Phase 1 Geomorphic Assessment

Direct Drain to Lake Champlain in Shelburne and Charlotte

Prepared by Lewis Creek Association

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LCA thanks the Towns of Charlotte and Shelburne for supporting efforts to improve stream and riparian conditions and avoid future conflicts.

1.0 Executive Summary

The Lewis Creek Association (LCA) received a 2007 Clean and Clear grant from the Vermont Agency of Natural Resources to complete Phase 1 Stream Geomorphic Assessments for streams draining directly into Lake Champlain in the towns of Shelburne and Charlotte. Study streams included Thorp, Kimball, Holmes, Pringle and 9 unnamed streams that have small watershed sizes and short lengths. These streams were identified as potential contributors to lake pollution due to high agricultural land use and growing population densities. Additional development pressure is spreading into this area from Burlington, and increasing impervious cover associated with this development is of concern. Phase 1 data were collected for 44 reaches. Phase 2 data were collected for 4 reaches including one reach on the tributary leading to Shelburne beach, one reach on Thorp Brook, and 2 reaches on Mud Hollow Brook, a tributary to the LaPlatte River.

Methods for this study followed the VT DEC Stream Geomorphic Assessment Protocols (the Protocols) (VT DEC, May 2007). The Protocols are listed on the River Management website at: http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_geoassesspro.htm.

The study streams have relatively small drainage areas, with watersheds ranging from 0.16-3.8 square miles in size. Soils of the study area are predominantly Glacial Lake with some areas having Till and Alluvial soils. The topography of the study watersheds is characterized largely by undulating hills and fairly shallow slopes. Many of the subwatersheds have over 10% urban land use and the majority of the subwatersheds had over 10% cropland cover. Most of the study streams are over 20% straightened. Many reaches have corridor encroachment impact ratings of “not significant,” with only a few reaches have “high” impact ratings for corridor encroachments.

Phase 2 data for the 4 study reaches is summarized in the following table:

Segment & Town	**Stream Type**	**Geomorphic Condition**	**Evolution Stage**	**Sensitivity**	**Habitat Condition**
T1S1.02 Shelburne	B5 Dune-Ripple (C-B)*	Fair	II	High	Fair
T2.01 & T2.02A Charlotte	E5 Dune-Ripple	Fair	IIc (D)	Very High	Fair
T2.02B Charlotte	C4 Riffle-Pool	Fair	IV	Very High	Good
T8.03 Charlotte	E5 Dune-Ripple	Good	IV	High	Good

*Indicates a stream type departure from C to B.

Based on Phase 1 data, Phase 2 SGAs are highly recommended for a total of 16 reaches. Pursuing Phase 2 assessments in these areas along with river corridor planning tasks such as project identification and landowner outreach will highlight potential restoration and protection projects. While Phase 2 assessments are not recommended for all reaches due to their small watersheds, potential projects such as corridor protection and buffer planting could be identified through landowner outreach and possible field visits. In addition to the above recommendations for Phase 2 assessments, studying impervious surface cover and stormwater contributions to these streams would be valuable. Potential projects identified based on the Phase 2 data for the 4 study reaches include protecting the river corridor with possible active restoration of channel incision in T1S1.02 and T2.01.

2.0 Introduction

The Lewis Creek Association (LCA) received a 2007 Clean and Clear grant from the Vermont Agency of Natural Resources, Department of Environmental Conservation, Water Quality Division to complete Phase 1 and 2 Stream Geomorphic Assessments for streams in the lake valley, Lewis Creek and LaPlatte region. Study streams included Thorp, Kimball, Holmes, Pringle and 9 unnamed streams that have small watershed sizes and short lengths. These streams were identified as potential contributors to lake pollution because agriculture is the predominant land use. As well, they contain growing population densities and densely settled summer camp dwelling communities adjacent to the lake with impervious surface ratios that suggest negative impacts to stream channel equilibrium. Additional development pressure is spreading into this area from Burlington, and increasing impervious cover associated with this development is of concern.

The Phase 1 process is a standardized method for identification of reaches and location of land features relative to the river system. In addition, Phase 1 data provide a frame of reference for future restoration, and conservation work and additional water-based studies. (e.g. habitat, and natural communities mapping, surficial geological mapping and water quality assessments).

This study will inform a reach-based approach to in-process Better Back Road restoration projects that are lacking the benefit of geomorphic assessment results. A town planning or river corridor management plan process can also promote river geomorphology based strategies to reduce sedimentation and restore fluvial geomorphic equilibrium in the Champlain Valley drainages flowing directly to Lake Champlain. Data results from this work can also inform water quality sampling plan strategies of the LaPlatte Watershed Partnership and Addison County RiverWatch Collaborative.

Phase 2 data were collected for 4 reaches following DEC protocols and recommended tasks. Reaches were selected with guidance from River Management staff and LCA following the Phase 1 assessment.

3.0 Setting

The Phase 1 study area includes the small streams that drain directly into Lake Champlain in Shelburne and Charlotte. The study area stretches from the first stream south of Shelburne Bay to Kimball Brook just north of Lewis Creek. Appendix A contains maps of the study area including topographic maps and orthophotos with overlays of the streams and subwatersheds.

The study streams have relatively small drainage areas, with watersheds ranging from 0.16-3.8 square miles in size. The largest, named streams include Holmes Creek, Pringle Brook, Kimball Brook and Thorp Brook. Soils of the study area are predominantly Glacial Lake, as would be expected near Lake Champlain, with some areas having Till and Alluvial soils.

The topography of the study watersheds is characterized largely by undulating hills and fairly shallow slopes. The area has historically been agricultural, as seen in old orthophotos and topographic maps depicting limited forested area. Current land use remains agricultural with increasing residential development and roughly the same limited forest cover.

Historical topographic maps of the study area show stream locations over time as well as forest cover and roads. Historical maps of the study area are presented in Appendix B. Historical Topographic Maps were acquired from UNH Library Government Information Department at: http://docs.unh.edu/nhtopos/nhtopos.htm

4.0 Tasks

Phase 1 Tasks

The Phase 1 Stream Geomorphic Assessments of direct drainage streams strictly followed the May 2007 Vermont Stream Geomorphic Assessment Phase 1 Handbook published by the Vermont Agency of Natural Resources (VTANR). Reference is hereby made to this protocol for the specific scope of work, summarized as follows:

- Identify reach breaks
- Delineate watershed and sub-watersheds
- Identify valley walls and stream centerline
- Obtain and review orthophotographs for land use, land cover, roads, berms, railroads, improved paths, and river corridor development data for each reach.
- Identify geologic material and soils characteristics for each reach.
- Review orthophotographs and topographic maps for reach descriptions, alluvial fan and side slope information, riparian buffer widths, and tributary inputs.
- Identify channel bars, meander migrations, dominant bed material, bank erosion, and debris or ice jam potential for each reach.
- Obtain data on flow regulations, bridges, bank revetments, channel modifications and sediment removal for each reach.
- Calculate meander width and wavelength ratios for each reach.
- Evaluate reach condition, impact rating, adjustment process, and reach sensitivity for each reach.
- Using the FIT, index data for alluvial fans, grade controls, dredging, flow regulations, development, corridor encroachments, bank armoring, erosion, straightening, bridges and culverts.
- Enter all data into the DMS database.
- Conduct windshield surveys of each reach to verify remote sensing data.

The Phase 1 assessment identified distinct reaches, based on various in valley confinement, slope and sinuosity, as identified through analysis of topographic maps. Using the SGAT developed by RMP, data were generated for channel elevation, valley length and slope, channel length and slope, sinuosity, watershed size, channel width, valley width, confinement, geologic material, soil characteristics, watershed land cover/land use and corridor land cover/land use. Reference stream types were assigned to each reach and the reaches were assessed for dominant and sub-dominant land cover and soil types.

Orthophotographs were used to identify existing riparian buffer widths, sediment storage types, bridges and culverts, and any channel modifications such as straightening. Historic information such as bank revetments, dredging, or gravel mining were investigated. Current and historic orthophotographs were used to assess changes in land use and channel planform. A windshield survey of the study reaches was conducted to verify channel characteristics and remote sensing data and to identify channel bed substrates, bank erosion sites, and debris or ice jam potential.

All data were entered into the Data Management System (DMS) maintained by VTDEC. The DMS then used this information to assign a Stream Impact Rating and a Stream Sensitivity Rating to each reach. "Like Reaches" in the watershed were then evaluated based on valley and stream types, geomorphic condition, and stream impact rating.

Phase 2 Tasks

This project exclusively used the VT DEC Stream Geomorphic Assessment Protocols (the Protocols) (VT DEC, May 2007) to perform the Phase 2 Assessment and utilized data and information collected in the Phase 1 Assessment.

The following tasks were completed in the Phase 2 Stream Geomorphic Assessments according to the Protocols:

- Notified landowners along study reaches before performing the assessment along their segment of river;
- Used the Phase 1 data, field checked reaches and types identified in Phase 1 and segmented or modify as necessary;
- Walked the length of each reach to map features and evaluate conditions;
- Photographed and mapped reaches and segments and collected GPS points;
- Identified natural and artificial features of the channel and adjacent valley (watershed zone, channel constraints, floodplain terrace, valley slope, habitat barriers);
- Measured channel dimensions, bankfull and flood elevations and depths, width-to-depth ratio, entrenchment ratio, riffle-step distribution, substrate size and verified stream typing;
- Evaluated stream banks, buffer strips, and riparian corridor;
- Documented flow modifiers such as impoundments, springs, wetlands, drainage ditches, constrictions, and condition of the upper watershed;
- Identified evidence of channel bed and planform changes;
- Conducted a Rapid Habitat Assessment (RHA) using the RHA field form developed by VT ANR;
- Conducted a Rapid Geomorphic Assessment (RGA) using the RGA field form developed by VT ANR;
- Entered all data into ANR Stream Geomorphic Assessment Data Management System.

Please refer to the Vermont DEC River Management Section website for more information about the protocols and methods at:
http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_geoassesspro.htm.

Rapid Geomorphic Assessment

The RGA is useful in evaluating current stream processes, departures from a reference condition, and stages of channel evolution for a given reach. Three separate RGA forms are used in the Phase 2 SGA, one for unconfined streams, one for confined streams, and one for naturally occurring Plane-Bed streams. Parameters evaluated in the RGA are summarized as follows:

- **Degree of channel degradation or incision** (sharp changes in slope, measured incision and entrenchment ratios, loss of riffle-pool characteristics, floodplain encroachment, historical channel or flow alterations).
- **Degree of channel aggradation** (filling of pools, loss of riffle-pool characteristics, mid-channel or diagonal bars, increases in fine sediments, high width-to-depth ratios, flow alterations, sediment deposition upstream of constrictions).
- **Degree of channel widening** (high width-to-depth ratios, scour on both banks at riffles, mid-channel or diagonal bars, historical channel or flow alterations).
- **Change in channel planform** (bank erosion on outside meander bends, flood chutes or channel avulsions, mid-channel or diagonal bars, additional deposition and scour features, floodplain encroachment, sediment deposition upstream of constrictions).

Please refer to the VT ANR Protocols for more on the RGA (VT DEC, May 2007).

According to protocols, once a RGA is completed and a "condition" category selected, a stage of channel evolution is determined. One of two channel evolution models can be used; either the F-stage model or the D-stage model.

In the F-stage model, a channel loses floodplain access either by undergoing degradation or a floodplain build-up (Stage II), due to a disturbance. This degradation is typically followed by channel widening (Stage III), then aggradation and planform adjustments (Stage IV), before then regaining stability with regard to its water and sediment loads (Stage V).

In the D-stage model, aggradation, widening, and planform changes are the main adjustment processes, with degradation being limited, sometimes by resistant bed material or grade controls. The D-stage process can include moderate entrenchment and loss of bed features (Stage IIb), channel widening and/or planform changes (Stage IIc), bed aggradation, bar formation (Stage IId), and regaining a balance similar to reference condition (Stage III). These adjustments have been described in channel evolution models as described by Schumm (1977) (Figure 4.1) and others. Please refer to the VT ANR Protocol Appendices for more information on channel evolution models.

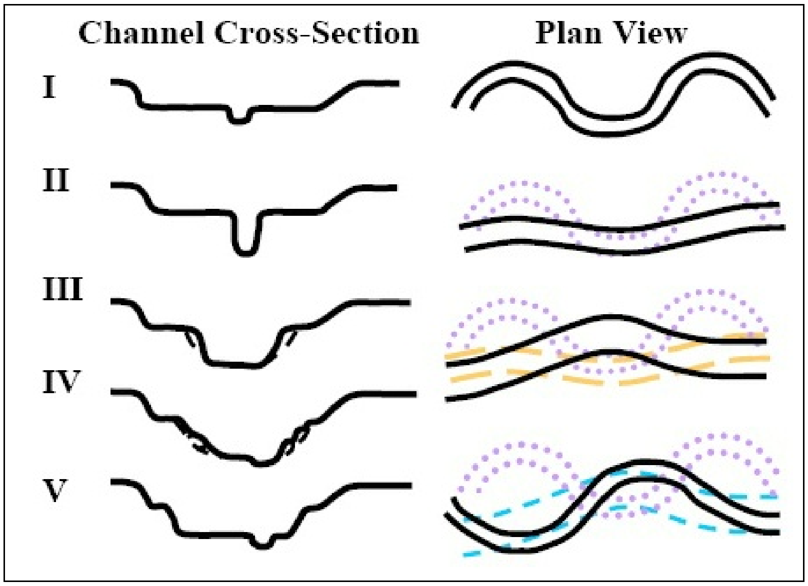


Figure 4.1. Diagram of Channel Evolution from VT ANR 11 July 2007 as adapted from Schumm 1977. Stage I indicates reference equilibrium conditions, Stage II shows incision, Stage III shows widening through bank erosion, Stage IV shows aggradation and lateral channel migration, followed by Stage V, a return to equilibrium conditions, but typically at a lower elevation.

Parameters for the RGA and RHA were scored and assigned to the correlating "condition" category describing departure from a reference condition and degree of adjustment (VTANR, May 2007) as follows:

- Reference – Reaches in dynamic equilibrium, having stream geomorphic processes and habitats found in mostly undisturbed streams.
- Good – Reaches having stream geomorphology or habitat that is slightly impacted by human or natural disturbance, showing signs of minor adjustment, but functioning for the most part.
- Fair – Reaches in moderate adjustment, having major changes in channel form, process or habitat.
- Poor – Reaches experiencing extreme adjustment or departure from their reference (expected) stream type or habitat condition.

In some cases, where a score lies at one end limit of a category, the condition category that best described the reach was selected.

A "Stream Sensitivity Rating" was then generated for each reach or segment according to stream type and geomorphic condition. The range of sensitivity ratings includes: Very Low, Low, Moderate, High, Very High, and Extreme. These indicate the sensitivity of a reach or segment to ongoing disturbance or stressors.

Rapid Habitat Assessment

The RHA is useful in determining the ability of a given reach to support aquatic biota, the extent to which a given reach is impaired, and potential factors affecting habitat. Two separate RHA forms are used in the Phase 2 SGA, one for low gradient streams and one for high gradient streams. Parameters evaluated in the RHA are summarized as follows:

- Presence of a variety of substrate types suitable for aquatic insect colonization and cover for fish, reptiles and amphibians;
- Degree to which gravel, coble and boulder particles are surrounded by fine sediments;
- Type of bed material in pools;
- Presence of a variety of water speeds and depths to include fast-shallow, fast-deep, slow-shallow, and slow-deep;
- Variety of pool sizes to include large-shallow, large-deep, small-shallow, small-deep;
- Increase in sediment deposition on the channel bed or bars;
- Degree to which the channel bottom is exposed, reference being minimal channel bed exposed;
- Extent of channel alteration including dredging, straightening, berms, or riprap;
- Frequency of riffles or steps along the channel length;
- Channel sinuosity or degree of channel meandering;
- Amount of bank erosion;
- Amount and types of bank vegetation;
- Width of naturally vegetated riparian buffer.

Please refer to the VT ANR Protocols for more on the RHA (VT DEC, May 2007).

Bridge and Culvert Assessment

Phase 2 Bridge and Culvert Assessments were also performed according to the VT ANR Protocols. Bridges and culverts crossing study reaches were assessed and field data entered into the VT ANR Data Management System. Data from these assessments can be used to guide planning for bridge and culvert maintenance or replacement. Refer to the VT ANR Protocols for more on Bridge and Culvert Assessments (VT DEC, May 2007).

QAQC Summary

The VT ANR Protocols were followed exclusively in conducting the Phase 1 and 2 SGAs. RMP member Gretchen Alexander oversaw the project. The project’s consultant had completed the required Phase 2 training conducted by personnel from the Vermont DEC River Management Division. All data entered into the States DMS were reviewed by RMP staff as part of the quality control program and corrections were made as necessary.

5.0 Phase 1 Results

From the Phase 1 Protocols (p.71):

> “Since the Phase 1 Watershed Assessment is largely dependent on remote sensing data, it is assumed that the channel and floodplain modifications identified elicit predictable responses by the various stream types due to assumed changes in channel slope and watershed inputs of sediment and water caused by these modifications.

> An example would be the well-documented response that certain riffle-pool streams undergo following channelization and floodplain development. The increased channel slope and stormwater runoff initiate major adjustment processes. Such streams exhibit a high degree of vertical and lateral adjustment and at times may become high erosion hazard areas, threatening channel equilibrium in both upstream and downstream reaches, and possibly containing little or no habitat value."

Some reaches in the study could not be evaluated for all parameters due to lack of visibility on orthophotos and during the windshield survey, or lack of documentation of activities such as dredging. While many reaches appeared to have been straightened based on changes visible in topographic maps of various years overlain with current stream patterns, any dredging activities were not documented or visible through these remote-sensing techniques. Most of the reaches were too small to be able to view any bank erosion, bar features, or bank armoring on orthophotos and only a few areas were visible on windshield surveys. Therefore impact ratings for most reaches are likely lower than they would be if the entire reach were visible.

Table 5.1 Phase 1 Summary

Reach ID	Stream or Tributary	Stream Type[1]				Total[2] (out of 32)	Step 4 Land Use (out of 6)	Step 5 Instream Modification (out of 10)	Step 6 Floodplain Modification (out of 12)	Step 7 Bed & Bank Survey (out of 4)
		Stream Type	Bed Material	Subclass Slope	Bedform					
T1.02	Unnamed Stream 1	C	Gravel	b	Riffle-Pool	17	6	4	7	0
T1.S1.01	Unnamed Stream 2	C	Gravel	None	Riffle-Pool	16	5	3	8	0
T1.S1.02	Unnamed Stream 2	C	Sand	None	Dune-Ripple	16	6	3	6	1
T1.S1.03	Unnamed Stream 2	C	Sand	None	Dune-Ripple	15	6	4	5	0
T1.S1.S1.01	Unnamed Stream 3	C	Gravel	b	Riffle-Pool	13	6	2	4	1
T1.S1.S2.01	Unnamed Stream 2 Trib 1	C	Gravel	b	Riffle-Pool	14	5	2	7	0
T1.S1.S2.02	Unnamed Stream 2 Trib 1	C	Gravel	b	Riffle-Pool	5	4	1	0	0
T2.02	Unnamed Stream 4	C	Gravel	None	Riffle-Pool	6	5	0	1	0
T3.03	Holmes Creek	E	Sand	None	Dune-Ripple	8	3	0	5	0
T3.04	Holmes Creek	C	Sand	None	Dune-Ripple	7	3	0	4	0
T3.05	Holmes Creek	C	Gravel	None	Riffle-Pool	20	6	5	8	1
T3.06	Holmes Creek	C	Gravel	b	Riffle-Pool	16	6	4	6	0
T3.S1.01	Unnamed Stream 5	C	Sand	None	Dune-Ripple	17	6	5	6	0
T3.S2.01	Holmes Creek Trib 1	C	Sand	None	Dune-Ripple	16	5	2	7	2
T3.S2.02	Holmes Creek Trib 1	C	Sand	None	Dune-Ripple	18	6	4	7	1
T3.S2.03	Holmes Creek Trib 1	C	Sand	None	Dune-Ripple	15	6	4	5	0
T3.S6.01	Pringle Brook	C	Sand	None	Dune-Ripple	2	2	0	0	0
T3.S6.02	Pringle Brook	C	Sand	None	Dune-Ripple	22	6	5	10	1
T3.S6.03	Pringle Brook	C	Gravel	None	Riffle-Pool	11	6	4	1	0
T3.S8.01	Holmes Creek Trib 3	C	Gravel	None	Riffle-Pool	12	4	1	6	1
T3.S8.02	Holmes Creek Trib 3	B	Cobble	a	Step-Pool	8	6	2	0	0
T5.02	Unnamed Stream 6	C	Sand	None	Dune-Ripple	16	6	4	5	1
T6.02	Unnamed Stream 7	C	Gravel	None	Riffle-Pool	13	6	3	3	1

Reach ID	Stream or Tributary	Stream Type[1]				Total[2] (out of 32)	Step 4 Land Use (out of 6)	Step 5 Instream Modification (out of 10)	Step 6 Floodplain Modification (out of 12)	Step 7 Bed & Bank Survey (out of 4)
		Stream Type	Bed Material	Subclass Slope	Bedform					
T7.02	Unnamed Stream 8	C	Gravel	None	Riffle-Pool	7	4	2	0	1
T8.02	Thorp Brook	C	Sand	None	Dune-Ripple	14	4	1	8	1
T8.03	Thorp Brook	E	Sand	None	Dune-Ripple	15	4	2	6	3
T8.04	Thorp Brook	C	Gravel	None	Riffle-Pool	11	3	2	6	0
T8.05	Thorp Brook	C	Gravel	None	Riffle-Pool	6	6	0	0	0
T8.S1.01	Unnamed Stream 9	C	Sand	None	Dune-Ripple	13	6	2	5	0
T8.S2.01	Kimball Brook	E	Sand	None	Dune-Ripple	19	6	5	7	1
T8.S2.02	Kimball Brook	E	Sand	None	Dune-Ripple	16	5	3	7	1
T8.S2.03	Kimball Brook	C	Gravel	None	Riffle-Pool	14	6	2	6	0
T8.S2.04	Kimball Brook	C	Gravel	None	Riffle-Pool	22	6	4	10	2
T8.S2.05	Kimball Brook	C	Sand	None	Dune-Ripple	16	5	4	6	1
T8.S2.06	Kimball Brook	C	Gravel	None	Riffle-Pool	18	6	3	8	1
T8.S2.07	Kimball Brook	C	Gravel	b	Riffle-Pool	16	6	3	6	1
T8.S3.01	Thorp Brook Trib 1	C	Sand	None	Dune-Ripple	6	5	0	0	1
T8.S3.03	Thorp Brook Trib 1	C	Sand	None	Dune-Ripple	13	5	4	4	0
T8.S4.01	Thorp Brook Trib 2	C	Gravel	None	Riffle-Pool	12	6	2	3	1
T8.S5.01	Thorp Brook Trib 3	C	Sand	None	Dune-Ripple	9	3	0	6	0
T8.S5.02	Thorp Brook Trib 3	C	Gravel	None	Riffle-Pool	10	3	1	6	0
T8.S5.04	Thorp Brook Trib 3	C	Gravel	None	Riffle-Pool	18	6	5	7	0
T8.S5.S1.01	Thorp Brook Trib 3 S1	C	Gravel	b	Riffle-Pool	10	6	4	0	0
T8.S7.01	Thorp Brook Trib 4	C	Gravel	b	Riffle-Pool	12	6	2	4	0

[1]Stream Type follows Rosgen classification system (Rosgen 1994). [2]Higher scores correlate to higher impacts.

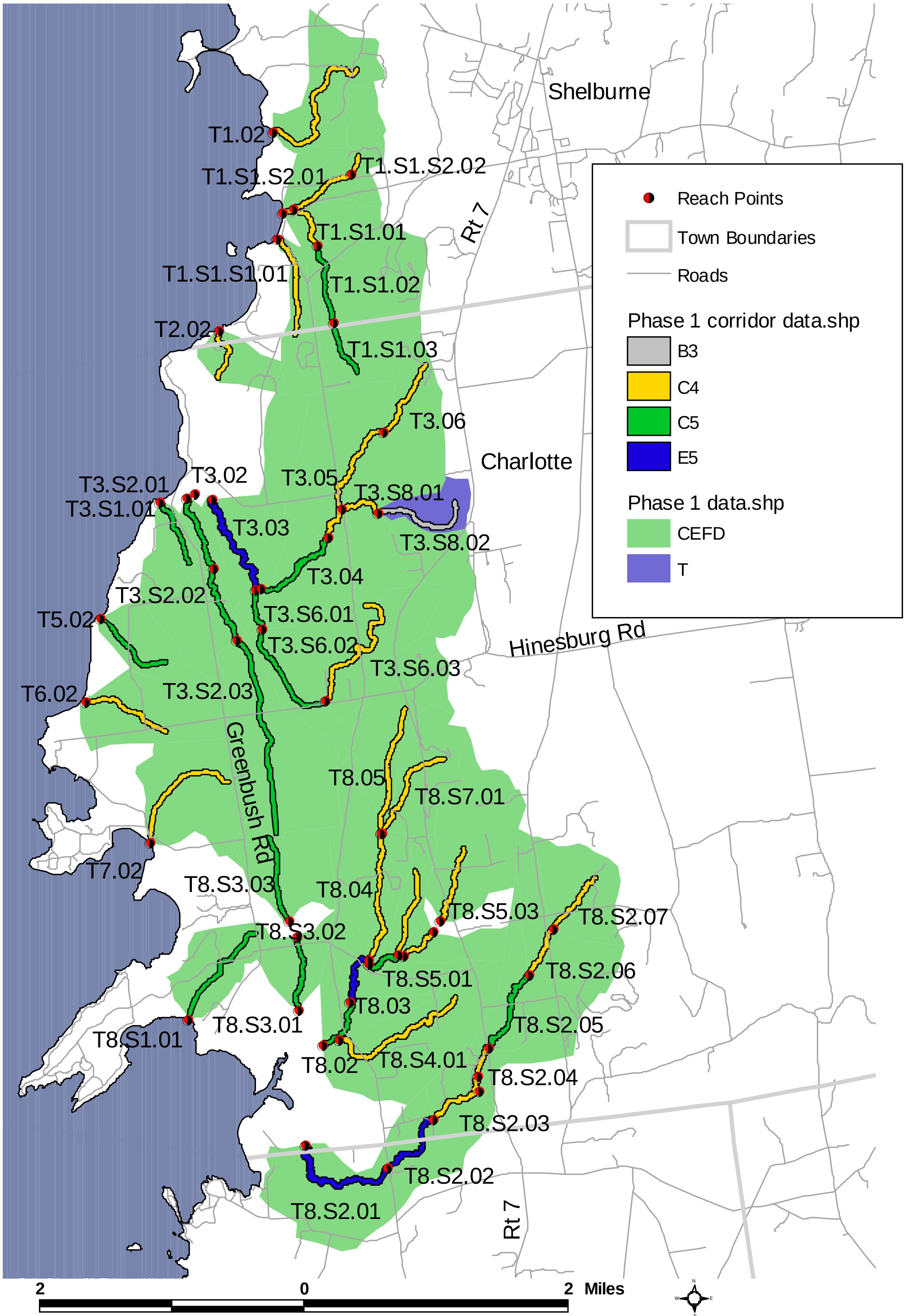


Figure 5.1 Phase 1 Stream Types and Sediment Regimes

5.1 Tributary Summaries

Figure 5.1 shows stream types and sediment regimes for each of the study reaches. Stream features identified during the study and indexed using the FIT are mapped and presented in Appendix C.

Unnamed Stream 1 (T1)

Unnamed Stream 1 flows west, then south, then west again and enters lake Champlain north of Shelburne Beach. Watershed land cover is mainly fields with some forested area. Some areas have little to no woody riparian buffer vegetation. Total watershed area is 0.45 square miles. About 70% of the stream channel appears to have been straightened and signs of current lateral migration are visible. A dam with a large pond upstream is present and likely acts as a grade control in addition to restricting sediment flow. The reach flows through 2 culverts and some roads encroach into the stream corridor.

Unnamed Stream 2 (T1 S1)

Unnamed Stream 2, or the Shelburne Beach Tributary, flows north along the east side of Greenbush Road and then Beach Road and enters Lake Champlain at Shelburne Beach. This stream has a small tributary of its own (T1S1S2.02). Watershed land cover is mainly fields with some forested area and the stream corridor is field and cropland. Most areas have little to no woody riparian buffer vegetation. Total watershed area is 1.46 square miles. The lower reach (T1S1.01) has 3 dams with ponds upstream, installed in the 1930s-1940s. These ponds comprise most of the stream length and appear to have breached recently as new repairs are visible. Another dam and pond is in the upstream reach (T1S1.03). The middle reach (T1S1.02) appears entirely straightened with significant straightening in the upper reach as well. This stream flows through 5 culverts with an additional 2 culverts on a tributary. Roads and some development encroach into the corridors. Some bank erosion was visible.


View of culvert, fields and grassy stream banks (L); view of downstream end of pond/dam with recent repairs and flow emerging (R).

Unnamed Stream 3 (T1 S1 S1)

Unnamed Stream 3 flows north along the west side of Greenbush Road and then Beach Road and enters Lake Champlain south of Shelburne Beach. Watershed land cover is mainly fields with some forested area. Some areas have little to no woody riparian buffer vegetation. Total watershed area is 0.26 square miles. This stream flows through 5 culverts with some bank armoring visible from the windshield survey. About 18% of the channel appears to have been straightened with roads and development encroaching into the corridor.

Riparian area (L) and old riprap/channelization (R).

Unnamed Stream 4 (T2)

Unnamed Stream 4 is a short 2346 feet long, flowing north and entering Lake Champlain at the north end of Hill Point. Watershed and corridor land use is mainly forest with urban the sub-dominant land use due to many lakefront properties. Some areas near the lake had little to no woody riparian buffer vegetation due to the development. Total watershed area is 0.19 square miles. This stream flows through one culvert with some development encroaching into the corridor along the lake.

Holmes Creek (T3)

Holmes Creek begins just south of Nature Road, west of Route 7 south of the Shelburne/Charlotte boarder. It flows southwest, crossing under Greenbush Road near the intersection with the railroad track. It continues southwest until the Pringle Brook confluence, where it turns northwest and enters Lake Champlain at the Holmes Creek Covered Bridge. Dominant watershed land use is agricultural (crop and field) with some forested area, and increasing development. Many areas along upper Holmes Creek and its tributaries have little to no riparian buffer vegetation. The lower reaches of Holmes Creek appear to have good buffers. Total watershed area is 3.78 square miles. Several dams and ponds are in the upper reaches of Holmes Creek and its tributaries. The mainstem flows through 4 culverts with an additional 8 culverts on the tributaries. The upper 2 reaches of the mainstem are over 50% straightened with roads encroaching into the corridor, while the downstream reaches appear to meander freely. Some bank erosion was visible in the windshield survey.


Near the mouth of Holmes Creek (L) and upstream portion of Holmes Creek (R).


Views of Holmes Creek Tributary (T3S2) incised into the terrace (L); ponding upstream of a culvert (R).

Unnamed Stream 5 (T3 S1)

Unnamed Stream 5 flows north and enters Lake Champlain southwest of Holmes Creek. Watershed land use is field and crop with some development. Most of the stream has little to no woody riparian buffer vegetation. Total watershed area is 0.19 square miles. A dam with a pond is in the reach along with 3 culverts. About 75% of the reach appears to have been straightened with some current channel migration evident. Some roads and development encroach into the corridor along the reach.

View of the small channel and vegetation management.

Pringle Brook (T3 S6)

Pringle Brook is a tributary to Holmes Creek. It begins east of Greenbush Road, flowing southwest to Hinesburg Road, then turning north northwest to Holmes Creek. Watershed land use is field and forest with fairly high urban area (residential and commercial) in the upper 2 reaches. Many areas along Pringle Brook have little to no woody riparian buffer vegetation. Total watershed area is 1.02 square miles. Three dams with ponds are along Pringle Brook along with 5 culverts in the upstream section. Significant channel straightening is evident with some signs of current channel migration. Some roads and development encroach into the corridor, especially along Hinesburg Road.

View of Pringle Brook near Hinesburg Rd with thin buffer vegetation.

Unnamed Stream 6 (T5)

Unnamed Stream 6 flows northwest, crossing Orchard Road and enters lake Champlain north of Wings Point. Watershed land use is forest and field, with residential use dominant in the riparian corridor. Most of the stream has little to no riparian buffer. Total watershed area is 0.3 square miles. A dam with pond is in the reach along with 2 culverts. Over 70% of the reach appears straightened with some migration evident. Few roads and development encroach into the corridor.

Channel flowing through fields to lake (L) and ponding upstream of road crossing (R).

Unnamed Stream 7 (T6)

Unnamed Stream 7 flows northwest, crossing Orchard Road and enters lake Champlain at the north end of Wings Point. Watershed land use is urban (35%) and forest. The riparian corridor also has significant development, reducing woody riparian buffer in some areas. Total watershed area is 0.47 square miles. This stream flows through 3 culverts. About half of the stream appears straightened with migration evident. Few roads and development encroach into the corridor.

View of stream corridor with hardly a defined channel and significant vegetation management.

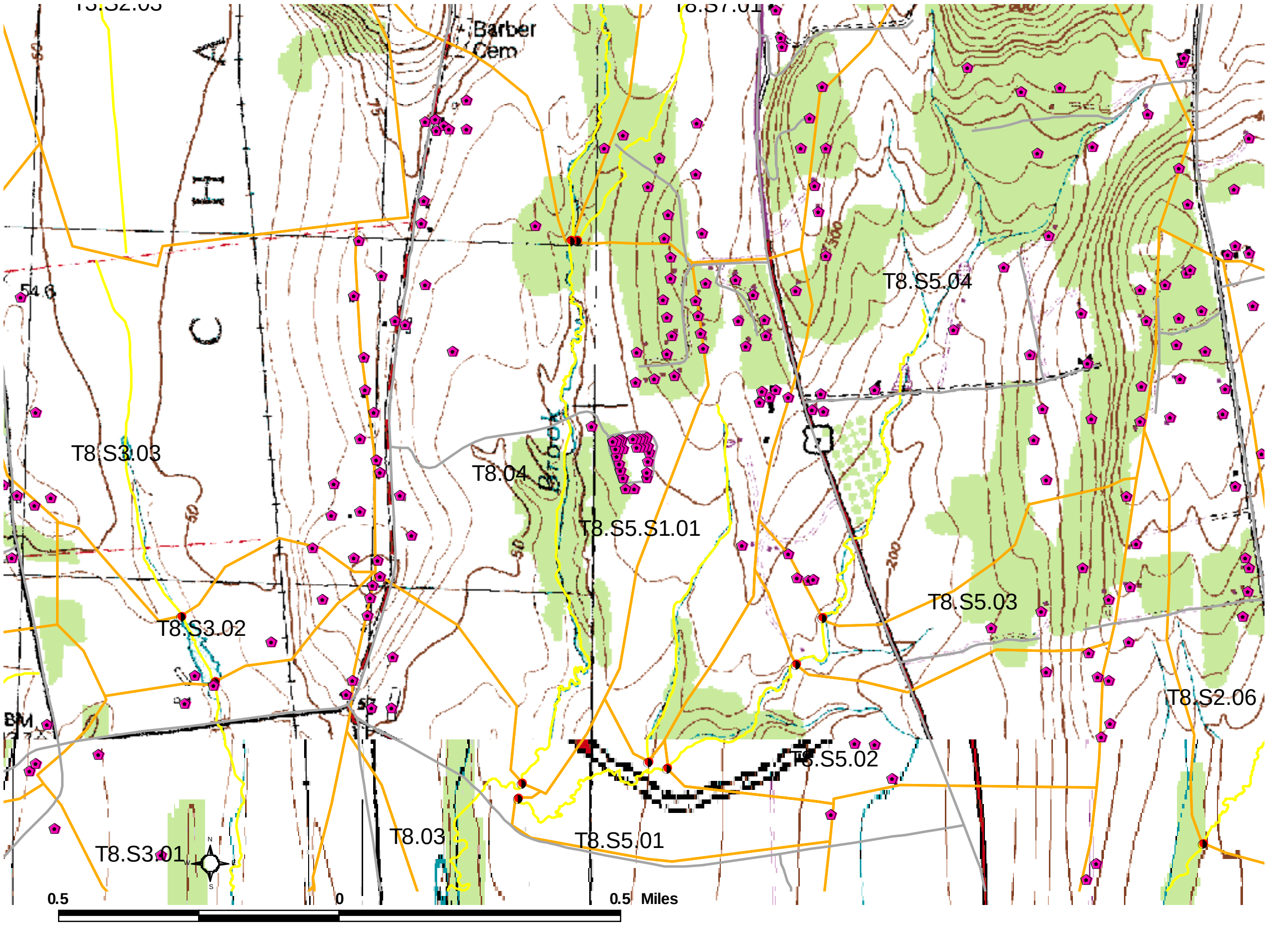
Unnamed Stream 8 (T7)

Unnamed Stream 8 begins just west of Lake Road, flowing west, then southwest to cross Converse Bay Road and enters Lake Champlain at Converse Bay. Watershed land use is forest and field with some cropland. Riparian buffer is greater than 100 feet in most areas. Total watershed area is 0.59 square miles. One culvert is present on this stream. About 25% of the stream appears to have been straightened.

Thorp Brook (T8)

Thorp Brook and its 4 tributaries flow mainly south from the Route 7 and Hinesburg Road area across Albee Road and Greenbush Road, entering Lake Champlain in Town Farm Bay. Watershed land use is field and forest with increasing development. Many areas have little to no woody riparian buffer vegetation. Total watershed area is 3.8 square miles. Total watershed area is 3.8 square miles. One dam with pond is present along the mainstem with several more on tributaries. Relatively little straightening is evident, however the channel appears to be migrating, especially in the downstream reaches. The mainstem flows through 5 culverts with 10 more on tributaries. Relatively few roads and developments encroached into the corridor. Some bank erosion was visible in the windshield survey.

View of a culvert and bank erosion (L) and the stream channel (R).



Topo map showing development in the Thorp Brook area. Buildings (E911 sites) are highlighted in pink.

Unnamed Stream 9 (T8 S1)

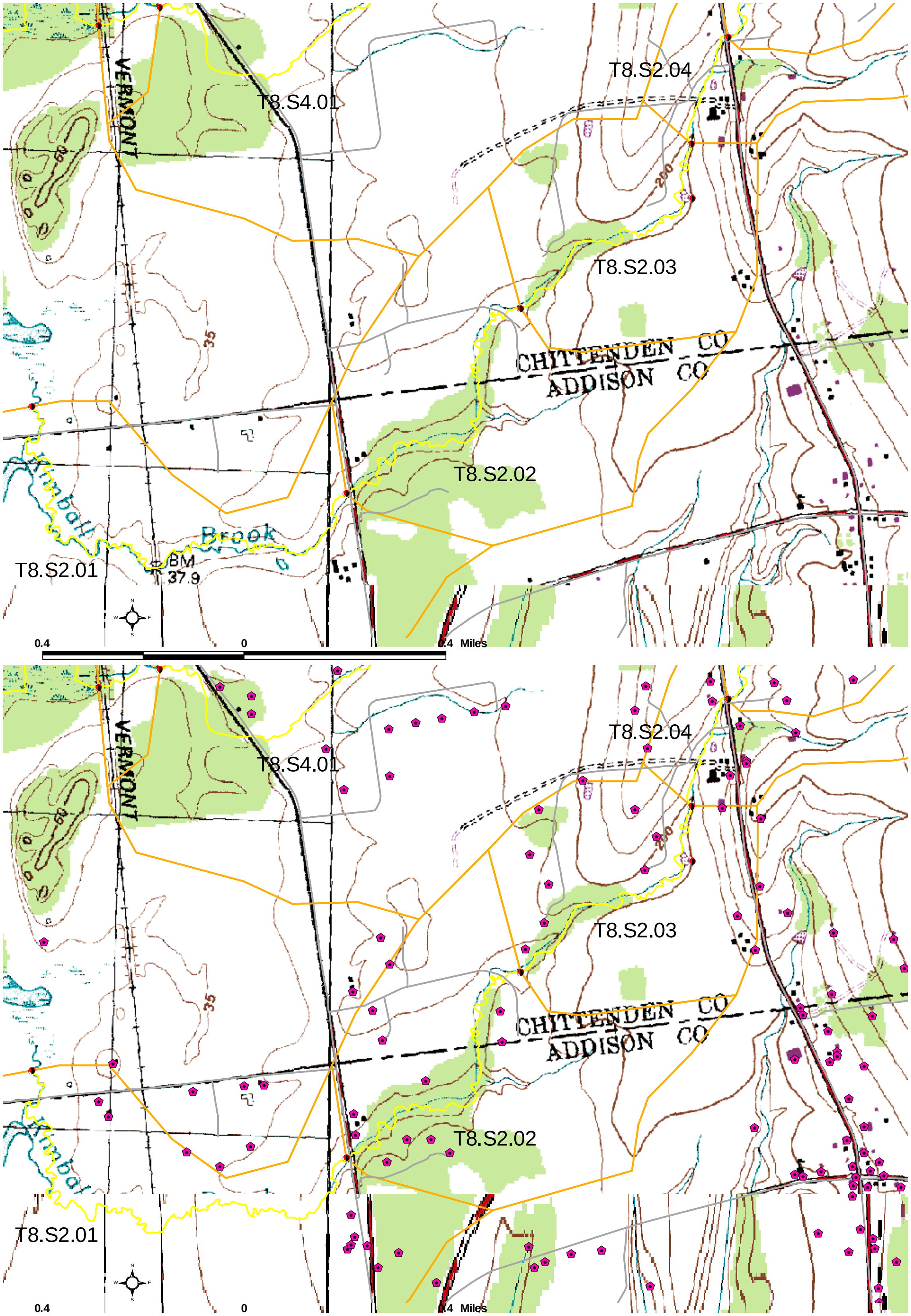
Unnamed Stream 9 begins at Lake Road just north of Thompson's Point Road and flows southwest, crossing Thompson's Point Road and entering Lake Champlain at the north end of Town Farm Bay. Watershed land use is forest and field with some residential development. Most of the reach (mainly the upstream portion) has little to no woody riparian buffer vegetation. Total watershed area is 0.32 square miles. This stream flows through one culvert. Over 50% of the reach appears straightened with some roads encroaching into the corridor.

The small channel flows through fields and then forest.

Kimball Brook (T8 S2)

Kimball Brook begins northeast of the Mt. Philo Road and One Mile Road intersection. It flows southwest crossing Route 7 and Greenbush Road before turning northwest and enters Lake Champlain at the south end of Town Farm Bay. Watershed land use is field and cropland with increasing residential development, especially in the subwatersheds near Route 7. Many areas have little to no woody riparian buffer vegetation. Total watershed area is 2.45 square miles. Almost the entire stream appears to have been straightened historically with much current channel migration evident. Kimball Brook flows through 11 culverts and has one dam and one water withdrawal evident. Some roads and development encroach into the corridor. Some bank erosion was visible in the windshield survey.

Downstream area of Kimball Brook (L) and upstream section with straightening and a pond (R).



Kimball Brook area with 2006 buildings (E911 sites) overlaid on bottom map to illustrate development.

5.2 Stressors

Figure 5.2 shows the percent urban land use for each study subwatershed. Many of the subwatersheds have over 10% urban land use. In a study of impervious surfaces (SMRC 2005), this study area was divided into larger subwatersheds. Overall, the study found this area to have 4% impervious surface cover with the Kimball Brook watershed having 5% impervious cover and the area around T5, T6, and T7 having 6% impervious cover. Fitzgerald (2007) found 5% watershed impervious cover to be the threshold for impacts to stream geomorphology. (Please note that percent urban land use does not equal percent impervious surface cover.)

Figure 5.3 shows the percent cropland use for each study subwatershed. Soil exposed by tilling crops is much more prone to erosion, contributing sediment to streams. The majority of the subwatersheds had over 10% cropland cover. Such high percentages of cropland can contribute significantly to the sediment load.

Figure 5.4 shows the percentage of each stream reach that has been straightened at some point, shaded by subwatershed. Most of the study streams are over 20% straightened.

Figure 5.5 shows the impact ratings for corridor encroachments (roads, berms, railroads, development). Many reaches have encroachment impact ratings of “not significant.” Only a few reaches have “high” impact ratings for encroachments.

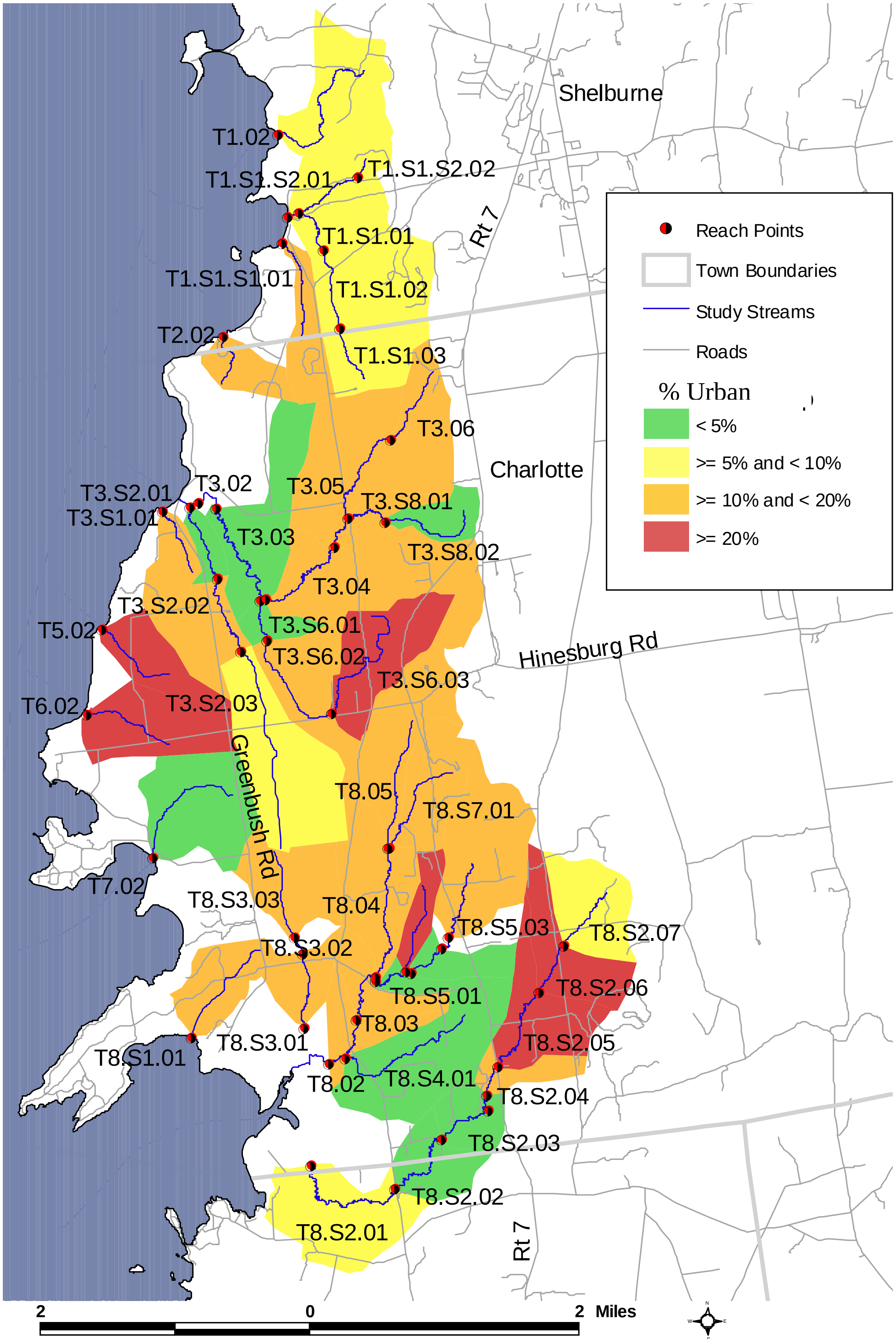


Figure 5.2 Subwatershed % Urban Land Use

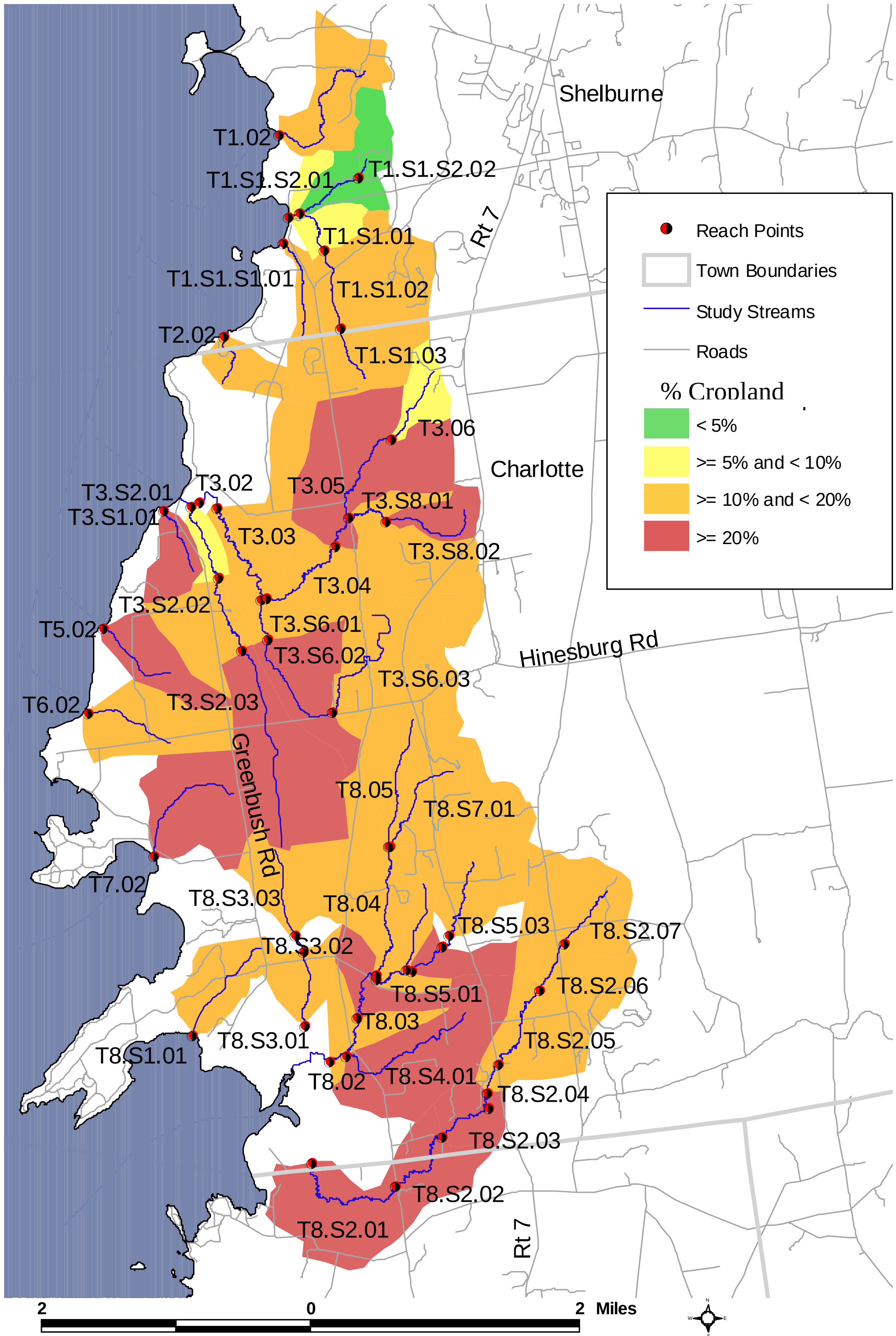


Figure 5.3 Subwatershed Crop Land Use

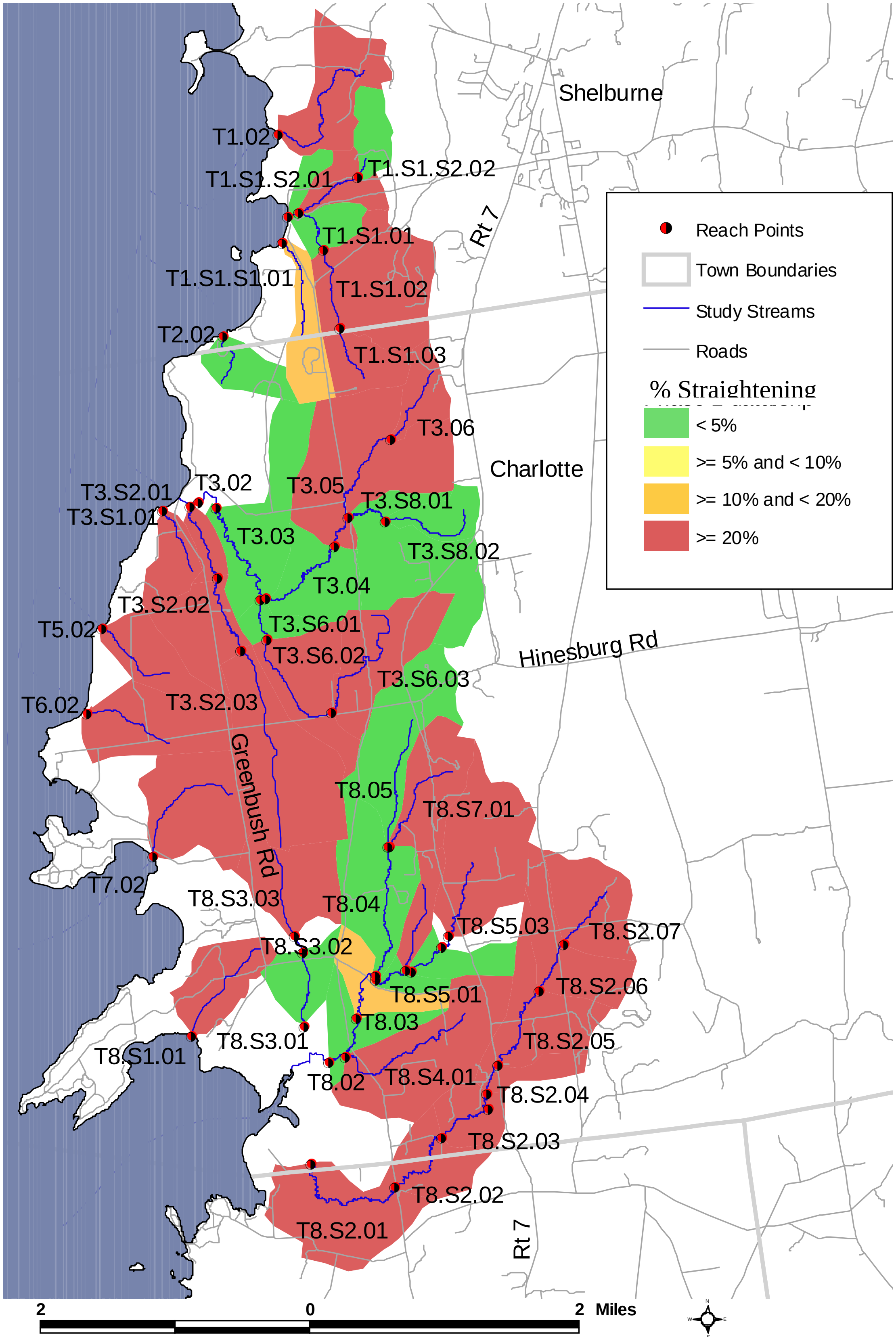


Figure 5.4 Stream Straightening % by Subwatershed

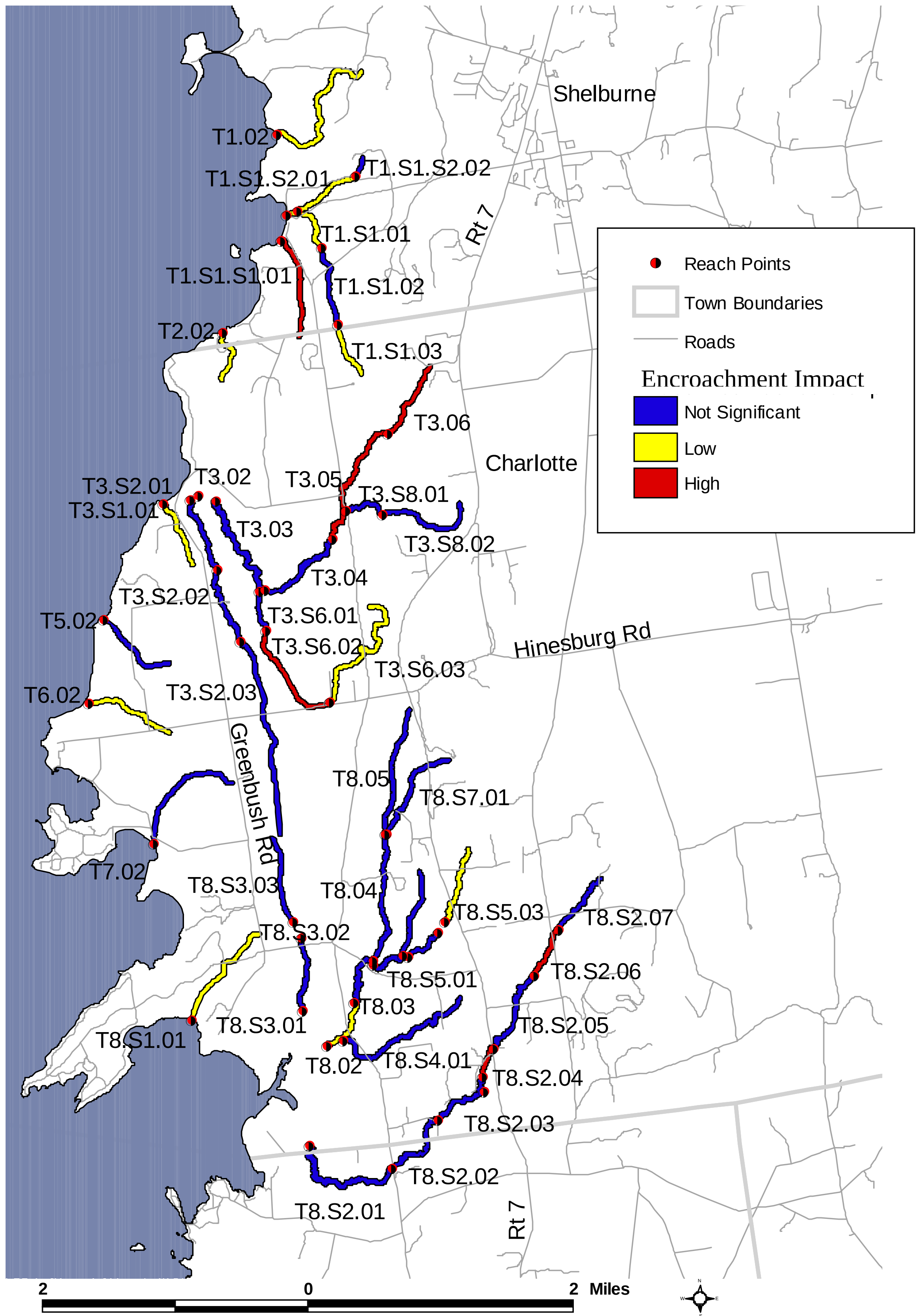


Figure 5.5 Stream Corridor Encroachment Impact Rating

5.3 Adjustment Process and Reach Condition

Predicted Adjustment Process scores in Table 5.2 use the remote sensing data to predict the stream channel adjustment processes ongoing for each reach based on the parameters evaluated in Phase1. RMP considers the adjustment process with the highest score as the dominant adjustment process. The adjustment process with the second highest score is considered the "concurrent adjustment process" as adjustments (especially degradation and aggradation) are usually coupled with other adjustments. RMP considers a score of 4 or greater as in adjustment. If an adjustment process has a score of less than 4, it may be in equilibrium (not in adjustment).

The adjustment processes are described in the Protocols as follows (see Figure 3.1 for a diagram):

Degrading – Downward erosion of streambed via head-cutting process
Aggrading – Excessive sediment build up on streambed and bars
Widening – Erosion of both banks leading to an over-widened stream bed
Planform – Rapid and/or irregular meander movement and pattern
None – No significant adjustment processes indicated
Multiple – Multiple adjustments indicated

Table 5.2 Adjustment, Condition and Sensitivity

		Stream Type						9.1 Predicted Adjustment Scores				9.2 Reach Condition		9.3
	Confinement	Stream	Bed	Subclass		Watershed	Total							Reach
Reach ID	Type	Type	Material	Slope	Bedform	Area	Impact	Degrad.	Aggrad.	Widen.	Planf.	Project	Statewide	Sensitivity
T1.02	BD	C	Gravel	b	Riffle-Pool	0.45	17	8	10	9	12	Poor	Fair	High
T1.S1.01	VB	C	Gravel	None	Riffle-Pool	1.46	16	7	9	7	9	Fair	Fair	High
T1.S1.02	VB	C	Sand	None	Dune-Ripple	0.91	16	7	8	7	11	Fair	Fair	High
T1.S1.03	VB	C	Sand	None	Dune-Ripple	0.23	15	8	10	9	10	Poor	Fair	High
T1.S1.S1.01	VB	C	Gravel	b	Riffle-Pool	0.26	13	8	8	7	8	Fair	Fair	High
T1.S1.S2.01	VB	C	Gravel	b	Riffle-Pool	0.33	14	6	7	7	10	Fair	Fair	High
T1.S1.S2.02	VB	C	Gravel	b	Riffle-Pool	0.16	5	5	6	5	5	Fair	Good	High
T2.02	VB	C	Gravel	None	Riffle-Pool	0.19	6	4	5	4	2	Good	Good	High
T3.03	VB	E	Sand	None	Dune-Ripple	3.78	8	4	3	2	2	Good	Reference	High
T3.04	VB	C	Sand	None	Dune-Ripple	2.21	7	2	3	2	2	Good	Reference	High
T3.05	VB	C	Gravel	None	Riffle-Pool	1.87	20	11	10	9	13	Poor	Fair	High
T3.06	VB	C	Gravel	b	Riffle-Pool	0.17	16	10	10	9	10	Poor	Fair	High
T3.S1.01	VB	C	Sand	None	Dune-Ripple	0.19	17	9	10	9	11	Poor	Fair	High
T3.S2.01	VB	C	Sand	None	Dune-Ripple	1.24	16	6	9	7	10	Fair	Fair	High
T3.S2.02	VB	C	Sand	None	Dune-Ripple	1.13	18	8	10	9	12	Poor	Fair	High
T3.S2.03	VB	C	Sand	None	Dune-Ripple	0.78	15	8	10	9	10	Poor	Fair	High
T3.S6.01	VB	C	Sand	None	Dune-Ripple	1.02	2	4	2	2	0	Good	Reference	High
T3.S6.02	VB	C	Sand	None	Dune-Ripple	0.91	22	11	10	9	13	Poor	Fair	High
T3.S6.03	VB	C	Gravel	None	Riffle-Pool	0.5	11	8	10	9	10	Poor	Fair	High
T3.S8.01	BD	C	Gravel	None	Riffle-Pool	0.81	12	5	6	5	7	Fair	Good	High
T3.S8.02	NW	B	Cobble	a	Step-Pool	0.17	8	6	10	9	8	Fair	Fair	Moderate
T5.02	VB	C	Sand	None	Dune-Ripple	0.3	16	8	10	9	10	Poor	Fair	High
T6.02	VB	C	Gravel	None	Riffle-Pool	0.47	13	7	8	7	9	Fair	Fair	High
T7.02	VB	C	Gravel	None	Riffle-Pool	0.59	7	6	6	5	6	Fair	Good	High
T8.02	VB	C	Sand	None	Dune-Ripple	3.8	14	5	6	5	7	Fair	Good	High

		Stream Type						9.1 Predicted Adjustment Scores				9.2 Reach Condition		9.3
	Confinement	Stream	Bed	Subclass		Watershed	Total							Reach
Reach ID	Type	Type	Material	Slope	Bedform	Area	Impact	Degrad.	Aggrad.	Widen.	Planf.	Project	Statewide	Sensitivity
T8.03	VB	E	Sand	None	Dune-Ripple	2.82	15	6	8	5	8	Fair	Good	High
T8.04	VB	C	Gravel	None	Riffle-Pool	1.43	11	6	7	7	8	Fair	Good	High
T8.05	VB	C	Gravel	None	Riffle-Pool	0.54	6	4	6	6	4	Fair	Good	High
T8.S1.01	VB	C	Sand	None	Dune-Ripple	0.32	13	6	8	7	8	Fair	Fair	High
T8.S2.01	VB	E	Sand	None	Dune-Ripple	2.45	19	9	10	9	13	Poor	Fair	High
T8.S2.02	VB	E	Sand	None	Dune-Ripple	1.82	16	7	7	7	11	Fair	Fair	High
T8.S2.03	VB	C	Gravel	None	Riffle-Pool	1.54	14	6	8	7	10	Fair	Fair	High
T8.S2.04	VB	C	Gravel	None	Riffle-Pool	1.33	22	10	10	7	12	Poor	Fair	High
T8.S2.05	VB	C	Sand	None	Dune-Ripple	1.19	16	8	9	7	10	Poor	Fair	High
T8.S2.06	VB	C	Gravel	None	Riffle-Pool	0.76	18	9	8	7	11	Poor	Fair	High
T8.S2.07	VB	C	Gravel	b	Riffle-Pool	0.39	16	7	8	7	11	Fair	Fair	High
T8.S3.01	VB	C	Sand	None	Dune-Ripple	0.72	6	4	5	4	2	Good	Good	High
T8.S3.03	VB	C	Sand	None	Dune-Ripple	0.41	13	8	9	9	10	Poor	Fair	High
T8.S4.01	VB	C	Gravel	None	Riffle-Pool	0.75	12	4	6	6	6	Fair	Good	High
T8.S5.01	VB	C	Sand	None	Dune-Ripple	1.18	9	4	3	2	2	Good	Reference	High
T8.S5.02	BD	C	Gravel	None	Riffle-Pool	0.95	10	5	5	5	7	Fair	Good	High
T8.S5.04	VB	C	Gravel	None	Riffle-Pool	0.66	18	9	10	9	13	Poor	Fair	High
T8.S5.S1.01	VB	C	Gravel	b	Riffle-Pool	0.15	10	8	10	9	10	Poor	Fair	High
T8.S7.01	VB	C	Gravel	b	Riffle-Pool	0.38	12	6	8	7	8	Fair	Fair	High

6.0 Phase 2 Results

Phase 2 Assessments were completed on 2 reaches from this Phase 1 study, Thorp Brook T8.3, and the Unnamed Tributary near Shelburne Beach T1S1.02. Phase 2 Assessments were also completed for 2 reaches in the LaPlatte watershed on Mud Hollow Brook T2.01 and T2.02. Table 6.1 presents a summary of the Phase 2 stream conditions. Please see Appendix E for Phase 2 FIT features mapping.

Table 6.1 Summary of Phase 2 Data

Segment & Town	Stream Type	Geomorphic Condition	Evolution Stage	Sensitivity	Habitat Condition
T1S1.02 Shelburne	B5 Dune-Ripple (C-B)*	Fair	II	High	Fair
T2.01 & T2.02A Charlotte	E5 Dune-Ripple	Fair	IIc (D)	Very High	Fair
T2.02B Charlotte	C4 Riffle-Pool	Fair	IV	Very High	Good
T8.03 Charlotte	E5 Dune-Ripple	Good	IV	High	Good

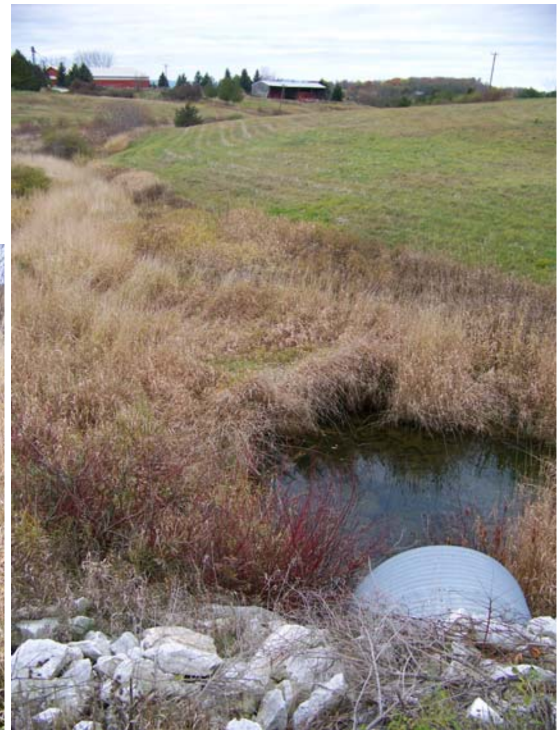
*Indicates a stream type departure from C to B.

Phase 2 Reach Summaries

T1S1.02 Shelburne Beach Tributary

The reach begins just downstream of a large pond with a dam. The stream flows north and through a culvert under Bostwick Road where a tributary enters as well. The stream continues north and the reach break is just upstream of the first pond, where the channel begins to braid. This reach appeared to have incised, with one headcut present, so incision was still active. Some incision could be related to channel straightening or possible dredging. Almost the entire reach appeared to have been straightened historically. Some incision could also be related to increased flows out of the culvert. Overall stream channel width was 12 feet wide and the culvert width was only 5.5 feet wide, causing scour downstream. The channel did have a small floodplain area developing at the lower elevation, however the main adjustment process appeared to be incision with some widening and planform adjustments as well. The reach appeared to have experienced a stream type departure from a C (meandering) type to a B (entrenched) type.

Bank and buffer vegetation was mainly herbaceous and appeared to be cut all the way to the channel in areas. Other areas had some shrubs and saplings. Hay fields occupied the remainder of the corridor. Some bank erosion was observed. Habitat condition was “Fair” and mainly affected by a poor mix of substrate and cover types, lack of woody riparian buffer, lack of healthy pools, and bank instability.

Eroding bank at headcut with large pool (L) and channel view with herbaceous riparian vegetation and undersized culvert with scour pool downstream (R).

T8.03 Thorp Brook

The reach begins upstream of Albee Road where a tributary enters. The stream flows southwest under Albee Road and continues south for approximately 200 feet. The area appeared heavily impacted by beavers with trees chewed and signs of water fluctuations such as flood chutes and channel migration. A neighbor noted a large beaver dam downstream of the reach, causing some water to back up into this reach. The reach was not segmented due to the presence of beaver activity throughout the reach and the fact that the dams are likely to move around over time. Overall stream condition appeared to be “Good” with only slight incision, likely masked by the aggradation. Current adjustments were aggradation and widening, but mainly planform. The beaver activity throughout the reach was also likely contributing to channel adjustments.

The Albee Road crossing appeared to have been a site of concern for the town as much work has been done. A total of 3 culverts were at the crossing one at low flow level, one slightly higher, and one overflow. Overall channel width was 22 feet wide with the culverts being 3 (low flow), 5 (high flow) and 3 (overflow) feet wide. The low flow culvert appeared poorly aligned with overbank flows, as it was after a bend in the stream.

Overall habitat condition was “Good” with some bank instability, some areas of reduced buffer and few substrate types.


Channel views with some bank erosion/migration.


Culverts with overflow pipes (L) and beaver activity (R).

T2.01 & T2.02A Mud Hollow Brook

The reach described here includes the downstream portion of T2.02 (segmented) as it had similar characteristics as T2.01. This section begins upstream of the southern Spear Street crossing for Mud Hollow Brook at the upstream end of the field, after the stream emerges from the wooded area. This is where the slope flattens out and the channel takes on the E type characteristics, meandering and low width-to-depth ratio. The sinuosity was slightly low for E type stream classification, but that could be due to historical straightening and the road construction. Overall, the stream appeared to be in “Fair” condition with major planform adjustment processes with minor widening and aggradation. Beaver activity in the reach may account for some of the adjustments as well as the lack of woody vegetation regeneration on the terrace.

Overall channel width was 24 feet while the 2 culverts were only 14 (downstream) and 10 (upstream) feet wide. Scour was present downstream of both culverts and a beaver dam was constructed at the opening of the downstream culvert.

The corridor land use was wetland/grasses. The corridor area did not appear to be managed, but presumably beaver activity and flooding/ice has limited sapling growth. Habitat condition appeared to be "Fair" and mainly affected by sediment deposition, bank instability, few substrate types, and some straightening.

Channel views with Spear Street abutting the channel (L) and herbaceous vegetation (R).

Upstream (L) and downstream (R) views of the southern (upstream) culvert. Note the woody debris upstream and scour downstream.

T2.02B Mud Hollow Brook

This reach flows north and northeast on the western side of Spear Street. The segment appeared to have incised historically from an upper terrace. A new terrace and floodplain are developing at bankfull elevation. The stream appeared to be in "Fair" condition with planform the dominant adjustment process. Some aggradation was present but channel widening appeared historical.

Bank vegetation was herbaceous, but appeared to be natural. The riparian corridor was forested with only corners of hay fields encroaching into the corridor. The channel had many grassy mid channel bars. Overall Habitat condition was “Good” and affected by sediment deposition.

A pond was in the corridor at the upstream end of the reach. It was difficult to determine if the pond had been dug out of the floodplain or if the stream had been moved over and bermed to create the pond. An overflow pipe from the pond had evidence of scour on the terrace at the outflow.



Channel view (L) and mass failure (R).


Failing riprap and bank erosion along the pond and possible berm.

7.0 Next Steps

Like Reach Evaluation

From the Phase 1 Protocols (p. 78):

> "The purpose of a "Like Reach Evaluation" is to group reaches in the watershed by similar stream types and similar geomorphic condition assessments.
>
> Grouping streams by like reaches is useful in selecting a manageable number of reaches for which to conduct the more detailed Phase 2 and Phase 3 assessments. By collecting detailed information on a few reaches that represent all the stream types in your watershed you are better able to characterize the entire watershed without conducting extensive and time consuming field surveys on the entire watershed."

Table 7.1 shows results of a Like Reach Evaluation for the study streams where the reaches were sorted by stream type, then confinement, then geomorphic condition, and finally watershed size. Reaches are then prioritized in the Priority Ranking column according to watershed size, impacts, and representation of like reaches and are recommended for possible further study (Phase 2 SGA). Recommendations for Phase 2 assessment are largely based on watershed size, as the smaller watershed streams are difficult to assess, especially when the channel is overgrown with vegetation.

Pursuing Phase 2 assessments in these areas along with river corridor planning tasks such as project identification and landowner outreach will highlight potential restoration and protection projects. While Phase 2 assessments are not recommended for all reaches due to their small watersheds, potential projects such as corridor protection and buffer planting could be identified through landowner outreach and possible field visits.

Table 7.1 Like Reach Evaluation sorted by Stream Type, then Confinement Type, then Reach Condition, then Watershed Area.

Stream Type - B													
		Stream Type						Predicted Adjustment Scores					Priority
	Confinement	Stream	Bed	Subclass		Watershed	Total					Reach	Ranking[1]
Reach ID	Type	Type	Material	Slope	Bedform	Area	Impact	Degrad.	Aggrad.	Widen.	Planf.	Condition	
T3.S8.02	NW	B	Cobble	a	Step-Pool	0.17	8	6	10	9	8	Fair	M

Stream Type - C													
		Stream Type						Predicted Adjustment Scores					Priority
	Confinement	Stream	Bed	Subclass		Watershed	Total					Reach	Ranking[1]
Reach ID	Type	Type	Material	Slope	Bedform	Area	Impact	Degrad.	Aggrad.	Widen.	Planf.	Condition	
T3.S8.01	BD	C	Gravel	None	Riffle-Pool	0.81	12	5	6	5	7	Fair	M
T8.S5.02	BD	C	Gravel	None	Riffle-Pool	0.95	10	5	5	5	7	Fair	H
T1.02	BD	C	Gravel	b	Riffle-Pool	0.45	17	8	10	9	12	Poor	M
T1.S1.S2.02	VB	C	Gravel	b	Riffle-Pool	0.16	5	5	6	5	5	Fair	L
T1.S1.S1.01	VB	C	Gravel	b	Riffle-Pool	0.26	13	8	8	7	8	Fair	L
T8.S1.01	VB	C	Sand	None	Dune-Ripple	0.32	13	6	8	7	8	Fair	L
T1.S1.S2.01	VB	C	Gravel	b	Riffle-Pool	0.33	14	6	7	7	10	Fair	M
T8.S7.01	VB	C	Gravel	b	Riffle-Pool	0.38	12	6	8	7	8	Fair	L
T8.S2.07	VB	C	Gravel	b	Riffle-Pool	0.39	16	7	8	7	11	Fair	L
T6.02	VB	C	Gravel	None	Riffle-Pool	0.47	13	7	8	7	9	Fair	L
T8.05	VB	C	Gravel	None	Riffle-Pool	0.54	6	4	6	6	4	Fair	M
T7.02	VB	C	Gravel	None	Riffle-Pool	0.59	7	6	6	5	6	Fair	L
T8.S4.01	VB	C	Gravel	None	Riffle-Pool	0.75	12	4	6	6	6	Fair	M
T1.S1.02	VB	C	Sand	None	Dune-Ripple	0.91	16	7	8	7	11	Fair	complete
T3.S2.01	VB	C	Sand	None	Dune-Ripple	1.24	16	6	9	7	10	Fair	H
T8.04	VB	C	Gravel	None	Riffle-Pool	1.43	11	6	7	7	8	Fair	H
T1.S1.01	VB	C	Gravel	None	Riffle-Pool	1.46	16	7	9	7	9	Fair	L

Stream Type - C														
		Stream Type						Predicted Adjustment Scores						Priority
	Confinement	Stream	Bed	Subclass		Watershed	Total					Reach	Ranking[1]
Reach ID	Type	Type	Material	Slope	Bedform	Area	Impact	Degrad.	Aggrad.	Widen.	Planf.	Condition	
T8.S2.03	VB	C	Gravel	None	Riffle-Pool	1.54	14	6	8	7	10	Fair	H
T8.02	VB	C	Sand	None	Dune-Ripple	3.8	14	5	6	5	7	Fair	H
T2.02	VB	C	Gravel	None	Riffle-Pool	0.19	6	4	5	4	2	Good	L
T8.S3.01	VB	C	Sand	None	Dune-Ripple	0.72	6	4	5	4	2	Good	M
T3.S6.01	VB	C	Sand	None	Dune-Ripple	1.02	2	4	2	2	0	Good	H
T8.S5.01	VB	C	Sand	None	Dune-Ripple	1.18	9	4	3	2	2	Good	H
T3.04	VB	C	Sand	None	Dune-Ripple	2.21	7	2	3	2	2	Good	H
T8.S5.S1.01	VB	C	Gravel	b	Riffle-Pool	0.15	10	8	10	9	10	Poor	L
T3.06	VB	C	Gravel	b	Riffle-Pool	0.17	16	10	10	9	10	Poor	L
T3.S1.01	VB	C	Sand	None	Dune-Ripple	0.19	17	9	10	9	11	Poor	L
T1.S1.03	VB	C	Sand	None	Dune-Ripple	0.23	15	8	10	9	10	Poor	L
T5.02	VB	C	Sand	None	Dune-Ripple	0.3	16	8	10	9	10	Poor	L
T8.S3.03	VB	C	Sand	None	Dune-Ripple	0.41	13	8	9	9	10	Poor	L
T3.S6.03	VB	C	Gravel	None	Riffle-Pool	0.5	11	8	10	9	10	Poor	M
T8.S5.04	VB	C	Gravel	None	Riffle-Pool	0.66	18	9	10	9	13	Poor	L
T8.S2.06	VB	C	Gravel	None	Riffle-Pool	0.76	18	9	8	7	11	Poor	M
T3.S2.03	VB	C	Sand	None	Dune-Ripple	0.78	15	8	10	9	10	Poor	M
T3.S6.02	VB	C	Sand	None	Dune-Ripple	0.91	22	11	10	9	13	Poor	H
T3.S2.02	VB	C	Sand	None	Dune-Ripple	1.13	18	8	10	9	12	Poor	H
T8.S2.05	VB	C	Sand	None	Dune-Ripple	1.19	16	8	9	7	10	Poor	H
T8.S2.04	VB	C	Gravel	None	Riffle-Pool	1.33	22	10	10	7	12	Poor	H
T3.05	VB	C	Gravel	None	Riffle-Pool	1.87	20	11	10	9	13	Poor	H

Stream Type – E													
		Stream Type						Predicted Adjustment Scores					
	Confinement	Stream	Bed	Subclass		Watershed	Total					Reach	Priority
Reach ID	Type	Type	Material	Slope	Bedform	Area	Impact	Degrad.	Aggrad.	Widen.	Planf.	Condition	Ranking[1]
T8.S2.02	VB	E	Sand	None	Dune-Ripple	1.82	16	7	7	7	11	Fair	H
T8.03	VB	E	Sand	None	Dune-Ripple	2.82	15	6	8	5	8	Fair	complete
T3.03	VB	E	Sand	None	Dune-Ripple	3.78	8	4	3	2	2	Good	H
T8.S2.01	VB	E	Sand	None	Dune-Ripple	2.45	19	9	10	9	13	Poor	H

[1]Prioritization for further assessment, rated according to watershed size, impacts and representation (L=Low; M=Medium; H=High).

Further Study

In addition to the above recommendations for Phase 2 assessments, studying impervious surface cover and stormwater contributions to these streams would be valuable, especially as development in the area increases. Impervious surface cover was studied by SMRC (2005) however the subwatersheds were combined into larger study areas. With increased development in certain areas, breaking out the impervious surface coverage into the individual Phase 1 subwatersheds would more closely relate impervious surface coverage to reach condition and adjustments.

Potential Project Opportunities

The Phase 2 SGA of the 4 reaches (Thorp Brook T8.3, Unnamed Tributary near Shelburne Beach T1S1.02, Mud Hollow Brook T2.01 and T2.02) resulted in the following recommendations for potential projects. Working with landowners and stakeholders is recommended to gauge interest and further develop these projects. Further development would include feasibility analysis, landowner outreach and commitment, project designs, and permits.

T1S1.02 – Protect the river corridor and plant woody buffer vegetation to eliminate vegetation cutting and potential encroachment as well as to enhance bank stability and habitat. Investigate options for restoring the channel incision downstream of Bostwick Road. Resize the Bostwick Road culvert as it is up for replacement.

T8.03 – Protect the stream corridor to allow for continued channel migration, beaver activity, and vegetation renewal. Work with the town of Charlotte to address the issues at the Albee Road crossing, which may require resizing, realignment and replacement of the culverts. Much work has evidently been done here, so working with the town to learn what has been done and what they think could be improved is recommended. Planting buffer vegetation is not recommended due to the beaver activity.

T2.01 and T2.02A – Protect the river corridor and possibly restore channel incision downstream of the northern culvert and along the LaPlatte mainstem reach M08. This area is currently in crop use (corn) with some greenhouses. This project would coordinate with project recommendations for M08 on the LaPlatte. Resize the 2 culverts in T2.01 and T2.02 as they are up for replacement to eliminate the channel constriction and erosion hazards.

T2.02B – Protect the river corridor to allow for continued adjustment and to avoid encroachments. Work with landowners to address issues near the pond including identification of any past channel management or berm construction.

River management currently recommends stream crossings (bridges and culverts) to be at least equal to stream channel bankfull width. Crossings may need to be wider if a channel is experiencing major adjustments. Watershed cropland can be addressed by establishing woody buffers to filter runoff from fields. Additionally, wooded buffers can help provide bank stability to reduce bank erosion. Protecting stream corridors to allow for the reestablishment of equilibrium conditions and woody buffers can reduce instream production of sediment over the long-term while increasing channel stability and habitat value.

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Acronym List

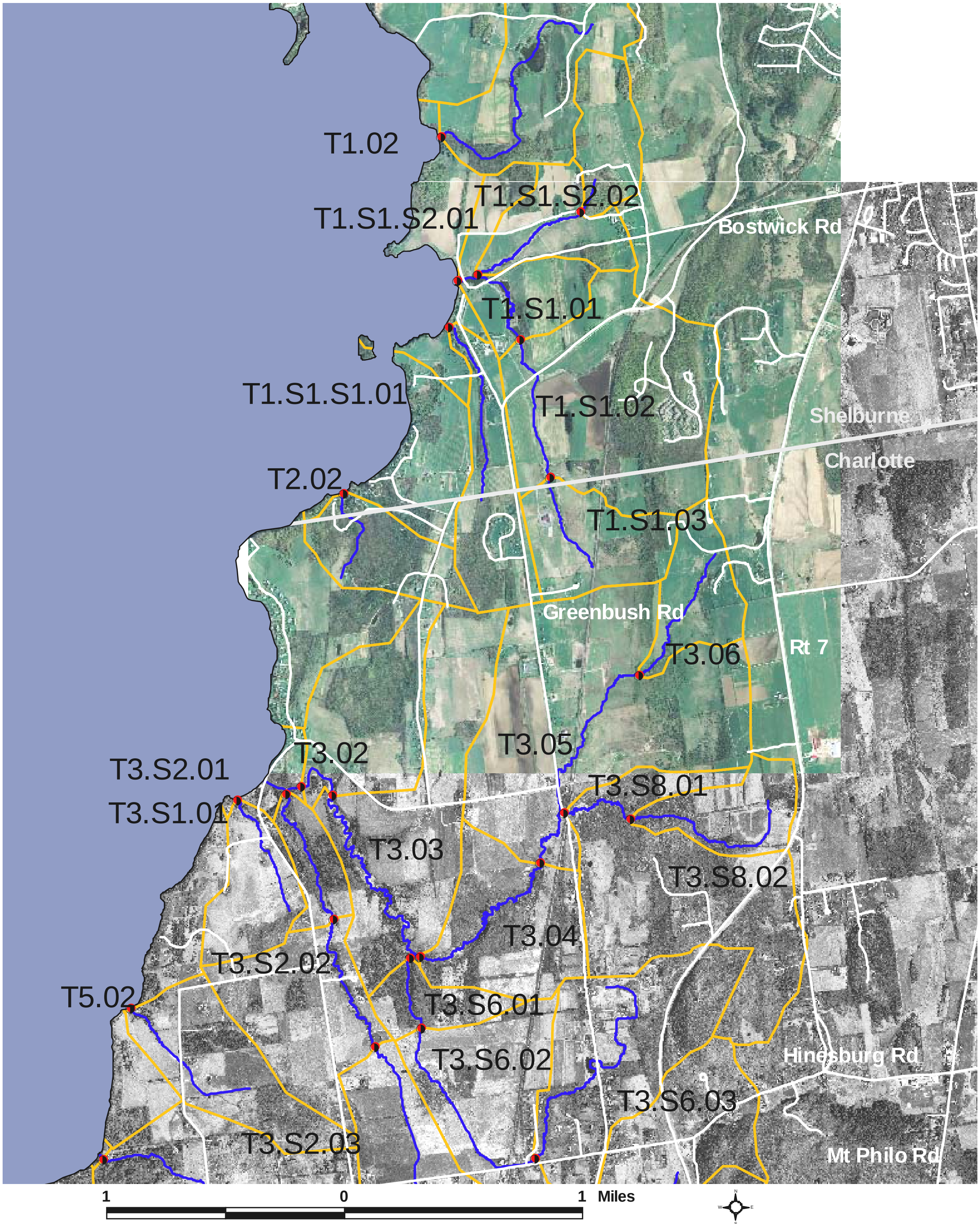
DMS – Data Management System (Developed by the DEC)
FEH – Fluvial Erosion Hazard area
FIT – Feature indexing Tool (in SGAT)
GIS – Geographic Information System
GPS – Global Positioning System
LCA – Lewis Creek Association
LWD – Large Woody Debris
LWP – LaPlatte Watershed Partnership
RGA – Rapid Geomorphic Assessment
RHA – Rapid Habitat Assessment
RMP – River Management Program
SCP – Stream Corridor Plan
SGA - Stream Geomorphic Assessment
SGAT – Stream Geomorphic Assessment Tool
VT ANR DEC – Vermont Agency of Natural Resources Department of Environmental Conservation

Glossary of Terms

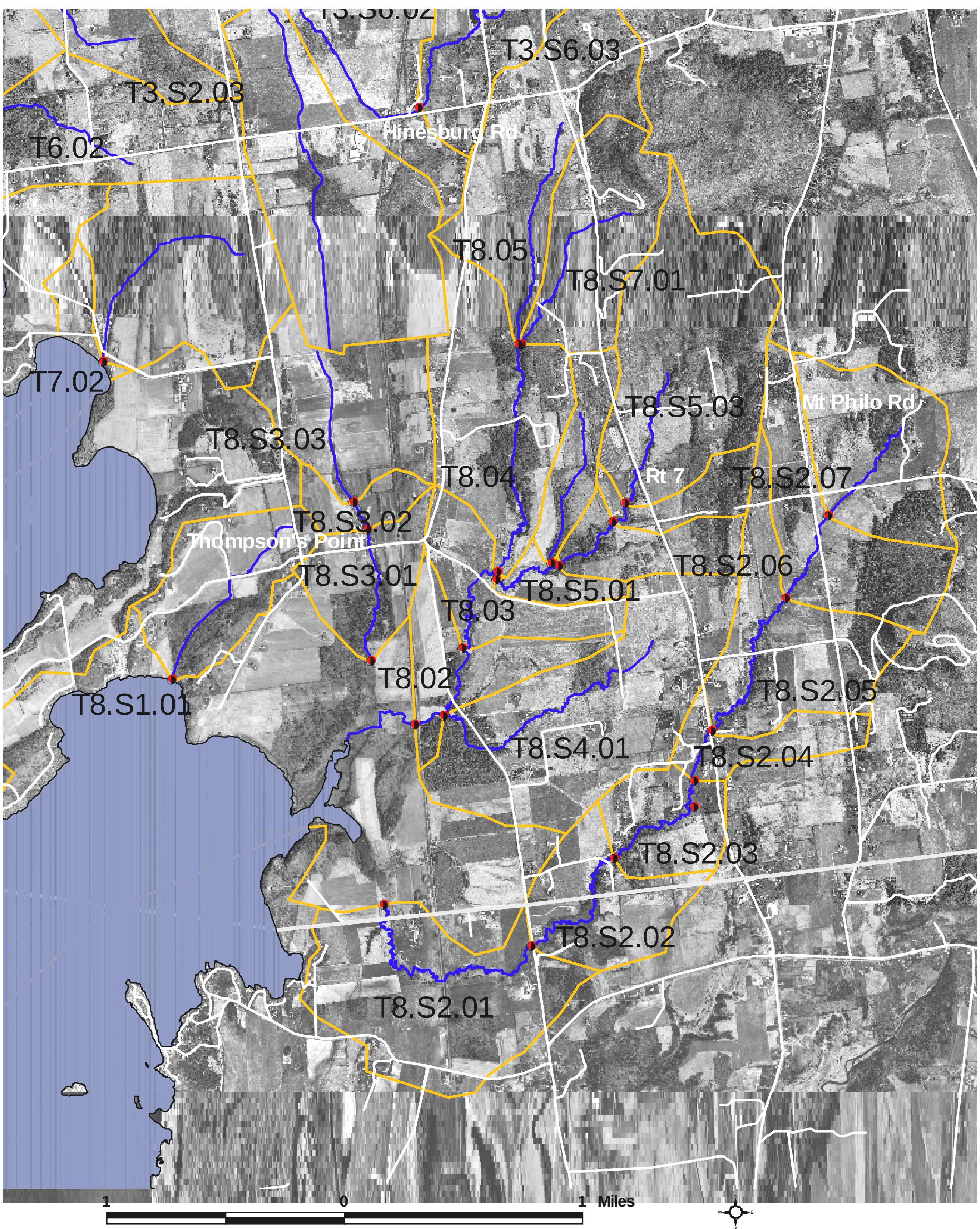
Aggradation - The build up of sediment in a streambed.
Avulsion – A change in a river's course; a section of channel that has moved laterally from its bed to create another segment of channel some distance from the previous bed location.
Bankfull width - The width of the channel at a height corresponding to the level of stream flow that would overtop the natural banks in a reference stream system, occurring on average 1.5 to 2 years.
Bankfull maximum depth – The depth of the channel from the bankfull elevation to the thalweg.
Confinement – Referring to the ratio of valley width to channel width. Unconfined channels (confinement of 4 or greater) flow through broader valleys and typically have higher sinuosity and area for floodplain. Confined channels (confinement of less than 4) typically flow through narrower valleys.
Debris jam - A collection of large woody debris that has lodged in a stream channel and spans the channel from bank to bank.
Degradation or incision - Down cutting of the streambed by erosion of bed material.
Embedded – Larger bed substrate particles (gravels, cobbles, boulders) surrounded by fine sediment, reducing the oxygen in the substrata and the ability of organisms to retreat into the substrata for cover.
Entrenched - A state where a channel has lowered significantly and floodwaters can no longer overtop the banks and access the floodplain.

Flood chute - A small side channel crossing the inside of a meander bend where flood waters will bypass the main channel, taking a shorter route through the chute.
Floodprone width - The area outward from the channel that is at an elevation that could be inundated by a flood, measured in Phase 2 SGA as at an elevation of 2 times the bankfull maximum depth.
Grade control – A fixed surface on the streambed that controls the bed elevation at that point, effectively fixing the bed elevation from potential incision, typically bedrock or culverts.
Head-cut – A sharp change in slope, almost vertical, where the streambed is being eroded from downstream to upstream.
High gradient streams - Typically found in steep, narrow valleys, these streams have steep slopes and are usually fast moving with many riffles or steps and low sinuosity.
Impervious surface – A hard surface, such as concrete or a rooftop, which prevents water from infiltrating the soil.
In Regime – Referring to a stream that is in an equilibrium state, one that would be expected given the stream setting.
Large woody debris - Pieces of wood in the active channel (within the bankfull width) usually from trees falling into the channel and with minimum dimensions of 12 inches in diameter (at one end) by 6 feet long.
Low gradient streams – Typically found in wide valleys, these streams have shallow slopes and are usually slow and meandering.
Meander – A bend in a stream, or referring to the way a stream winds down its valley.
Sinuosity – The level of bends or turns in a stream, calculated by dividing the stream length by the valley length.
Thalweg – Deepest point along the length of the stream, as if the deepest point of all cross sections were connected. The thalweg of a meandering channel typically alternates from right to left bank connecting pools.
Width/depth Ratio – The ratio of channel bankfull width to the average bankfull depth. An indicator of channel widening or aggradation.
Windrowing - Digging material from the channel bed and piling it on the bank, creating berms.

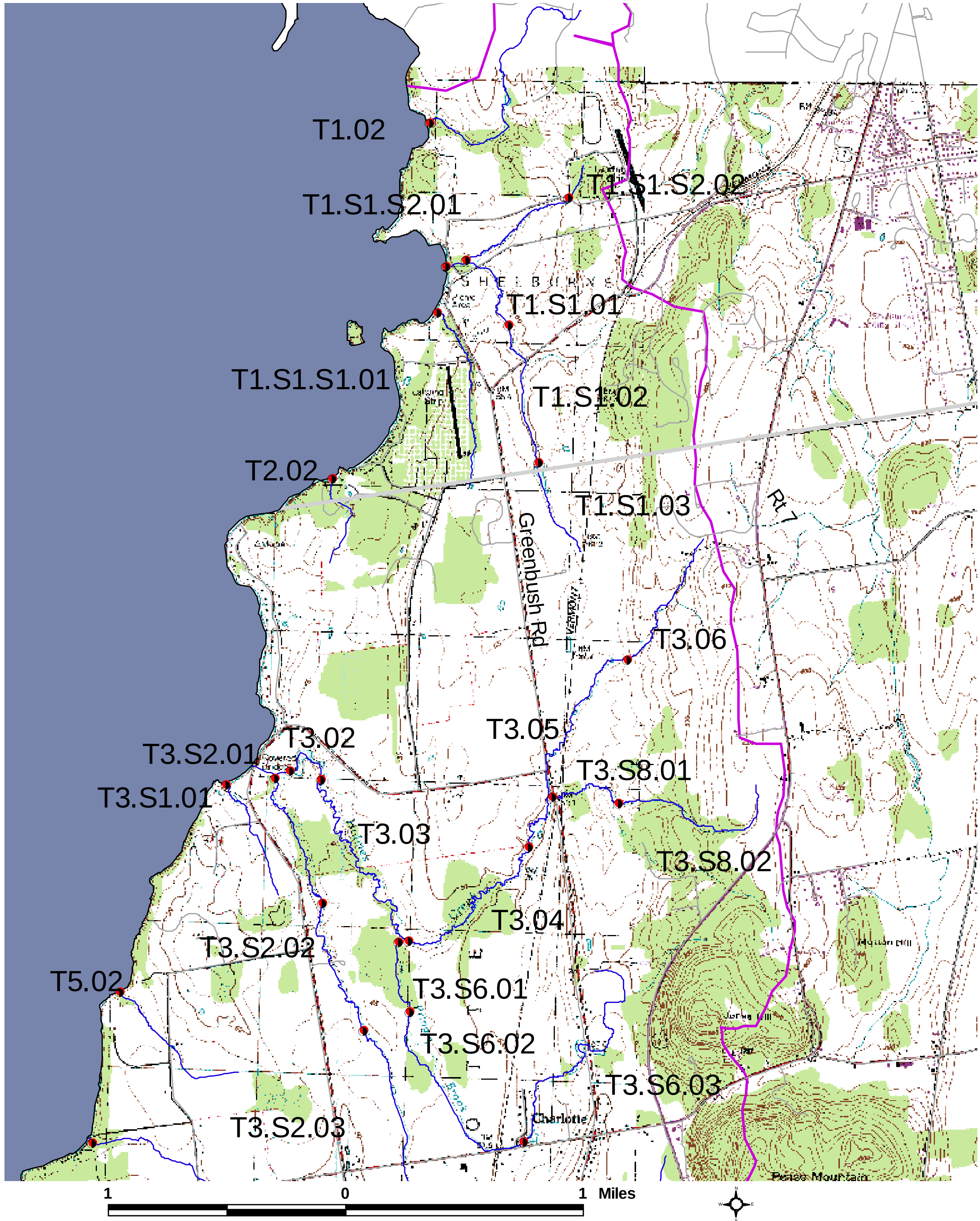
Appendix A Study Area Maps



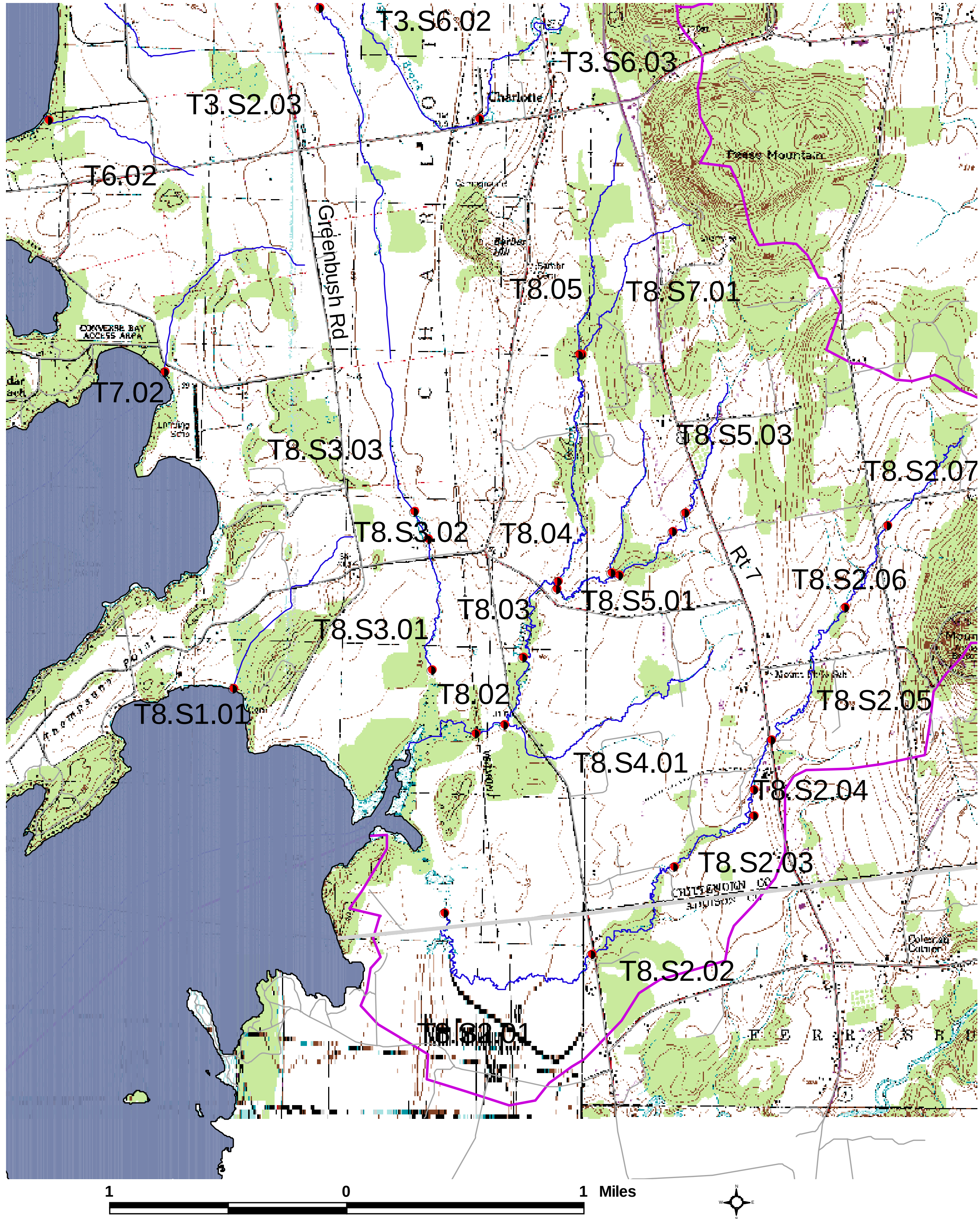
Northern Study Area



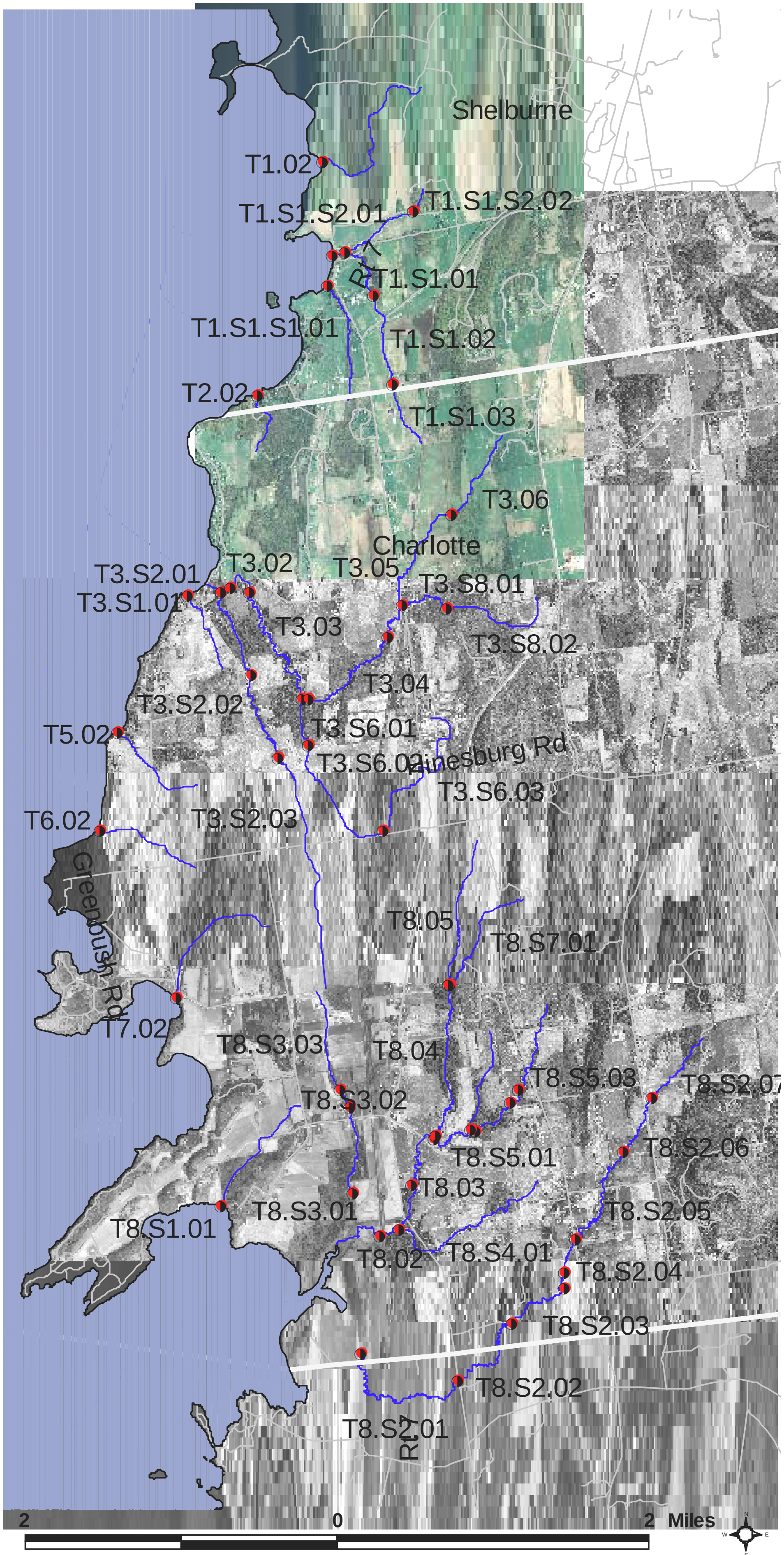
Southern Study Area



Northern Study Area Topo



Southern Area Topo


Shelburne
T1.02
T1.S1.S2.01
T1.S1.S2.02
Rt 7
T1.S1.01
T1.S1.S1.01
T1.S1.02
T2.02
T1.S1.03
T3.06
Charlotte
T3.S2.01
T3.02
T3.05
T3.S8.01
T3.S1.01
T3.03
T3.S8.02
T3.04
T3.S2.02
T3.S6.01
T5.02
T3.S6.02
Hinesburg Rd
T3.S6.03
T6.02
T3.S2.03
Greenbush Rd
T8.05
T8.S7.01
T7.02
T8.S3.03
T8.04
T8.S5.03
T8.S2.07
T8.S3.02
T8.S2.06
T8.S5.01
T8.03
T8.S3.01
T8.S2.05
T8.S1.01
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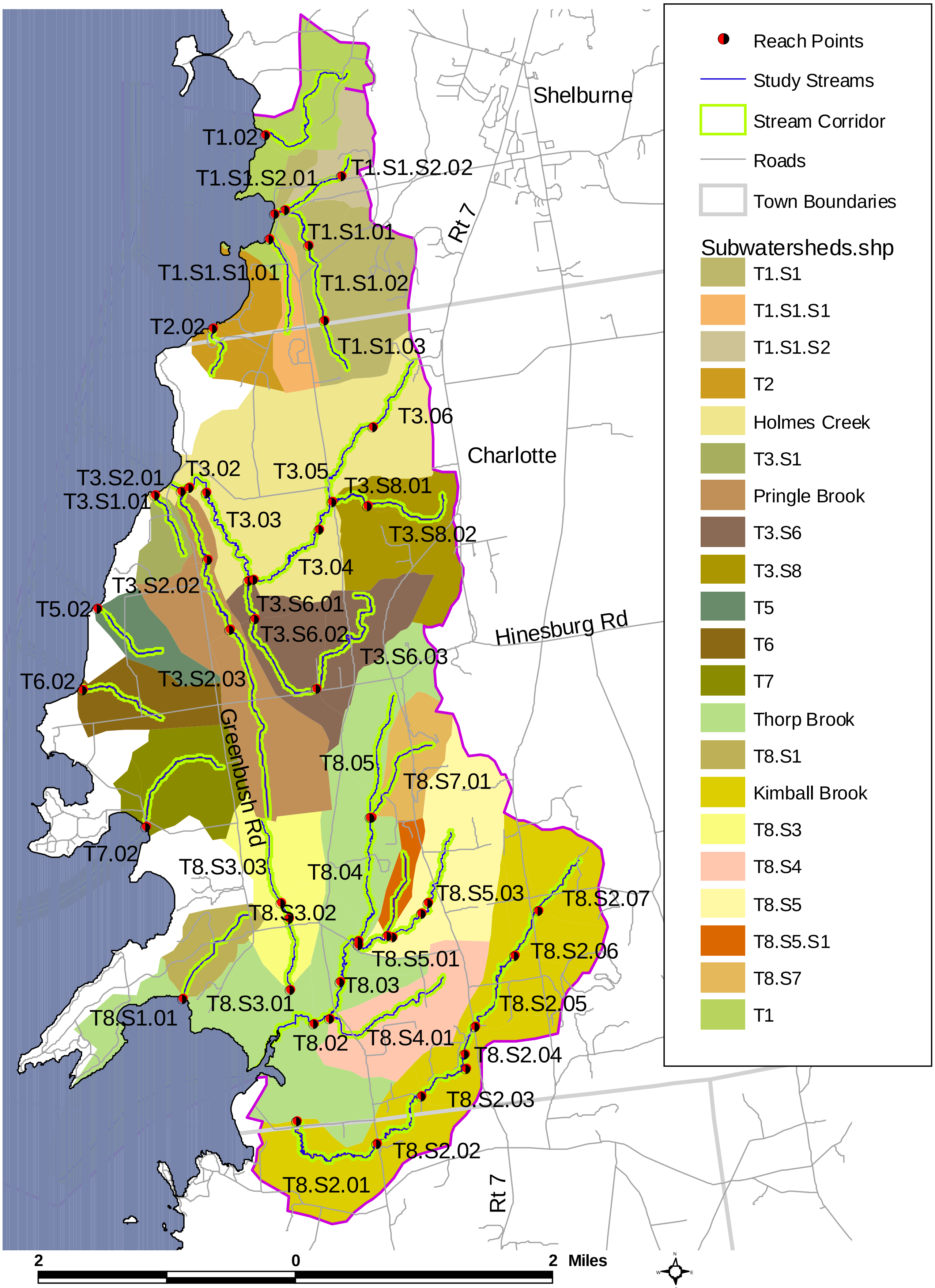
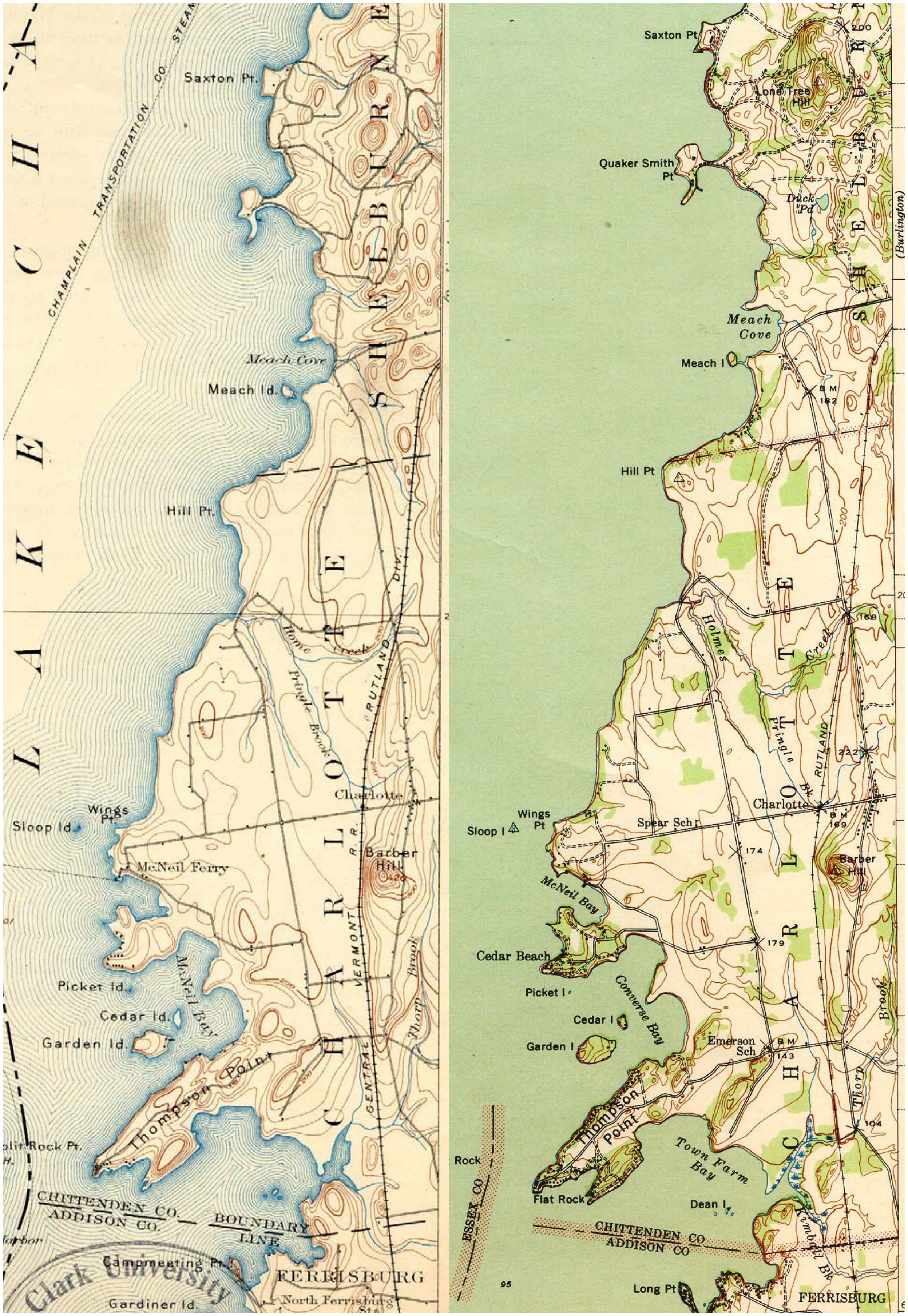
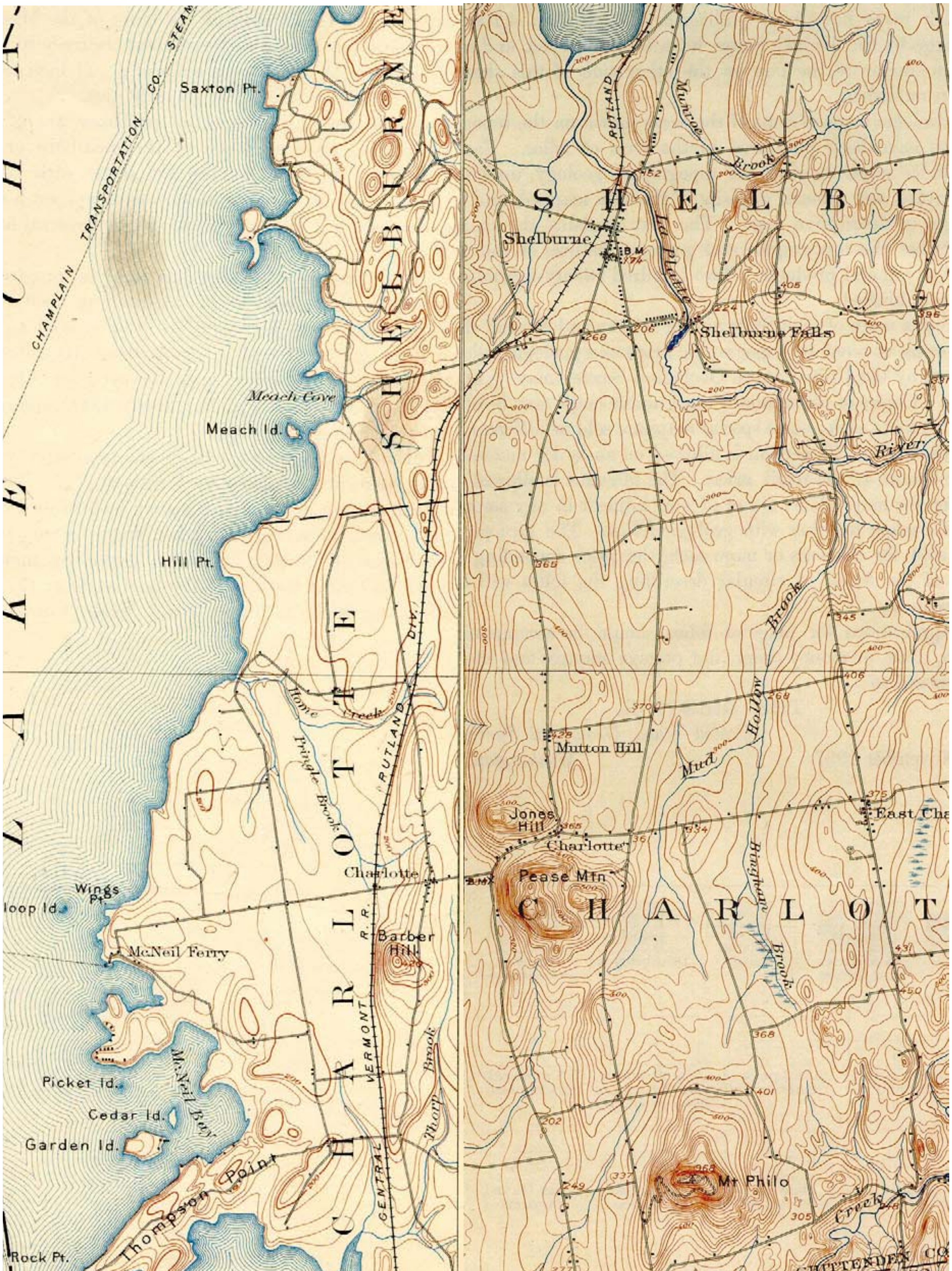


Study Streams and their Subwatersheds

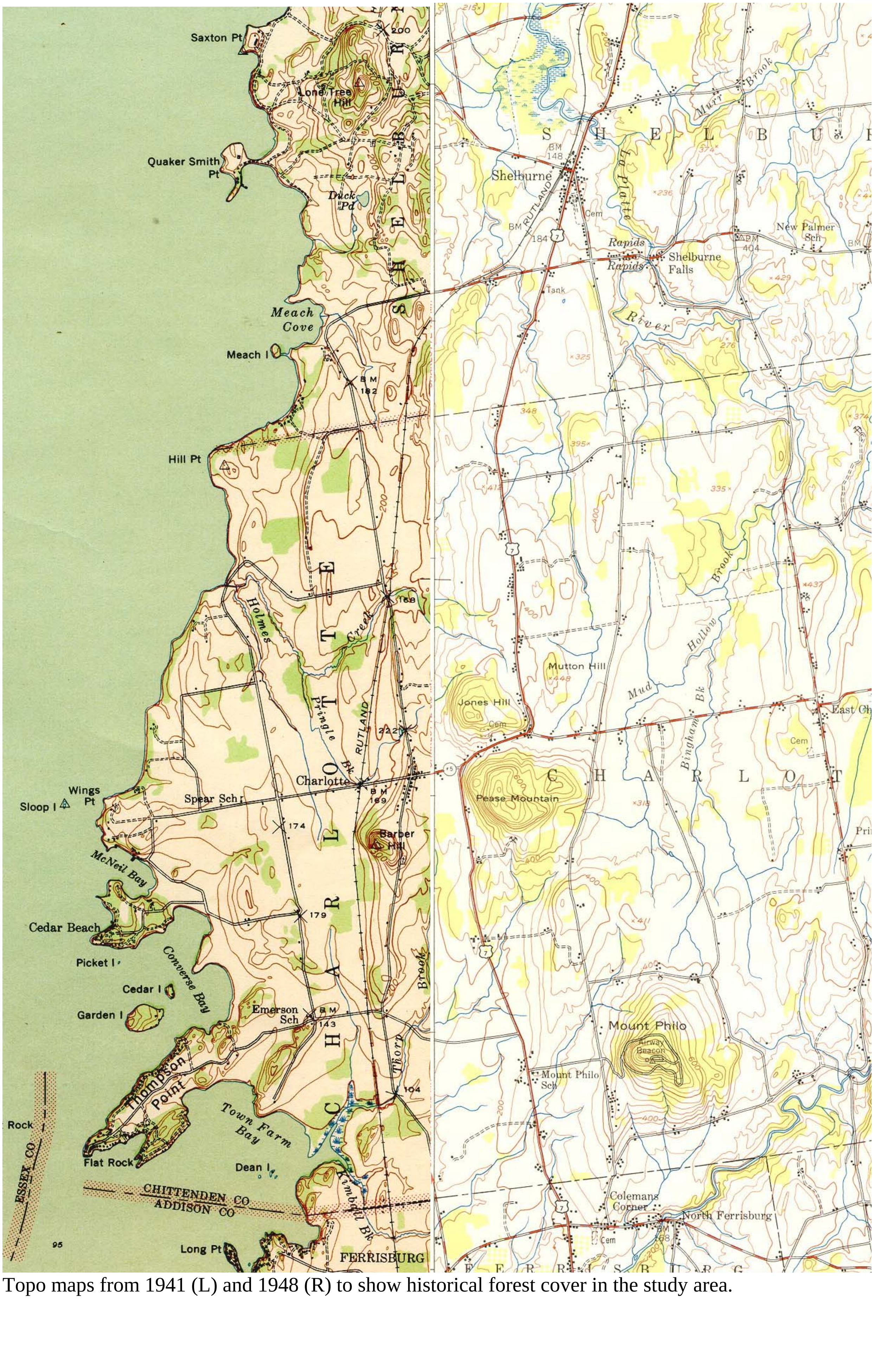
Appendix B Historical Topo Maps



Historical Topographic Maps from 1895 (left) and 1941 (right). From UNH Library.

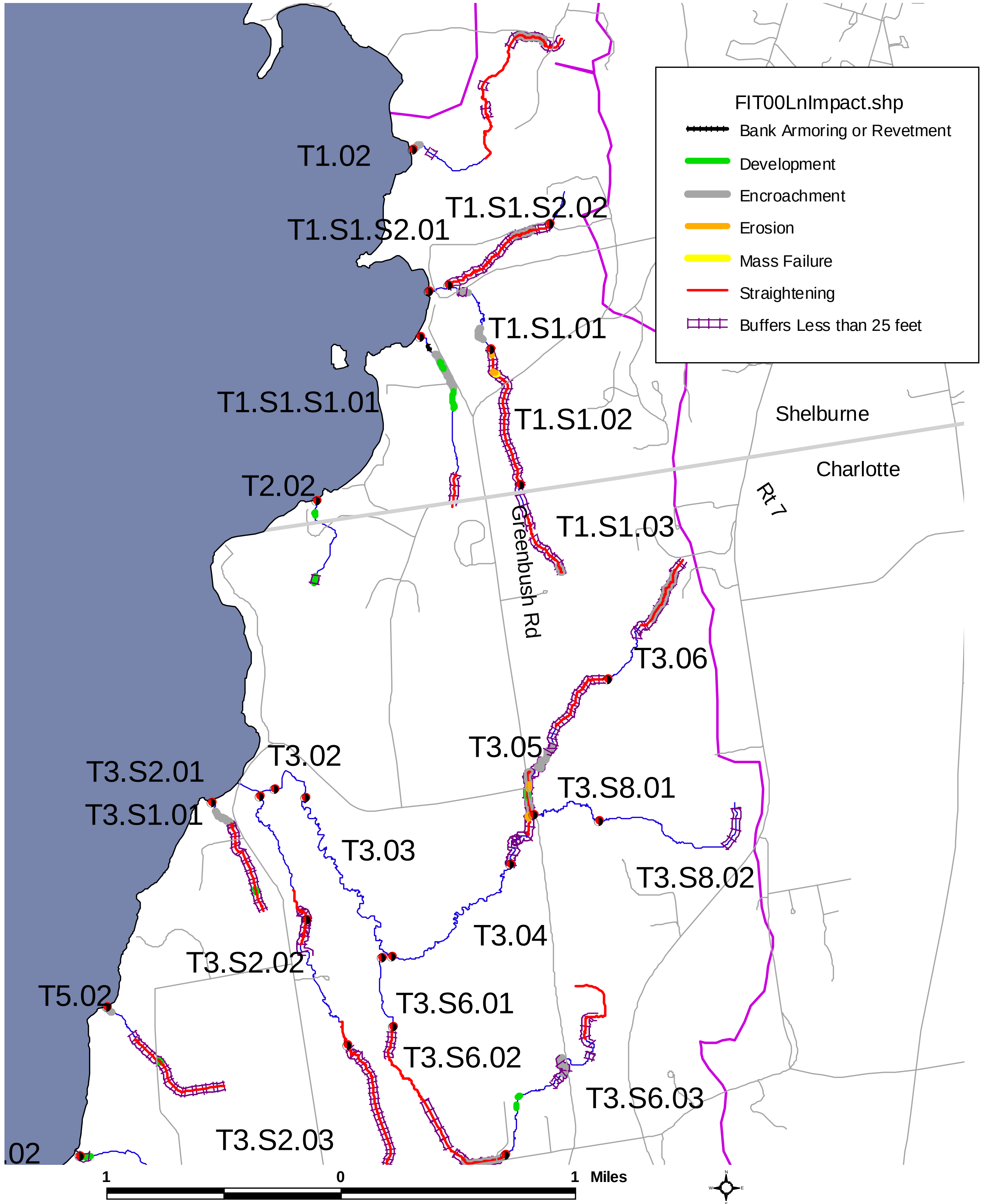


Historical Topographic Map Shelburne Charlotte area (note maps are not from the same year, but used side-by-side to illustrate approximately the stream channel locations around 1895-1906).

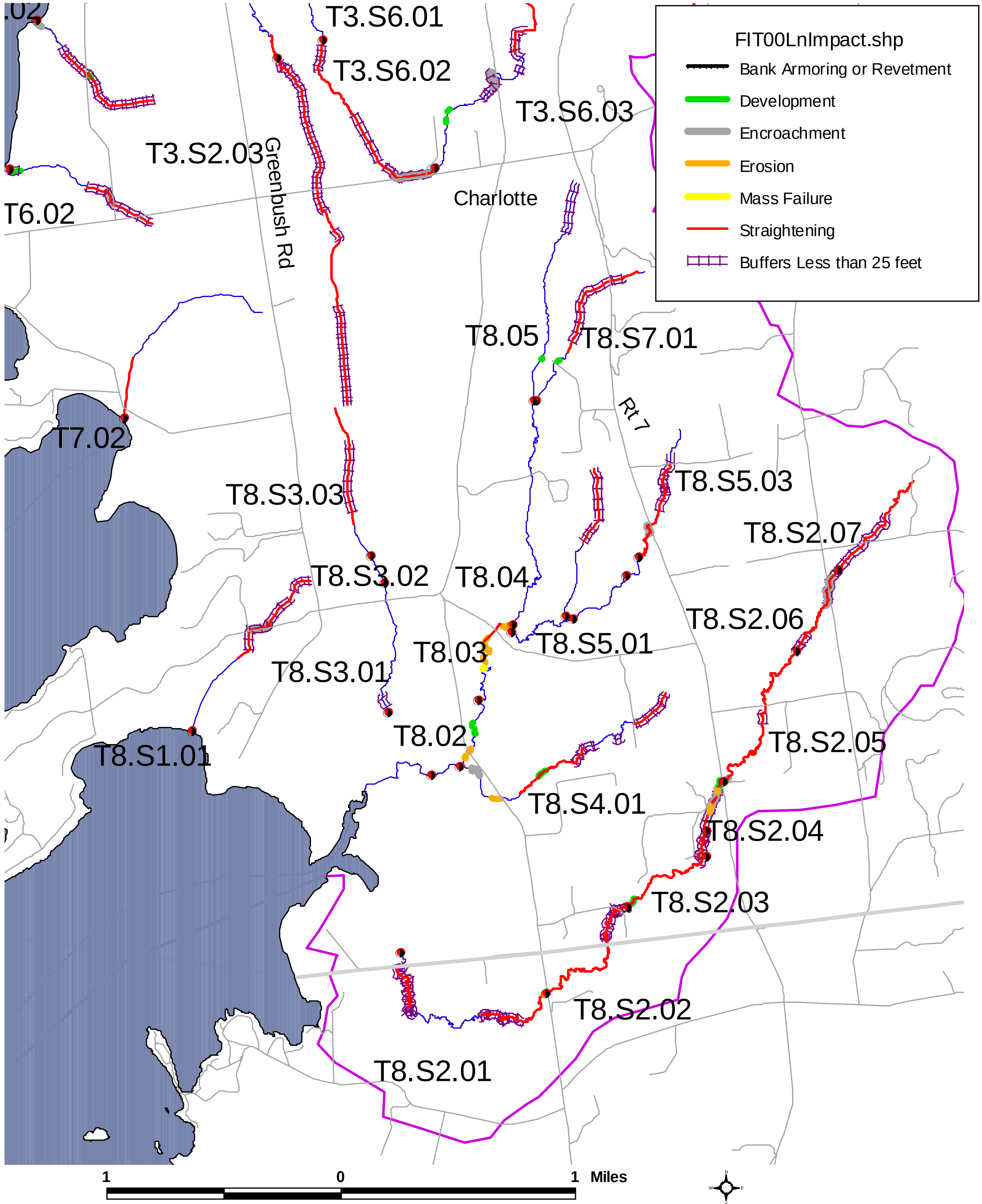


Topo maps from 1941 (L) and 1948 (R) to show historical forest cover in the study area.

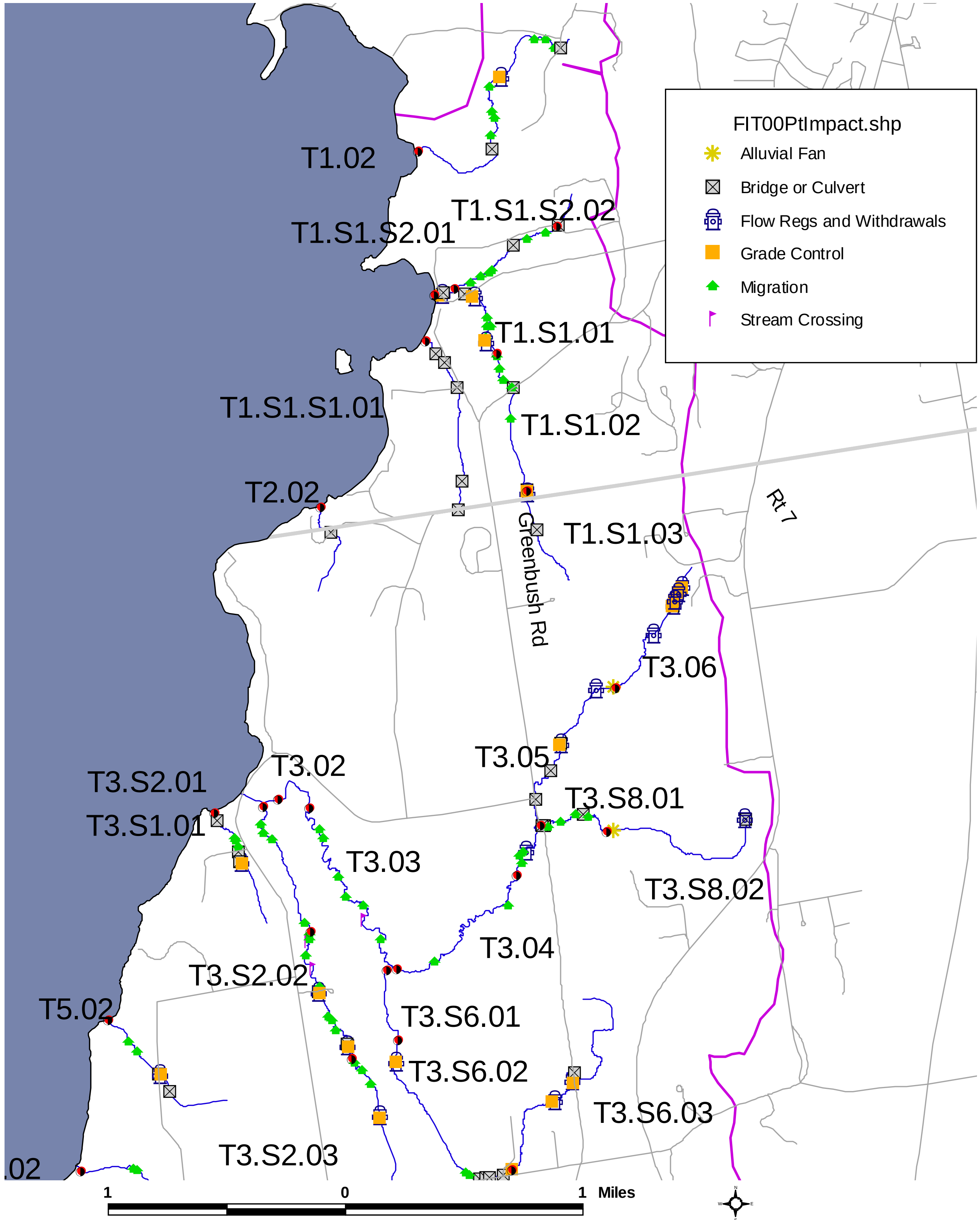
Appendix C FIT Features Mapping



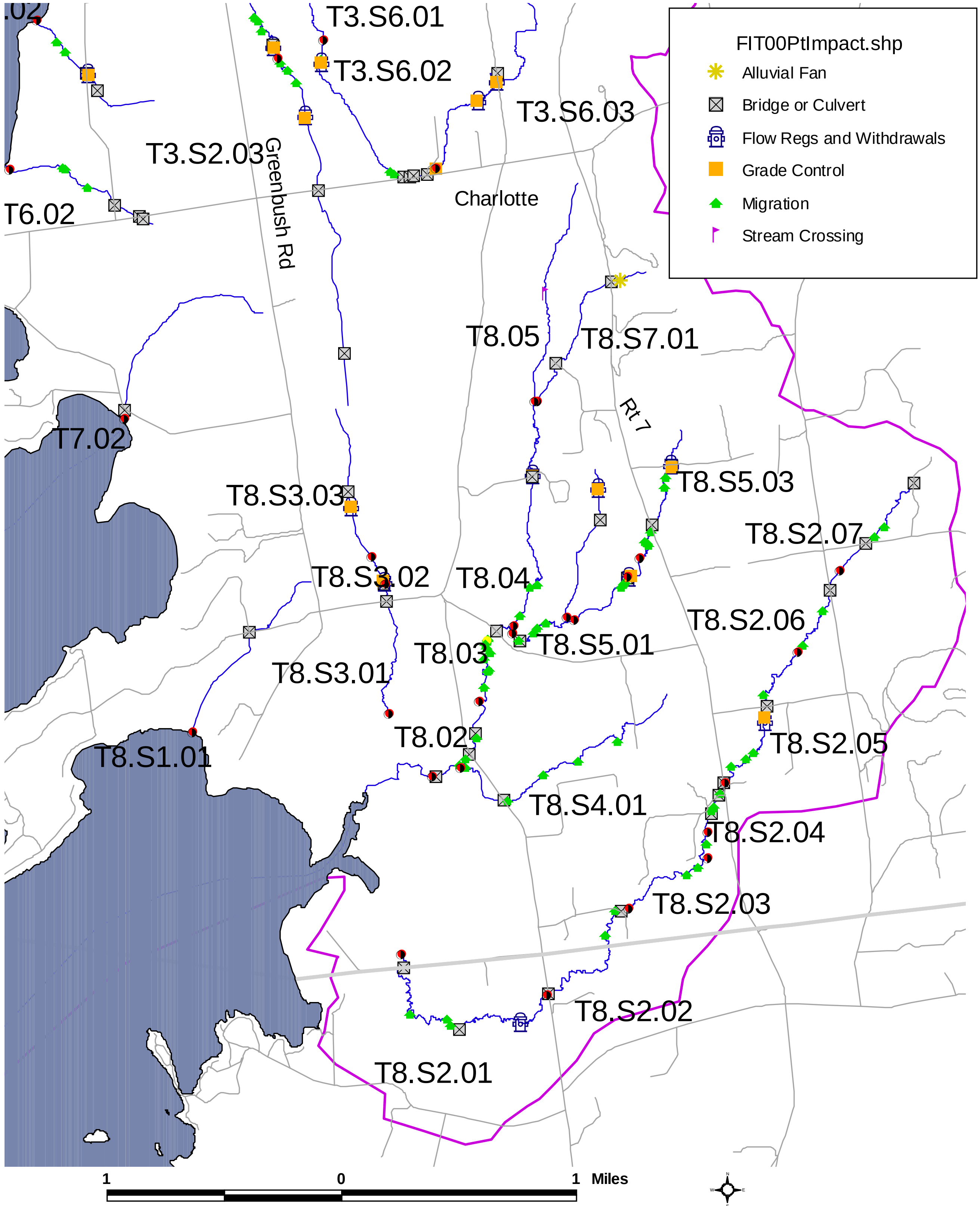
Northern FIT Line Features



Southern FIT Line Features



Northern FIT Point Features



Southern FIT Point Features

Appendix D Phase 1 Reach Summary Reports

Appendix E Phase 2 Mapping

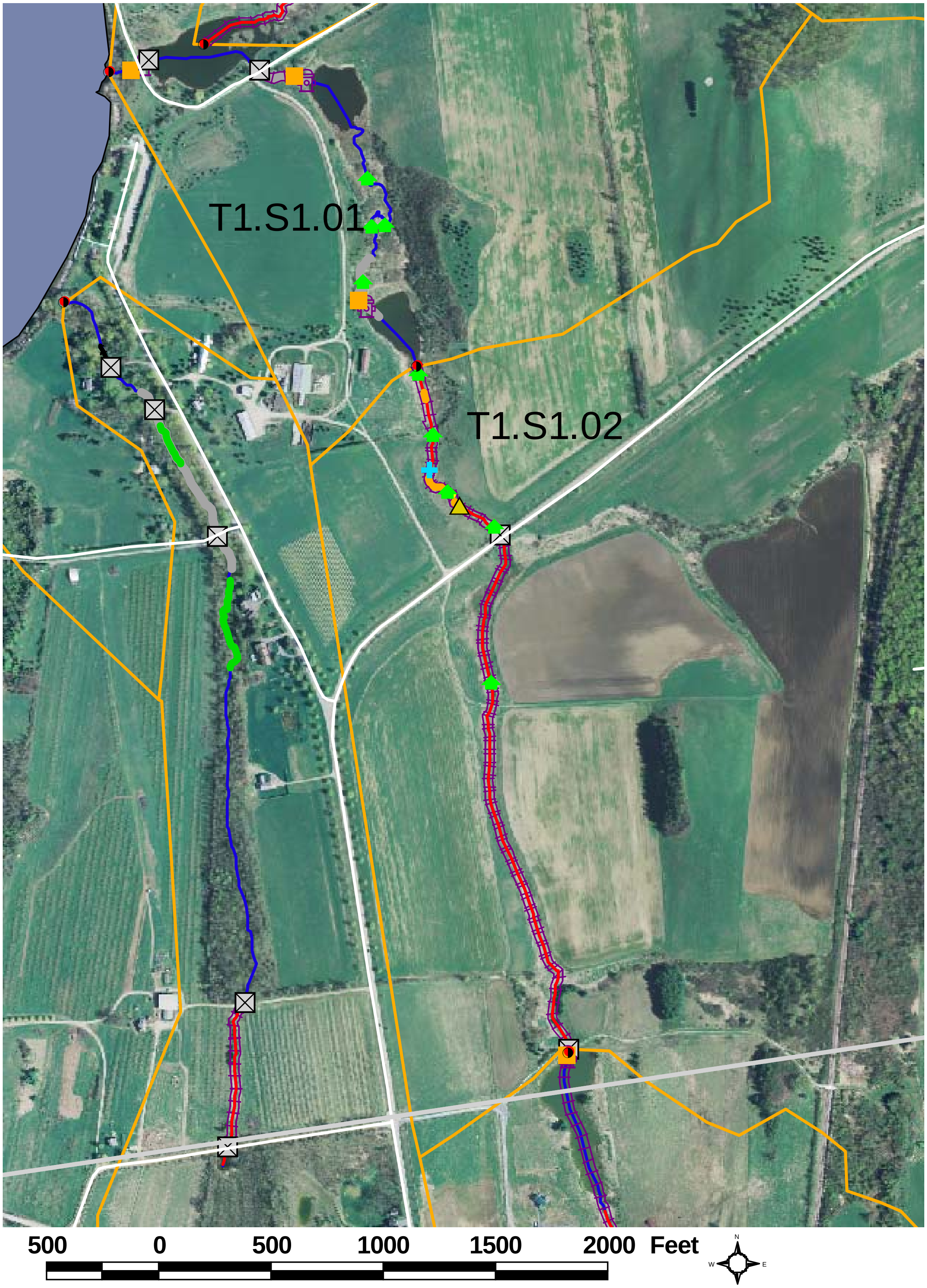
Phase 2 FIT Features

FIT00PtImpact.shp

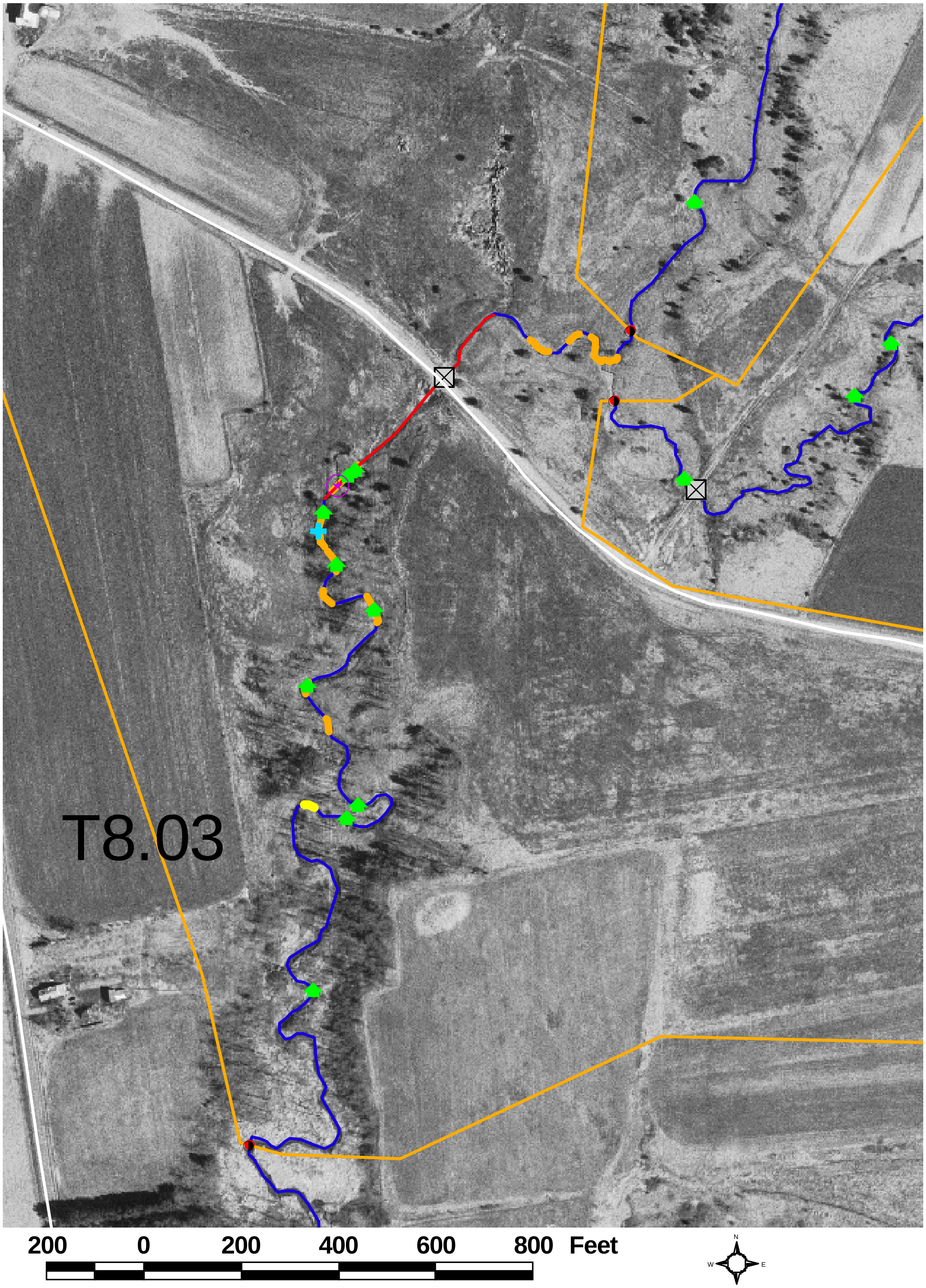
- Alluvial Fan
- Beaver Dam
- Bridge or Culvert
- Cross Section Location
- Flow Regs and Withdrawals
- Grade Control
- Migration
- Steep Riffle or Head Cut
- Stream Crossing

FIT00LnImpact.shp

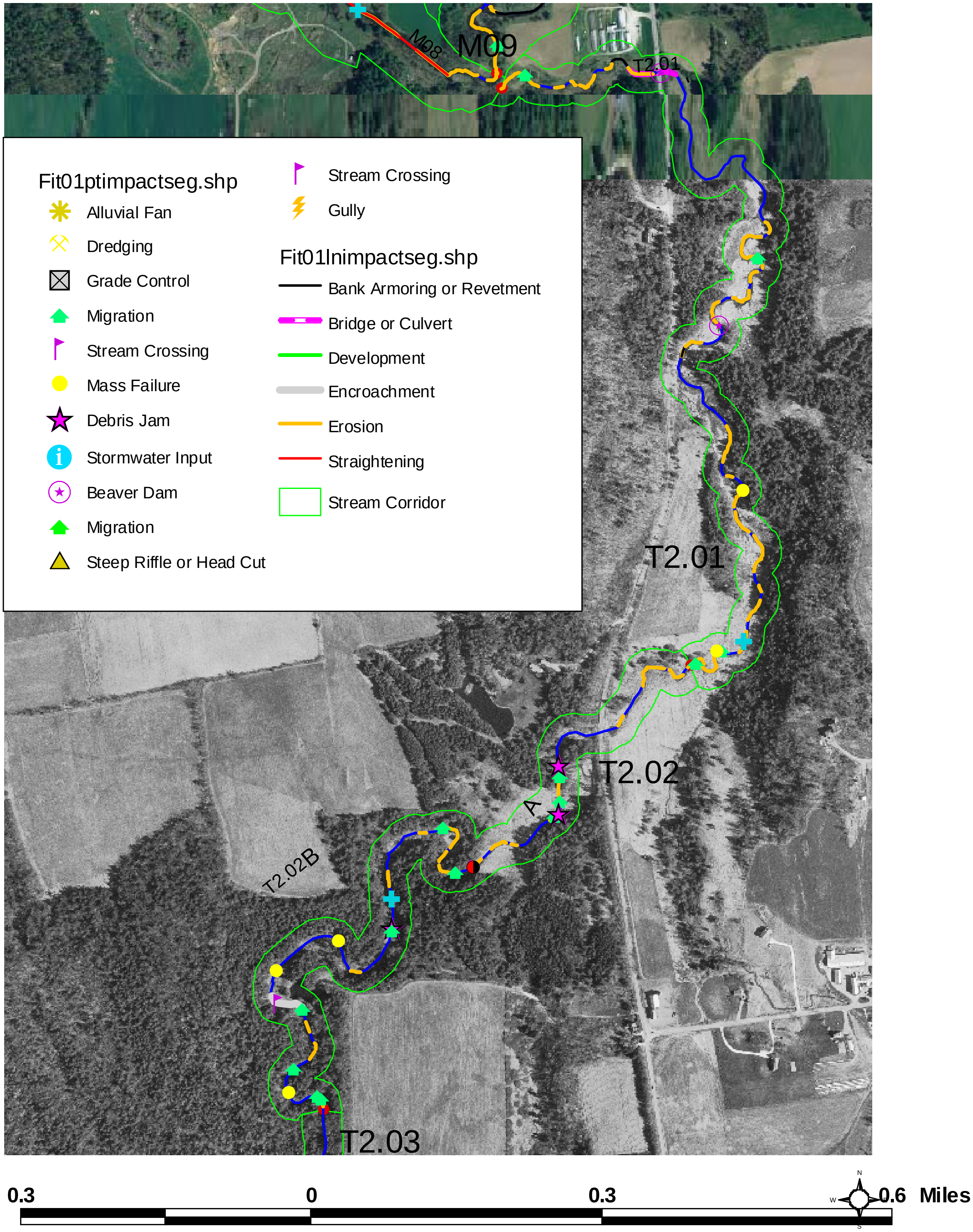
- Bank Armoring or Revetment
- Development
- Encroachment
- Erosion
- Mass Failure
- Straightening
- Buffers Less than 25 feet



Shelburne Beach Tributary T1S1.02



Thorp Brook T8.03



Mud Hollow Brook T2.01 & T2.02 (key is different due to older SGAT project)