Road	Detention in Field	Town of Shelburne	34-52-03.000	M04, Village	0.958	40.03	8.02	1.17
Green Hills Drive, Timber Lane, Meadow Lane Area Neighborhood	Rainwater Disconnection / LID Approaches	Multiple	N/A	M04, Village	0.958	126.96	24.85	1.17
Mt. Philo Road Drainage, Outfall between John St. and Littlefield Drive	Install Detention	Peter & Susan Plumb, Town of Shelburne, Frederick Schmidt & Ann Revtrusts, Mark & Judy Willis	36-51-21.000, -72.000, -65.000, -66.000	M06, Village	0.435	43.26	8.52	0.47
John Street	Install Infiltration	Inger Dybfest	36-51-18.000	M06, Village	0.435	11.29	1.61	0.47
Harbor Road Collection System, near Althetic Drive	Divert Pipe Flow to Detention near Althetic Drive	McCabe's Circle Community	30-50-33.200	T1.03, Northern	0.847	107.49	25.14	0.93
Harbor Road Collection System, Detention behind Town Garage	Divert Pipe Flow to Detention behind Town Garage	Town of Shelburne	30-50-03.000	T1.03, Northern	0.847	107.49	25.14	0.93
School Street and Elementary School	Install Detention behind Tennis Courts	Town of Shelburne	30-50-20.000	T1.03, Southern	0.493	17.42	1.81	0.72
Heritage Lane, Fletcher Lane, Davis Lane, Stoeks Lane, Tracy Lane Area Neighborhood	Rainwater Disconnection / LID Approaches	Multiple	N/A	T1.03, Southern	0.493	201.81	16.09	0.72
Teddy Bear Factory	Investigate and Improve Treatment	Teddy Bear Factory	10-02-07.000, -09.000	T1.05	0.315	62.57	6.52	0.50

Notes: Teddy Bear Factory Areas assume all impervious area on site could be collected.

Table 8: Summary of Suggested Projects in Hinesburg

Project Location	Recommendations	Property Owner	Parcel ID	Stream Reach ID	Subwatershed Runoff Ranking	Approximate Drainage Area to Outlet (acres)	Approximate Impervious Area to Outlet (acres)	Subwatershed Runoff Depth (inches)
Saputo Factory Site	Retrofit Existing Pre-treatment Pond / Infiltration	Saputo Cheese USA Inc	20-50-66.000	M16, Northern	0.628	86.63	13.36	0.72
Lyman Meadows Northern Section	Swale Improvement	Andrew Burton/ Town of Hinesburg	20-50-81.000/ 20-50-	M16, Northern	0.628	2.77	0.85	0.72
Gas Station/Lyman Meadows	Swale Improvement	Hart & Mead Inc / Andrew Burton	20-50-37.000/ 20-50-	M16, Northern	0.628	19.78	5.06	0.72
Charlotte Road	Swale Improvement, Bioretention, or Infiltration	Public ROW / Green Street LLC.	Road ROW / 20-50-43.000	M16, Middle	0.408	7.43	2.63	0.62
Silver Street and Route 116 Corner	Detention	Town of Hinesburg	08-01-09.000	M16, Middle	0.408	6.47	2.53	0.62
Hinesburg Community School Play Area	Bioretention	Town of Hinesburg	08-01-32.000	M16, Middle	0.408	3.41	0.42	0.62
Hinesburg Community School, Parking Area	Bioretention or Infiltration	Town of Hinesburg	08-01-32.000	M16, Middle	0.408	5.2	2.33	0.62
Route 116 Crossing over Patrick Brook	Detention on South side	Jolley Associates	16-20-68.000	M15S02.1	0.515	16.65	4.19	0.67
Hinesburg Cemetery, Patrick Brook	Patrick Brook Storwater Overflow	Town of Hinesburg	17-22-60.00	T4.03 & US Reaches	0.405	4036.67	166.68	0.62

Notes: Hinesburg Cemetery site, includes area from upstream subwatersheds that contribute flow to Patrick Brook at that point.

8.3 General Stormwater Recommendations

This study has demonstrated that stormwater runoff is an issue within the LaPlatte River watershed. Many of the specific areas experiencing the most problems are focused in and around the village centers of Shelburne and Hinesburg. Older stormwater conveyance systems without any treatment are now handling increased volumes of runoff as properties in village centers converted land use to impervious cover and the already limited infiltration capacity was reduced. Data suggest that receiving waters are showing signs of impairment from stormwater discharge.

The areas that have been identified for mitigation projects add treatment to the existing system and seek to expand capacity at the village center where growth is likely to take place since municipal infrastructure (sidewalks, water and sewer, schools) and services already exist. Although rural areas do not have the same permitted development density or amount of impervious cover, stormwater impacts do exist from field and road ditch runoff that influences downstream channels. These areas will have different approaches to stormwater mitigation as there are not obvious collection systems to target projects.

Recommended strategies for improving water quality through stormwater treatment.

- Begin implementation of the projects identified during this study to eliminate discharge of untreated stormwater to receiving waters. Community and school hands-on demonstration projects are recommended to gain public support for minimizing stormwater impacts from village centers.

- Require all properties submitting an application for a building permit to demonstrate stormwater mitigation using Low Impact Development (LID) techniques. The ultimate goal is mimicking pre-development hydrology by reducing runoff volume for future development (Smith 2010). This strategy would specifically target small developments that are under the threshold for obtaining a state stormwater permit, but have a cumulative impact by joining the existing stormwater systems with such little treatment facilities. Innovative design approaches would be required to size and construct best management practices to reduce runoff (e.g., Hirschman and Collins 2008).

- Fund and implement a low impact development (LID) outreach program to promote and support single lot-scale stormwater reduction and re-use methods such as rain barrels, cisterns, and rain gardens. This would include adoption and distribution of an LID guidance manual such as that used by the South Burlington Stormwater Utility (Utility 2009) or VTDEC's *The Small Sites Guide for Stormwater Management* (VTDEC 2009). An important message is that LID techniques reduce stormwater runoff (Bedan and

Clausen 2009), improves the quality of receiving waters, is often aesthetically pleasing in village centers, and is cost-effective design approach (USEPA 2007).

- Building on the findings presented here, use stormwater treatment potential to guide future development and plans for growth in the village centers. The potential exists for infiltration-based stormwater mitigation in select locations in most of the priority watersheds. These possible treatment sites should be investigated further for verification of infiltration capacity based on soil mapping, proximity to potential development sites, and identification of parcel information.

- Revise planning and zoning ordinances to include specific strategies for stormwater improvement. Create a green infrastructure overlay district to reserve prime areas for infiltration and groundwater recharge based on soils and surficial geology. This type of overlay would allow for natural infiltration as well as locations for sighting engineered stormwater management areas.

There are many ways to reduce and re-use stormwater. A summary of popular approaches that could be incorporated into standard practices, master plans, or municipal code follow.

- Limit the amount of impervious surface and preserve open space
    - Cluster development for to share drives and roads
    - Minimizing pavement widths
    - Reduce setbacks from property lines to limit driveway lengths
    - Reduce necessary property frontages to reduce main road length per property
    - Encourage minimal disturbance practices during construction to preserve natural vegetation, heterogeneous land surface, and soil permeability
    - Use permeable pavement or pavers where possible
    - Use green roof tops
    - Increase infiltration capacity of lawns, sports fields and parks by mowing high and over seeding bare spots.

- Disconnect impervious surfaces from collection systems and receiving waters
    - Install rain barrels or cisterns for rainwater collection at roof downspouts for irrigation.
    - Install rain gardens to collect runoff from driveways and medians. Technical guidance for design and building is provided by the Vermont Rain Garden Manual created by the Winooski Natural Resource Conservation District (District 2009). Assistance is also available through UVM extension services.
    - Install infiltration systems such as infiltration trenches, basins, or underground galleys where soils are permeable.

- Eliminate use of curbing where possible to promote overland flow of runoff from impervious surfaces.

- Preserve river corridor natural stormwater functions
  - Restrict new development from designated floodplain areas. These areas are critical for water storage during flood events and sediment and nutrient removal.
  - Maintain and expand vegetated buffers to filter stormwater runoff.

- Improve stormwater treatment function of roadside ditches
  - Encourage natural vegetation for reduction of water velocity, improved settling of solids, and reduction of erosion.
  - Include small depressions to promote settling of solids and collection of gravel in road runoff.
  - Install sediment forebays and check dams where appropriate along existing ditches to increase water storage, promote infiltration, and allowing settling of solids.
  - Stone lined ditches raise water temperatures due to sun exposure and ultimately raise temperatures in streams that is harmful to many aquatic species.

- Improve stormwater runoff from agricultural areas
  - Encourage landowners to take advantage of USDA fencing and buffer programs to protect riparian areas.
  - Promote soil protection using cover crops and other methods.
  - Reduce pollutant load from fields.

Future considerations for the Towns.

- There is value in planning for stormwater mitigation on a watershed and town-wide basis instead of a site by site level as required by current state regulations. How can this more efficient level of planning be incorporated into policy?

- The benefits of being proactive in mitigating effects of stormwater are numerous and more economical in the long run. Could implementation of a stormwater management plan avoid state and federal mandated regulation?

- Minimizing ecological impacts in the watershed should be a priority for towns. Our health and that of the ecosystem depend on it.

- Should a green infrastructure overlay be created to conserve infiltration areas and describe their priority for stormwater mitigation and groundwater aquifer recharge?

- Due to the rural nature of the towns, development is often dispersed and small scale. Should new development of this type be required to meet a town stormwater treatment standard? How easily can the town implement low-impact design approaches?

- Are the costs and benefits for stormwater discharge appropriately shared between rural and urban areas?

- Would the town foster partnership with LaPlatte Watershed Partnership to facilitate outreach to property owners to provide education and technical advice on improved stormwater management?

- Many municipalities are moving towards tougher development standards where rather than no increase in peak flow rate no increase in stormwater runoff volume leaving the site is allowed. Is this standard a fair burden on future development?

- Roadside ditches contribute untreated stormwater directly to streams in the majority of the watershed. Is there a way to target specific areas for improvement during scheduled ditch maintenance? Will the town agree to change ditch practices to improve stormwater treatment and formalize these approaches in a policy?

8.4 Growth Center Considerations

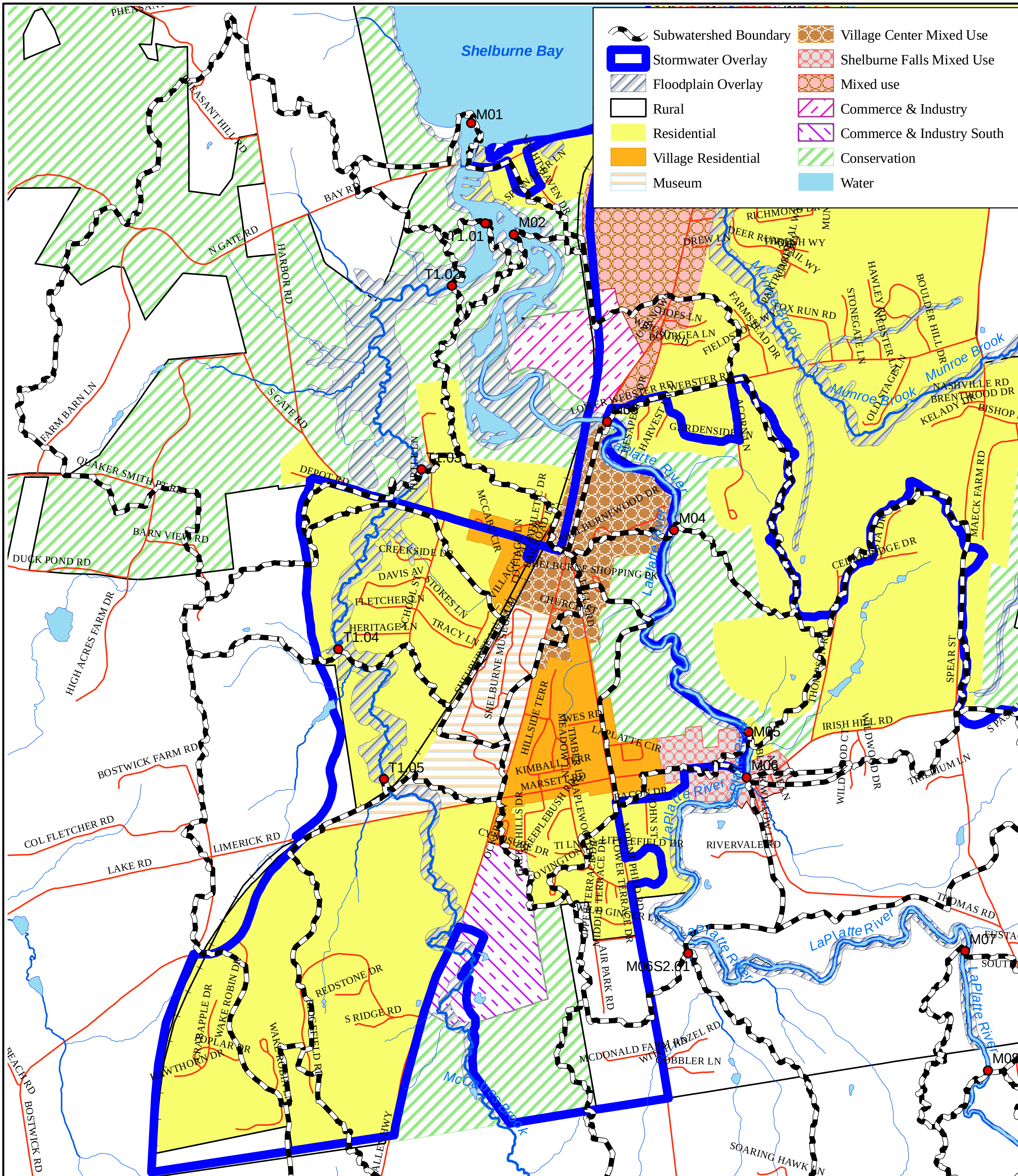
The Town of Shelburne has taken steps to implement stormwater improvement strategies as part of MS4 permit requirements. A floodplain overlay has been incorporated into municipal zoning that includes stream buffers and stormwater overlay districts (Figure 23). Details and standards for stormwater treatment have been included in the Town Public Works Specifications. The Town has passed a Stormwater Ordinance. All of these steps have worked towards improved stormwater treatment and protection of the river corridors.

The Town of Shelburne's stormwater overlay district includes the majority of the developed area in and around the village center that has been discussed as high risk in this study. It requires that any new or redevelopment project exceeding 10,000 square feet (approximately ¼ acre) may be subject to individual permit requirements from the DEC Water Quality Division. The focus on stormwater has been on developed areas with designated stormwater impaired rivers. This report illustrates the need for prevention of future impacts and provides suggestions for refinement of the designated stormwater overlay district to preserve important infiltration areas or protect open space.

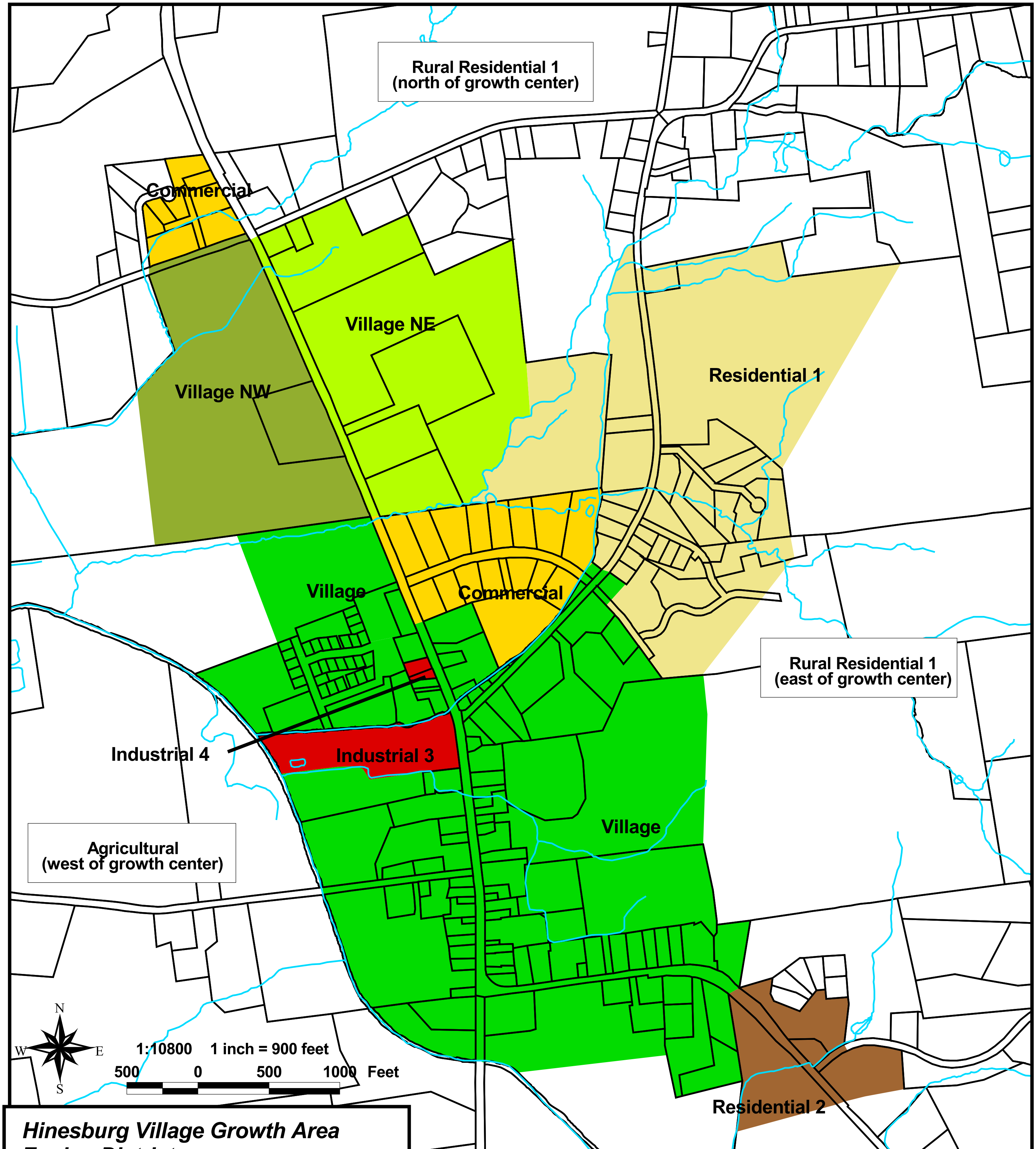
The Hinesburg Zoning districts include a Village Growth Area (Figure 24). This Growth Area designates a significant amount of currently undeveloped land to be part of future development. These areas are within many subwatersheds that were identified to be stormwater hot spots including LaPlatte River (M16) and Patrick Brook and Canal (M15.S02, T4.01, T4.02). The Patrick Brook and Canal reaches have already been identified as contributing to degraded conditions in the LaPlatte River reach (M15). Stream buffers have been included as part of the designated Growth Area. These buffers begin to set priority for stream functions and decrease pollutants in runoff, but may benefit from being extended to include more of the adjacent areas shown to have high infiltration capacity to support current and future stormwater treatment.

It is recommended that the Hinesburg Village Growth area be refined based on a village-wide stormwater management plan. This plan would strategize mitigation of current stormwater problems and set guidance for future development. Mitigation of stormwater runoff from public infrastructure would be addressed in the plan. A few areas with soils conducive to infiltration should be designated for infiltration type stormwater treatment and be incorporated in site planning.

Charlotte remains mostly rural within the LaPlatte River watershed. Town zoning designated most of the area as rural (Figure 25). Conservation areas show stream buffers and a few large areas adjacent to streams. East Charlotte village, including a small section of Village Commercial zoning is included in the watershed. This area of concentrated development is located at the headwaters of a few tributaries that appear to have adequate open space to provide stormwater treatment before discharge to a receiving water.



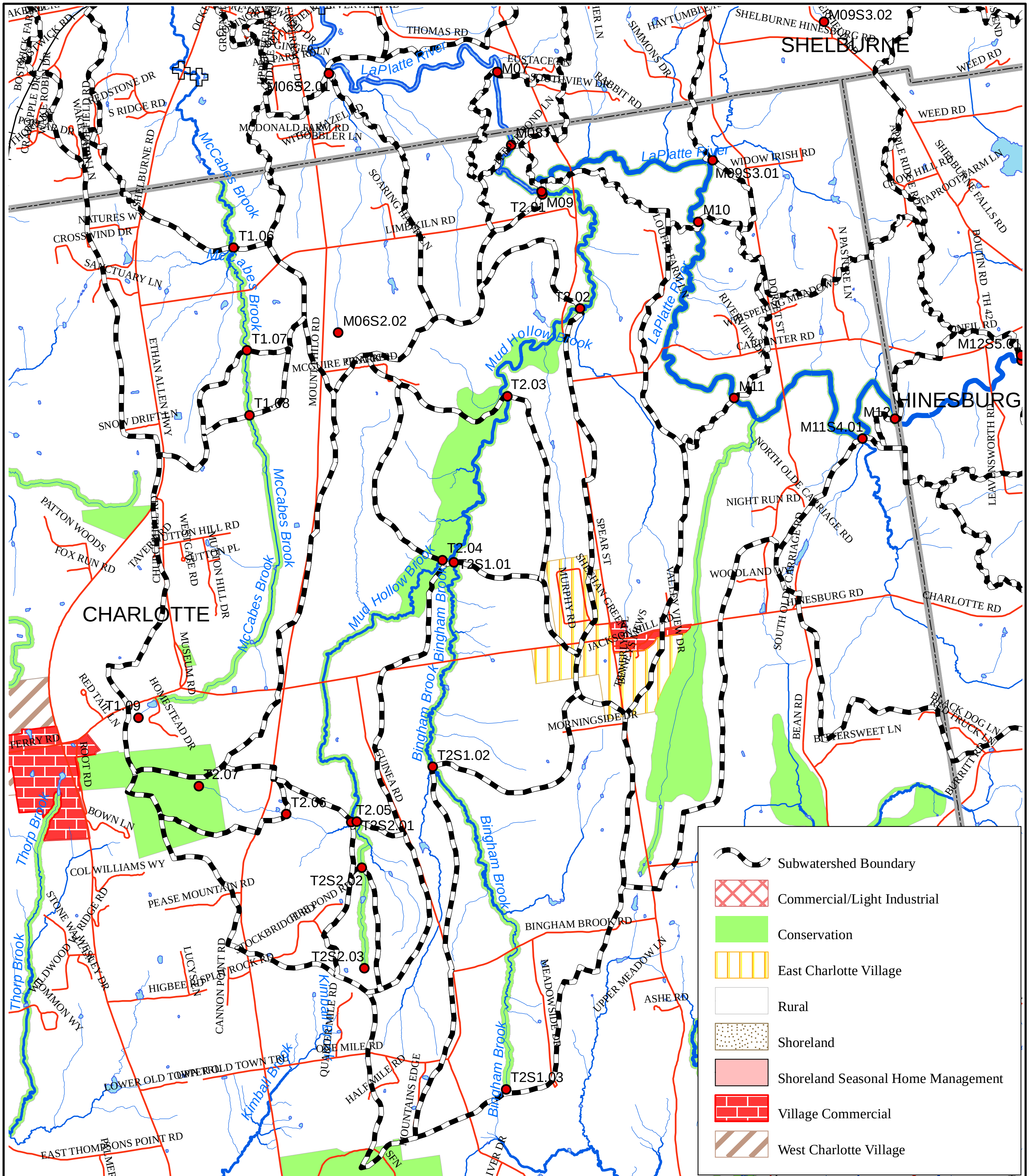
Engineering, Landscape Architecture and Environmental Science **MILONE & MACBROOM®** 1233 Shelburne Road, Suite 150 South Burlington, VT 05403 (802) 864-1600 Fax: (802) 864-1601 www.miloneandmacbroom.com	**Shelburne Village Zoning Districts**	N E S W 0 500 1,000 2,000 Feet		
	LaPlatte River Watershed Stormwater Project	DATE: March 2010 SCALE: 1" = 1,000'	SHEET: **Figure 23**	



Hinesburg Village Growth Area Zoning Districts

Adopted by Selectboard May 4, 2009
Effective May 25, 2009

map date 5/14/2009
by Hinesburg Planning/Zoning Office



Engineering, Landscape Architecture and Environmental Science

MILONE & MACBROOM®

1233 Shelburne Road, Suite 150
South Burlington, VT 05403
(802) 864-1600 Fax: (802) 864-1601
www.miloneandmacbroom.com

Charlotte Village Zoning Districts

LaPlatte River Watershed Stormwater Project

DATE: October 2010

SCALE: 1" = 3,500'

SHEET: Figure 25

8.5 Stormwater Utility Considerations

The information presented here is fundamental to stormwater utility planning and implementation. Impervious cover layers and infrastructure mapping could be used to guide locating where the utility is applicable and setting rates. The project list provides a first take on a wide array of projects that utility fees could be applied to for improved local stormwater management.

Most residents in the LaPlatte River watershed currently do not pay the cost of generating increased stormwater runoff that is impacting the river and the cost of servicing existing infrastructure. Results of this study indicate that village centers have increased infrastructure needs, yet rural areas also have stormwater management project needs. A regular funding source is needed to update existing stormwater systems with necessary treatment facilities and begin proactive planning for treating runoff from all future development regardless of size.

A regional stormwater approach seems to make sense for the LaPlatte River watershed given the small size of village centers and generally small population. A watershed-based administration of a utility would create efficiencies and reduce operating costs.

9.0 References

Bedan, E. S. and J. C. Clausen (2009). "Stormwater Runoff Quality and Quantity From Traditional and Low Impact Development Watersheds(1)." Journal of the American Water Resources Association **45**(4): 998-1008.

Brabec, E., S. Schulte, et al. (2002). "Impervious surfaces and water quality: A review of current literature and its implications for watershed planning." Journal of Planning Literature **16**(4): 499-514.

CWP (2003). "Is impervious cover still important? Impacts of Urbanization on Downstream Receiving Waters." Runoff Rundown, Center for Watershed Protection **9**: 1-15.

District, W. N. R. C. (2009). "The Vermont Rain Garden Manual "Gardening to Absorb the Storm"." Retrieved March 30, 2010, 2010, from http://vacd.org/winooski/VtRainGardenManual.pdf.

Fitzgerald, E. P. (2007). LINKING URBANIZATION TO STREAM GEOMORPHOLOGY, AND BIOTIC INTEGRITY IN THE LAKE CHAMPLAIN BASIN, VERMONT (Masters Thesis). Graduate College. Burlington, VT, University of Vermont. **Master of Science**.

Hirschman, D. and K. Collins (2008). The Runoff Reduction Method. Ellicott City, MD, Center for Watershed Protection, Inc. **8:** 1-26.

Lane, E. W. (1955). The importance of fluvial morphology in hydraulic engineering. American Society of Civil Engineering, Journal of the Hydraulics Division.

LWP (2006). LaPlatte River Phase 2 Stream Geomorphic Assessment: Hinesburg Reaches. Shelburne and Charlotte, VT, LaPlatte Watershed Partnership, with support from VT

DEC River Management Program, VT ANR Department of Fish and Wildlife, and Lewis Creek Association.

LWP (2007). Phase 2 Stream Geomorphic Assessments, Lower LaPlatte River & McCabe's Brook, Shelburne and Charlotte, Vermont. Shelburne and Charlotte, VT, LaPlatte Watershed Partnership, with support from VT DEC River Management Program and Lewis Creek Association.

LWP (2007). Stream Corridor Plan for the LaPlatte River and Tributaries, Town of Hinesburg, Vermont. Hinesburg, VT, LaPlatte Watershed Partnership, with support from VT DEC River Management Program and Lewis Creek Association.

LWP (2008). Shelburne Bay Tributaries - LaPlatte River (Background and Interpretation of Results: 2004-2007).

LWP (2008). Stream Corridor Plan Reaches M6-M11, Towns of Charlotte and Shelburne, Vermont. Hinesburg, VT, LaPlatte Watershed Partnership, with support from VT DEC River Management Program and Lewis Creek Association.

Schiff, R. and G. Benoit (2007). "Effects of impervious cover at multiple spatial scales on coastal watershed streams." Journal of the American Water Resources Association **43**(3): 712-730.

SCS (1986). Technical Release 55: Urban Hydrology for Small Watersheds (TR-55), The Soil Conservation Service (forerunner of NRCS) Hydrology Branch in cooperation with the Agricultural Research Service, Hydrology Laboratory, U.S. Department of Agriculture.

Smith, T. (2010). "Runoff volume reduction: A perspective from springfield and greene coutny, missouri." Water Resources IMPACT **12**(2): 13-16.

Strahler, A. N. (1952). "Hypsometric (area-altitude) analysis of erosional topography." Bulletin of the Geological Society of America **63**: 1117-1142.

Thompson, E. H. and E. R. Sorenson (2005). Wetland, woodland, and wildland: A guide to the natural communities of Vermont. Lebanon, NH, University Press of New England.

USEPA (2007). Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practises, EPA 841-F-07-006. U. S. E. P. Agency. Washington, DC, United States Environmental Protection Agency**:** 37.

Utility, S. B. S. (2009). Low Impact Development Guidance Manual. South Burlington, Vermont, Sout Burlington Stormwater Utility.

VTANR (2009). Vermont Stream Geomorphic Assessment Protocol Handbooks: Remote Sensing and Field Surveys Techniques for Conducting Watershed and Reach Level Assessments (http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_geoassesspro.htm). Waterbury, VT, Vermont Agency of Natural Resources, Department of Environmental Conservation, Division of Water Quality, River Management Program.

VTDEC (2002). The Vermont Stormwater Management Manual. VTANR. Waterbury, VT**:** 119.

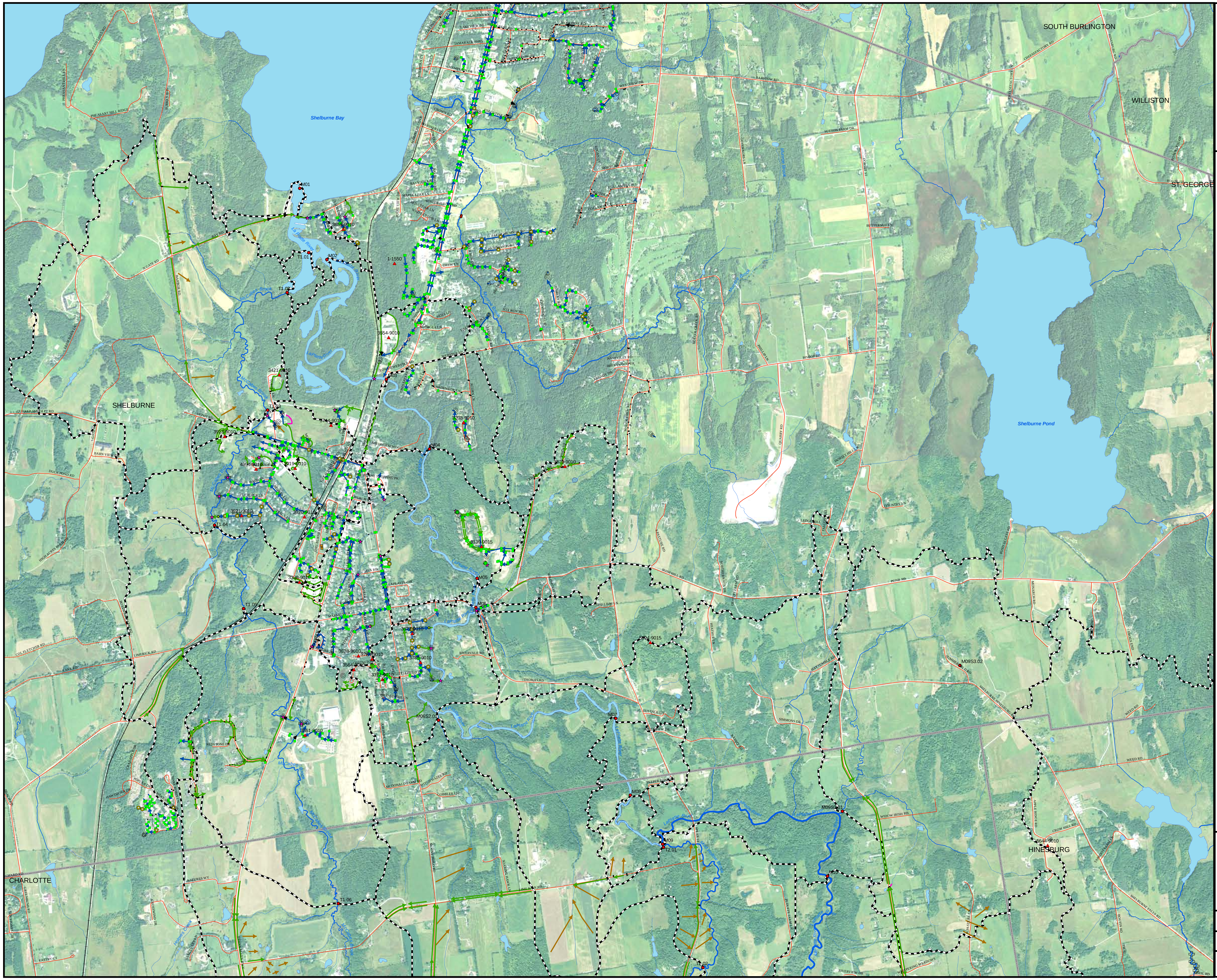
VTDEC (2008). STATE OF VERMONT 303(d) LIST OF WATERS: PART A - IMPAIRED SURFACE WATERS IN NEED OF TMDL. Waterbury, VT, Vermont Agency of Natural Resources, Department of Environmental Conservation, Water Quality Division.

VTDEC (2008). Total Maximum Daily Load to Address Biological Impairment in Munroe Brook (VT05-11) Chittenden County, Vermont. Approved by USEPA: August 21, 2008. V. D. o. E. Conservation. Waterbury, Vermont.

VTDEC (2009). The Small Sites Guide for Stormwater Management. VTANR. Waterbury, VT**:** 48.

Appendix A – Town Stormwater Infrastructure Maps

Attached as electronic file (PDF).



Legend

- ANR Issued Stormwater Permits
- ANR SGA Identified Stormwater Inputs

MMI Stormwater Points
- Catchbasin
- Concrete Pad
- Detention Pond
- Drop Inlet
- Dry Well
- Grease Trap
- Manhole
- Outfall
- Outlet Structure
- Spillway
- Stone Filter

MMI Stormwater Lines
- Other
- Culvert
- Overland
- Stormline
- Swale
- Subwatershed Boundary
- Towns
- Lakes and Ponds
- Roads
- Railroad

River (By Stream Order)

1 2 3 4 5

Aerial Photography is 2008 1:40,000 (1 meter) Color NAIP

SHELBURNE STORMWATER INFRASTRUCTURE

LAPLATTE RIVER WATERSHED STORMWATER PROJECT

SHELBURNE, VERMONT

DESIGNED	DRAWN	CHECKED
JSC	JSC	RKS

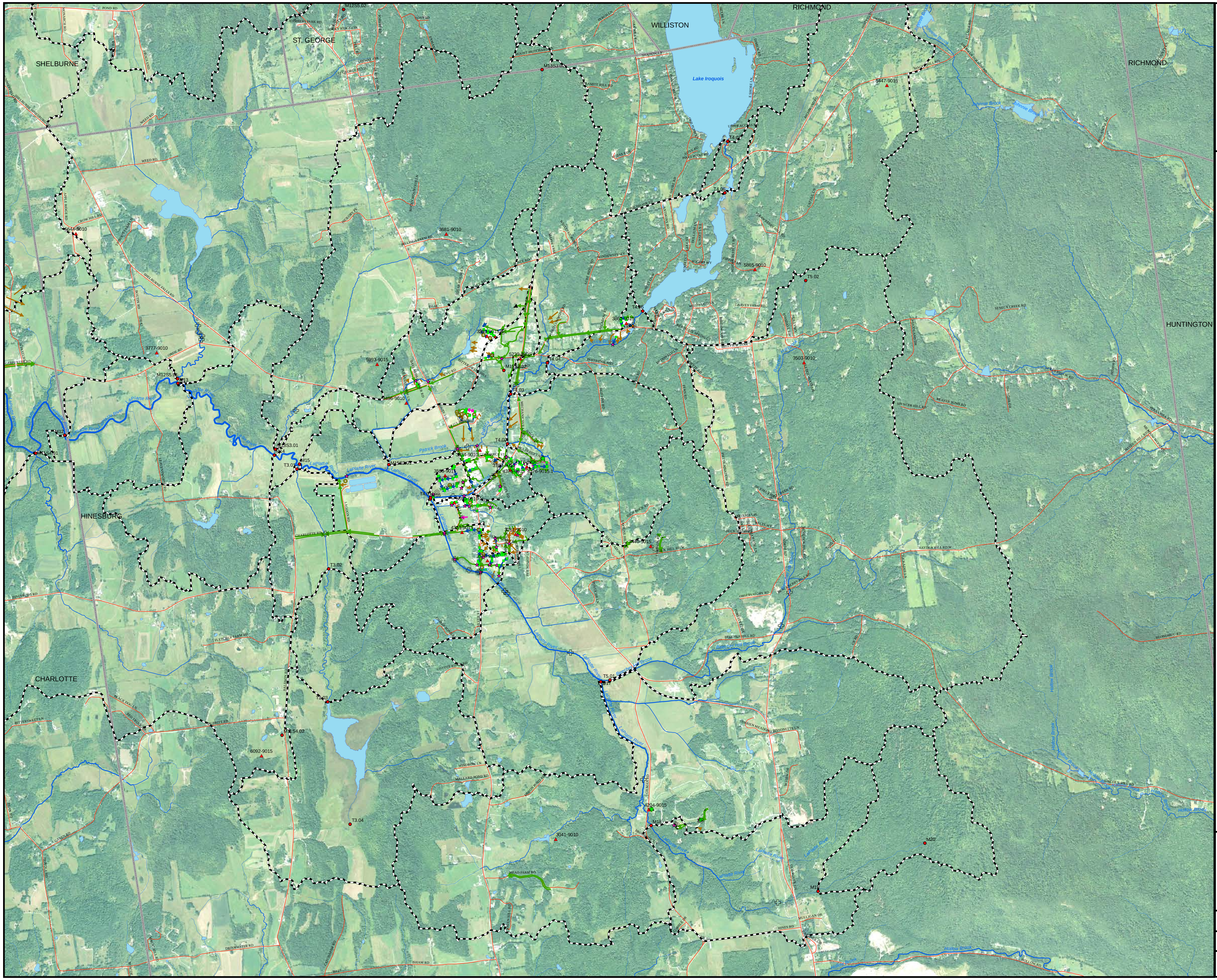
SCALE: 1" = 1300'

PROJECT NO.: 3452-03

Engineering, Landscape Architecture and Environmental Science
MILONE & MACBROOM®
1233 Shelburne Road, Suite 150
South Burlington, Vermont 05403
(802) 864-1600 Fax: (802) 864-1601
www.miloneandmacbroom.com

DATE: March 2010

SHEET: FIGURE A-1



N
W E
S

0 0.25 0.5 1 Miles

Legend

- ANR Issued Stormwater Permits
- ANR SGA Identified Stormwater Inputs

MMI Stormwater Points

- Catchbasin
- Concrete Pad
- Detention Pond
- Drop Inlet
- Dry Well
- Grease Trap
- Manhole
- Outfall
- Outlet Structure
- Spillway
- Stone Filter

MMI Stormwater Lines

- Other
- Culvert
- Overland
- Stormline
- Swale
- Subwatershed Boundary
- Towns
- Lakes and Ponds
- Roads
- Railroad

River (By Stream Order)

1 2 3 4 5

Aerial Photography is 2008 1:40,000 (1 meter) Color NAIP

HINESBURG STORMWATER INFRASTRUCTURE

LAPLATTE RIVER WATERSHED STORMWATER PROJECT

HINESBURG, VERMONT

DESIGNED	DRAWN	CHECKED
JSC	JSC	RKS

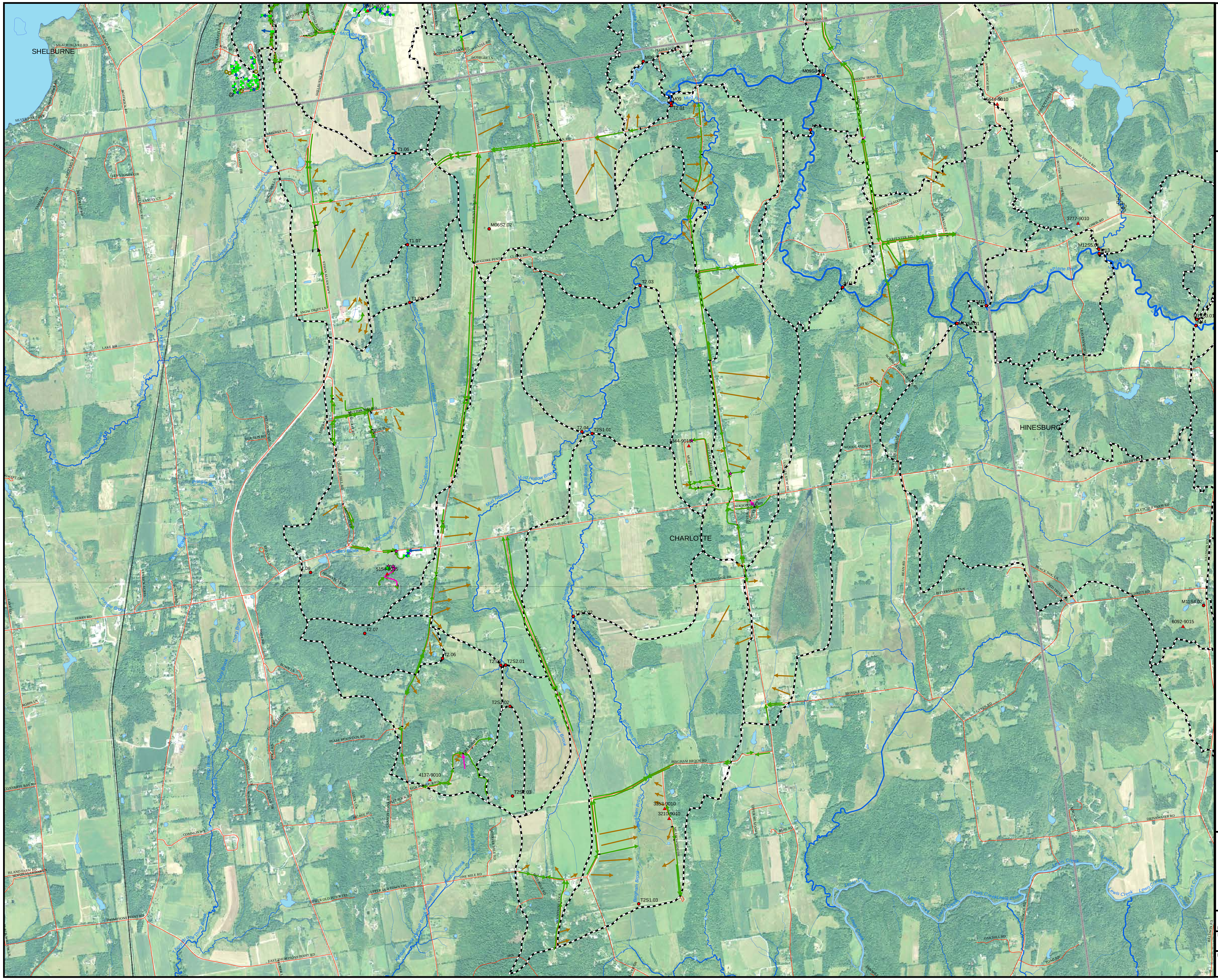
SCALE: 1" = 1300'

PROJECT NO.: 3452-03

Engineering, Landscape Architecture and Environmental Science
MILONE & MACBROOM®
1233 Shelburne Road, Suite 150
South Burlington, Vermont 05403
(802) 864-1600 Fax: (802) 864-1601
www.miloneandmacbroom.com

DATE: March 2010

SHEET: FIGURE A-2



N
W E
S

0 0.25 0.5 1 Miles

Legend

- ANR Issued Stormwater Permits
- ANR SGA Identified Stormwater Inputs

MMI Stormwater Points

- Catchbasin
- Concrete Pad
- Detention Pond
- Drop Inlet
- Dry Well
- Grease Trap
- Manhole
- Outfall
- Outlet Structure
- Spillway
- Stone Filter

MMI Stormwater Lines

- Other
- Culvert
- Overland
- Stormline
- Swale
- Subwatershed Boundary
- Towns
- Lakes and Ponds
- Roads
- Railroad

River (By Stream Order)

1 2 3 4 5

Aerial Photography is 2008 1:40,000 (1 meter) Color NAIP

CHARLOTTE STORMWATER INFRASTRUCTURE

LAPLATTE RIVER WATERSHED STORMWATER PROJECT

CHARLOTTE, VERMONT

DESIGNED	DRAWN	CHECKED
JSC	JSC	RKS

SCALE: 1" = 1300'

PROJECT NO.: 3452-03

Engineering, Landscape Architecture and Environmental Science
MILONE & MACBROOM®
1233 Shelburne Road, Suite 150
South Burlington, Vermont 05403
(802) 864-1600 Fax: (802) 864-1601
www.miloneandmacbroom.com

DATE: March 2010

SHEET: FIGURE A–3

Appendix B – Impervious Surface Calculation Procedures

Stormwater Analysis Documentation
Provided by Mark Suozzo of UVM College of Engineering and Mathematical Sciences
January 26, 2010

NDVI Impervious Cover and Impervious Density Documentation

This document describes the steps taken to create the impervious cover maps provided for the LaPlatte River Watershed stormwater analysis. Maps were created using ArcGIS and Imagine software.

NDVI Impervious Cover-

Reasoning:

To create high quality impervious cover data over the entire watershed imagery data was selected. Using the imagery, Normalized Difference Vegetation Index (NDVI) values were calculated with 1 meter resolution. Low NDVI values indicated the presence of impervious cover, however interference from surface water was present. This interference was corrected by overlaying known surface water features and marking low NDVI values as surface water rather than impervious cover. Additional corrections were made by overlay known roads and driveways and indicating those areas as impervious cover.

Data Used:

Imagery data from the NAIP imagery survey was used, the data contained four bands (red, green, blue and infrared) at a 1 meter resolution. Surface water features and E911 roads information was taken from VCGI.

Process:

1. Several separate image files, each covering a separate portion of the watershed, were combined using Imagine software. The combined image covered beyond the extent of the watershed.
2. The combined image was processed to determine the NDVI values for each raster cell. NDVI values were calculated by the following equation, where NIR represents the near infrared values and RED represents the red values.

$$\mathrm{NDVI} = \frac{(\mathrm{NIR} - \mathrm{RED})}{(\mathrm{NIR} + \mathrm{RED})}$$

3. NDVI raster data was imported into ArcGIS (All previous steps could also have been performed in ArcGIS).
4. A threshold value of -0.22 was used to determine impervious area, values below this were considered impervious while values above were considered to be previous. The resulting raster only indicated impervious by a 1 and impervious by 0.
5. Surface waters were added in shapefile format, the polygons were converted into raster data compatible with the impervious cover raster. Any areas covered by surface water were converted to pervious cover.
6. VCGI streams layers were imported. A buffer of 5 meters was created around the streams. This buffer polygon was converted to a raster in a manner similar to the surface waters layer. Any areas covered by the buffer were converted into pervious cover.
7. E911 roads data was imported. A buffer of 3 meters was created around the roads. This buffer polygon was converted to a raster in a manner similar to the surface waters layer. Any areas covered by the buffer were converted into impervious cover.
8. The final impervious cover raster was clipped to the extent of the subwatershed.

<u>Impervious Density-</u>

Reasoning:

To better locate areas with high density of impervious surfaces a density map was created. This map was intended to be combined with soils data to indicate areas where stormwater infiltration practices could be utilized. Density was determined by using E911 roads, driveways and buildings data.

Data Used:

E911 Roads, Driveways and Buildings data from VCGI.

Process:

1. Imported roads, driveways and buildings into the area defined by the watershed.
2. Roads and driveways were converted to point features using Hawth's tools Path to point tool.
3. Road, Driveway and building point data was used to create a density raster of impervious features per square acre. The density tool searched within a two acre radius to find impervious features.