GREENSBORO, VERMONT
Flood Reduction Study
using Green Infrastructure

WATERSHED CONSULTING

TOWN OF
Greensboro, Vermont

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List of Tables and Figures

Appendices

(Appendices are attached as separate documents from this report and include all previous project deliverables, GIS files associated with this work, modeling outputs in their native file format as well as PDF versions, and the complete set of plans (including existing conditions and 30% designs). These files should be downloaded and saved with this report for consistent reference.)

Introduction

Greensboro, Vermont is the southernmost town in Orleans County (Figure 1) and has a population of 762 (as of the 2010 census). Notable aquatic natural resource includes Caspian Lake – an oligotrophic lake with high quality aquatic habitat and dozens of recreational uses – and the smaller Lake Eligo. Caspian Lake provides recreation and tourism benefits to the Town and sits adjacent to Greensboro village center. The lake drains to the southeast through the Greensboro Brook which flows under the village center before daylighting behind Willey's store.

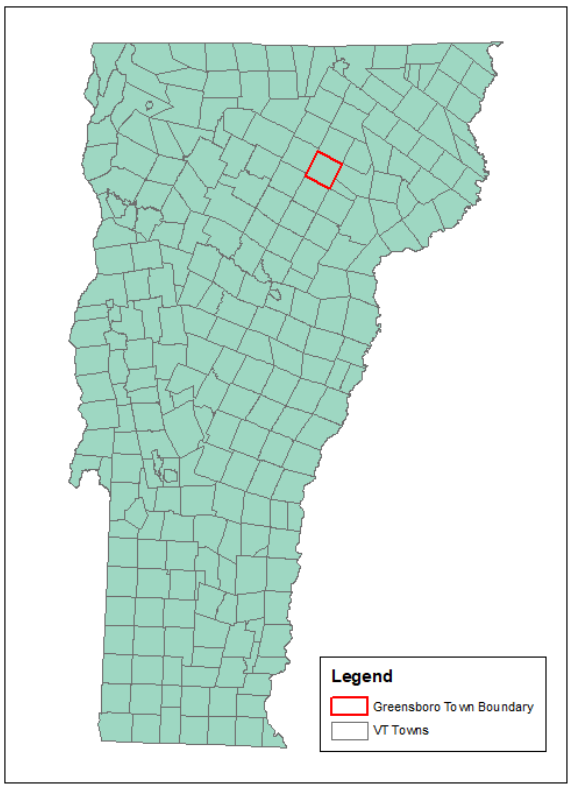

Figure 1: Greensboro is located in Vermont's Northeast Kingdom in Orleans County.

The Greensboro Brook is a conduit for both the lakes outflow as well as surface drainage from the roadways and properties to the north. Uncontrolled runoff frequently results in flooding of multiple private properties along the east side of East Craftsbury Road in the village during and after storm events. Further, the flooding overwhelms infrastructure, causing erosive flow over roads and parking lots leading to a maintenane burden for the Town and water quality impacts to the Greensboro Brook.

The cost, maintenance burden, property damage, and subsequent water quality impacts are of concern for residents of the Town and are recognized as a priority for corrective action.

Project Overview

The Town received funding from the VT Department of Environmental Conservation in 2017 to study the issue and evaluate potential best management practices to address the flooding and associated water quality impacts. The Town of Greensboro contracted with Watershed Consulting to carry out the study. The project team elected to take a master planning approach which includes problem evaluation, drainage infrastructure confirmation and correction, drainage area delineation, hydrologic & hydraulic modeling, retrofit option identification, and design. For this study, three 30% construction plans of retrofit areas are included as proposed remedies of the drainage issues and for improved water quality.

The project area includes approximately 24 acres with a focus on the Town office, near the intersection of Craftsbury Road and Lauredon Avenue to the north, and the Town Green area to the south (**Error! Reference source not found.**).

Figure 2. Greensboro flooding study area. Parcels are labeled with owner's names as indicated in Town records.

Methodology

The methodology used to investigate the study area includes review and field confirmation of mapped stormwater infrastructure, drainage area delineation, land use land cover mapping, hydrologic and hydraulic modeling of existing conditions (using HydroCAD), and water quality modeling (using WinSLAMM). With existing conditions accurately determined, proposed best management practices (BMPs) are integrated into the modeling framework to determine predicted flood attenuation and water quality improvements as a result of design interventions. At this time, property owners at the proposed BMP sites were contacted and State permitting requirements were reviewed for determination of project feasibility. When the modeled results reach the project goals of peak flow reduction and adequate conveyance capacity and feasibility was determined at the concept level, BMP design drawings are created with those details integrated. Price estimates for implementation of each BMP follow the same methodology used in stormwater master planning cost estimation. More information on the details of the cost estimation methodology and the sources used can be found in Appendix G.

Results

The study identified two discharge points of focus (Figure 3). The first (Study Point 01) is located at the South end of the Town Green and the other (Study Point 02) is located within the stream, behind Willey's store. These points represent the collection locations of all of the stormwater flow from this part of the Town and serve as locations from which flow is modeled to determine existing conditions in a range of storm sizes and conditions after proposed interventions. This approach allows determination of flood reduction outcomes at the key areas of concern. The drainage area associated with Study Point 01 discharges storm flow that exceeds the capacity of the conveyance structures. As a result, heavy rainfall results in flood conditions when the rate exceeds infrastructural capacity. To mitigate flooding, a two-pronged approach was employed:
1. Reduce volume discharging to Study Point 01 by rerouting flows higher in the watershed and
2. Install control structures to reduce peak discharge to Study Point 01.

Figure 3. Project drainage area with proposed BMPs in red. Additional grading and infrastructural upgrades that are not pictured here accompany some designs. More information can be found on the design drawings.

Three BMP designs were sized and modeled for flow reduction targets. Additional features of each design are called out in the design drawings and include regrading the roadway to the east of the Town Office to encourage flow into a swale on the west side of the roadway and towards the gravel wetland, as well as regrading the driveway and parking area at the Town green and upgrading and rerouting the pipe to connect the catch basin in the Burgess property with the catch basin on East Street to the south (Figure 3). The Greensboro United Church of Christ parcel

was identified for a potential BMP along the roadway in front of the building to capture runoff from the parking lot and rooftop as well as East Craftsbury Road prior to discharge through a culvert to the wetland on the East side of the street. This project did not advance to 30% design because the other identified options were preferable to meet flow reduction targets, but an existing conditions base map was created for the site which will provide the groundwork should the Town elect to use that site for stormwater treatment in the future. Those plans are located in Appendix F.

Table 1 provides a summary description of each selected BMP that advanced to 30% design.

Table 1: BMP Summary

Project Name	Description
Town Office Gravel Wetland	A gravel wetland is proposed at the southernmost point of the Town Office parcel. The wetland will collect runoff from the roadway to the north (with some improved grading to facilitate collection) and will overflow to the west, eliminating the large volume currently discharging to the wetland on the east of the roadway. This rerouting reduces the overall drainage area size of Study Point 01, eliminating flow to the problem area while improving the quality of the water being discharged to the west. The total drainage area to this practice is 1.40 acres.
Wetland Outlet Control Structure	An outlet structure (berm with small orifice) is proposed at the southern end of the wetland at the property line to control the speed of discharge from the wetland and avoid overwhelming the surface and buried infrastructure to the south. The total drainage area to this practice is 4.36 acres.
Town Green Bioretention/ Upgraded infrastructure	Improved grading of the driveway and parking area adjacent to the Town Green will allow surface flow to a grass swale and ultimately to a bioretention in the grassy area on the southern portion of the Town Park. The drainage area of this practice is small and will effectively reduce sediment transport and erosion in the gravel drive area. Upgraded pipe sizing is recommended at the lawn catch basin in the back of the Burgess property and rerouting the pipe to avoid intersection with the basin in the parking area for direct connection to an existing catch basin on East Street. The total drainage area to the bioretention practice is 0.73 acres while the upgraded 12” pipe has a drainage area of 1.8 acres – a project total of 2.53 acres.

Modeling Overview

The two Study Points (at the southern tip of the Town Green and in the stream just south of Willey’s store) were modeled under existing conditions and with proposed improvements (BMP

installation). The following Tables (2-4) outline the predicted reduction in flow at each study location after complete BMP installation. Table 5 outlines the predicted water quality improvement benefits of the practices that are expected to impact water quality conditions.

Table 2: 1-Year Storm Flood Reduction Summary

Study Location	1-year storm peak flow (cfs)		% Reduction
	Existing Conditions	Proposed Conditions	
Study Point 01 – Town Green	3.14	1.18	62
Study Point 02 – Stream south of Willey's store	6.83	4.66	32

Table 3: 10-Year Storm Flood Reduction Summary

Study Location	10-year storm peak flow (cfs)		% Reduction
	Existing Conditions	Proposed Conditions	
Study Point 01 – Town Green	7.38	3.26	56
Study Point 02 – Stream south of Willey's store	18.96	14.5	24

Table 4: 100-Year Storm Flood Reduction Summary

Study Location	100-year storm peak flow (cfs)		% Reduction
	Existing Conditions	Proposed Conditions	
Study Point 01 – Town Green	11.75	5.74	51
Study Point 02 – Stream south of Willey's store	32.09	26.35	18

Table 5: Water Quality Improvement Summary

BMP Description	Average total phosphorus loading (lbs/year)		% Reduction
	Existing Conditions	Proposed Conditions	
Town Office Gravel Wetland	1.6	0.67*	58
Town Green Bioretention	1.1	0.675	39

**Gravel wetland pollutant removal estimation is based on UNH Stormwater Center published results from 2012* (Ballestero, 2012) *(https://www.unh.edu/unhsc/sites/unh.edu.unhsc/files/docs/UNHSC.2012Report.10.10.12.pdf)*

Plans and Cost Estimates

The complete 30% design drawings are located in Appendix G and the full cost estimation tables are located in Appendix E. Summary cost table is below.

Table 6: Project Cost Summary

BMP Description	Total Estimated Cost	$/ acre drainage area
Town Office Gravel Wetland	$76,000	$54,286
Wetland outlet control structure	$22,000	$5,046
Town Green Bioretention & infrastructure upgrades	$34,000	$13,439
Total	$132,000	

Permitting Summary

Each of the BMP site locations was reviewed for potential permitting needs. No indication of Act 250 permits was evident at any site. No stormwater permits (operational or construction) would be required for any of the project locations. Local approval will be required in the methods used by the Town for construction projects at all sites. The only additional anticipated permitting needs are associated with the wetland outlet control structure and the Town Office gravel wetland and are summarized below.

The District Wetland Ecologist was consulted on the wetland berm project who indicated that a wetland permit would be required for this project and is feasible given our description of the project. (A record of the correspondence with Shannon Morrison can be found in Appendix H.) Landowner permission was secured for all properties where BMPs are proposed, however, the owners of the wetland parcel should also be included in the next phases of design to confirm their understanding of the project and secure their permission to continue (a summary of landowner contacts can be found in Appendix I with the letters of support).

The Town Office gravel wetland site proposes rerouting flow to the other side of the street in order to avoid the affected area. The new discharge point may be within a wetland buffer and will therefore require review and comment by the wetlands program in the next phase of design to ensure that the discharge point and method is allowable. The Town will also need to review and approve the rerouting plan as the new discharge point will be on town land.

Next Steps

The Town is in a position to move forward with final design, permitting, and installation of these projects as a collection or as single projects in a series. It is recommended that the practices higher in the watershed (gravel wetland and wetland outlet control structure) be pursued first as they will have the most significant benefit to water quality and drainage improvement. The VT Department of Environmental Conservation is expected to release its next round of request for proposals for the Ecosystem Restoration Program grants in March 2019. These projects (especially where direct water quality improvement can be derived) are well suited for competitive application for those funds. Some financial and/or in-kind match from the Town may be required for the application. Coordination with the region's wetland ecologist and Basin Planner is recommended early in the proposal development process.