STORMWATER MANAGEMENT PLAN

The Town of SHELBURNE Vermont

PREPARED IN 2012

LAST REVISED JANUARY 22, 2019

VERMONT MS4 GENERAL PERMIT 3-9014

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Introduction

Following are the components of the Town of Shelburne's Stormwater Management Plan (SWMP). This SWMP documents the Town of Shelburne's strategy to address and reduce the impacts of stormwater runoff. Preparation of this plan is required by the Vermont Municipal Separate Storm Sewer System (MS4) permit number 3-9014 issued by the Vermont Department of Environment al Conservation (DEC) last issued on July 27, 2018. This plan contains all the required elements described in the 2018 Vermont MS4 permit and is intended to minimize the adverse impact that unmanaged stormwater runoff from the Town of Shelburne can have on water quality.

In addition to this written plan, the Town has adopted a number of ordinances and policies that will aid the Town in achieving its overall goal of improving the quality of the water. Copies of those ordinances and policies are available as appendices to this document or are on the Town website at www.shelburnevt.org.

Municipal Background

Chartered in 1763, the Town of Shelburne is situated on the shores of Lake Champlain in southwestern Chittenden County (Figure 1). The Town covers 24.3 square miles and includes numerous commercial enterprises and tourist attractions. Shelburne is a suburb of Vermont's largest city, Burlington, and lies 7 miles south of the city center. The population was 7,144 at the 2010 census.

Impacts of Stormwater

The impervious surfaces created by the buildings and pavement that make up our urban areas causes rainwater and snowmelt to flow quickly over the landscape rather than soak naturally into the soil. This can lead to changes in stream flow, increase flooding, damage private and public property, erode stream banks, and destroy aquatic habitat. As runoff flows over impervious surfaces it can collect pollutants such as sediment, petroleum products from automobiles, nutrients from lawn fertilizer, trash, bacteria from pet waste, soaps, detergents, and other chemicals. These pollutants are then carried by runoff to lakes and streams. The combined impacts of hydrologic change in streams and water pollution can have serious negative impacts for water bodies.

Watershed Descriptions

All of Shelburne drains to Lake Champlain (Figure 2). Runoff from the Town reaches the lake via the LaPlatte River and its tributaries, Munroe Brook, or small streams that drain directly to the Lake. The Town contains Munroe Brook, Shelburne Pond and McCabe's Brook, all designated as impaired. Munroe Brook has an established TMDL.

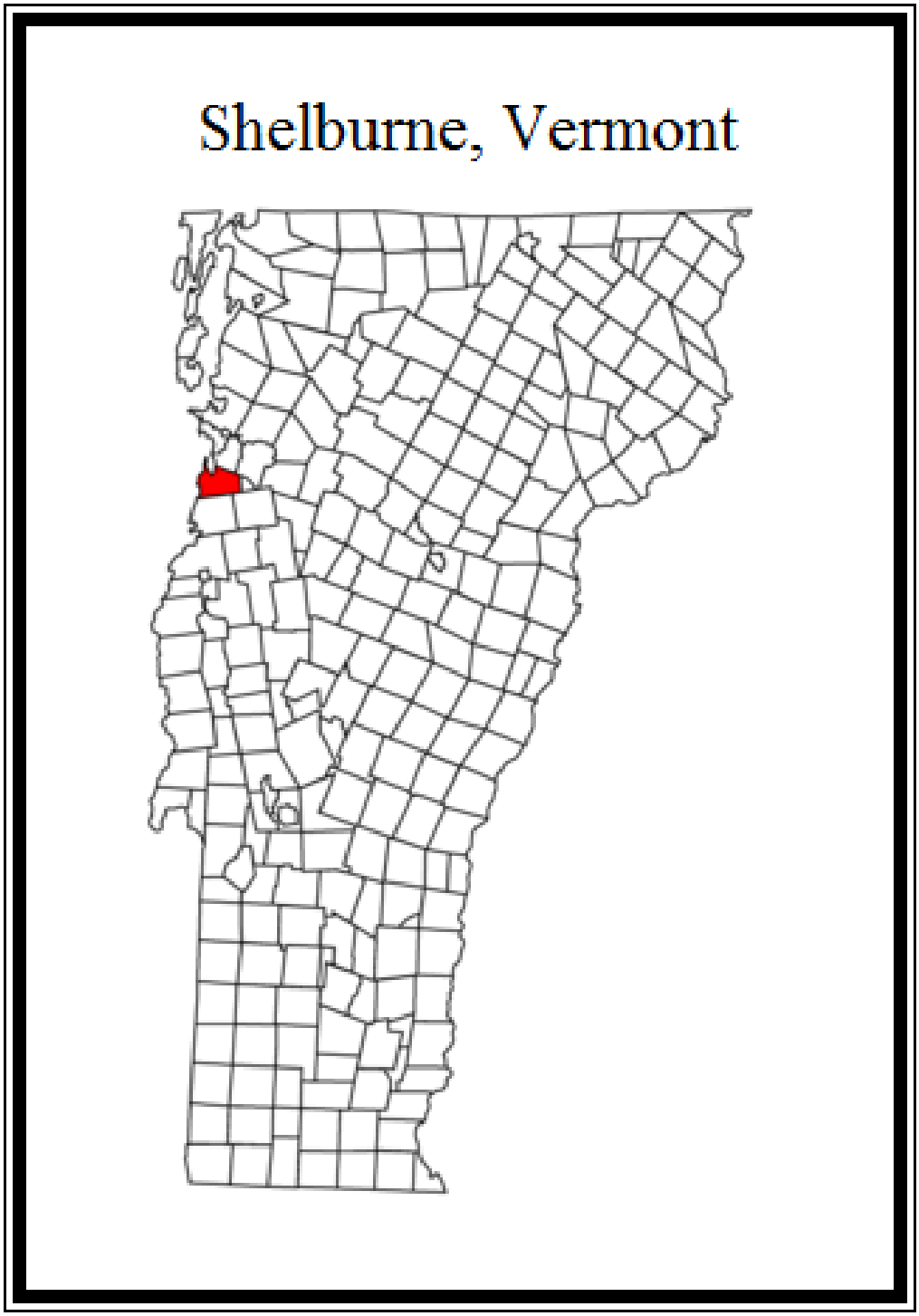

Figure 1 – Town of Shelburne, Vermont Location Map

Watershed	Total Watershed Drainage Area (Acres)	Total Watershed Drainage Area in Shelburne (Acres)	Number of Shelburne owned Stormwater Outfalls in the Watershed	303(d) Part D Listed Pollutants	303(d) Part A Listed Pollutants
Bartlett Brook	704	58.00	0	Stormwater	
Lake Champlain	5,269,760		20		
Main Lake		2,781.00		Phosphorous	
Sheburne Bay		1,020.00		Phosphorous	PCBs
LaPlatte River	33,920	3,732.00	10	E. Coli	
McCabe's Brook	3,968	2,304.00	12		Nutrients
Munroe Brook	3,468	3,190.00	100	Stormwater	
Shelburne Pond	4,470	3,130.00			Phosphorous

Figure 2 - Shelburne Watershed Summary Information

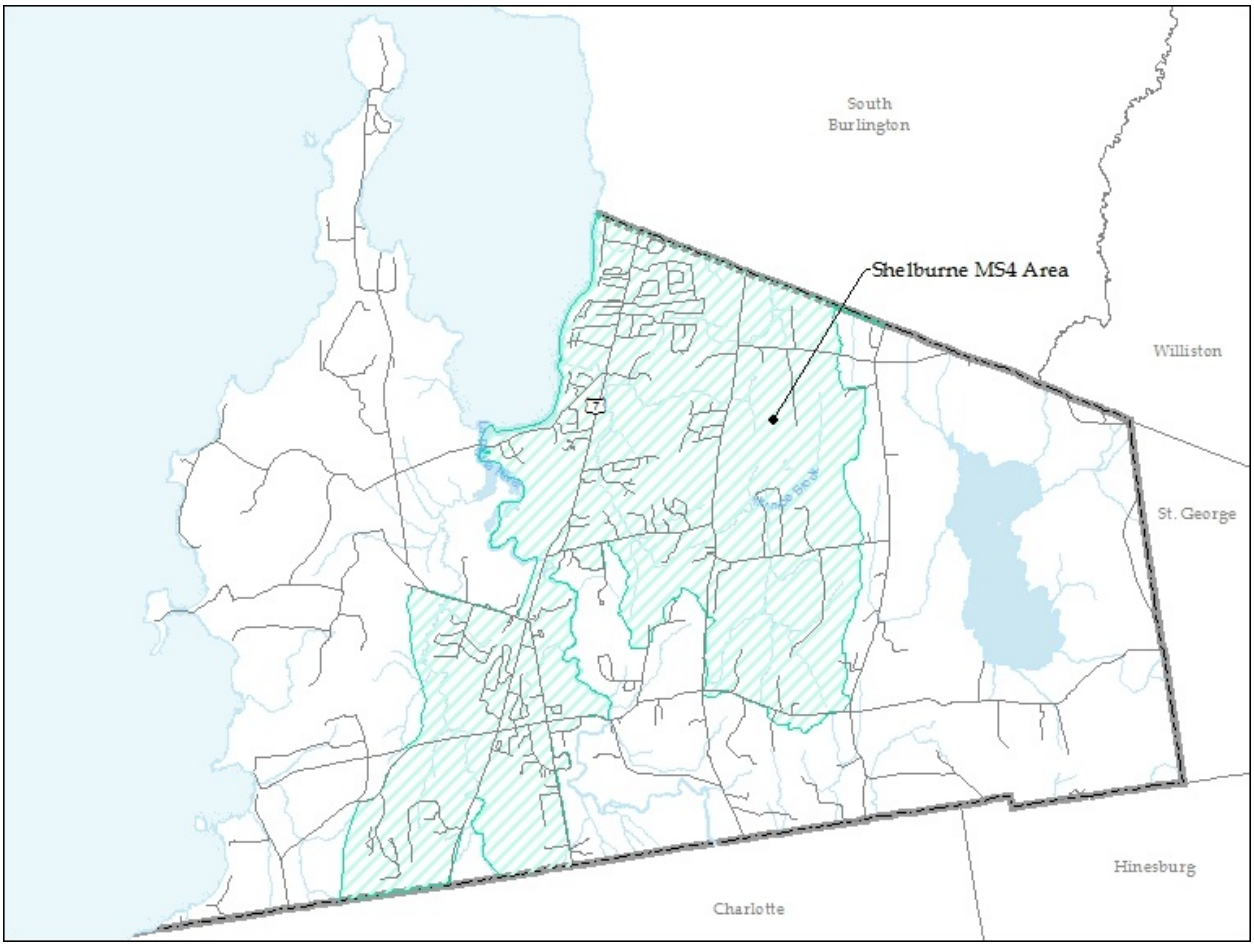

Figure 3 - Map of Shelburne MS4 Area

Stormwater Management Program

The MS4 permit is a federally mandated stormwater permit under the National Pollutant Discharge Elimination Systems (NPDES) program. In Vermont, the MS4 permit program is administered by the Department of Environmental Conservation (DEC), which is a division of the Agency of Natural Resources (ANR). The MS4 permit is issued by DEC for a five-year period.

The Town of Shelburne's Stormwater Program is a division of the Department of Public Works (DPW) and its operation is overseen by the Water Quality Superintendent. In 2016, the Town approached the neighboring municipality of Shelburne to contract specific stormwater services. Further discussions between the municipalities regarding economies of scale resulted in the signing of an "Interlocal Agreement for Stormwater Services between the Town of Shelburne and the City of South Burlington" in July of 2016 (Appendix A). The agreement allows for the South Burlington Stormwater Utility (SBSU) to provide stormwater management services, as needed, to the Town of Shelburne for various MS4 permit requirements. While the Town of Shelburne has partnered with the City of South Burlington in the implementation of its Stormwater Management Plan, it is the Town of Shelburne that is still ultimately responsible for implementing each control measure.

Stormwater Eligible Discharges

The MS4 permit authorizes discharges of stormwater to enter waters of the State and waters of the United States. The following non-stormwater discharges are allowed to co-mingle with discharges of stormwater provided they are not substantial contributors of pollution to the MS4:

- Water line flushing
- Landscape irrigation and lawn watering, provided all pesticides, herbicides and fertilizers have been applied in accordance with the approved label
- Diverted stream flows
- Rising ground waters
- Uncontaminated ground water
- Uncontaminated pumped ground water
- Discharges from potable water sources
- Foundation drains or footing drains where flows are not contaminated with process materials, and to which there are no floor drain, septic wastewater, or grey water connections
- Uncontaminated condensate from air conditioners, coolers/ chillers, and other compressors and from the outside storage of refrigerated gases or liquids
- Irrigation water
- Spring water
- Uncontaminated water from crawl spaces
- Flows from riparian habitats and wetlands
- Discharges from emergency/ unplanned fire-fighting activities

- Fire hydrant flushing
- Incidental windblown mist
- De-chlorinated swimming pool discharges

Any discharge to the Town's MS4 that is not contained in the above list, or covered under a separate NPDES permit, will be treated as illicit discharges and dealt with according to requirements of the MS4 permit and regulations established in Town ordinance.

Six Minimum Control Measures

The Six Minimum Control Measures (MCM) are MS4 permit requirements that include:

1. Public Education and Outreach
2. Public Participation/Involvement
3. Illicit Discharge Detection and Elimination
4. Construction Site Runoff Control
5. Post-Construction Runoff Control
6. Pollution Prevention/Good Housekeeping.

The MS4 permit requires that the Town identify Best Management Practices (BMPs) by which it will achieve the goals of each MCM. The Town must also provide a rationale regarding why each BMP was selected and a Measurable goal for each BMP.

Public Education and Outreach on Stormwater Impacts

In order to comply with MCM 1, Public Education and Outreach, the Town must implement a public education program that distributes educational materials to the community. In order to meet this requirement, the Town will take the following steps:

- Maintain a website dedicated to stormwater management – The Town maintains a website (www.shelburnevt.org) which contains general stormwater information as well as references to local ordinances and polices governing stormwater, copies of all permits, as well as links to other websites for additional information. Use of the web site will be continued.
  - Responsible Parties: Shelburne DPW
  - Rationale: Public education is a key component to any effective stormwater management program. The site has proven to be an excellent way for the Town to communicate directly with the public on topics related to stormwater, including updates on stormwater improvement projects.
  - Measurable Goals:
    - The Town's annual report will contain information on web site visitors and other web statistics.

- The website provides links to valuable resources for residents, staff, and consultants.
- The website provides Stormwater Project information and updates

- Participate in Rethink Runoff – In order to provide education and outreach to the public on stormwater impacts, the Town of Shelburne will continue to partner with other area MS4 communities in Rethink Runoff, managed by the Chittenden County Regional Planning Commission (CCRPC). Rethink Runoff is responsible for advertising focused on regional residential stormwater impacts and solutions to mitigate those impacts on water quality. The partnered MS4 communities additionally formed the Chittenden County Stream Team (CCST) in 2011 to act as the outreach and hands-on event arm of the regional education program. CCST educates the public and gets them involved in hands-on activities through hands-on events within the community. For more information: http://rethinkrunoff.org/get-involved/get-involved-stream-team. For further information on the partnership, see the Chittenden County MS4 Stormwater Program Agreement (Appendix B).
  - Responsible Parties: Shelburne DPW, CCRPC
  - Rationale: The intent of Rethink Runoff is to combine the resources of multiple MS4 communities to create and distribute educational materials related to stormwater and reach a more diverse audience than any municipality could reasonably achieve on its own. Working together also provides a consistent message to the public.
  - Measurable Goals:
    - The Town will continue to participate on the MS4 steering committee and make payments in accordance with the terms of the MOU.
    - The Town will provide a summary of steering committee activities, website statistics (http://rethinkrunoff.org/), and a total of the Town's cash contributions to the CCRPC MS4 program on an annual basis.

- Technical Assistance for Low Impact Best Management Practices – In conjunction with the 2012 MS4 permit, the Town developed a program to identify opportunities for and provide technical assistance related to low impact BMPs to landowners in Shelburne.
  - Responsible Parties: Shelburne DPW
  - Rationale: By identifying opportunities for Low Impact BMPs the Town can help to maximize infiltration of stormwater runoff, prevent and eliminate soil erosion and the delivery of pollutants to stormwater conveyances.
  - Measurable Goals:
    - In May 2015 the Town developed a LID guidance manual to support optional LID requirements in the Form-Based Zoning (FBZ) Regulations. Shelburne planning commission is currently considering revising the Town's Zoning Bylaws to require the use of infiltration or LID practices on a Town-wide basis. The revised language

is expected to reference LID and the existing Guidance Manual (available for download at: http://www.shelburnevt.org/404/Stormwater-Information-Resource

- The Chittenden County Stream Team (CCST) and Regional Stormwater Education Program (RSEP) provide on-going education and technical support related to LID practices. The Town participates in these programs and makes financial contributions to support this work. In addition, these organizations help the Town meet MS4 MCMs 1 and 2. Additional information on these programs can be found at http://rethinkrunoff.org/ .

Public Involvement and Participation

In order to comply with MCM 2, Public Involvement and Participation, the Town must implement a public involvement/participation program designed to engage the public in stormwater issues. In order to meet this requirement, the Town will take the following steps:

- Participate in the Rethink Runoff program - The Rethink Runoff program leverages the resources of multiple communities to create a more engaging public participation program than any single municipality could reasonably achieve on its own. The Town will continue to participate on the MS4 steering committee and make payments in accordance with the terms of the Chittenden County MS4 Stormwater Program Agreement (Appendix B). For more information: http://rethinkrunoff.org/the-stream-team/.
  - Responsible Parties: Shelburne DPW, CCRPC
  - Rationale: The Rethink Runoff program offers volunteer opportunities, educational workshops and events, and provides community engagement. These learning opportunities increase public awareness of issues related to stormwater management and builds a community of stakeholders. This approach to public involvement is capable of reaching a greater percentage of the public than alternatives such as coordination of public meetings that may be difficult for individuals to attend.
  - Measurable Goal: The Town will report annually on Rethink Runoff activities including the number of volunteers that participated in stormwater related events and a total of the Town's cash contributions to the Rethink Runoff program.

- Storm drain stenciling program - The Town has added markers to each catch basin grate and checks them annually to assure that the markers are in place. New markers are attached annually where they are missing. In some cases, the asphalt adjacent to the storm drain is painted with a similar message. These "stencils" will be installed/painted by staff and public volunteers whenever possible.
  - Responsible Parties: Shelburne DPW

- Rationale: Storm drain stenciling sends a clear message to keep trash and debris, leaf litter, and pollutants out of the storm drain system, and may deter illegal dumping and discharges. Stenciling may increase watershed awareness and stewardship and can be used in any neighborhood with enclosed storm drains.
- Measurable Goal: The Town will continue its storm drain stenciling program and report the number of new and/or renewed "no dumping" labels put in place on an annual basis.

Illicit Discharge Detection and Elimination

In order to comply with MCM 3, Illicit Discharge Detection and Elimination (IDDE), the Town must develop, implement, and enforce a program to detect and eliminate non-stormwater discharges that may be entering the MS4. In order to meet this requirement, the Town will take the following steps:

- Maintain a storm sewer systems map – Knowing the location and type of structures that make up the Town's storm sewer system is critical to its maintenance. The Town previously developed a Geographic Information System (GIS) based map of stormwater infrastructure located in Shelburne. Included in the database is information pertaining to: storm drains, stormwater piping, stormwater outfalls, and stormwater treatment practices. The Shelburne DPW will continue to maintain and improve this information and make it available upon request.
  - Responsible Parties: Shelburne DPW
  - Rationale: Knowing the location and type of structures that make up the Town's stormwater system is critical to system maintenance.
  - Measurable Goal: The Town's annual report will contain information on the number of stormwater drainage structures, miles of stormwater conveyance, and stormwater outfalls that are located in Shelburne. Digital versions of the map will be made available upon request.

- Conduct stormwater outfall inspections – Evaluating the water at stormwater outfalls allows the Town to identify potential locations where illicit discharges may be entering the MS4. The Town has developed a program to inspect Town owned stormwater outfalls and will continue this program. These inspections are conducted in accordance with procedures outlined in the EPA's Illicit Discharge Detection and Elimination Guidance Manual (October 2004). An Outfall Inspection summary is completed for each outfall and this information is kept in a GIS database. Should the Town determine that there are significant water quality concerns at an outfall it will take proactive steps to identify the source of the problem. This may include video inspection of the upstream system or water sample collection and analysis.
  - Responsible Parties: Shelburne DPW
  - Rationale: Regular inspection of stormwater outfalls allows the Town to monitor areas of concern. These inspections can target dry weather flows and note potential cold climate indicators of an illicit discharge. Additionally, the Town will be able to coordinate

management activities to remove illicit connections and track storm drain system maintenance.

- Measurable Goals:
  - The Town will inspect no less than 50% of Town-owned stormwater outfalls each year and report the number of inspections completed annually.
  - Measurable Goals: The Town will report the number of outfall samples collected annually. Sample results will be made available upon request.

- Enforce existing ordinances regulating non-stormwater discharges to the MS4 – The Town passed a "Ordinance Regulating the Use of Public and Private Stormwater Systems" to prohibit non-stormwater discharges into the MS4 system on August 10, 2006 (Appendix C). The Town is currently working on updating the ordinance in conjunction with creating a stormwater utility.
  - Responsible Parties: Shelburne DPW
  - Rationale: The Ordinance provides a framework for inspection and enforcement of illicit discharges to the stormwater system. The Ordinance describes the power and authority of inspectors and enforcement regarding violations, judicial enforcement, and fines that may be recovered by the Town (see Appendix C: Ordinance Regulating the Use of Public and Private Stormwater Systems).
  - Measurable Goals:
    - The Town will track the number of illicit discharges encountered each year. A summary of the discharge and actions taken to correct the situation will be available upon request.
    - The Town will continue to enforce it existing ordinance.
    - The Town will review its existing ordinance and make any updates required by the new permit within 3 years of authorization under the 2018 MS4 permit.

- Coordination with drinking water suppliers – The Town of Shelburne Water Department (SWD) operates a potable water system within the Town area. As part of their normal preventative maintenance procedures, the district must annually flush the lines and fire hydrants in the water system. Regular flushing helps ensure the reliability of water system components and that customers receive high quality, sanitary, potable water at their tap. The SWD has BMPs in place to ensure that their maintenance activities will not result in discharges to the surface water. Example BMPs include the use of a hydrant diffuser, dechlorinator and positioning diffusers to prevent erosion when flushing hydrants.
  - Responsible Parties: Shelburne DPW
  - Rationale: Flushing the water lines is necessary to keep the pipes clean and prevent accumulation of silt and tuberculation in the pipes that would be stirred up during a hard use (e.g. firefighting) of the system. This activity ensures reliability of the water system and helps to deliver a quality product. The SWD has BMPs in place to ensure that their

maintenance activities will not result in discharges to the MS4 that could contribute to water quality issues.

- Measurable Goal: The SWD will continue to use BMPs to prevent pollution from entering the MS4. Before the end of the permit cycle the Town will meet with SWD to review their BMPs relating to discharges of drinking water to the MS4. If necessary, improvements will be made to SWD BMPs.

- Inform public employees, businesses and the general public of hazards associated with illegal discharges and improper disposal of waste – The Town's stormwater web site has a section dedicated to detection and elimination of illicit discharges. Information on the site indicates how illicit discharges were successfully eliminated and describes the resulting benefits to water quality.
  - Responsible Parties: Shelburne DPW
  - Rationale: Learning about illicit discharges and its effects on our rivers, streams and lakes is an important step in minimizing the pollutants in stormwater. Educating the public on the impacts of illicit discharges will foster a sense of responsibility and ultimately result in a collaborative approach in the detection and elimination of occurrences.
  - Measurable Goal: The public will be informed of the impacts of illicit discharges through various components of the town outreach program including: https://www.shelburnevt.org/221/Stormwater-Water-Quality and www.rethinkrunoff.org.

Construction Site Stormwater Runoff Control

In order to comply with MCM 4, Construction Site Stormwater Runoff Control, the Town must develop and enforce a program to reduce pollutants originating at construction sites from entering the MS4. The Town recognizes construction site runoff control as a key means of protecting and improving surface water quality in Shelburne. Therefore, the Town will assist the ANR in implementing requirements of the Construction General Permit (3-9020) and maintain its own standards related to construction erosion control. In order to meet this requirement, the Town will take the following steps:

- Implement local regulations related to erosion control – The Town adopted The Town of Shelburne Zoning Bylaws (amended 2018) and Subdivision Bylaws (amended 2016), as well as the Town of Shelburne Public Works Specifications (revised in 2008) to include requirements for construction site erosion control, inspection authority and enforcement measures. Town planning staff and Public Works employees received training in plan review and currently review all site plans for erosion and sediment control and are conducting site inspections. The Town will continue to review its ordinances to seek additional effective measures to control waste such as discarded building materials, concrete truck wash out, chemicals, litter and sanitary waste at construction sites.

- Responsible Parties: Shelburne DPW
- Rationale: This is an efficient manner of addressing erosion control because it efficiently utilizes the Development Review process and also allows trained town staff to perform inspections and enforcement. Ensuring that construction contractors working in the Town implement and maintain these BMPs is critical to establishing construction practices that include understanding and implementation of erosion prevention and sediment control practices.
- Measurable Goal: Continue to enforce the existing Ordinances pertaining to Construction and Erosion Control Standards.

- Conduct construction site inspections – Shelburne DPW staff will be trained in the appropriate use of construction site BMPs and conduct inspections to ensure that construction contractors working in the Town are implementing BMPs in compliance with local regulations and any State permits that their project may be subject to.
  - Responsible Parties: Shelburne DPW
  - Rationale: Educating contractors about the proper selection, installation, inspection, and maintenance of BMPs will help to ensure compliance with Erosion Prevention and Sediment Control (EPSC) requirements.
  - Measurable Goal: The Town will track the number of construction site inspections it conducts each year.

- Assist the ANR with implementation of its Construction General Permit (3-9020) – The Vermont ANR has issued General Permit 3-9020 for stormwater runoff from construction activities which result in land disturbance of greater than 1 acre. The Town will assist ANR with its implementation of this program.
  - Responsible Parties: Shelburne DPW and Planning and Zoning
  - Rationale: Through plan review and site inspection, the Shelburne DPW will become more aware of the intended outcome of a project and can support the ANR with achieving the goals of the CGP 3-9020.
  - Measurable Goal: When a project will disturb greater than 1 acre of land the Town will include in its findings of fact a note that we believe the project requires a State of Vermont Construction General Permit (3-9020). A summary of the projects in Shelburne that will exceed 1 acre of disturbance will be reported each year.

Post Construction Stormwater Management for New Development and Redevelopment

In order to comply with MCM 5, Post Construction Stormwater Management, the Town must develop and enforce a program to control stormwater runoff from new and re-development projects. In order to meet this requirement, the Town will take the following steps:

- Maintain an updated list of the Stormwater Treatment Practices (STPs) covered by the Town's MS4 permit authorization - All STPs that the Town maintains are included in the SWMP in Figure 4. The list included in Figure 4 will be updated as the Town assumes responsibility for stormwater systems under its MS4 permit.
  - Responsible Parties: Shelburne DPW
  - Rationale: Record keeping will help to track systems that need maintenance and improvements.
  - Measurable Goals:
    - The list will be available to the crew and the public as needed.
    - The Town will report on an annual basis any new STPs for which it has assumed responsibility.

Permit Number	Old Permit Number	Project Name	Permittee Business	Impevious Acres	Permit Expiration Date
3659-9010.R	3659-9010, 1-0717	Bay Colony Estates	Town of Shelburne	8.52	9/16/2020
3660-9010.R	3660-9010, 2-0748	Bayfield Estates	Town of Shelburne	2.3	9/16/2020
1-1534.0302		Boulder Hill	Sterling Construction, Inc.	5.5	3/12/2008
3879-9010.R	3879-9010, 2-0788	Cedar Ridge Estates	Town of Shelburne	4.06	9/20/2020
3744-9010	3744-9015	Fieldhouse Athletic Fields and Housing	Field View Condominium Association Inc, J. Hutchins, Inc., Bullrock, Inc., Field House LLC, Town of Shelburne	4.04	11/3/2024
3785-9010.R	3785-9010, 2-1114	Green Meadows - Littlefield Drive	Town of Shelburne	3.35	9/16/2020
3921-9010.R	3921-9010, 1-0246	Heritage Lane	Town of Shelburne	3.7	4/21/2020
3928-INDO.R1	3928-INDO, 3928-INDO.R	Hullcrest offset capacity project	All Seasons Excavating, N.L Chagnon's, Inc, Town of Shelburne	16.21	11/15/2021
3673-9010.R	3673-9010, 2-0990	John Street Subdivision	Town of Shelburne	1.15	9/20/2020
6231-INDO.R	2-0956	Longmeadow Drive	Town of Shelburne	7.87	5/5/2015
1-0779.0003		Maeck Farm	Town of Shelburne	-	9/30/2006
3920-9010.R	3920-9010, 2-0166	Tracy Lane Extension	Town of Shelburne	0.81	4/21/2020
3784-9010.R	3784-9010, 2-0746	Upper Meadows Development	Town of Shelburne	5.96	9/20/2020

Figure 4 – Stormwater Treatment Practices Maintained by the Town of Shelburne and Covered Under the MS4 Permit

- Inspect and ensure the proper maintenance of all STPs covered under the Town's MS4 permit authorization – The Shelburne DPW will inspect and ensure proper maintenance of all STPs included in Figure 4.
  - Responsible Parties: Shelburne DPW
  - Rationale: Regular inspection of STPs allows the municipality to better maintain the systems by quickly identifying any concerns such as damage to fences, evidence of burrowing animals, woody growth detrimental to function, erosion, and vegetative maintenance needs.
  - Measurable Goals: The Town will ensure proper maintenance of all STPs included in Figure 4. These STPs will be inspected at least twice a year. The Town will report the number of inspections conducted on an annual basis. The results of these inspections will be made available upon request.

- Implement local regulations related to post-construction stormwater management - The Town has measures within its ordinances to address post-construction runoff. The Town adopted amendments to the Zoning and Subdivision Bylaws and Public Works Specifications to provide effective tools to establish appropriate standards for inclusion in all site plans submitted to the Town in support of development.
  - Responsible Parties: Shelburne DPW, Planning and Zoning
  - Rationale: Through regular plan review, the Shelburne DPW will better serve the needs of the community by noting any concerns prior to construction.
  - Measurable Goals:
    - Continue to enforce the stormwater management regulations contained the Town Zoning laws.
    - Town staff in the department of planning and zoning and Public Works will ensure that stormwater management related regulations found in the Town's Zoning and Subdivision Bylaws, as well as Public Works Specifications, are properly interpreted and implemented during the Town's project approval process.

- Assist the ANR with implementation of its stormwater permitting program (3-9015) – The Vermont ANR has issued General Permit 3-9015 that regulates post-construction stormwater runoff. All projects that create greater than 1 acre of impervious area must obtain permit coverage from the ANR. The Town will assist ANR with its implementation of this program.
  - Responsible Parties: Shelburne DPW
  - Rationale: Through plan review and site inspection, the Shelburne DPW will become more aware of the intended outcome of a project and can support the ANR with achieving the goals of the CGP 3-9020.
  - Measurable Goal: When a project will create greater than 1 acre of impervious area the Town will include in its findings of fact a note that we believe the project requires a State

of Vermont General Stormwater Permit (3-9015). A summary of the projects in Shelburne that will create 1 acre of impervious area will be reported each year.

Pollution Prevention / Good Housekeeping for Municipal Operations

In order to comply with MCM 6, Pollution Prevention / Good Housekeeping for Municipal Operations, the Town must evaluate the systems it has in place to prevent and reduce polluted runoff from municipal operations. The Town must also develop and enforce a program to control stormwater runoff from new and re-development projects. In order to meet this requirement, the Town will take the following steps:

- Distribution of Pet Waste Bags – During the annual relicensing of dogs, the Town provides an informational package concerning cleaning up after one's dog, along with a package of biodegradable pet waste bags.
  - Responsible Parties: Shelburne DPW, residents and pet owners
  - Rationale: Pet waste is one of the many contributors of stormwater pollution that can degrade water quality. During rainfall, pet waste left on lawns, beaches, trails, and sidewalks washes into storm drains or into water bodies. The waste and the pathogens it contains (nutrients, bacteria, parasites, and viruses), end up flowing directly into streams, lakes and ponds where they can harm human health and the environment. By providing the pet waste bag dispensers, the Town allows easy access to pet owners to clean up after their pet, increasing the likelihood of the waste removal before a storm event.
  - Measurable Goal: The Town will report the number of pet waste bags distributed on an annual basis.

- Participate in the Municipal Compliance Assistance Program (MCAP) – Municipal staff and facilities are subject to many different state and federal environmental regulations. In order to ensure continued compliance with these regulations the Town works with ANR staff in the Environmental Assistance Office to identify shortfalls in current practices and design solutions to address any issues that could result in non-compliance with environmental regulations. The Town complies with all relevant regulations concerning disposal of contaminated products and waste fluids and materials. A sump and separator are in use to keep contaminants from reaching waters of the State.
  - Responsible Parties: Shelburne DPW, MCAP, and the ANR
  - Rationale: By identify shortfalls in the existing program, the overall accomplishments and goals will be strengthened.
  - Measurable Goal: The Town will work with ANR staff and complete an MCAP inspection before the end of the 5-year permit cycle.

- Inspection of Town Maintained STPs – The Town maintains numerous STPs located throughout Shelburne. Annually, inspections are conducted for these STPs to ensure that they are functioning properly. Some of these STPs are subject to State permits that also require inspections. In order to minimize efforts related to duplicative inspection and reporting requirements, inspection information for all Town maintained STPs will be relayed to DEC as part of the MS4 annual report.
    - Responsible Parties: Shelburne DPW
    - Rationale: Regular inspection of STPs allows the municipality to better maintain the systems by quickly identifying any concerns such as damage to fences, evidence of burrowing animals or trash, woody growth detrimental to function, erosion, and vegetative maintenance needs.
    - Measurable Goal: The Town will inspect all STPs for which it has maintenance responsibility at least twice a year. The Town will report the number of inspections conducted on an annual basis. The results of these inspections will be available upon request

- Street sweeping - Maintenance of the roadways includes sweeping on a regular basis. The Town's current practice is to sweep all roads twice per year. The first sweeping occurs as soon as practicable following snowmelt in the spring. The latter occurs as late in the fall as possible to allow for the collection of leaves.
    - Responsible Parties: Shelburne DPW
    - Rationale: The debris collected by street sweepers includes many materials that can be hazardous to the environment or our health, such as petroleum products, rubbish, sediment, and green waste. Sweeping the streets on a regular basis reduces the likelihood of these pollutants entering our stormwater systems. Keeping the drains and gutters clear will also reduce the chance for flooding during heavy rain.
    - Measurable Goal: Sweep all curbed streets, curbed bike paths, and parking lots with curb that the Town owns at least twice per year. The total volume of material removed will be reported annually.

- Storm drain cleaning – The Town is responsible for maintenance of the publicly owned stormwater drainage system in Shelburne. If the system is not properly maintained it can result in increased pollution and flooding issues.
    - Responsible Parties: Shelburne DWP
    - Rationale: A clean storm drain will more effectively collect stormwater and remove sediment. This minimizes pollution and flooding.
    - Measurable Goal: The Town will clean a minimum of 75 storm drains and the associated piping each year. The total volume of material removed will be reported annually.

- Storm drain inspections - The Town is responsible for maintenance of the publicly owned stormwater drainage system in Shelburne. Part of the Town's established maintenance program includes regular inspection of drainage structures to ensure their proper operation and condition.
  - Responsible Parties: Shelburne DPW
  - Rationale: Storm drains prevent pollution from reaching the waterways by collecting some of the sediment and debris that washes off the road. When the drain's basin fills with sediment, any new pollutants entering the catch basin will continue through the stormwater system and into waterways. Debris may also clog catch basin covers and prevent water from entering the drainage system. Regular inspection allows SHELBURNE DPW to determine if a system requires maintenance prior to a storm event.
  - Measurable Goal: Inspect a minimum of 75 storm drains each year. The total number of storm drains inspected will be reported annually.

- Properly dispose of materials collected from street sweeping, pond maintenance, and the stormwater drainage system – The Town of Shelburne has in place procedures for disposing of materials collected from street sweeping, maintenance of STPs, and cleaning of the stormwater drainage system.
  - Responsible Parties: Shelburne DPW
  - Rationale: The sediment collected from storm drains is tested for pollution and hazardous materials before being used as construction fill or treated as hazardous waste. The effort allows the clean material to be reused as opposed to being sent to the landfill.
  - Measurable Goal: Materials collected during street sweeping, maintenance of STPs, and cleaning of the stormwater drainage system will continue to be handled and disposed of by Shelburne in accordance with the Town's disposal procedures.

- Minimize winter sand and salt usage – The Town has adopted a winter highway maintenance plan. Each plow truck is equipped with computer controls for proper calibration and spreading of deicing materials. Efforts have been made to reduce the amount of salt applied per lane mile by using melting enhancers to enable less salt to melt ice and snow at lower temperatures. The Town does not operate a snow storage area. Sand use has decreased dramatically and is used only on about 2.5 miles of gravel road and during extreme cold temperatures at intersections and on hills.
  - Responsible Parties: Shelburne DPW
  - Rationale: These practices will reduce the total amount of salt needed to achieve similar results. Proper calibration of the equipment is necessary to know how much material is being applied to a roadway, benefiting both the environment and the budget. Calibration of the trucks will subsequently reduce the amount of salt reaching surface waters.

- Measurable Goal: The salt delivery systems on plow trucks will be calibrated at the beginning of each winter to ensure proper distribution of salt. TMDL Implementation

Municipally Operated Industrial Facilities

The Town does not own facilities that are subject to the ANR's Multi-Sector General Permit (MSGP). Both of its wastewater treatment facilities are below the jurisdictional threshold.

Discharges to Impaired Waters

Lake Champlain- Shelburne Bay

Shelburne Bay has documentation and data indicating impairment and does not meet VT Water Quality Standards according to the methodology described in the VT Surface Water Assessment and Listing Methodology. Shelburne Bay is recognized as having elevated levels of polychlorinated biphenyl (PCB), impacting allowable fish consumption. Establishing a TMDL is listed as "low" on the state's schedule. The Response Plan to this impairment includes implementing the Phosphorous Control Plan for Lake Champlain and implementing the municipal road standard.

McCabe's Brook

McCabe's Brook is currently listed as impaired due to excessive nutrients from the mouth to river mile 1.4. The Response Plan to this impairment includes implementing the Phosphorous Control Plan for Lake Champlain and implementing the Municipal Road General Permit (MRGP) standards.

Shelburne Pond

Shelburne Pond is currently listed as impaired due to excessive Phosphorous. The Response Plan to this impairment includes implementing the Phosphorous Control Plan and implementing the Municipal Road General Permit (MRGP) standards.

TMDL Implementation

Impaired waters are those waters that the Secretary of ANR has identified as not meeting Vermont Water Quality Standards. Once a waterbody is designated as impaired, the State of Vermont lists it on the Vermont "303(d) Part A list" and submits this information to the U.S. Environmental Protection Agency (EPA). In some cases, ANR will prepare a Total Maximum Daily Load (TMDL) for an impaired waterbody. A TMDL is a calculation of the maximum amount of a particular pollutant that a waterbody can receive and still meet water quality standards. These waterbodies are then moved to the "303(d) Part D list".

Flow Restoration Plan (FRP)

The Town of Shelburne has developed Flow Restoration Plans (FRPs) for Munroe Brook and Bartlett Brook, both stormwater impaired watersheds. FRPs are included in this Stormwater Management Plan as follows:

- Munroe Brook Flow Restoration Plan – Appendix D
- Bartlett Brook Flow Restoration Plan– Appendix E

Schedule of Compliance

Part 8.1.C of the 2018 MS4 permit requires that the Town shall implement all measures necessary to achieve the flow restoration targets in the TMDLs no later than December 5, 2032. Each FRP contains an implementation schedule that ends before this date.

Annual Reporting

The Town will submit an annual report to the Vermont ANR on or before April 1 of each year. The report will detail the Town's efforts over the previous calendar year and include the following information:

- The status of the Town's compliance with MS4 permit conditions
- An assessment of the appropriateness of the BMPs identified in the SWMP
- A report on progress towards implementation of the BMPs identified in the SWMP
- A report on the progress of FRP development and implementation
- A summary of stream flow monitoring data in the stormwater impaired watersheds
- A summary of stormwater activities that the Town plans to undertake during the next reporting cycle (i.e. calendar year)
- Proposed changes to the Town's approved SWMP
- Notice that the Town if relying on another entity to satisfy permit obligations.

Flow Monitoring

Part 8.1.D of the 2018 MS4 permit requires that the Town prepare a plan for flow monitoring in stormwater impaired streams. The Town currently is under contract with Vermont DEC to monitor 9 stormwater impaired watersheds in Chittenden County and St. Albans. There are 16 individual sites monitoring precipitation, stream flows or both, two of which are within Shelburne's borders. In the 2018 MS4 permit cycle, the Town will:

- Continue working with the consultant selected by DEC to conduct stream flow monitoring.
- Sign an MOU with Vermont DEC related to paying for stream flow monitoring services.
- Continue to make payments to Vermont DEC as outlined in the signed MOU.
- The Town, in collaboration with DEC stormwater section staff, will continue to evaluate the data collected as part of the stream flow monitoring MOU.

Stream Corridor Protection

Article XVIII: Floodplain and Watercourse Overlay District of the Shelburne Zoning Bylaws is the foundation to minimize adverse impacts of development upon the sensitive natural areas adjacent to Shelburne's various watercourses and to minimize public and private loss caused by periodic flooding conditions. More specifically, this Article seeks to preserve water quality, prevent pollution,

avoid erosion, and protect the ecology of stream beds and lands adjacent to watercourses. The Town's Zoning Bylaws designate Special Flood Hazard Areas to include all land within 100 feet of the centerline of the south branch of Munroe Brook, plus all land within 50 feet of the centerline of the north branch of Munroe Brook and other Munroe Brook tributaries. The Zoning Bylaws regulate development of new structures or the expansion of existing structures within the Flood Hazard Areas.

Lake Champlain PCP

All of Shelburne ultimately drains to Lake Champlain. Vermont's 303(d) list of impaired waters indicates that Lake Champlain is impaired due to excessive phosphorus. The state of Vermont has a TMDL required reduction for the Shelburne Bay and the Main Lake of 20.2%

Shelburne has initiated the process of developing the Phosphorous Control Plan for the Town. At a minimum, the PCP will be designed to achieve a level of phosphorus reduction equivalent to the percent reduction target for developed land in the associated TMDL lake segment.

The PCP will adhere to the following schedule:

April 1, 2019	- Submit the first Annual PCP Report
April 1, 2020	- Submit the Annual PCP Report and the Implementation Table with results of the Road Erosion Inventory (REI)
April 1, 2021	- Complete the Phosphorus Control Plan (PCP) and submit it to the Secretary - Submit the Annual PCP Report
April 1, 2022 and every year thereafter	- Submit Annual PCP Report
No later than June 17, 2036	- Complete full implementation of the approved PCP

Figure 5 – PCP Implementation Table

An Annual PCP Report will be submitted each April 1 of the permit. The reports shall address actions taken to implement all PCP components, including:

- Extent of implementation of the Municipal Roads Standards and any necessary updates to the MRGP Implementation Table,
- Extent of street sweeping and catch basin cleaning,
- Extent of stormwater BMP implementation,
- An estimate of the extent of remaining items requiring completion,
- An assessment of the ability to meet outstanding schedule items, and
- A written statement, signed by a designer acceptable to the Secretary, that any

structural BMP built or implemented within the preceding six-month period was constructed in compliance with the approved plans.

Municipal Road Requirement

The Municipal Roads General Permit is intended to achieve significant reductions in stormwater-related erosion from municipal roads, both paved and unpaved. The Town of Shelburne will implement a customized, multi-year plan to stabilize the road drainage system. The plan will include bringing road drainage systems up to basic maintenance standards, and additional corrective measure to reduce erosion as necessary to meet a TMDL or other water quality restoration effort.

Road Erosion Inventory (REI)

The Town of Shelburne has initiated a Road Erosion Inventory (REI) of all hydrologically-connected road segments within the municipality. The REI is intended to verify which municipal road segments are hydrologically connected, and identify which of those segments meet the operational standards required under this permit. The municipal road segments are broken down into the following categories: Gravel and Paved Roads with Ditches, Paved Roads with Catch Basins, and Class 4 Roads. Beginning in 2019, an Annual MRGP compliance update will be submitted by April 1st. The Initial Road Erosion Inventory and Implementation Table will be submitted by April 1, 2020. A minimum of 15% of non-compliant segments will be upgraded to meet the standards in 2021 and 2022.

Implementation Table

The Town will record the REI scoring information in the Implementation Table. In the Implementation Table, the municipality shall prioritize road segments for upgrades to meet the standards in Subpart 8.3.C. The municipality shall submit the Implementation Table on April 1, 2020. The Table shall include:

- The planned road upgrades for the first permit term period;
- Updates pertaining to the segments brought up to standards;
- Itemization of the segments planned to be brought up to standard in the following year.

Road Stormwater Management Standards

The Town will update the Public Works Specifications and utilize these specifications to implement the minimum required BMPs applicable to all hydrologically-connected municipal roads. The Town will be responsible to maintain all practices after installation. If the feasibility affects the implementation of the standards, the Town will document the instance in the MRGP Implementation.

Monitoring, Record Keeping, and Reporting

Monitoring

When the Shelburne DPW conducts monitoring of illicit discharges pursuant to Subpart 6.2.3, all records of monitoring information shall include:

- The date, exact place, and time of sampling or measurements;
- The names(s) of the individual(s) who performed the sampling or measurements;
- The date(s) analyses were performed;
- The names of the individuals who performed the analyses;
- The analytical techniques or methods used; and
- The results of such analyses.

Record Keeping

The Shelburne DPW shall retain all records required by this permit, including records of all monitoring information, copies of all reports required by this permit, a copy of its authorization and amended authorizations under this permit, and records of all data used to complete the application (NOI) for this permit, for a period of at least three years from the date of the sample, measurement, report, or application. The Town will submit its records to the Secretary when specifically asked to do so. The Town will retain a copy of the SWMP required by this permit, and a copy of the permit language, at a location accessible to the Secretary. All records, including the NOI and SWMP, will be available to the public on the Town website, or in writing if requested.

Annual Report

The permittee shall submit an annual report that shall evaluate the permittee's compliance with the MCMs. The permittee shall submit its annual reports to the Department of Environmental Conservation, Watershed Management Division, Stormwater Management Program by April 1st each year, and upon receipt, the Department shall post each annual report on its website. FRP and PCP reports shall be included with the annual report. In addition to any FRP and PCP reporting requirements, the annual report shall include all annual reporting requirements under Parts 4, 5, and 6 of this permit as well as:

- The status of the progress, compliance and assessment towards achieving TMDL requirements;
- Results of information collected and analyzed, if any, during the reporting period,
- A summary of the stormwater activities to be undertaken during the next reporting cycle,
- A change in any identified BMPs or measurable goals for any of the minimum measures, and
- Notice that the Town is relying on another entity to satisfy some of its permit obligations, if applicable.

Amendments

Amendments or changes to the Town's SWMP will be made in writing to ANR and contain the signatures of appropriate Shelburne town staff. These changes may occur at any time, but efforts will be made to coordinate these requests with scheduled reporting activities. Appendix F contains a summary of amendments made to the Town's 2019 SWMP.

Individual Responsible for Implementation

The Shelburne Town Manager is ultimately responsible for implementation of the Town's SWMP. The Water Quality Superintendent is responsible for various subcomponents of the plan, but through the Town Manager's overall authority.

Signatures

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Christopher R. Robinson,
Water Quality Superintendent

1/22/2019
Date

Lee Krohn
Town Manager

01-23-2019
Date

Appendix A – Interlocal Agreement for Stormwater Services

INTERLOCAL AGREEMENT FOR STORMWATER SERVICES BETWEEN THE CITY OF SOUTH BURLINGTON AND THE TOWN OF SHELBURNE

THIS AGREEMENT ("Agreement") is made this 1st day of July, 2016 (the "Effective Date"), by and between the City of South Burlington, a Vermont municipality located in the County of Chittenden and State of Vermont ("City"), and the Town of Shelburne, a Vermont municipality located in the County of Chittenden and State of Vermont ("Town") This Agreement is an interlocal contract made under the provisions of 24 V.S.A. §§ 4901-4902.

WHEREAS, the Town requires the services of qualified professionals to provide services in the areas of stormwater management; and,

WHEREAS, the City, through its Department of Public Works Stormwater Services Division, represents that it has the expertise and is qualified to perform the stormwater management services required by the Town; and,

WHEREAS, the Selectboard of the Town and the City Council of the City have approved this Agreement and the expenses for the governmental services, activities and undertakings contemplated hereunder have been included in the municipal budgets of the City and Town under 17 V.S.A §2664 or comparable charter provisions; and,

NOW THEREFORE, in consideration of these promises and the mutual covenants herein set forth, it is agreed by the parties hereto, as follows:

1. Services Provided by the City.

From time to time, the Town and City may execute one or more statements of work, substantially in the form attached hereto as **Exhibit A** that describe the specific services to be performed by City (a "Statement of Work"). Each Statement of Work will form a part of this Agreement and will be subject to the terms and conditions of this Agreement. A Statement of Work may be amended only by written agreement of the parties.

2. Performance of Services.

The City will perform the services described in each Statement of Work in accordance with the terms and conditions set forth in each such Statement of Work and this Agreement. In the case of any inconsistency between this Agreement and a Statement of Work, this Agreement shall control.

3. **Standard of Performance.** The standard of care for all professional services performed or delivered by the City will be the skill and care used by practitioners of the stormwater profession practicing under similar circumstances at the same time and in the same region. The City makes no warranties, express or implied, under this Agreement or otherwise, in connection with the services performed or delivered by the City under this Agreement or any Statement of Work.

4. **Town Responsibilities.** The Town shall provide the City with all information available to the Town relevant to the City's work under this Agreement or any Statement of Work. The Town shall make decisions and perform other Town obligations in a timely manner so as not to delay the City's performance of services.

5. **Inspection.** The Town shall, at all times, have access to the plans, studies, data, diagrams, calculations, and other materials prepared or collected by the City pursuant to this Agreement (the "Instruments of Professional Service"). The City shall surrender upon demand any Instruments of Professional Service that have been prepared or developed or collected by the City pursuant to this Agreement.

6. **Delivery.** The City will deliver to the Town the deliverables, products, and other materials specified in a Statement of Work (the "Deliverables") in accordance with the delivery schedule and other terms and conditions set forth in the Statement of Work.

7. **Acceptance.** Following the City's delivery of each Deliverable, the Town will evaluate each Deliverable to confirm its conformance to the Statement of Work. If a Deliverable fails to conform to the Statement of Work, the Town will notify the City within ten (10) business days and, if applicable, specify the modifications that must be made to the Deliverable. Upon receipt of such notice, the City will modify the Deliverable to conform to the Statement of Work. If the Town finally rejects a Deliverable, the Town may terminate the applicable portion of the Statement of Work.

8. **Ownership.** The City agrees that the ownership of all Instruments of Professional Service and Deliverables shall become the property of the Town as they are prepared or developed. Intellectual property rights to any Instruments of Professional Service and Deliverable are reserved to the Town.

9. **Compensation.** As The City's compensation for the performance of services under this Agreement, the Town will pay the City the

fees specified in each Statement of Work in accordance with the terms set forth therein.

10. **Invoices.** Invoices shall be submitted to the Town as often as monthly, but no more frequently. Electronic invoices delivered over email are acceptable provided that they are sent to both the Town Manager and Wastewater Superintendent. All invoices and correspondence shall reference the appropriate Statement of Work. Invoices are payable within thirty (30) days of the invoice date. The Town shall pay a finance charge of one and one half percent (1.5%) per month on any unpaid balance not received by the City within 30 days of the invoice date. All payments made by the Town should specify the invoice numbers being paid.

11. **Term.** This Agreement will commence on the Effective Date and, unless terminated earlier in accordance with the terms of this Agreement, will remain in force and effect for as long as the City is performing services pursuant to a Statement of Work.

12. **Termination.** This Agreement may be terminated in accordance with the following provisions:

a) Termination for Cause. If either party shall fail to fulfill any obligations under this Agreement, or if either party shall breach any of the terms of this Agreement, the other party shall have the right to terminate the Agreement by giving twenty (20) days' written notice.

b) Termination for Convenience. In addition, the Town may terminate this Agreement for its convenience by giving twenty (20) days' written notice to the City. In such case, the City shall be entitled to receive full compensation for all services performed hereunder prior to the date of termination.

13. **Relationship.** The City shall have responsibility for general supervision of City's agents and employees and shall be solely responsible for all procedures, methods of analysis, interpretation, conclusions and contents of work performed under this Agreement. The City shall be responsible for all costs and expenses incurred relative to the City and agents and employees of the City, in connection with this Agreement, including, without limitation, payment of salaries, fringe benefit contributions, payroll taxes, withholding taxes and other taxes or levies, office overhead expenses, travel expenses, telephone and other telecommunication expenses, and document reproduction expenses.

14. Insurance. The City shall agree to procure and maintain the following types and limits of insurance for the term of this contract.

Commercial General Liability Insurance including but not limited to Bodily Injury, Personal/Advertising Injury, Broad Form Property Damage, Products and Completed Operations Liability and Contractual Liability with limits of at least $3,000,000[jd1] per occurrence and $6,000,000 in the aggregate annually.

Commercial Auto Liability Insurance covering all Owned & Hired and Non-Owned vehicles, with limits of at least $3,000,000[jd2] Combined Single Limit per occurrence.

Statutory Workers' Compensation Insurance and Employers Liability Insurance with a limit of at least $1,000,000[jd3] each accident.

Before signing this contract and before work begins, the City shall provide the Town with a Certificate of Insurance showing evidence of all coverages required above and naming the Town as an Additional Covered Party (named insured).

15. Indemnification. The City shall, to the fullest extent permitted by the law, indemnify and hold harmless the Town, its officers, agents and employees, from liability for damages to third parties, together with costs and expenses, including attorney's fees[jd4], incurred in defending claims by third parties, to the extent such liability is caused by the negligent or intentional acts, errors, or omissions of the City, its agents or employees, in the performance of the services to be provided under this Agreement.

The Town shall, to the fullest extent permitted by the law, indemnify and hold harmless the City, its officers, agents and employees, from liability for damages to third parties, together with costs and expenses, including attorney's fees[jd5], incurred in defending claims by third parties, to the extent such liability is caused by the negligent or intentional acts, errors, or omissions of the Town, its agents, or employees, in performance under this Agreement.

Notwithstanding any contrary provision hereof, all of the rights and obligations of the parties under this Section 15 shall survive expiration or termination (for any reason) of the Agreement and remain in full force and effect.

16. Right of Entry. If the services to be performed under a Statement of Work require entry on property controlled by the Town, the Town hereby grants the City, and its agents and employees, the right to enter the property in order for the City to fulfill its obligations under the Statement of Work. If the services to be performed under a Statement of Work require entry on property which is not controlled by the Town, the Town agrees to obtain permission from the party controlling the property to allow City agents and employees entry on the property.

17. Compliance. The City shall comply with all applicable Federal, State and local laws in the performance of the services to be provided under this Agreement.

18. Assignment. The City shall not assign or transfer this Agreement, or any interest herein or obligation hereunder, directly or indirectly without the prior written consent of the Town. Any attempt to do so without the prior written consent of the Town shall be null and void. Approval or consent to assign or transfer any portion of the work shall in no way relieve the City of responsibility for the performance of that portion of the work so transferred.

19. Changes and Amendments. Changes, modifications, or amendments in the terms, conditions, and fees of this Agreement or any Statement of Work shall be written and signed by the duly authorized representatives of the Town and the City.

20. Notices. Notices and other communications are to be delivered to:

For the Town:

Christopher Robinson
Water Quality Superintendent
Town of Shelburne
53 Turtle Lane
Shelburne, VT 05482

For the City:

Thomas J. DiPietro Jr.
Deputy Director of Public Works
City of South Burlington
575 Dorset Street
South Burlington, VT 05403

21. Governing Law, Jurisdiction, Severability. This Agreement and any and all issues arising hereunder or relating hereto shall be

governed and construed according to the laws of the State of Vermont without reference to principles of conflicts of laws. The Courts of the State of Vermont shall have exclusive jurisdiction to adjudicate any dispute arising under or in connection with this Agreement. In the event that one or more components of this Agreement is deemed by a court of competent jurisdiction to be unenforceable, then it is the intention of the parties that such component be stricken, and the rest and remainder of the Agreement be enforced in accordance with the plain meaning of the language of the Agreement as if the stricken component had not ever been a part hereof.

22. **Entire Agreement.** This Agreement, together with the Statements of Work, constitute the final, complete and exclusive Agreement of the parties and supersedes all prior understandings and agreements, whether written or oral, with respect to the subject matter.

23. **Construction.** This Agreement has been reviewed by the City and the Town and their respective legal counsel and the terms and provisions hereof have been negotiated by both parties and this Agreement shall not be construed for or against the City or the Town. This Agreement shall not create any relationship of agency, partnership, or joint venture. No provision contained in this Agreement shall create or confer any benefit with or rights to any third parties nor give to third parties any claim or right of action beyond such as may legally exist in the absence of any such provision.

24. **Force Majure.** The City shall not be liable for any delay or failure to perform services when such delays or failures are caused by circumstances beyond the City's reasonable control, including without limitation, acts of God, acts and/or omissions of federal, state, and local governmental authorities and regulatory agencies, strikes, riots, civil unrest, and war. For delays caused by the Town or circumstances beyond the reasonable control of the City, the City shall be given a reasonable time extension.

IN WITNESS WHEREOF, the parties hereto have caused this Agreement to be executed on the day and year first written above.

CITY OF SOUTH BURLINGTON
SOUTH BURLINGTON, VERMONT

Witness: _____ BY: _____
KEVIN DORN, CITY MANAGER AND DULY AUTHORIZED REPRESENTATIVE

DATE: 6/30/16

Town of Shelburne

Witness: _____ BY: _____
JOE COLANGELO, TOWN MANAGER AND DULY AUTHORIZED REPRESENTATIVE

DATE: 28-June-2016

EXHIBIT A
STATEMENT OF WORK

This Statement of Work Number ___ is issued under and subject to all the terms and conditions of the **AGREEMENT FOR STORMWATER SERVICES** dated as of _____, 2016 between the City of South Burlington ("City") and Town of Shelburne ("Town")

1. **Description of Services.**

2. **Payment Terms.** [Use if City will be paid on the completion of milestones].

Description of Milestones	Milestone Payments	Milestone Completion Dates

OR

2. **Payment Terms.** [Use if City will be paid on an hourly basis]

Hourly Consulting Rate: $_____

Maximum Number of Hours: _____

Maximum Consulting Fee: $_____

Start Date: _____

Completion Date: _____

3. **Other Terms (Scope of Work related).**

Agreed as of _____, 2016.

CITY OF SOUTH BURLINGTON
SOUTH BURLINGTON, VERMONT

Witness:_____ BY:_____
THOMAS J. DIPIETRO JR.
DEPUTY DIRECTOR OF PUBLIC WORKS

DATE:_____

TOWN OF SHELBURNE
SHELBURNE, VERMONT

Witness:_____ BY:_____
CHRISTOPHER ROBINSON
WATER QUALITY SUPERINTENDENT

DATE:_____

Appendix B – Chittenden County MS4 Stormwater Program Agreement

CHITTENDEN COUNTY MS4
STORMWATER PROGRAM AGREEMENT
EFFECTIVE July 1, 2017
Amended effective July 1, 2018

Preamble

This Stormwater Program Agreement ("Agreement") is entered into by and between a group of Municipal Separate Storm Sewer System ("MS4") permittees ("MS4 Permittees") and the Chittenden County Regional Planning Commission ("CCRPC") to operate an MS4 Stormwater Program ("Program") that conforms with and satisfies the relevant requirements of both Minimum Control Measure One (Public Outreach and Education) and Minimum Control Measure Two (Public Involvement and Participation) of the Phase II NPDES Permit issued by the Vermont Department of Environmental Conservation ("DEC") on December 2012 through General Permit 3-9014 ("MS4 Permit"), as these requirements may be continued, renewed, amended, or otherwise modified during the term of this Agreement.

1. **Prior Agreements** – Effective July 1, 2017, this Agreement

    a. supersedes an MOU signed by the CCRPC and twelve MS4 permittees, effective March 10, 2013 through March 9, 2018, governing the operation of a Regional Stormwater Education Program to satisfy the relevant requirements of Minimum Control Measure One (Public Outreach and Education), and

    b. supersedes an MOU signed by the CCRPC and eleven MS4 permittees, effective July 1, 2011 through June 30, 2016, and an amendment to this MOU extending its effective date through June 30, 2017, governing the operation of a Regional Stormwater Public Involvement and Participation Program to satisfy the relevant requirements of Minimum Control Measure Two (Public Involvement and Participation).

2. **Service Agreement** – This Agreement constitutes a service agreement pursuant to 24 V.S.A. § 4345b (Intermunicipal Service Agreements).

3. **Definitions**—For purposes of this Agreement, the term "MS4 Permittees" includes the Vermont Agency of Transportation, which on December 28, 2016 became eligible for coverage under General Permit 3-9007 for Stormwater Discharges from the State Transportation Separate Storm Sewer System (TS4).

4. **Parties** – The following are the parties to this Agreement:

    a. **MS4 Permittees** – the undersigned MS4 Permittees, and

    b. **CCRPC** – the undersigned regional planning commission.

5. **MS4 Steering Committee**

    a. **Composition** – The Members of the Steering Committee shall consist of one representative from each of the signatory MS4 Permittees to this Agreement. Another MS4 permittee may request

to join this Agreement if approved by a two-thirds vote of the Members. The Members shall be appointed either by the governing bodies of their municipalities at publicly warned meetings or, if a Member representing an MS4 Permittee is non-municipal agency, via a process consistent with that agency's policies. At its first meeting, the Steering Committee shall elect a Chair by a majority vote. The Chair shall serve until such time as the Chair resigns or the Steering Committee elects a new Chair.

b. **Duties** – The Steering Committee shall direct the CCRPC on the development and performance of Program Services in particular and on all other matters bearing on the administration of this Agreement. All actions of the Steering Committee shall be by majority vote unless otherwise specified in this Agreement.

c. **Organization of Meetings** – The Steering Committee shall meet on a quarterly basis at a minimum. The CCRPC shall provide Steering Committee Members with reasonable notice of meetings. Notice shall include a meeting agenda and draft meeting minutes. In addition, the CCRPC shall post notice of Steering Committee meetings on its website and on the Program website.

6. **CCRPC**

a. **Duties** – The CCRPC shall:

1) Administer this Agreement and agreements with contractors (including executing contracts approved by the Steering Committee, receiving and disbursing funds, and monitoring the provision of services) for the benefit of the MS4 Permittees.

2) Provide other services contributing to the operation of the Program (including, but not limited to, social media management, public relations, grant writing, creating and managing a Program website, organizing meetings as set forth in Section 4.c, above, etc.) as directed by the Steering Committee; and at a level consistent with each year's Program Budget as described in Section 8.b, below.

3) Provide a quarterly budget report to the Steering Committee detailing expenses the CCRPC incurred and the payments it has received.

4) Pay contractors and vendors for charges consistent with the relevant contract, using funds from the Program Budget, as defined in Section 8, below.

5) Upon approval of the Steering Committee or its designee, reimburse itself for personnel and other expenses for charges consistent with its duties, using funds from the Program Budget.

6) Consult with the Steering Committee prior to authorizing any contractor activities or charges outside the scope of work of a contract.

7) Notify the Steering Committee when 75% of the annual budget (as defined in Section 8, below) for an individual category of expenses (e.g., contractors, CCRPC fees, advertising, etc.) is reached. When these levels are reached, subsequent expenditures by the CCRPC in that category shall be reviewed and approved by the Steering Committee Chair in advance.

8) At the request of the Steering Committee, assign any or all contracts that the CCRPC has entered into pursuant to this Agreement to the MS4 Permittees who are signatories to this Agreement at the time or to another contractor of the Steering Committee's choosing.

9) Comply with all applicable federal, state, and local laws, including Burlington's Livable Wage Ordinance as applicable.

b. **Compensation** – Through the Program Budget, the MS4 Permittees shall compensate the CCRPC for the actual costs of performing its duties defined in Section 5.a, above; provided, however, that the CCRPC shall not be entitled to compensation that would exceed ten percent (10%) of the Program Budget as specified in Section 8.b, below, without the prior approval of a majority of the Steering Committee.

c. **Invoices** – The CCRPC shall invoice the Program to cover personnel charges, mileage reimbursement, and other direct expenses necessary to perform its duties. Personnel charges for CCRPC staff shall be calculated at a rate of salary plus fringe plus CCRPC's applicable indirect rate as required by 24 V.S.A. § 4345b. As set forth in Section 5.b, above, upon approval of the Steering Committee or its designee, the CCRPC may reimburse itself for charges consistent with its duties, using funds from the Program Budget.

7. **Selection of Contractors**

a. The CCRPC, in consultation with the Steering Committee, shall competitively bid for contract(s) for Program services that collectively satisfy the requirements for Minimum Control Measure One (Public Outreach and Education) and Minimum Control Measure Two (Public Involvement and Participation) of the Phase II NPDES Permit then in effect. The parties to the contracts shall be the contractors and the CCRPC. All contracts shall require the contractor to indemnify and hold harmless the MS4 Permittees from any claims related to the contract and to procure and maintain liability insurance for all services performed under the contract.

b. All contracts shall be awarded based on qualifications, price, and the ability of the entity to provide services that meet the relevant MS4 Permit requirements. The selection of contractors shall comply with the procurement policy of the CCRPC and with applicable state and federal procurement laws and procedures.

c. Contracts shall generally be 1 to 5 years in length and shall include, but not be limited to, a Maximum Limiting Amount and the right of the CCRPC to 1) cancel a contract if services are not being adequately provided, 2) specify that payments to contractors shall be made only for services rendered, 3) specify the annual scope of work and budget as approved by the Steering Committee, 4) allow a contract extension if desired, and 5) assign the contract to the MS4 Permittees that are signatories to this Agreement at the time of the assignment or to a contractor of the Steering Committee's choosing.

d. Contracting for services under this Agreement shall comply with the Fair Employment Act and Americans with Disabilities Act: the CCRPC shall comply with the requirement of Title 21 V.S.A Chapter 5, Subchapter 6, relating to fair employment practices, to the full extent applicable. The CCRPC shall also ensure, to the full extent required by the Americans with Disabilities Act of

1990, that qualified individuals with disabilities receive equitable access to the services, programs, and activities provided by the Steering Committee under this Agreement. This provision shall also be included in all contracts and subcontracts executed under this Agreement.

e. The CCRPC and the Steering Committee recognize the important contribution and vital impact which small businesses have on the State's economy. In this regard, the CCRPC shall ensure a free and open bidding process that affords all businesses equal access and opportunity to compete, except under circumstances where competitive bidding may not be practicable and is not required by applicable procurement policies. The CCRPC and the Steering Committee also recognize the existence of businesses owned by minorities and women, and the CCRPC shall make a good faith effort to encourage these firms to compete for contracts involving state or federal funds and comply with applicable law relating to civil rights and disadvantaged business enterprises.

8. **Program Services** – The Steering Committee, assisted by the CCRPC and its contractors, shall implement a unified Program that satisfies the relevant requirements of Minimum Control Measure One (Public Education and Outreach) and Minimum Control Measure Two (Public Involvement and Participation) of the MS4 Permit.

   The Program Content for each Program Year shall be as defined in writing by a majority of the Steering Committee. The Program Year shall be the State of Vermont's fiscal year. The Program Content shall implement the following deliverables:

   a. **Public Education and Outreach** – Elements shall include, at a minimum:

      1) operating the Program's website, www.smartwaterways.org, or its equivalent; and

      2) advertising in various media.

   b. **Public Involvement and Participation** – Elements shall include, at a minimum:

      1) operating the Program's website, www.ccstreamteam.org, or its equivalent;

      2) hosting and/or organizing workshops, projects, and other events to engage the public; and

      3) recruiting volunteers to support projects, promote events, and/or engage the public.

   c. **End of MS4 permit year annual reporting** – Elements shall include preparation of a narrative report 25 business days prior to the MS4 Permittees' reporting deadline to DEC.

9. **Program Dues, Budget, Costs, and Payments**

   a. **Dues**

      1) For State Fiscal Year, FY18, July 2017-June 2018, the annual dues for each of the undersigned MS4 Permittees shall be $5,500.

2) For the following fiscal years, the annual dues shall be set by a two-thirds majority by October 15th of the preceding calendar year. In the absence of agreement, the dues shall remain at $5,500.

3) The CCRPC shall invoice each MS4 Permittee on or about July 1st of each year with payment to the CCRPC due 30 days later.

4) All Members shall pay equal dues.

b. **Program Budget**

1) The annual Program Budget shall consist of the sum of the annual payments for each Program Year made by MS4 Permittees, plus any funds from other sources made available to the Program by majority vote of the Steering Committee.

2) Prior to the start of each Program Year, the Steering Committee shall adopt a Program Budget governing expenditures for the subsequent Program Year. Budget categories shall include, but not be limited to: CCRPC Duties, Contractual Services, and Expenses.

3) Once the Program Year starts, a majority of the Steering Committee may amend the Program Budget as needed, for example to reflect any surplus or deficits from the prior Program Year, receipt of new sources of funds, or a desired change in the Program Budget, subject to Section 8.a, above.

4) In the event that costs are less than anticipated or that grants or other funding sources become available, a majority of the voting Members of the Steering Committee may decide to reduce each Member's payment by an equal amount or to credit all or part of the following Program Year assessment to each MS4 Permittee.

c. **Maximum Annual Costs and Payments** – Except as otherwise provided by this section, each MS4 Permittee shall within 30 days of receipt of an invoice make a single annual dues payment, as provided by Section 8.a, above.

d. **Other Funds** – Any funds made available to the Program shall be dedicated to reducing the annual costs of each MS4 Permittee participating in the Program, except as a majority of the voting Members of the Steering Committee may decide.

e. **Excess Funds** – Any funds remaining at the end of a Program Year shall be carried over to the next Program Year, unless a majority of the voting Members of the Steering Committee decides otherwise.

f. **Non-appropriation** – The obligations of each MS4 Permittee to make payments under this Agreement shall constitute a current expense of the MS4 Permittee and shall not in any way be construed to be a debt of the MS4 Permittee in contravention of any applicable constitutional or statutory limitation or requirement, or the MS4 Permittee's charter or articles of incorporation; nor shall anything contained in this Agreement constitute a pledge of the credit or tax revenues, funds, or monies of the MS4 Permittee. The decision whether or not to budget and appropriate funds during each fiscal year of the MS4 Permittee is within the discretion of the governing body

of the MS4 Permittee. The obligations of a MS4 Permittee under the Agreement are subject to annual appropriations by the governing body of the MS4 Permittee, except as provided by Section 12 of this Agreement. An MS4 Permittee cannot choose to not appropriate funds and then withdraw in a manner that shifts prior contractual obligations on to the others. Non-appropriation will be considered withdrawal and must be prospective in fairness to all signatories as per Section 13.

10. **Contract Approval** – All CCRPC contracts shall be conditioned upon approval by a majority of the voting Members of the Steering Committee and shall be consistent with Section 6, above.

11. **Termination of CCRPC** – The CCRPC on its own or the Steering Committee by a majority vote of its full Membership may elect to terminate the CCRPC's future participation in this Agreement by providing 90 days' written notice to the other. In the event of termination under this section, the CCRPC shall continue to administer and comply with each existing contract, and the MS4 Permittees shall continue to reimburse the CCRPC from the Program Budget for the actual costs of administering and complying with each contract, as provided by this Agreement, unless and until the CCRPC assigns the contract pursuant to Sections 5.a.8 and 6.c of this Agreement.

12. **Termination of Agreement**

    a. This Agreement shall become null and void with no further obligation of the parties if:

        1) Two-thirds of the Members of the Steering Committee vote to end participation, or

        2) DEC determines that the Program outlined in this Agreement does not meet the relevant requirements for Minimum Control Measure One (Public Education and Outreach) or Minimum Control Measure Two (Public Involvement and Participation), and the parties to this Agreement are unable to craft a Program to satisfy DEC.

    b. In the event of termination, any funds remaining in the Program Budget (after payment of obligations to vendors or to satisfy debts) shall be reimbursed to the MS4 Permittees with each MS4 Permittee receiving a share proportional to the number of MS4 Permittees at the time of termination. For example, if there are twelve MS4 Permittees at the time of termination, each MS4 Permittee shall receive a 1/12th share.

13. **Withdrawal of Member** – An MS4 Permittee may withdrawal from participation in this Agreement only at the end of a state fiscal year. If an MS4 Permittee wishes to withdrawal from participation, it shall provide at least 90 days' notice to the other MS4 Permittees and the CCRPC. After withdrawal, a MS4 Permittee shall remain responsible for its share of the costs of contracts that the Steering Committee approved prior to the effective date of the withdrawal.

14. **Effective Date and Duration of Agreement** – The effective date of this Agreement shall be July 1, 2017, and this Agreement shall terminate June 30, 2022.

15. **Amendment** – This Agreement may be amended only upon unanimous action of all the Members.

16. **Counterparts** – This Agreement may be executed in multiple counterparts, each of which is deemed an original and all of which constitute one and the same document. Each such counterpart may be a facsimile or PDF copy, and such facsimile or PDF copy shall be deemed an original.

17. **Public Records** – Any and all records submitted to the CCRPC or MS4 Permittees - including Bids, Proposals, Qualifications, Contracts, etc.-- whether electronic, paper, or otherwise recorded, are subject to the Vermont Public Records Act.

Signature of CCRPC

Christopher D. Roy, Board Chair, Chittenden County Regional Planning Commission — Date: 5/24/18

Signatures of Members

Name	Title	The Burlington International Airport	Date
Name	Title	The City of Burlington	Date
Name	Title	The Town of Colchester	Date
Name	Title	The Town of Essex	Date
Name	Title	The Village of Essex Junction	Date
Name	Title	The Town of Milton	Date

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Signature of CCRPC

Christopher D. Roy, Board Chair, Chittenden County Regional Planning Commission Date

Signatures of Members

Name Title Director of Aviation The Burlington International Airport 3-28-18 Date

Name Title The City of Burlington Date

Name Title The Town of Colchester Date

Name Title The Town of Essex Date

Name Title The Village of Essex Junction Date

Name Title The Town of Milton Date

14. **Effective Date and Duration of Agreement** – The effective date of this **Agreement** shall be July 1, 2017, and this **Agreement** shall **terminate** June 30, 2022.

15. **Amendment** – This **Agreement** may be **amended** only upon unanimous action of all the Members.

16. **Counterparts** – This **Agreement** may be **executed** in multiple **counterparts**, each of which is deemed an original and all of which **constitute** one and the same **document**. Each such **counterpart** may be a **facsimile** or PDF copy, and such **facsimile** or PDF copy shall be **deemed** an **original**.

17. **Public Records** – Any and all **records submitted** to the CCRPC or **MS4** Permittees - **including** Bids, **Proposals, Qualifications, Contracts,** etc.-- **whether** electronic, paper, or **otherwise recorded,** are **subject** to the Vermont Public **Records** Act.

Signature of CCRPC

_____ _____

Christopher D. Roy, Board Chair, **Chittenden County Regional** Planning **Commission** Date

Signatures of Members

_____ _____

Name Title The Burlington **International Airport** Date

S. Chapin Spencer - Director _____ 4/9/18

Name Title The City of **Burlington** Date

_____ _____

Name Title The Town of **Colchester** Date

_____ _____

Name Title The Town of Essex Date

_____ _____

Name Title The **Village** of Essex **Junction** Date

_____ _____

Name **Title** The Town of **Milton** Date

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Signature of CCRPC

_____ _____

Christopher D. Roy, Board Chair, Chittenden County Regional Planning Commission Date

Signatures of Members

_____ _____

Name Title The Burlington International Airport Date

_____ _____

Name Title The City of Burlington Date

Jacob H. Jancis Town Manager Town of Colchester 3/27/18

Name Title The Town of Colchester Date

_____ _____

Name Title The Town of Essex Date

_____ _____

Name Title The Village of Essex Junction Date

_____ _____

Name Title The Town of Milton Date

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Signature of CCRPC

_____ _____

Christopher D. Roy, Board Chair, Chittenden County Regional Planning Commission Date

Signatures of Members

_____ _____

Name Title The Burlington International Airport Date

_____ _____

Name Title The City of Burlington Date

_____ _____

Name Title The Town of Colchester Date

Public Works Director 4-11-18

Name Title The Town of Essex Date

_____ _____

Name Title The Village of Essex Junction Date

_____ _____

Name Title The Town of Milton Date

14. **Effective Date and Duration of Agreement** – The effective date of this Agreement shall be July 1, 2017, and this Agreement shall terminate June 30, 2022.

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Signature of CCRPC

_____ _____

Christopher D. Roy, Board Chair, Chittenden County Regional Planning Commission Date

Signatures of Members

_____ _____

Name Title The Burlington International Airport Date

_____ _____

Name Title The City of Burlington Date

_____ _____

Name Title The Town of Colchester Date

_____ _____

Name Title The Town of Essex Date

James [illegible] Water Quality Supt 4/13/2018

Name Title The Village of Essex Junction Date

_____ _____

Name Title The Town of Milton Date

14. **Effective Date and Duration of Agreement** – The effective date of this Agreement shall be July 1, 2017, and this Agreement shall terminate June 30, 2022.

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Signature of CCRPC

_____ _____

Christopher D. Roy, Board Chair, Chittenden County Regional Planning Commission Date

Signatures of Members

_____ _____

Name Title The Burlington International Airport Date

_____ _____

Name Title The City of Burlington Date

_____ _____

Name Title The Town of Colchester Date

_____ _____

Name Title The Town of Essex Date

_____ _____

Name Title The Village of Essex Junction Date

Town Manager 5/8/18

Name Title The Town of Milton Date

Joe Colangelo	Town Manager	The Town of Shelburne	6-March-2018
Name	Title	The City of South Burlington	Date
Name	Title	Vermont Agency of Transportation	Date
Name	Title	The University of Vermont	Date
Name	Title	The Town of Williston	Date
Name	Title	The City of Winooski	Date

Name	Title		Date
		The Town of Shelburne	
Helen Riehle	Chair		4/2/18
Name	Title	The City of South Burlington	Date
Name	Title	Vermont Agency of Transportation	Date
Name	Title	The University of Vermont	Date
Name	Title	The Town of Williston	Date
Name	Title	The City of Winooski	Date

Name	Title	The Town of Shelburne	Date
Name	Title	The City of South Burlington	Date
Joe Flynn		e-Signed by Joe Flynn on 2018-04-02 12:47:56 GMT	April 02, 2018
Name	Title	Vermont Agency of Transportation	Date
Name	Title	The University of Vermont	Date
Name	Title	The Town of Williston	Date
Name	Title	The City of Winooski	Date

Name	Title	The Town of Shelburne	Date
Name	Title	The City of South Burlington	Date
Name	Title	Vermont Agency of Transportation	Date
Linda Seavey			3/28/2018
Linda Seavey, Director, Campus Planning Services		The University of Vermont	Date
Name	Title	The Town of Williston	Date
Name	Title	The City of Winooski	Date

Name	Title	The Town of Shelburne	Date
Name	Title	The City of South Burlington	Date
Name	Title	Vermont Agency of Transportation	Date
Name	Title	The University of Vermont	Date
Richard McGuire	Town Manager	The Town of Williston	3/21/18
Name	Title	The City of Winooski	Date

Name	Title	The Town of Shelburne	Date
Name	Title	The City of South Burlington	Date
Name	Title	Vermont Agency of Transportation	Date
Name	Title	The University of Vermont	Date
Name	Title	The Town of Williston	Date
Jessie Baker - City Manager	City Manager	The City of Winooski	3/23/18 Date

Appendix C – Ordinance Regulating the Use of Public and Private Stormwater Systems

SHELBURNE TOWN CLERK'S OFFICE
8/10 2006
RECEIVED FOR RECORD 8 O'CLOCK 30 MINUTES
A M., AND RECORDED IN BOOK 1 PAGE 30 (1-13)
OF SHELBURNE Ordinance RECORDS
ATTEST Colleen T Hall CLERK

Vol. 1
Page 30-1

TOWN of SHELBURNE, VERMONT

The Selectboard of the Town of Shelburne hereby ordains:

STORMWATER DISCHARGE ORDINANCE

SECTION 1. AUTHORITY.

This ordinance is adopted pursuant to 24 V.S.A. §3617 and Section 1.4(3) of the Town of Shelburne Charter. It shall be a civil ordinance within the meaning of 24 V.S.A. Chapter 59.

SECTION 2. PURPOSE.

The purpose of this ordinance is to provide for the health, safety, and general welfare of the citizens of the Town of Shelburne, Vermont through the regulation of non-storm water discharges to the storm drainage system to the maximum extent practicable as required by federal and state law. This ordinance establishes methods for controlling the introduction of pollutants into the storm drainage system in order to comply with requirements of the National Pollutant Discharge Elimination System (NPDES) permit process. The objectives of this ordinance are:

(1) To regulate the contribution of pollutants to the storm drainage system by storm water discharges by any user.
(2) To prohibit illicit connections and discharges to the storm drainage system.
(3) To establish legal authority to carry out all inspection, surveillance, monitoring, and enforcement procedures necessary to ensure compliance with this ordinance.

SECTION 3. APPLICABILITY.

This ordinance shall apply to all water entering the storm drain system generated on any developed and undeveloped lands unless explicitly exempted by the Town.

SECTION 4. DEFINITIONS.

For the purposes of this ordinance, the following shall mean

Authorized Enforcement Agency. Employees or designees of the Shelburne Department of Public Works are designated to enforce this ordinance.

Best Management Practices (BMPs). Schedules of activities, prohibitions of practices, general good house keeping practices, pollution prevention and educational practices, maintenance procedures, and other management practices to prevent or reduce the discharge of pollutants directly or indirectly to storm water, receiving waters, or storm water conveyance systems. BMPs also include treatment practices, operating procedures, and practices to control site runoff, spillage or leaks, sludge or water disposal, or drainage from raw materials storage.

Clean Water Act. The federal Water Pollution Control Act (33 U.S.C. § 1251 et seq.), and any subsequent amendments thereto.

Construction Activity. Activities subject to National Pollution Discharge Elimination System (NPDES) Construction Permits. These include construction projects resulting in land disturbance of one acre or more. Such activities include but are not limited to clearing and grubbing, grading, excavating, and demolition.

Direct Discharge. Any discharge that flows directly into the storm water system by means of a connected pipe.

Hazardous Materials. Any material, including any substance, waste, or combination thereof, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may cause, or significantly contribute to, a substantial present or potential hazard to human health, safety, property, or the environment when improperly treated, stored, transported, disposed of, or otherwise managed.

Illegal Discharge. Any direct or indirect non-storm water discharge to the storm drain system, except as exempted in Section 5 of this ordinance.

Illicit Connections. An illicit connection is defined as either of the following:

(1) Any drain or conveyance, whether on the surface or subsurface that allows an illegal discharge to enter the storm drain system including but not limited to any conveyances that allow any non-storm water discharge including sewage, process wastewater, and wash water to enter the storm drain system and any connections to the storm drain system from indoor drains and sinks, regardless of whether said drain or connection had been previously allowed, permitted, or approved by an authorized enforcement agency or,

(2) Any drain or conveyance connected from a commercial or industrial land use to the storm drain system that has not been documented in plans, maps, or equivalent records and approved by an authorized enforcement agency.

Indirect Discharge. Any discharge to the storm water system that first flows outside of the system and may enter the system through the process of

infiltration or through a drainage structure.

Industrial Activity. Activities subject to NPDES Industrial Storm Water Permits as defined in 40 CFR, Section 122.26 (b)(14).

National Pollutant Discharge Elimination System (NPDES) Storm Water Discharge Permit. means a permit issued by EPA (or by a State under authority delegated pursuant to 33 USC § 1342(b)) that authorizes the discharge of pollutants to waters of the United States, whether the permit is applicable on an individual, group, or general area-wide basis.

Non-Storm Water Discharge. Any discharge to the storm drain system that is not composed entirely of storm water.

Person. Any individual, association, organization, partnership, firm, corporation or other entity recognized by law and acting as either the owner or as the owner's agent.

Pollutant. Anything which causes or contributes to pollution. Pollutants may include, but are not limited to: paints, varnishes, and solvents; oil and other automotive fluids; non-hazardous liquid and solid wastes and yard wastes; refuse, rubbish, garbage, litter, or other discarded or abandoned objects, ordinances, and accumulations, so that same may cause or contribute to pollution; floatables; pesticides, herbicides, and fertilizers; hazardous substances and wastes; sewage, fecal coliform and pathogens; dissolved and particulate metals; animal wastes; wastes and residues that result from constructing a building or structure; and noxious or offensive matter of any kind.

Premises. Any building, lot, parcel of land, or portion of land whether improved or unimproved, including adjacent sidewalks and parking strips.

Storm Drainage System. Publicly-owned facilities by which storm water is collected and/or conveyed, including but not limited to any roads with drainage systems, municipal streets, gutters, curbs, inlets, piped storm drains, pumping facilities, retention and detention basins, natural and human-made or altered drainage channels, reservoirs, and other drainage structures.

Storm Water. Any surface flow, runoff, and drainage consisting entirely of water from any form of natural precipitation, and resulting from such precipitation.

Storm Water Management Plan. A document which describes the Best Management Practices and activities to be implemented by a person or business to identify sources of pollution or contamination at a site and the actions to eliminate or reduce pollutant discharges to storm water, storm water conveyance systems, and/or receiving waters to the maximum extent practicable.

Wastewater. Any water or other liquid, other than uncontaminated storm water, discharged from a facility.

Watercourse. Any perennial, intermittent or ephemeral stream, and any natural or human-made channel that carries storm water to any perennial, intermittent or ephemeral stream or the storm drainage system.

SECTION 5. DISCHARGE PROHIBITIONS.

5.1. Prohibition of Illegal Discharges.

No person shall discharge, cause to be discharged, or allow others under its control to discharge into the storm drainage system any pollutants or waters containing any pollutants, other than storm water. Nor shall any person fail to install or maintain on any property storm water management improvements or utilize any BMPs that are required pursuant to any land use permit issued by the Town of Shelburne. The commencement, conduct or continuance of any illegal discharge to the storm drain system is prohibited except as described as follows:

(1) The following discharges are exempt from discharge prohibitions established by this ordinance, unless the discharge results in a direct discharge and the discharge is identified as containing pollutants or chemicals that are required to be controlled by state or federal regulation:
   (a) water line flushing,
   (b) landscape irrigation or lawn watering,
   (c) diverted stream flows,
   (d) rising ground waters,
   (e) uncontaminated ground water infiltration,
   (f) uncontaminated pumped ground water,
   (g) discharges from potable water sources,
   (h) foundation drains,
   (i) air conditioning condensation,
   (j) uncontaminated irrigation water,
   (k) uncontaminated springs,
   (l) water from sump pumps,
   (m) footing drains,
   (n) individual residential (non-commercial) car washing,
   (o) flows from riparian habitats and wetlands,
   (p) dechlorinated swimming pool discharges, and
   (q) street wash water.

(2) Discharges or flow from firefighting, and other discharges specified in writing by the Shelburne Selectboard as being necessary to protect public health and safety.

(3) Discharges associated with dye testing, however this activity requires a verbal notification to the Department of Public Works prior to the time of the test.

(4) The prohibition shall not apply to any non-storm water discharge

permitted under an NPDES permit, waiver, or waste discharge order issued to the discharger and administered under the authority of the United States Environmental Protection Agency (EPA), provided that the discharger is in full compliance with all requirements of the permit, waiver, or order and other applicable laws and regulations, and provided that written approval has been granted by the Department of Public Works for any discharge to the storm drain system.

5.2. Prohibition of Illicit Connections.

(1) The construction, use, maintenance or continued existence of illicit connections to the storm drain system is prohibited.

(2) This prohibition expressly includes, without limitation, illicit connections made in the past, regardless of whether the connection was permissible under law or practices applicable or prevailing at the time of connection.

5.3. Waste Disposal Prohibitions

No person shall throw, deposit, leave, maintain, keep, or permit to be thrown, deposited, left, or maintained, in or upon any public or private property, driveway, parking area, street, alley, sidewalk, component of the storm drain system, or water of the U.S., any refuse, rubbish, garbage, litter, or other discarded or abandoned objects, articles, and accumulations, so that the same may cause or contribute to pollution. Wastes deposited in streets in proper waste receptacles for the purposes of collection are exempted from this prohibition.

5.4. Industrial and Construction Activity Discharges

(1) Any person subject to an industrial or construction activity NPDES storm water discharge permit shall comply with all provisions of such permit. Proof of compliance with said permit may be required in a form acceptable to the Director of Planning prior to the allowing of discharges to the storm drainage system.

(2) The operator of a facility, including construction sites, required to have an NPDES permit to discharge storm water associated with industrial activity shall submit a copy of the Notice of Intent (NOI) to the Director of Planning at the same time the operator submits the original Notice of Intent to the EPA as applicable.

(3) The copy of the Notice of Intent may be delivered to the Director of Planning either in person or by mailing it to:

Notice of Intent to Discharge Storm Water
Director of Planning
P.O. Box 88
5420 Shelburne Road
Shelburne, VT 05482

(4) A person commits an offense if the person operates a facility that is discharging storm water associated with industrial activity without having submitted a copy of the Notice of Intent to do so to the Director

of Planning.

SECTION 6. STORMWATER MANAGEMENT REQUIREMENTS

6.1 Best Management Practices

The Director of Public Works will adopt requirements identifying Best Management Practices for any activity, operation, or facility which may cause or contribute to pollution or contamination of storm water, the storm drain system, or waters of the United States. The owner or operator of such activity, operation, or facility shall provide, at their own expense, reasonable protection from accidental discharge of prohibited materials or other wastes into the municipal storm drain system or watercourses through the use of these structural and non-structural BMPs. Further, any person responsible for a property or premise that is, or may be, the source of an illicit discharge, may be required to implement, at said person's expense, additional structural and non-structural BMPs to prevent the further discharge of pollutants to the storm drainage system. Compliance with all terms and conditions of a valid NPDES permit authorizing the discharge of storm water associated with industrial activity, to the extent practicable, shall be deemed compliance with the provisions of this section. These BMPs shall be part of a storm water management plan (SWMP) as necessary for compliance with requirements of the NPDES permit.

6.2 Watercourse Protection

Every Person owning property through which a water course passes, or such person's lessee, shall not dump or dispose of trash, debris or other obstacles that would pollute, contaminate or significantly retard the flow of water through the watercourse . In addition, the owner or lessee shall maintain existing privately owned structures within or adjacent to a watercourse, so that such structures will not become a hazard to the use, function, or physical integrity of the watercourse. Riparian Buffers established as part of the development and required by Town regulations shall be maintained by the developer and all other subsequent property owners or associations within the development.

6.3 Notification of Spills

Notwithstanding other requirements of law, as soon as any person responsible for a facility or operation, or responsible for emergency response for a facility or operation has information of any known or suspected release of materials which are resulting or may result in illegal discharges or pollutants discharging into storm water, the storm drain system, or waters of the United States, said person shall take all necessary steps to ensure the discovery, containment, and cleanup of such release. In the event of such a release of hazardous materials said person shall immediately notify emergency response agencies of the occurrence via emergency dispatch services. In the event of a release of non-hazardous materials, said person shall notify the Director of Public Works in person or by phone or facsimile no later than the next business day. Notifications in person or

by phone shall be confirmed by written notice addressed and mailed to the Director of Public Works within 3 business days of the phone notice. If the discharge of prohibited materials emanates from a commercial or industrial establishment, the owner or operator of such establishment shall also retain an on-site written record of the discharge and the actions taken to prevent its recurrence. Such records shall be retained for at least 3 years. Failure to provide notification of a release as provided above is a violation of this ordinance.

6.4 Undocumented Discharges or Connections
Any drain or conveyance that has not been documented in plans, maps or equivalent, and which may be connected to the storm sewer system, shall be located by the owner or occupant of that property upon receipt of written notice of violation from the Town requiring that such locating be completed. Such notice will specify a reasonable time period within which the location of the drain or conveyance is to be determined, that the drain or conveyance be identified as storm sewer, sanitary sewer or other, and that the outfall location or point of connection to the storm sewer system, sanitary sewer system or other discharge point be identified. Results of these investigations are to be documented and provided to the Director of Public Works.

6.5 Elimination of Illegal Discharges
The Public Works Director may require by written notice that a person responsible for an illegal discharge immediately, or by a specified date, discontinue the discharge and, if necessary, take measures to eliminate the source of the discharge to prevent the occurrence of future illegal discharges.

6.6 Elimination of Illicit Connections
The Public Works Director may require by written notice that a person responsible for an illicit connection to the storm drain system comply with the requirements of this Ordinance to eliminate or secure approval for the connection by a specified date, regardless of whether or not the connection or discharges to it had been established or approved prior to the effective date of this Ordinance.

SECTION 7. COMPLIANCE MONITORING

7.1. Right of Entry: Inspection and Sampling.
The Director of Public Works, or other authorized representatives, shall be permitted to enter and inspect facilities subject to regulation under this ordinance as often as may be necessary to determine compliance with this ordinance.

(1) If a discharger has security measures in force which require proper identification and clearance before entry into its premises, the discharger shall make the necessary arrangements to allow access to representatives of the Town.
(2) Facility operators shall allow the Town ready access to all parts of the premises for the purposes of inspection, sampling, examination and copying of records that must be kept under the conditions of an

NPDES permit to discharge storm water, and the performance of any additional duties as defined by state and federal law.

(3) The Town shall have the right to set up on any permitted facility such devices as are necessary in the opinion of the Town to conduct monitoring and/or sampling of the facility's storm water discharge.

(4) The Town has the right to require the discharger to install monitoring equipment as necessary. The facility's sampling and monitoring equipment shall be maintained at all times in a safe and proper operating condition by the discharger at its own expense. All devices used to measure storm water flow and quality shall be calibrated to ensure their accuracy.

(5) Any temporary or permanent obstruction to safe and easy access to the facility to be inspected and/or sampled shall be promptly removed by the operator at the written or oral request of the Town and shall not be replaced. The costs of clearing such access shall be borne by the operator.

(6) Unreasonable delays in allowing the Town access to a permitted facility is a violation of a storm water discharge permit and of this ordinance. A person who is the operator of a facility with an NPDES permit to discharge storm water associated with industrial activity commits an offense if the person denies the Town reasonable access to the permitted facility for the purpose of conducting any activity authorized or required by this ordinance.

7.2. Search Warrants.

If the Town has been refused access to any part of the premises from which storm water is discharged, and he/she is able to demonstrate probable cause to believe that there may be a violation of this ordinance, or that there is a need to inspect and/or sample as part of a routine inspection and sampling program designed to verify compliance with this ordinance or any order issued hereunder, or to protect the overall public health, safety, and welfare of the community, then the Town may seek issuance of a search warrant from any court of competent jurisdiction.

SECTION 8. ULTIMATE RESPONSIBILITY.

The standards set forth herein and promulgated pursuant to this ordinance are minimum standards; therefore this ordinance does not intend or imply that compliance by any person will ensure that there will be no contamination, pollution, or unauthorized discharge of pollutants.

SECTION 9. RESPONSIBILITY FOR ADMINISTRATION.

The Department of Public Works shall administer, implement, and enforce the provisions of this ordinance. Any powers granted or duties imposed upon the Department of Public Works may be delegated in writing by the Director of Public

Works to persons or entities acting in the beneficial interest of or in the employ of the Town.

SECTION 10. VIOLATIONS, ENFORCEMENT, AND PENALTIES.

10.1. Violations.

It shall be unlawful for any person to violate any provision or fail to comply with any of the requirements of this ordinance. Any person who has violated or continues to violate the provisions of this ordinance, may be subject to the enforcement actions outlined in this section or may be restrained by injunction or otherwise abated in a manner provided by law. In the event the violation constitutes an immediate danger to public health or public safety, the Town is authorized to proceed in the manner provided for in Section 11.

10.2. Notice of Violation.

Whenever the Town finds that a person has violated a prohibition or failed to meet a requirement of this ordinance, the Town may order compliance by written Notice of Violation to the responsible person. The Notice of Violation shall contain:

(1) The name and address of the alleged violator;
(2) The address when available or a description of the building, structure or land upon which the violation is occurring, or has occurred;
(3) A statement specifying the nature of the violation;
(4) A description of the remedial measures necessary to restore compliance with this ordinance and a time schedule for the completion of such remedial action
(5) A statement of the penalty or penalties that shall or may be assessed against the person to whom the notice of violation is directed;
(6) A statement that the determination of violation may be appealed to the Selectboard by filing a written notice of appeal within seven (7) days of service of notice of violation; an
(7) A statement specifying that, should the violator fail to restore compliance within the established time schedule, the work will be done by a designated governmental agency or a contractor and the expense thereof shall be charged to the violator.

Such notice may require without limitation:

(1) The performance of monitoring, analyses, and reporting;
(2) The elimination of illicit connections or discharges;
(3) That violating discharges, practices, or operations shall cease and desist;
(4) The abatement or remediation of storm water pollution or contamination hazards and the restoration of any affected property;
(5) Payment of a fine to cover administrative and remediation costs; and
(6) The implementation of source control or treatment BMPs.

10.3. Issuance of Municipal Complaint
If the violation has not been corrected pursuant to the requirements set forth in the Notice of Violation within thirty [30] days of its issuance, then the Director of Public Works may, in addition to taking any other action to address the violation, issue a municipal complaint pursuant to 24 V.S.A. §1977.

10.4. Waiver
Any person who declines to contest a municipal complaint and, within ten (10) days of issuance of the complaint, takes those actions necessary to correct the violation may pay a waiver fee to the Town Clerk within fifteen (15) days of issuance of the complaint as follows:

First offense	$50
Second offense	$100
Third offense	$150
Fourth offense	$250
Fifth and subsequent offenses	$400

Offenses shall be counted on a calendar year basis.

10.5. Civil Fine for Ordinance Violation
Any person who fails to take the corrective action and pay the waiver fee provided for in Section 10.6 above shall be required to pay a civil fine in the amount set forth below :

First offense	$100
Second offense	$200
Third offense	$300
Fourth offense	$400
Fifth and subsequent offenses	$500

Offenses shall be counted on a calendar year basis.

10.6. Injunctive Relief
In addition to any other remedy available to the Town to obtain compliance with this Ordinance, the Town may commence any appropriate civil action to seek an injunction or other appropriate relief, including an order authorizing the Town to enter upon the subject private property, take any and all measures necessary to abate the violation and/or restore the property, and recover from the property owner the Town's costs in performing such work.

10.7. Compensatory Action.
In lieu of enforcement proceedings, penalties, and remedies authorized by this ordinance, the Town may impose upon a violator, alternative compensatory actions, such as storm drain stenciling, attendance at compliance workshops, creek cleanup, etc.

SECTION 11. EMERGENCY SITUATIONS AND SUSPENSION OF STORM DRAIN SYSTEM ACCESS

11.1. Emergency Cease and Desist Orders

When the Town finds that any person has violated, or continues to violate, any provision of this ordinance, or any order issued hereunder, or that the person's past violations are likely to recur, and that the person's violation(s) has (have) caused or contributed to an actual or threatened discharge to the Storm Drainage System or waters of the United States which reasonably appears to present an imminent or substantial endangerment to the health or welfare of persons or to the environment, the Town may issue an order to the violator directing it immediately to cease and desist all such violations and directing the violator to:

(1) Immediately comply with all ordinance requirements; and
(2) Take such appropriate preventive action as may be needed to properly address a continuing or threatened violation, including immediately halting operations and/or terminating the discharge.

Any person notified of an emergency order directed to it under this Subsection shall immediately comply and stop or eliminate its endangering discharge. In the event of a discharger's failure to immediately comply voluntarily with the emergency order, the Town may take such steps as deemed necessary to prevent or minimize harm to the storm drainage system or waters of the United States, and/or endangerment to persons or to the environment, including immediate termination of a facility's water supply, sewer connection, or other municipal utility services. The Town may allow the person to recommence its discharge when it has demonstrated to the satisfaction of the Director of Public Works that the period of endangerment has passed, unless further termination proceedings are initiated against the discharger under this ordinance. A person that is responsible, in whole or in part, for any discharge presenting imminent endangerment shall submit a detailed written statement, describing the causes of the harmful discharge and the measures taken to prevent any future occurrence, to the Director of Public Works within seven [7] days of receipt of the emergency order. Issuance of an emergency cease and desist order shall not be a bar against, or a prerequisite for, taking any other action against the violator.

11.2. Suspension due to Illicit Discharges in Emergency Situations

The Town may, without prior notice, suspend storm drainage system discharge access to a person when such suspension is necessary to stop an actual or threatened discharge which presents or may present imminent and substantial danger to the environment, or to the health or welfare of persons, or to the storm drainage system or waters of the United States. If the violator fails to comply with a suspension order issued in an emergency, the Town may take such steps as deemed necessary to prevent or minimize damage to the storm drainage system or waters of the United States, or to minimize danger to persons.

SECTION 12. VIOLATIONS DEEMED A PUBLIC NUISANCE.

In addition to the enforcement processes and penalties provided, any condition caused or permitted to exist in violation of any of the provisions of this ordinance is a threat to public health, safety, and welfare, and is declared and deemed a nuisance, and may be summarily abated or restored at the violator's expense, and/or a civil action to abate, enjoin, or otherwise compel the cessation of such nuisance may be taken.

SECTION 13. REMEDIES NOT EXCLUSIVE.

The remedies listed in this ordinance are not exclusive of any other remedies available under any applicable federal, state or local law and it is within the discretion of the Town to seek cumulative remedies. The Town may seek to recover all attorney's fees, court costs and other expenses associated with enforcement of this ordinance, including sampling and monitoring expenses.

SECTION 14. COMPATIBILITY WITH OTHER REGULATIONS.

This ordinance is not intended to modify or repeal any other ordinance, rule, regulation, or other provision of law. The requirements of this ordinance are in addition to the requirements of any other ordinance, rule, regulation, or other provision of law, and where any provision of this ordinance imposes restrictions different from those imposed by any other ordinance, rule, regulation, or other provision of law, whichever provision is more restrictive or imposes higher protective standards for human health or the environment, shall control.

SECTION 15. SEVERABILITY.

The provisions of this ordinance are hereby declared to be severable. If any provision, clause, sentence, or paragraph of this ordinance or the application thereof to any person, establishment, or circumstances shall be held invalid, such invalidity shall not affect the other provisions or application of this ordinance.

SECTION 16. EFFECTIVE DATE.

This ordinance shall be effective upon passage.

ADOPTED at Shelburne, Vermont this 8th day of August, 2006.

SHELBURNE SELECTBOARD

Chris Neme, Chairperson

Jim Talley

Chris Boyd

Bob Roesler

Jane Osborne McKnight

END OF DOCUMENT

Appendix D – Munroe Brook Flow Restoration Plan

MUNROE BROOK
FLOW RESTORATION PLAN

TCE# 14-042
Shelburne, Vermont

Date:
December 7, 2016
Revised: January 22, 2019

Prepared For:
Town of Shelburne

Prepared By:
Trudell Consulting Engineers
The Horsley Witten Group

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Sustainable Environmental Solutions
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1) EXECUTIVE SUMMARY

The State of Vermont (VT) Agency of Natural Resources (ANR) Department of Environmental Conservation (DEC) has issued a National Pollutant Discharge Elimination System (NPDES) General Permit 3-9014 (2012) for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems (MS4). The VT MS4 permit requires communities that drain to waters impaired by stormwater runoff to develop Flow Restoration Plans (FRPs) capable of meeting the targets established in approved stormwater Total Maximum Daily Load (TMDLs). The purpose of this FRP is to identify stormwater Best Management Practices (BMPs), including retrofits to existing BMPs, that will be implemented in order to meet the established TMDL targets for Munroe Brook.

This FRP meets the attainment goals defined in the Munroe Brook TMDL approved by the United States Environmental Protection Agency (EPA) on August 21, 2008. The attainment goals set forth in the TMDL are defined in terms of flow modification in the stream. The TMDL requires a 6.6% stream flow reduction in Munroe Brook during high flow events (Q0.3%) and recommends a 9.5% increase in stream flow during low flow (Q95%) conditions (Table 1).

Table 1: Summary of Stormwater TMDL Flow Targets for Munroe Brook

Scenario	High Flow Target Reduction (%)	Low Flow Target Increase (%)
2013 Conditions	6.2	9.5
2013 Conditions with future growth (20 impervious acres)	6.6[a]	9.5[b]
2013 Conditions + no Agriculture	4.8	7.4
Current + no Agriculture + future growth[c]	5.2	7.4

[a] TMDL flow reduction target of 6.6% (allocation of 4.8% from current urban/developed areas, 0.4% future development, and 1.6% agricultural areas)
[b] TMDL flow increase target of 9.5% (allocation of 7.4% from current urban/developed areas, 0 % future development, and 2.1% agricultural areas)
[c] Recommended TMDL targets for urban stormwater management only, 2003 conditions & no agriculture

In order to assess the impacts associated with construction of stormwater BMPs in the Munroe Brook watershed, VT DEC provided MS4 permittees with the Vermont Best Management Practice Decision Support System (VT BMP DSS) model. The BMP DSS model was created during the stormwater TMDL development process and is capable of estimating steam flow in Munroe Brook under current conditions. The model can also be modified to show the impact that new or retrofit stormwater BMPs will have on stream flow. Table 2 provides a summary of BMP DSS modeled stream flow in Munroe Brook for a number of model iterations.

Table 2: Summary of Munroe Brook Stream Flow Modeled at the Confluence of Lake Champlain

VT BMPDSS runs	Scenario Description	Area (acres)	Stream Flow (cfs)		% Flow Change from Base	
			High Q0.3	Low Q95	High Q0.3	Low Q95
ANR Original models	**Attainment flow ***		**73.4**	**1.2**		
	ANR Base (2002)	3,454	78.3	1.1	-	-
	ANR Credit (2013)	3,462	78.5	1.1	-0.3	-
Updated Models (1/8/15)	**Attainment flow****		**74.2**	**1.2**		
	Revised Base	3,454	78.5	1.10	-	-
	Revised Credit	3,484	80.5	1.10	+2.6	-
	Flow Restoration Scenario 7	3,484	74.1	1.10	-5.6	-

* Reflects 6.2% reduction of ANR Base Q0.3 flow and 9.5% increase of ANR Base Q95 Flow
** Reflects 5.2% reduction (Current + No Agriculture + Future Growth Scenario) reduction of Revised Base Q0.3 flow and 9.5% increase of Revised Base Q95 Flow

In order to determine the BMPs necessary to meet TMDL flow targets, the MS4 permittees worked with an engineering consultant to find opportunities in the watershed where existing BMPs could be improved or new BMPs could be installed. This was an iterative process. New BMPs were identified and added to the model until the BMP DSS model output indicated that the required high flow reduction target was achieved. This occurred in iteration 7 of the BMP DSS model run, also known as Flow Restoration Scenario 7 (FRS7).

The low flow target, which was included in the TMDL as a recommendation, was not met. Conditions within the watershed, in particular soil types, are not able to accommodate the infiltration based BMPs that would help meet the low flow target. Given that the TMDL requires the high flow target be met, but only recommends that the low flow target be achieved, this FRP has prioritized BMPs which help to meet the high flow target. This resulted in inclusion of detention based BMPs, which do not increase stream flow during low flow conditions.

The final BMP plan included in the Munroe Brook FRP includes 10 BMPs that are already in place and 20 new or retrofit BMPs. Construction of these BMPs has been scheduled so that work is completed before December 5, 2032, as require by the VT MS4 permit. It is estimated that construction of these BMPs will cost approximately $7.2M.

2) INTRODUCTION

Vermont DEC issued a revised NPDES General Permit 3-9014 for Stormwater Discharges from Small MS4's in 2012. The revised MS4 permit required communities that drain to waters impaired by stormwater runoff to develop FRPs capable of meeting the targets established in approved stormwater TMDLs.

The purpose of this FRP is to identify stormwater BMPs, including retrofits to existing BMPs, that will be implemented in order to meet the established TMDL targets for Munroe Brook. The ultimate goal of this FRP is to restore Munroe Brook so that it is removed from the State's list of impaired waters.

Munroe Brook is currently included on the Vermont 303(d) list of impaired waters. The source of impairment is identified as unmanaged stormwater runoff. MS4 permittees discharging to Munroe Brook are required to create a FRP for all stormwater impaired waters within their jurisdiction. The Munroe Brook impaired watershed is located almost entirely within the Town of Shelburne, with the exception of a small portion along the northern boundary that is located in the City of South Burlington. VTrans, which has been designated a Non-Traditional MS4, also has jurisdiction over portions of the drainage area along the U.S. Route 7 corridor.

VT DEC prepared, and the United States EPA approved, a stormwater TMDL for the Munroe Brook watershed in 2008. The *Total Maximum Daily Load to Address Biological Impairment in Munroe Brook* (September 2008) document includes an aggregate Waste Load Allocation (WLA), which applies to various watershed sources. No specific WLA was specified for MS4 sources. **The attainment goals set forth in the Munroe Brook TMDL are defined as stream flow targets. The TMDL requires a reduction in stream flow during high flow events (Q0.3%) and recommends an increase in stream flow during low flow (Q95%) conditions.**

3) WATERSHED MODELING

In order to assess the impacts associated with construction of stormwater BMPs in the watershed, Vermont DEC provided MS4 permittees with the VT BMP DSS model. The VT BMP DSS model was created during the TMDL development process and is capable of estimating steam flow under current conditions as well after stormwater BMPs are installed in the watershed.

BMPs were identified and incorporated into the VT BMP DSS watershed model in an iterative fashion. Identified BMPs were added to the VT BMP DSS model, which then

assessed the impact on stream flow. Potential BMPs were identified and included in the model over 7 iterations. The results of these BMP iterations are summarized in Table 3.

Additionally, drainage area information for existing BMPs was updated in the BMP DSS model. Review of the GIS mapping and field verification showed an increase in the overall watershed area of approximately 30 acres. This change resulted in a 2.6% increase in peak flow, as indicated in Table 3.

Table 3: Summary of BMP DSS Model Runs

VT BMPDSS runs	Scenario Description	Area (ac)	Flow (cfs)		% Flow Change from Base	
			High Q0.3	Low Q95	High Q0.3	Low Q95
ANR Original Model Runs	**Attainment flow ***		**73.4**	**1.2**		
	ANR Base (2002)	3,454	78.3	1.1	-	-
	ANR Credit (2013)	3,462	78.5	1.1	-0.3	-
Updated VT BMP DSS Model Runs	**Attainment flow****		**74.2**	**1.2**		
	Revised Base	3,454	78.5	1.08	-	-
	Revised Credit	3,484	80.5	1.08	+2.6	0
	FRS1	3,484	77.3	1.08	-1.5	0
	FRS2	3,484	77.5	1.08	-2.1	0
	FRS3	3,484	75.9	1.08	-3.4	0
	FRS4	3,484	74.7	1.08	-4.9	0
	FRS5	3,484	74.1	1.08	-5.7	0
	FRS6	3,484	74.2	1.08	-5.4	0
	FRS7	3,484	74.1	1.08	-5.6	0

* Reflects 6.2% reduction of ANR Base Q0.3 flow and 9.5% increase of ANR Base Q95 Flow
** Reflects 5.2% reduction (Current + No Agriculture + Future Growth Scenario) of Revised Base Q0.3 flow and 9.5% increase of Revised Base Q95 Flow

The BMPs included in the final BMP DSS model run will meet the high flow reduction target of the TMDL of 5.2%. This addresses peak flow requirements for developed land along with a projected non-jurisdictional growth of 20 acres of impervious surface in the Munroe Brook Watershed. This FRP does not address flow reduction requirements for agricultural areas within the watershed.

The TMDL's recommended low flow target is not met. This is the result of detention based BMPs being utilized to meet the high flow target. Detention based BMPs do not provide a significant improvement in stream flow during low flow conditions. Infiltration based BMPs would serve to meet both the high and low targets simultaneously. Based on information provided by web soil survey data and site observations, there was little opportunity for inclusion of infiltration based BMPs in the Munroe Brook watershed. However, soil borings were not carried out at BMP site locations, as projects included in the VT BMP DSS model were only developed to a concept level. It is recommend that as project design and engineering moves forward that each project be evaluated for additional opportunities to provide infiltration based on actual soil boring data. This

could increase recharge to groundwater, which would in turn increase stream flow during the low flow condition.

4) IDENTIFICATION OF REQUIRED CONTROLS

In 2014 site visits were performed throughout the Munroe Brook watershed to identify and evaluate existing stormwater BMPs that were candidates for retrofits as well as find locations for new BMPs. The BMPs included in this FRP are based on the results of this field work, potential construction costs, and the BMPs performance in the VT BMP DSS model. In general, priority was given to retrofit BMPs as they typically provide a better cost/benefit ratio than construction of new BMPs.

Each potential BMP site was reviewed to determine its ability to meet the channel protection criteria (CPv) from the 2002 Vermont Stormwater Management Manual. The CPv criteria requires 12 hour detention of stormwater runoff during the 1-year, 24-hour storm event in cold water fish habitats and 24 hour detention in warm water fish habitats. Munroe Brook is classified as a warm water fish habitat; therefore BMPs were designed to meet the 24-hour detention standard. Since the 1-year, 24-hour storm event is a close approximation to the storm event associated with the Q0.3 flow defined in the TMDL this criterion was utilized as part of the FRP evaluation. Hydrologic modeling for BMPs is provided in Appendix B.

As previously noted, BMPs included in the final FRP were only developed to a concept level. Significant field work was performed to identify and screen candidate sites, but this work did not include a detailed hydrologic analysis, property research, site engineering, wetlands delineation, and other necessary studies which will be required to move these projects towards a final engineering design and ultimately construction. There may be constraints that prevent certain BMPs from being utilized, either wholly or in part, in the FRP. **All BMP sites included in this FRP will require additional permitting, engineering and design work to determine the feasibility of installing a BMP in the specified location.**

Table 4 lists the BMPs included in this FRP and provides general information about each BMP. Detailed information for each BMP, including maps, can be found in Appendix A. All of the BMPs included in Table 4 have been incorporated into the BMP DSS model. If the BMP includes a note that indicates "No change" then this BMP will not require additional work. It either already meets the current design standards (2002) or retrofits of this BMP did not provide any additional benefit in the BMP DSS model.

Table 4: Summary of Best Management Practices Included in Munroe Brook Flow Restoration Plan

BMP ID #	Model ID	State Permit Number	Site Name	BMP Type	Notes
M01	134	1-0607 A	Westview Estates	Wet Pond	Retrofit outlet structure, lower permanent pool
M02	135	1-0607 B	Westview Estates	Wet Pond	Retrofit outlet structure, lower permanent pool
M03	138	1-0732 B	Deer Run	Wet Pond	Retrofit outlet structure
M04	140	1-0732 C	Farmstead Drive	Detention Pond	No change, BMP to be verified installed as assumed
M05	142	1-1155 P2	Pinnacle at Spear	Wet Pond	Retrofit outlet structure, converted to wet pond
M06	143	1-1155 P5	Pinnacle at Spear	Detention Pond	Retrofit outlet structure
M07	148	1-1155 P3	Pinnacle at Spear	Detention Pond	Retrofit outlet structure
M08	150	1-1291	Route 7	Wet Pond	Storage expanded with underground storage
M09	152	1-1390	Automaster Mini	Detention Pond	Retrofit outlet structure
M10	154	1-1400 A	Shelburne Meadows Business Park	Detention Pond	Retrofit outlet structure, expanded storage
M11	156	1-1400 B	Shelburne Meadows Business Park	Detention Pond	Retrofit outlet structure
M12	158	1-1534	Boulder Hill	Detention Pond	Retrofit outlet structure, expanded storage
M13	160	6959-INDO	Roberts Mini Storage	Detention Pond	No change
M14	161	6959-INDO	Roberts Mini Storage	Detention Pond	No change
M15	171	4444-INDS	Sutton Farms	Wet Pond	No change
M16	176	3443-INDS 2	South Pointe	Detention Pond	Retrofit outlet structure
M17	178	4096-INDS P3	South Village	Wet Pond	No change
M18	180	4096-INDS P1	South Village	Wet Pond	No change
M19	182	4096-INDS P2	South Village	Wet Pond	No change
M20	185	3928-INDO	Hullcrest Park	Detention Pond	No change
M21	193	6938-INDS P1	Automaster Parking Expansion	Detention Pond	No change

M22	194	6938-INDS P2	Automaster Parking Expansion	Detention Pond	No change
M23	195	6909-INDS	Lilly Creek	Detention Pond	No change
M27	199	1-0732 A	Deer Run	Wet Pond	New BMP (located where BMP was never built)
M28A	205	N/A	Shelburne Camping	Wet Pond	New BMP
M28B	206	N/A	Shelburne Camping	Wet Pond	New BMP
M29	207	N/A	Shelburne Commons-Rice Lumber	Wet Pond	New BMP
M32	201	N/A	Drew Lane	Wet Pond	New BMP
M34	208	N/A	Hullcrest South	Wet Pond	New BMP
M35	203	N/A	Morse Drive Neighborhood	Wet Pond	New BMP

5) DESIGN AND CONSTRUCTION SCHEDULE

A design and construction schedule is a required element of the final FRP. This schedule must show how the proposed BMPs included in the FRP can be implemented over a timeframe of less than 20 years from the date of MS4 permit issuance. This means that all BMPs associated with FRPs must be implemented prior to December 5, 2032.

The BMPs included in this FRP were scheduled with consideration given to expired permit sites, performance in the watershed, and estimated construction costs. As retrofit BMPs typically provide a better cost/benefit ratio than construction of new BMPs, retrofit projects were placed toward the front end of the construction schedule. A final BMP implementation schedule is included in Table 5.

The BMP schedule presented in this FRP is expected to receive updates on an annual basis. Projects will be added, modified, or removed as necessary to meet FRP flow targets and respond to real world conditions. This is necessary primarily due to the fact that the BMPs presented in this FRP have only been developed to concept level planning. It is reasonable to anticipate that changes will occur when these concepts are further developed. Depending on actual circumstances, the level of treatment achieved may be more or less than the level of treatment anticipated (e.g. variations in soil conditions allow for either more or less infiltration of stormwater runoff than originally anticipated). These type of modifications are common when advancing BMP plans from concept to final design. Therefore, flexibility in the schedule is necessary to accommodate these changes.

Additionally, in order for project implementation to move forward in a cost effective manner, the MS4s will need to take advantage of opportunities for stormwater improvements as they present themselves. For example, a private property owner may decide to redevelop their property on a schedule that was not anticipated in the current BMP implementation schedule. If this occurs, the MS4s may need to shift

available resources from a scheduled project in order to take advantage of a cost savings opportunity.

Finally, projects may need to be shifted in the BMP schedule based on Vermont's changing regulatory system. VTDEC is currently developing an implementation plan for the Lake Champlain Phosphorous TMDL. When this document is finalized, the MS4 permit will require regulated entities to develop Phosphorus Control Plans (PCPs), similar in size and scope to the FRPs being developed as part of stormwater TMDLs. When this occurs, the FRPs will likely need to be revised based on PCP requirements, which are yet to be defined by VTDEC.

Table 5: BMP Implementation Schedule

Project ID	Project Name	Project Rank	BMP Description	Construction Fiscal Year
M2	Westview Estates	1	Wet Pond	2021
M1	Westview Estates	2	Wet Pond	2021
M3	Deer Run	4	Wet Pond	2025
M10	Shelburne Meadows Business Park	3	Detention Pond	2024
M11	Shelburne Meadows Business Park	6	Detention Pond	2024
M4	Farmstead Drive	5	Detention Pond	2022
M5	Pinnacle @ Spear		Wet Pond	2030
M6	Pinnacle @ Spear		Detention Pond	2019
M7	Pinnacle @ Spear		Detention Pond	2019
M9	Automaster (CEA 99 design)	7	Detention Pond	2023
M32	Drew Lane	11	Wet Pond	2024
M16	South Pointe		Detention Pond	2023
M29	Shelburne Commons-Rice Lumber	10	Wet Pond	2024
M27	Deer Run	8	Wet Pond	2025
M12	Boulder Hill	9	Detention Pond	2026
M35	Morse Drive Neighborhood	12	#N/A	2027
M28B	Shelburne Camping	15	Wet Pond	2028
M28A	Shelburne Camping	16	Wet Pond	2028
M34	Hullcrest South	14	#N/A	2029
M8	Route 7	13	Wet Pond	2030
M13	Roberts Mini Storage		Detention Pond	NA
M14	Roberts Mini Storage		Detention Pond	NA

M15	Sutton Farms		Wet Pond	NA
M17	South Village		Wet Pond	NA
M18	South Village		Wet Pond	NA
M19	South Village		Wet Pond	NA
M20	Hulcrest Park		Detention Pond	NA
M21	Automaster Parking Expansion		Detention Pond	NA
M22	Automaster Parking Expansion		Detention Pond	NA
M23	Lilly Creek		Detention Pond	NA

6) FINANCIAL PLAN

Subject to the requirements of the MS4 permit, a financial plan is required as part of the final FRP. This plan must provide initial BMP cost estimates and demonstrate the means by which BMP implementation will be financed. The financial plan must also include the steps that each MS4 will take to implement the finance plan.

Costs for implementing each BMP were estimated based on a Tetra Tech, Inc. memorandum dated October 30, 2007 (Appendix C). This memorandum provided a methodology for estimating BMP construction costs based on simple BMP attributes. The methodology utilized a construction cost base year of 2000. In order to more accurately estimate these costs over the FRP's 20 year implementation schedule a 2.5% annual inflation rate was applied. Therefore, the estimated costs presented in this FRP reflect anticipated construction costs in the year 2032. While it is likely that many, if not all, of the BMPs will be constructed prior to the year 2032 utilizing these costs provide a margin of safety that will be useful for financial planning. Total project costs were calculated based on the following equation:

Total Cost = Installation Cost (I) + Land Cost (L) + Fixed Cost (F)

Where:
I = $5/cf of CPv detention, inflated at 2.5% to year 2032 = $11/cf ($479,160/acre-foot)
L = $0 as it is not anticipated that it will be necessary to purchase property
F = Design/permitting costs. Varies depending on whether a large project or simple retrofit BMP

For new BMPs and retrofits requiring storage expansion, the Installation Cost (I) value was calculated using the volume of the BMP. For retrofits requiring only a modification to the outlet structure, the I value was estimated based on conservative engineering judgement. In these cases, a minimum I value of $20,000 was utilized. The Fixed Cost (F) value for BMPs varies based on percentage of Installation Costs, with 5% of the estimated Installation Cost used for large projects and 20% of the estimated Installation

Cost used for small retrofit projects. This reflects a minimum Fixed Cost regardless of project scope. Estimated construction costs for each BMP are shown in Table 6. BMPs with no associated costs have been included in the BMPDSS model as they currently exist. Therefore, no additional implementation costs are anticipated for these BMPs.

The costs included in Table 6 are planning level estimates only. Unforeseen constraints or other factors have the potential to increase or lower the implementation cost of BMPs. These values should be reevaluated during the engineering design process.

Each MS4 that drains to Munroe Brook must determine how it will fund its portion of the FRP. The Town of Shelburne currently pays for stormwater related costs utilizing the General Fund derived by tax revenue. The implementation costs associated with this FRP will require a significant increase in expenditures. Shelburne is currently evaluating options for raising additional funds to pay for FRP related work. One option under evaluation is the implementation of a stormwater utility or a similar stormwater fee based on impervious area.

In addition to local funding sources, it is the Town's expectation that significant funding from the State of Vermont and other Federal sources will be available to help with the cost of stormwater TMDL implementation. The State of Vermont has already taken initial steps towards providing this funding. In 2015 the Vermont legislature created the Clean Water Fund (CWF). The CWF was provided with $2,005,000 in 2015, and $7,688,000 in 2016. While these initial investments are not at the level necessary to provide significant funding to the MS4 communities subject to stormwater TMDLs, it is the Town's understanding that the State is working to provide additional funding to the CWF in the future. In December 2016, the State Treasurer and State agencies will be delivering a report to the Vermont legislature that provides options for raising significant money to fund the CWF. The Town will also pursue funding from existing and new grant sources from other organizations including, but not limited to VTDEC, the Vermont Agency of Transportation, and the Lake Champlain Basin Program.

Table 6: BMP Cost Estimates

BMP ID #	Site Name	Storage Volume (Acre-Feet)	I	F	Total
M1	Westview Estates	N/A	$20,000	$4,000	$24,000
M2	Westview Estates	N/A	$20,000	$4,000	$24,000
M3	Deer Run	N/A	$20,000	$4,000	$24,000
M4	Farmstead Drive	N/A	$20,000	$4,000	$24,000
M5	Pinnacle @ Spear	N/A	$20,000	$4,000	$24,000
M6	Pinnacle @ Spear	N/A	$20,000	$4,000	$24,000
M7	Pinnacle @ Spear	N/A	$20,000	$4,000	$24,000
M8	Route 7	2.31	$1,104,464	$55,223	$1,159,687
M9	Automaster (CEA 99 design)	N/A	$20,000	$4,000	$24,000
M10	Shelburne Meadows Business Park	0.60	$287,496	$14,375	$301,871
M11	Shelburne Meadows Business Park	N/A	$20,000	$4,000	$24,000
M12	Boulder Hill	2.51	$1,204,608	$60,230	$1,264,838
M13	Roberts Mini Storage	N/A	N/A	$0	$0
M14	Roberts Mini Storage	N/A	N/A	$0	$0
M15	Sutton Farms	N/A	N/A	$0	$0
M16	South Pointe	N/A	$20,000	$4,000	$24,000
M17	South Village	N/A	N/A	$0	$0
M18	South Village	N/A	N/A	$0	$0
M19	South Village	N/A	N/A	$0	$0
M20	Hullcrest Park	N/A	N/A	$0	$0
M21	Automaster Parking Expansion	N/A	N/A	$0	$0
M22	Automaster Parking Expansion	N/A	N/A	$0	$0
M23	Lilly Creek	N/A	N/A	$0	$0
M27	Deer Run	0.51	$242,934	$12,147	$255,081
M28A	Shelburne Camping	0.34	$164,831	$8,242	$173,073
M28B	Shelburne Camping	0.60	$286,059	$14,303	$300,362
M29	Shelburne Comms-Rice	3.57	$1,709,643	$85,482	$1,795,125
M32	Drew Lane	0.87	$416,869	$20,843	$437,712
M34	Hullcrest South	1.53	$731,677	$36,584	$768,261
M35	Morse Drive Neighborhood	1.12	$534,743	$26,737	$561,480
				Total	$7,257,490

7) REGULATORY ANALYSIS

The VT MS4 permit requires that final FRPs include a regulatory analysis that identifies and describes what, if any, additional regulatory authorities the permittees will need to implement the FRP. Stormwater runoff in the Munroe Brook watershed is currently regulated by the VT DEC stormwater program which regulates new, expanded, or redeveloped sites as dictated by the Stormwater Management Rule for Impaired Waters (Environmental Protection Rules, Chapter 22), by the Town of Shelburne and City of South Burlington through zoning regulations and ordinances, and by VTrans through 19 V.S.A.1111 which covers discharges in State Right of Ways.

At this time, and based on the above existing regulatory authorities, the MS4s do not anticipate the need for additional regulatory authorities in order to implement the Munroe Brook FRP.

8) REGULATORY ASSISTANCE

The MS4 permit requires this FRP to identify any regulatory assistance the permittees will need from the Secretary in order to implement the FRP, such as use of Residual Designation Authority (RDA) pursuant to 40 C.F.R. §122.26. Based on the above regulatory analysis, and the fact that the BMPs identified in this FRP are capable of meeting the requirements of the TMDL, it is not anticipated that additional regulatory assistance will be necessary to implement the FRP at this time.

9) THIRD-PARTY IMPLEMENTATION

The MS4 permit requires the identification of any party, other than the MS4 permittees, that is responsible for implementing any portion of the FRP. There are several properties in the Munroe Brook watershed that are covered by expired State of Vermont stormwater permits. Some of these sites are located on private property. Properties covered by expired permits may be required to retrofit and/or construct BMPs to meet the level of treatment described in this FRP. The controlling interest of these permits will have the ability to obtain valid permit coverage under an existing Vermont DEC permit programs (e.g. the RDA permit or an individual stormwater permit). The Town of Shelburne is also considering allowing expired permit holders to transfer these permits under the Town's MS4 permit coverage. The details of this transfer are still being evaluated.

10) SUMMARY & IMPLEMENTATION

This FRP was developed for the MS4 permittees located within the Munroe Brook watershed. The proposed BMPs were identified via preliminary field work and discussions with the MS4 permittees. While the BMPs included in this FRP are capable of meeting the requirements of the TMDL, there are likely other combinations of BMPs that are also capable of meeting these same requirements. The permittees are not strictly bound to the BMPs included in this document and plan to make adjustments to this FRP, as necessary over the implementation schedule, in order to achieve the required TMDL stream flow target.

As this FRP is implemented the VT BMP DSS model will be updated to show the impacts of the BMPs as they are actually constructed. The BMP DSS model will also be updated to account for any other changes that occur in the watershed.

Appendix A: Overall BMP Maps and Individual BMP Information

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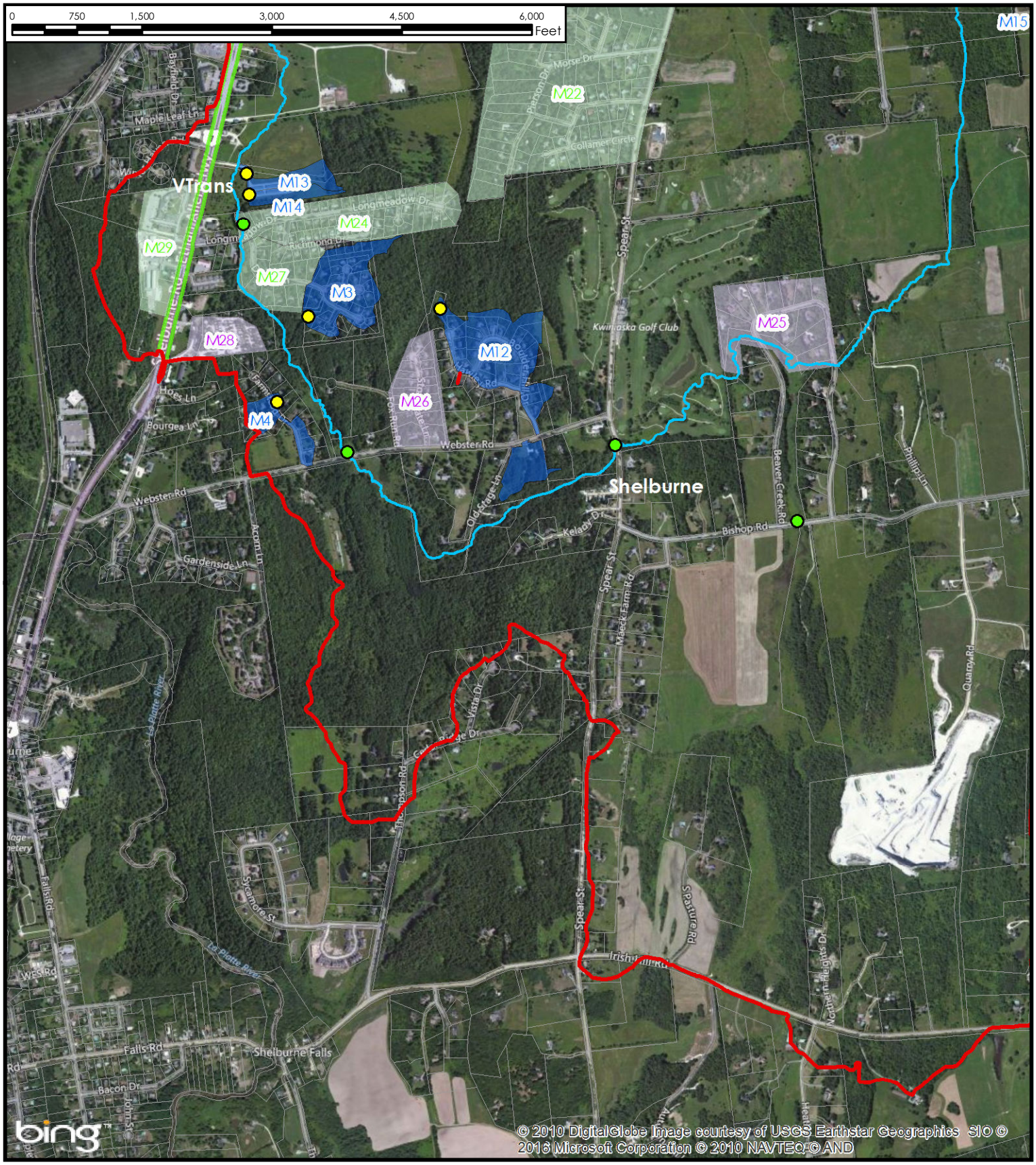
Munroe Brook Watershed
Northern Section - FRP BMPs
Shelburne & South Burlington, VT

Project: 14-042
Prepared By: ALD
09/14/2016
1 inch = 1500 feet

Sources: Bing Aerial Photography (2012); Streams by ANR (2012); Munroe Brook Subwatersheds by ANR (Updated by TCE 2014); Drainage Areas by ANR (Updated by TCE 2014); MS4 Boundaries by ANR; BMPs by Horsley Witten Group & TCE (2014). Disclaimer: The accuracy of information presented is determined by its sources.TCE is not responsible for any errors or omissions that may exist. Questions of on-the-ground location can be resolved by site inspections and/or surveys by a registered surveyor. This map is not a replacement for surveyed information or engineering studies.

- Munroe Brook Watershed
- BMP
- Munroe Brook
- No Change to BMP
- Potential Retrofit BMP
- Potential New BMP
- Town Boundary
- Tax Parcel Boundary



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Munroe Brook Watershed
Southern Section - FRP BMPs
Shelburne & South Burlington, VT

Project: 14-042
Prepared By: ALD
09/14/2016
1 inch = 1500 feet

Sources: Bing Aerial Photography (2012); Streams by ANR (2012); Munroe Brook Subwatersheds by ANR (Updated by TCE 2014); Drainage Areas by ANR (Updated by TCE 2014); MS4 Boundaries by ANR; BMPs by Horsley Witten Group & TCE (2014). Disclaimer: The accuracy of information presented is determined by its sources.TCE is not responsible for any errors or omissions that may exist. Questions of on-the-ground location can be resolved by site inspections and/or surveys by a registered surveyor. This map is not a replacement for surveyed information or engineering studies.

- Munroe Brook Watershed
- BMP
- Munroe Brook
- No Change to BMP
- Retrofit BMP
- New BMP
- Shelburne
- South Burlington
- VTrans
- Town Boundary
- Tax Parcel Boundary

ID#: M01

Name: Westview Estates

Permit #: 1-0607 A

Concept Description: Conversion of existing BMP to 2002 standard

Notes/Feasibility: 12 in horizontal stand pipe. Head available dependent on lowering water surface level, existing pond has +/-1' of freeboard.

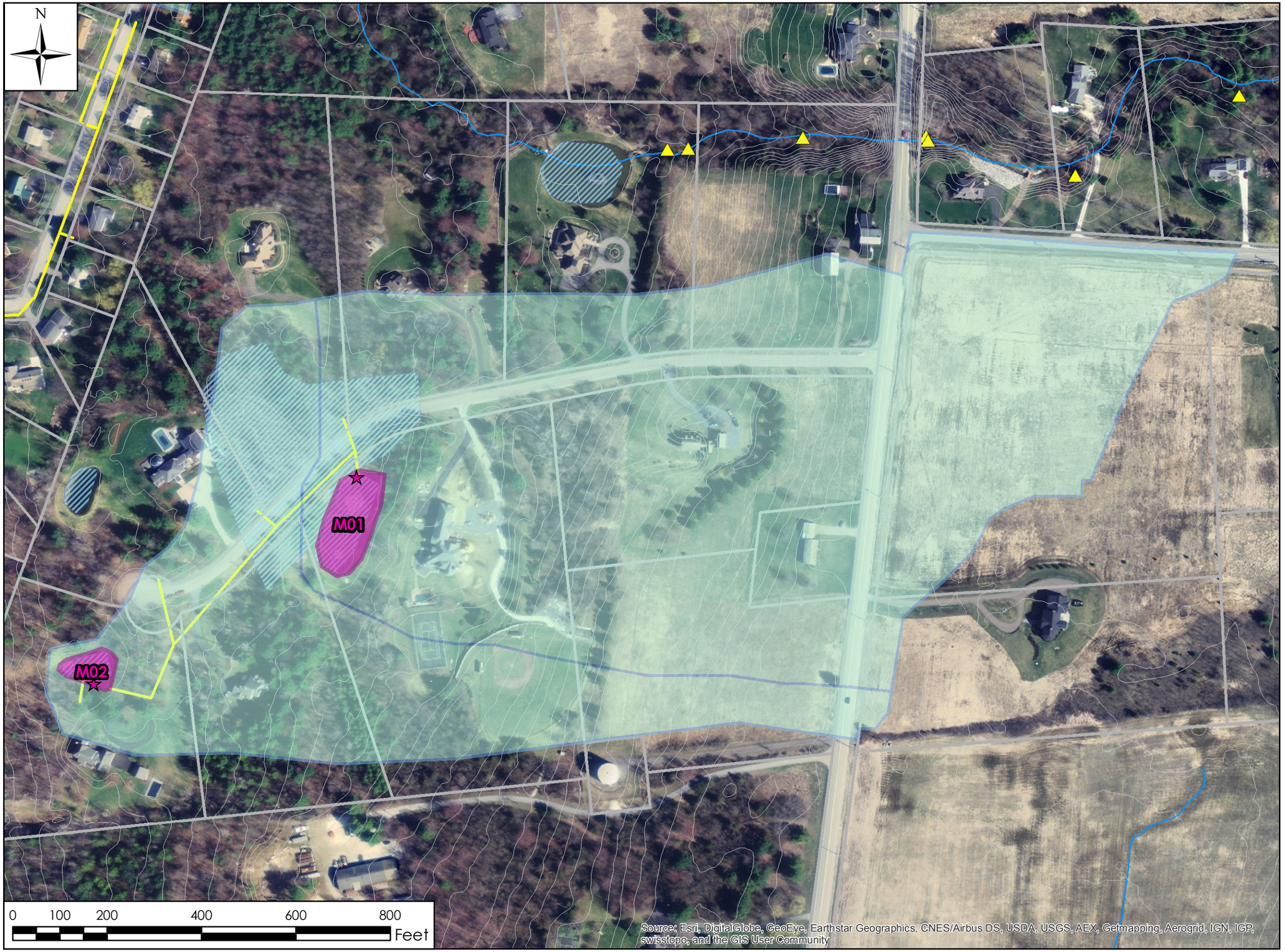
GENERAL SITE INFORMATION	RETROFIT DETAILS	
Site Contact Info: Shelburne	Project Candidate: Tier II	
Ownership:	New or Retrofit BMP: Retrofit	
Land Use 1: Residential	Proposed Retrofit Practice: Pond	
Land Use 2:	Non-Structural Controls: No	
Existing BMP on site? Yes	Maintenance Burden: Moderate	
Is site a hotspot? No	Benefits: Storage: Yes Water Quality: Yes Recharge: No Repair: No Other: N/A	Conflicts: Soils: No Access: No Land Use: No Utilities: No High WT: Unknown Wetlands: Yes Demo: No Other: N/A
Soils: C		
SIZING INFOMATION		
Drainage Area (ac): 29.90		
Impervious Area (ac): 4.01		
Practice Area Available(ft²): 20700		
Existing Head Available? 4-5' Est.		

Date Assessed: 10/30/2014 Assessed by: AGM/LMJ

ID#: M02	
Name: Westview Estates	No Image Available
Permit #: 1-0607 B	
Concept Description: Retrofit of existing BMP to 2002 standards	
Notes/Feasibility:	

GENERAL SITE INFORMATION	RETROFIT DETAILS	
Site Contact Info: Shelburne	Project Candidate: Tier II	
Ownership:	New or Retrofit BMP: Retrofit	
Land Use 1: Residential	Proposed Retrofit Practice: Pond	
Land Use 2:	Non-Structural Controls: no	
Existing BMP on site? Yes	Maintenance Burden: Moderate	
Is site a hotspot? No	Benefits: Storage: yes Water Quality: yes Recharge: No Repair: no Other: N/A	Conflicts: Soils: No Access: no Land Use: no Utilities: no High WT: unknown Wetlands: No Demo: no Other: N/A
Soils: C		
SIZING INFOMATION		
Drainage Area (ac): 12.43		
Impervious Area (ac): 0.92		
Practice Area Available(ft²): 6900		
Existing Head Available? N/A		

Date Assessed: 10/30/2014 Assessed by: AGM/LMJ



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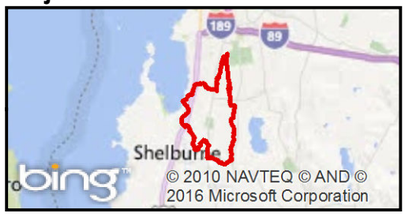
Project Location



Legend

- Munroe Brook Watershed
- Proposed BMP
- Practice Area
- BMP Drainage Area
- Contours (2')
- Tax Parcel Boundary
- Munroe Brook
- Outfalls
- Catch Basins
- Manholes
- Stormline
- VT Significant Wetland
- Stream

Notes

Sources: Bing Aerial Photography (2012); Streams by ANR (2012); Munroe Brook Subwatersheds by ANR (Updated by TCE 2014); Drainage Areas by ANR (Updated by TCE 2014); MS4 Boundaries by ANR; BMPs by Horsley Witten Group & TCE (2014).
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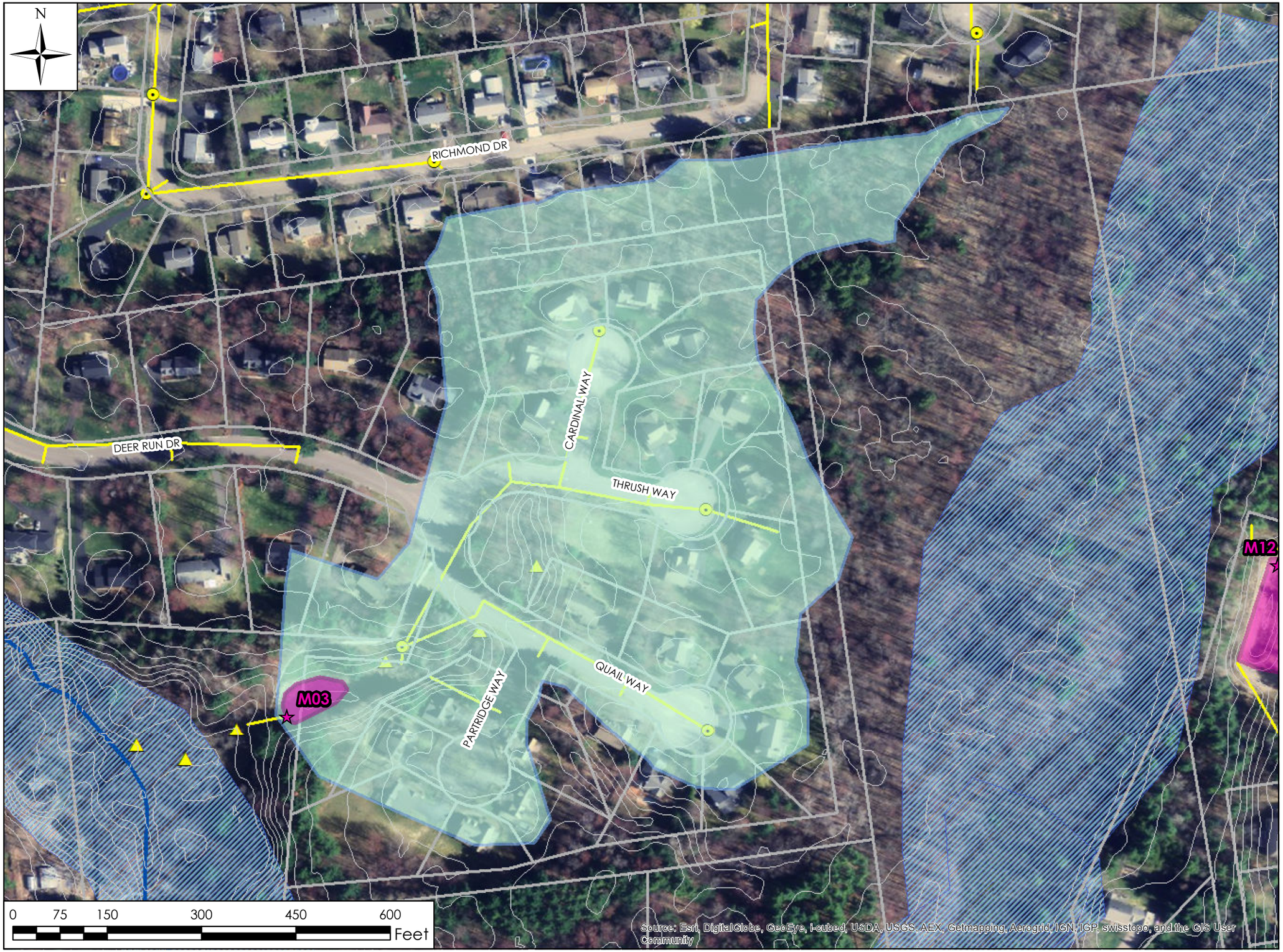
M1 & M2 - Westview Est
Shelburne, VT

Project: 14-042
Prepared By: ALD
09/14/2016
1 inch = 200 feet

ID#: M03	
Name: Deer Run	
Permit #: 1-0732 B	
Concept Description: Expand existing BMP	
Notes/Feasibility: Outlet clogged - unable to verify low flow orifices.	

GENERAL SITE INFORMATION	RETROFIT DETAILS	
Site Contact Info: Shelburne	Project Candidate: Tier I	
Ownership:	New or Retrofit BMP: Retrofit	
Land Use 1: Residential	Proposed Retrofit Practice: Pond	
Land Use 2:	Non-Structural Controls: No	
Existing BMP on site? Yes	Maintenance Burden: Moderate	
Is site a hotspot? No	Benefits: Storage: Yes Water Quality: Yes Recharge: No Repair: Yes Other: N/A	Conflicts: Soils: No Access: Yes Land Use: No Utilities: No High WT: Unknown Wetlands: No Demo: No Other: N/A
Soils: C		
SIZING INFOMATION		
Drainage Area (ac): 15.40		
Impervious Area (ac): 3.23		
Practice Area Available(ft²): 4600		
Existing Head Available? 2-3' Est.		

Date Assessed: 10/30/2014 Assessed by: AGM/LMJ



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Project Location

Legend

- Munroe Brook Watershed
- Proposed BMP
- Practice Area
- BMP Drainage Area
- Contours (2')
- Tax Parcel Boundary
- Munroe Brook
- Outfalls
- Catch Basins
- Manholes
- Stormline
- VT Significant Wetland
- Stream

Notes

Sources: Bing Aerial Photography (2012); Streams by ANR (2012); Munroe Brook Subwatersheds by ANR (Updated by TCE 2014); Drainage Areas by ANR (Updated by TCE 2014); MS4 Boundaries by ANR; BMPs by Horsley Witten Group & TCE (2014).
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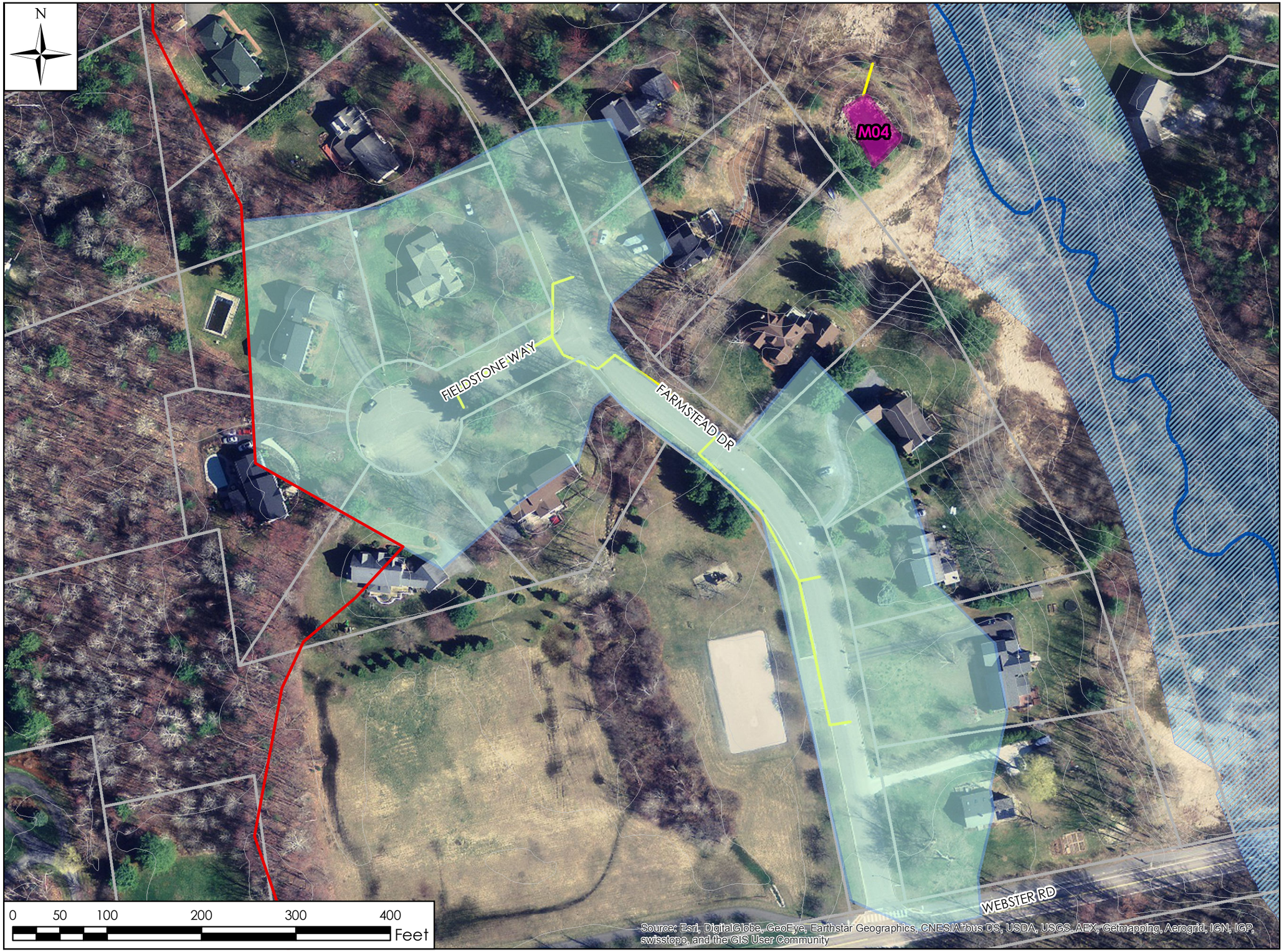
M03 - Deer Run
Shelburne, VT

Project: 14-042
Prepared By: LMJ
12/03/2014
1 inch = 150 feet

ID#: M04	
Name: Farmstead Drive	
Permit #: 1-0732 C	
Concept Description: Verify installed as designed	
Notes/Feasibility: No retrofit required provided that system is installed per assumed design. To be verified.	

GENERAL SITE INFORMATION	RETROFIT DETAILS	
Site Contact Info: Shelburne	Project Candidate: Tier II	
Ownership:	New or Retrofit BMP: Retrofit	
Land Use 1: Residential	Proposed Retrofit Practice: Pond	
Land Use 2:	Non-Structural Controls: no	
Existing BMP on site? Yes	Maintenance Burden: Moderate	
Is site a hotspot? No	Benefits: Storage: yes Water Quality: yes Recharge: No Repair: no Other: N/A	Conflicts: Soils: No Access: no Land Use: no Utilities: no High WT: unknown Wetlands: No Demo: no Other: N/A
Soils: C		
SIZING INFOMATION		
Drainage Area (ac): 5.60		
Impervious Area (ac): 1.83		
Practice Area Available(ft²): 2200		
Existing Head Available? 3' Est.		

Date Assessed: 10/29/2014 Assessed by: AGM/LMJ



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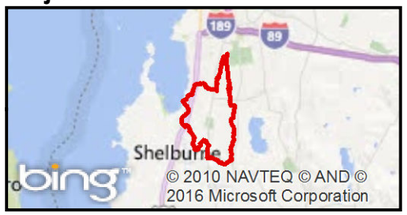
Project Location



Legend

- Munroe Brook Watershed
- Practice Area
- BMP Drainage Area
- Contours (2')
- Tax Parcel Boundary
- Munroe Brook
- Outfalls
- Catch Basins
- Manholes
- Stormline
- VT Significant Wetland
- Stream

Notes

Sources: Bing Aerial Photography (2012); Streams by ANR (2012); Munroe Brook Subwatersheds by ANR (Updated by TCE 2014); Drainage Areas by ANR (Updated by TCE 2014); MS4 Boundaries by ANR; BMPs by Horsley Witten Group & TCE (2014).
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M04 - Farmstead Drive
Shelburne, VT

Project: 14-042
Prepared By: ALD
09/14/2016
1 inch = 100 feet

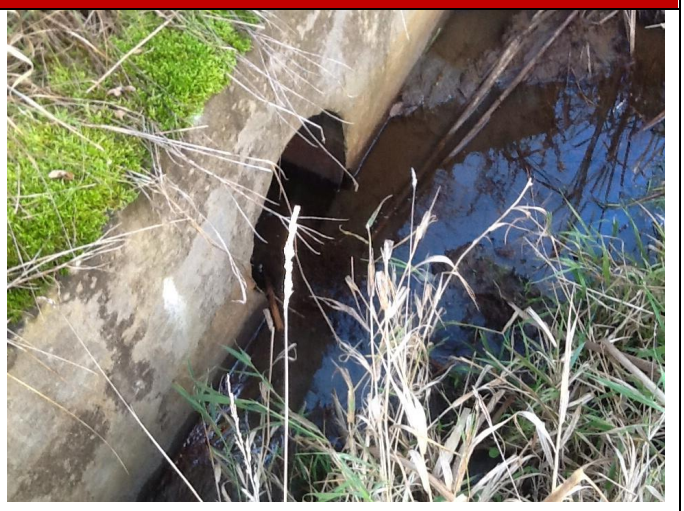
ID#: M05

Name: Pinnacle at Spear

Permit #: 1-1155 P2

Concept Description: Retrofit of existing BMP to 2002 standards

Notes/Feasibility:



GENERAL SITE INFORMATION	RETROFIT DETAILS	
Site Contact Info: South Burlington	Project Candidate: Tier I	
Ownership:	New or Retrofit BMP: Retrofit	
Land Use 1: Residential	Proposed Retrofit Practice: Pond	
Land Use 2:	Non-Structural Controls: No	
Existing BMP on site? Yes	Maintenance Burden: Minimal change	
Is site a hotspot? No	Benefits: Storage: Yes Water Quality: Yes Recharge: No Repair: No Other: N/A	Conflicts: Soils: No Access: Yes Land Use: No Utilities: No High WT: Yes Wetlands: No Demo: No Other: N/A
Soils: D		
SIZING INFOMATION		
Drainage Area (ac): 10.20		
Impervious Area (ac): 3.86		
Practice Area Available(ft²): 17400		
Existing Head Available? N/A		

Date Assessed: 10/30/2014 Assessed by: AGM/LMJ

ID#: M06

Name: Pinnacle at Spear

Permit #: 1-1155 P5

Concept Description: Retrofit of existing BMP to 2002 standards

Notes/Feasibility:

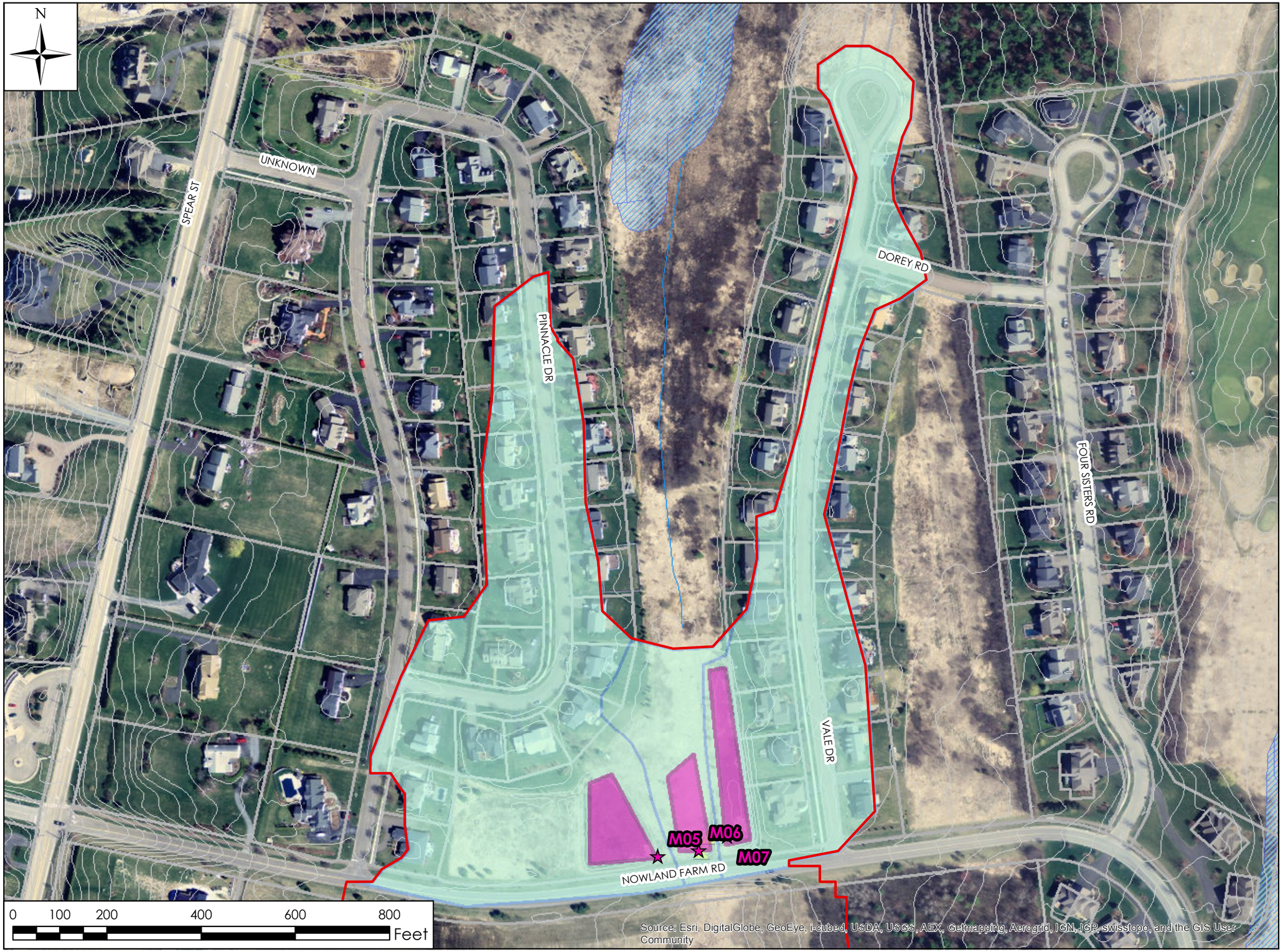
GENERAL SITE INFORMATION	RETROFIT DETAILS	
Site Contact Info: South Burlington	Project Candidate: Tier I	
Ownership:	New or Retrofit BMP: Retrofit	
Land Use 1: Residential	Proposed Retrofit Practice: Pond	
Land Use 2:	Non-Structural Controls: No	
Existing BMP on site? Yes	Maintenance Burden: Minimal change	
Is site a hotspot? No	Benefits: Storage: Yes Water Quality: Yes Recharge: No Repair: No Other: N/A	Conflicts: Soils: No Access: Yes Land Use: No Utilities: No High WT: Yes Wetlands: No Demo: No Other: N/A
Soils: D		
SIZING INFOMATION		
Drainage Area (ac): 1.76		
Impervious Area (ac): 0.06		
Practice Area Available(ft²): 11700		
Existing Head Available? N/A		

Date Assessed: 10/30/2014 Assessed by: AGM/LMJ

ID#: M07	
Name: Pinnacle at Spear	
Permit #: 1-1155 P3	
Concept Description: Retrofit of existing BMP to 2002 standards	
Notes/Feasibility:	

GENERAL SITE INFORMATION	RETROFIT DETAILS	
Site Contact Info: South Burlington	Project Candidate: Tier I	
Ownership:	New or Retrofit BMP: Retrofit	
Land Use 1: Residential	Proposed Retrofit Practice: Pond	
Land Use 2:	Non-Structural Controls: No	
Existing BMP on site? Yes	Maintenance Burden: Minimal change	
Is site a hotspot? No	Benefits: Storage: Yes Water Quality: Yes Recharge: No Repair: No Other: N/A	Conflicts: Soils: No Access: Yes Land Use: No Utilities: No High WT: Yes Wetlands: No Demo: No Other: N/A
Soils: D		
SIZING INFOMATION		
Drainage Area (ac): 7.60		
Impervious Area (ac): 3.84		
Practice Area Available(ft²): 16200		
Existing Head Available? N/A		

Date Assessed: 10/30/2014 Assessed by: AGM/LMJ



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802.879.6331 www.tcevt.com

Project Location

Legend

- Munroe Brook Watershed
- Proposed BMP
- Practice Area
- BMP Drainage Area
- Contours (2')
- Tax Parcel Boundary
- Munroe Brook
- Outfalls
- Catch Basins
- Manholes
- Stormline
- VT Significant Wetland
- Stream

Notes

Sources: Bing Aerial Photography (2012); Streams by ANR (2012); Munroe Brook Subwatersheds by ANR (Updated by TCE 2014); Drainage Areas by ANR (Updated by TCE 2014); MS4 Boundaries by ANR; BMPs by Horsley Witten Group & TCE (2014).
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M05, M06, M07
Pinnacle at Spear
South Burlington, VT
Project: 14-042
Prepared By: LMJ
12/03/2014
1 inch = 200 feet

ID#: M08	
Name: Route 7	
Permit #: 1-1291	
Concept Description: Retrofit of existing BMP to provide additional control as feasible.	
Notes/Feasibility: The drainage area for this practice is significantly larger than original models indicated, may limit feasibility for retrofit.	

GENERAL SITE INFORMATION	RETROFIT DETAILS	
Site Contact Info: Shelburne/VTrans	Project Candidate: Tier I	
Ownership:	New or Retrofit BMP: Retrofit	
Land Use 1: Transportation	Proposed Retrofit Practice: Pond	
Land Use 2:	Non-Structural Controls: no	
Existing BMP on site? Yes	Maintenance Burden: Moderate	
Is site a hotspot? No	Benefits: Storage: Yes Water Quality: Yes Recharge: No Repair: No Other: N/A	Conflicts: Soils: No Access: No Land Use: No Utilities: No High WT: Unknown Wetlands: No Demo: No Other: N/A
Soils: D		
SIZING INFOMATION		
Drainage Area (ac): 115.20		
Impervious Area (ac): 33.00		
Practice Area Available(ft²): 7900		
Existing Head Available? N/A		

Date Assessed: 10/29/2014 Assessed by: AGM/LMJ

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Project Location

Legend

- Munroe Brook Watershed
- Proposed BMP
- Practice Area
- BMP Drainage Area
- Contours (2')
- Tax Parcel Boundary
- Munroe Brook
- Outfalls
- Catch Basins
- Manholes
- Stormline
- VT Significant Wetland
- Stream

Notes

Sources: Bing Aerial Photography (2012); Streams by ANR (2012); Munroe Brook Subwatersheds by ANR (Updated by TCE 2014); Drainage Areas by ANR (Updated by TCE 2014); MS4 Boundaries by ANR; BMPs by Horsley Witten Group & TCE (2014).
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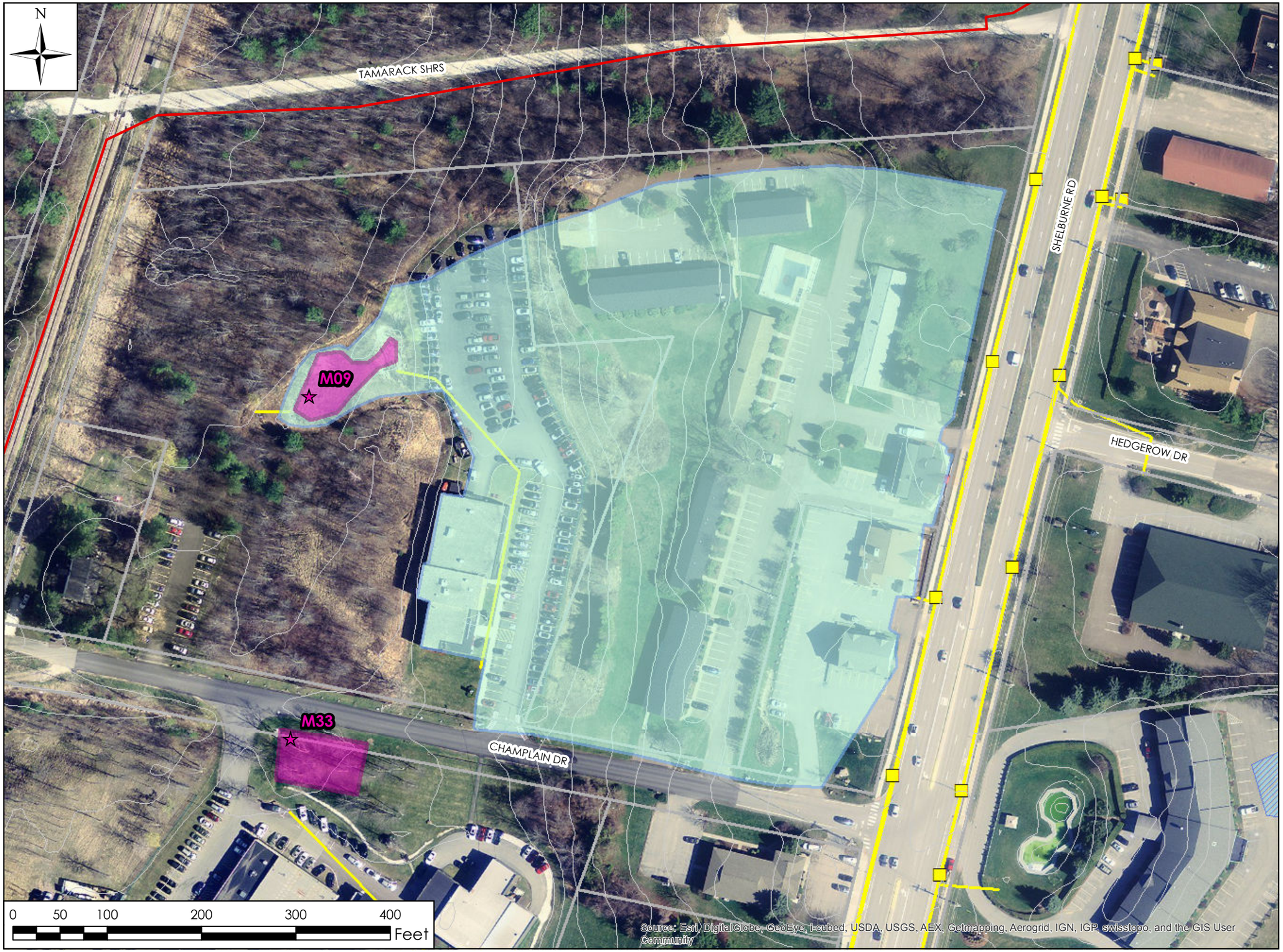
M08 - Route 7
Shelburne, VT

Project: 14-042
Prepared By: LMJ
12/03/2014
1 inch = 500 feet

ID#: M09	
Name: Automaster - MINI Dealership	
Permit #: 1-1390	
Concept Description: Expansion of existing BMP	
Notes/Feasibility: There is potential to redirect significant portions of Rt. 7 runoff to this practice if space allows.	

GENERAL SITE INFORMATION	RETROFIT DETAILS	
Site Contact Info: Shelburne/VTrans	Project Candidate: Tier I	
Ownership:	New or Retrofit BMP: Retrofit	
Land Use 1: Commercial	Proposed Retrofit Practice: Pond	
Land Use 2: Transportation	Non-Structural Controls: No	
Existing BMP on site? Yes	Maintenance Burden: Moderate	
Is site a hotspot? No	Benefits: Storage: Yes Water Quality: Yes Recharge: No Repair: Yes Other: N/A	Conflicts: Soils: No Access: Yes Land Use: No Utilities: No High WT: No Wetlands: No Demo: No Other: N/A
Soils: D		
SIZING INFOMATION		
Drainage Area (ac): 7.44		
Impervious Area (ac): 4.04		
Practice Area Available(ft²): 4000		
Existing Head Available? >10'		

Date Assessed: 10/30/2014 Assessed by: AGM/LMJ



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Project Location

Legend

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- Practice Area
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- Manholes
- Stormline
- VT Significant Wetland
- Stream

Notes

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M09 - MINI Dealership Shelburne, VT

Project: 14-042
Prepared By: LMJ
12/03/2014
1 inch = 100 feet

ID#: M10	
Name: Shelburne Meadows Business Park	
Permit #: 1-1400 A	
Concept Description: Retrofit of existing BMP to 2002 standards	
Notes/Feasibility: 2 3" orifices at 2 ft 24 by 24 in horizontal grate at 4 ft	

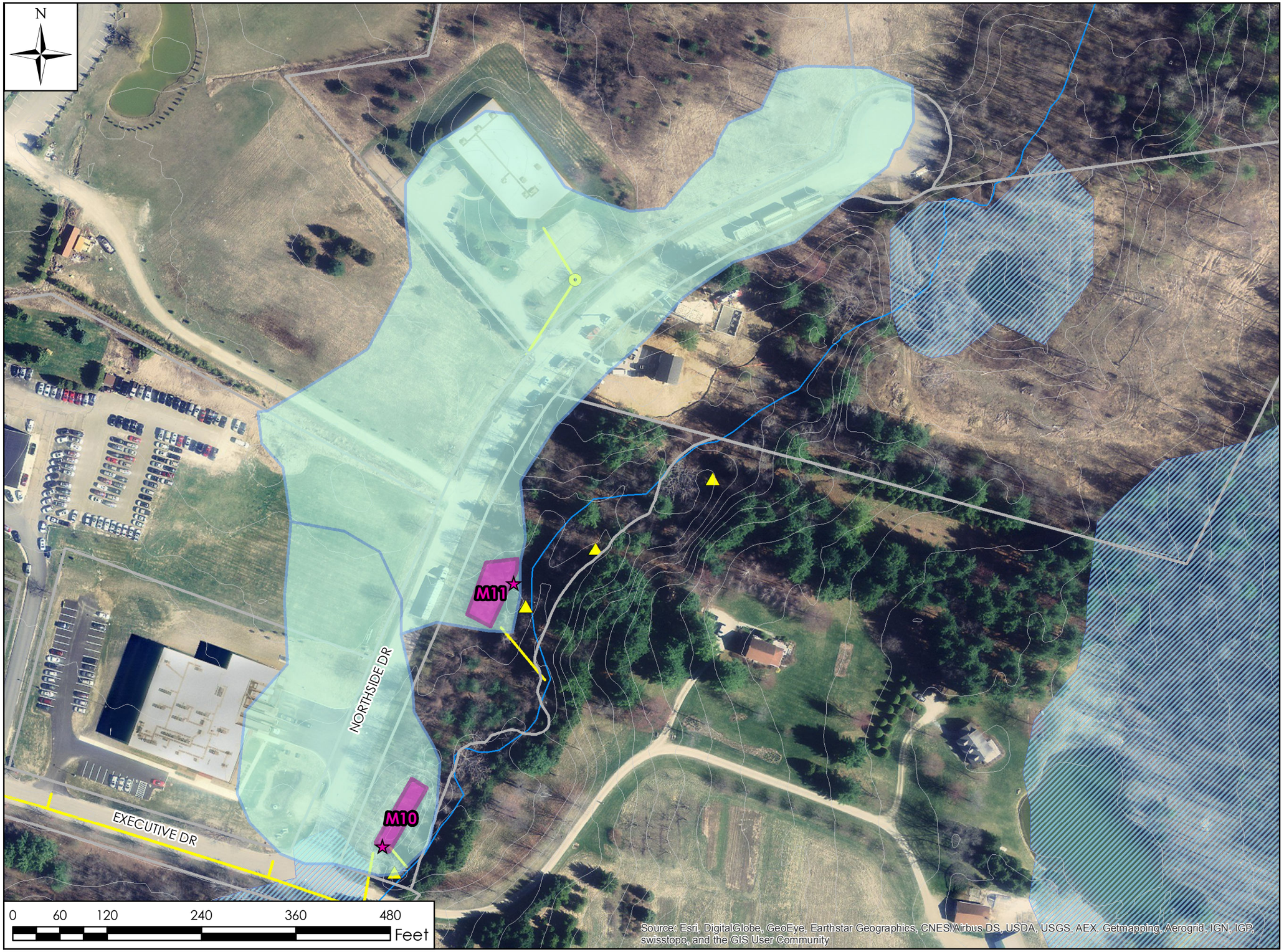
GENERAL SITE INFORMATION	RETROFIT DETAILS	
Site Contact Info: Shelburne	Project Candidate: Tier II	
Ownership:	New or Retrofit BMP: Retrofit	
Land Use 1: Commercial	Proposed Retrofit Practice: Pond	
Land Use 2:	Non-Structural Controls: No	
Existing BMP on site? Yes	Maintenance Burden: Minimal change	
Is site a hotspot? No	Benefits: Storage: Yes Water Quality: Yes Recharge: No Repair: No Other: N/A	Conflicts: Soils: No Access: No Land Use: No Utilities: no High WT: Yes Wetlands: Yes Demo: Other: N/A
Soils: C		
SIZING INFOMATION		
Drainage Area (ac): 1.80		
Impervious Area (ac): 0.74		
Practice Area Available(ft²): 2100		
Existing Head Available? 2' Est.		

Date Assessed: 10/30/2014 Assessed by: AGM/LMJ

ID#: M11	
Name: Shelburne Meadows Business Park	No Image Available
Permit #: 1-1400 B	
Concept Description: Retrofit of existing BMP to 2002 standards	
Notes/Feasibility: 24 in pipe with 15 in end cap	

GENERAL SITE INFORMATION	RETROFIT DETAILS	
Site Contact Info: Shelburne	Project Candidate: Tier II	
Ownership:	New or Retrofit BMP: Retrofit	
Land Use 1: Commercial	Proposed Retrofit Practice: Pond	
Land Use 2:	Non-Structural Controls: No	
Existing BMP on site? Yes	Maintenance Burden: Minimal change	
Is site a hotspot? No	Benefits: Storage: Yes Water Quality: Yes Recharge: Yes Repair: No Other: N/A	Conflicts: Soils: No Access: No Land Use: Utilities: no High WT: yes Wetlands: No Demo: No Other: N/A
Soils: B		
SIZING INFOMATION		
Drainage Area (ac): 5.30		
Impervious Area (ac): 1.74		
Practice Area Available(ft²): 3000		
Existing Head Available? 2' Est.		

Date Assessed: 10/30/2014 Assessed by: AGM/LMJ



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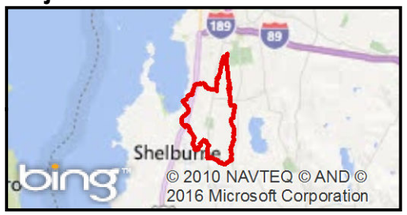
Project Location



Legend

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Notes

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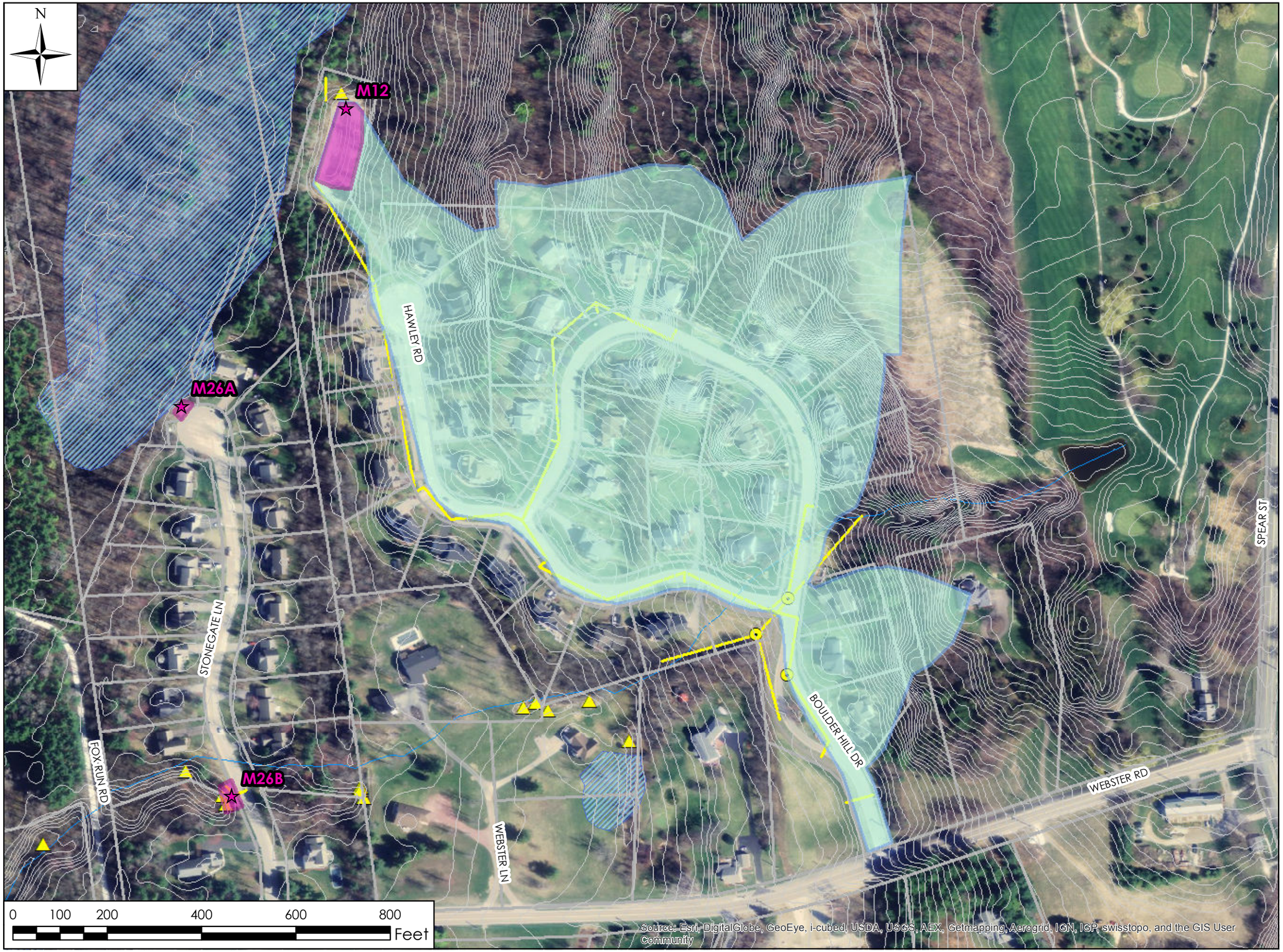
M10 & M11
Shelburne Meadows
Shelburne, VT

Project: 14-042
Prepared By: ALD
09/14/2016
1 inch = 120 feet

ID#: M12	
Name: Boulder Hill Drive	No Image Available
Permit #: 1-1534	
Concept Description: Retrofit of existing BMP to 2002 standards	
Notes/Feasibility: Existing practice has significant room for expansion.	

GENERAL SITE INFORMATION	RETROFIT DETAILS	
Site Contact Info: Shelburne	Project Candidate: Tier I	
Ownership:	New or Retrofit BMP: Retrofit	
Land Use 1: Residential	Proposed Retrofit Practice: Pond	
Land Use 2:	Non-Structural Controls: No	
Existing BMP on site? Yes	Maintenance Burden: Moderate	
Is site a hotspot? No	Benefits: Storage: Yes Water Quality: Yes Recharge: Yes Repair: No Other: N/A	Conflicts: Soils: No Access: Yes Land Use: No Utilities: No High WT: Unknown Wetlands: No Demo: No Other: N/A
Soils: B		
SIZING INFOMATION		
Drainage Area (ac): 22.30		
Impervious Area (ac): 5.36		
Practice Area Available(ft²): 11700		
Existing Head Available? N/A		

Date Assessed: 10/30/2014 Assessed by: AGM/LMJ



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Project Location

Legend

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Notes

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M12 - Boulder Hill Drive
Shelburne, VT

Project: 14-042
Prepared By: LMJ
12/03/2014
1 inch = 200 feet

ID#: M16	
Name: South Pointe	
Permit #: 3443-INDS M1	
Concept Description: Retrofit Outlet Structure	
Notes/Feasibility: While designed to 2002 standards, there was benefit to retrofitting the outlet structure	

GENERAL SITE INFORMATION	RETROFIT DETAILS	
Site Contact Info: South Burlington	Project Candidate: Tier III	
Ownership:	New or Retrofit BMP: Retrofit	
Land Use 1: Residential	Proposed Retrofit Practice:	
Land Use 2:	Non-Structural Controls: No	
Existing BMP on site? Yes	Maintenance Burden:	
Is site a hotspot? No	Benefits: Storage: Yes Water Quality: Yes Recharge: No Repair: No Other: N/A	Conflicts: Soils: No Access: No Land Use: No Utilities: No High WT: Yes Wetlands: Yes Demo: No Other: N/A
Soils: D		
SIZING INFOMATION		
Drainage Area (ac): 4.98		
Impervious Area (ac): 2.10		
Practice Area Available(ft²): 3900		
Existing Head Available? N/A		

Date Assessed: 10/30/2014 Assessed by: AGM/LMJ

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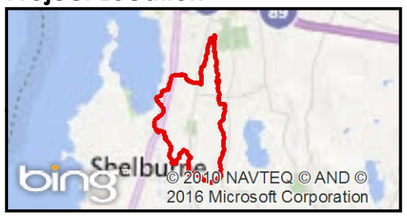
Project Location



Legend

- Munroe Brook Watershed
- Proposed BMP
- Practice Area
- BMP Drainage Area
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- Catch Basins
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- Stream

Notes

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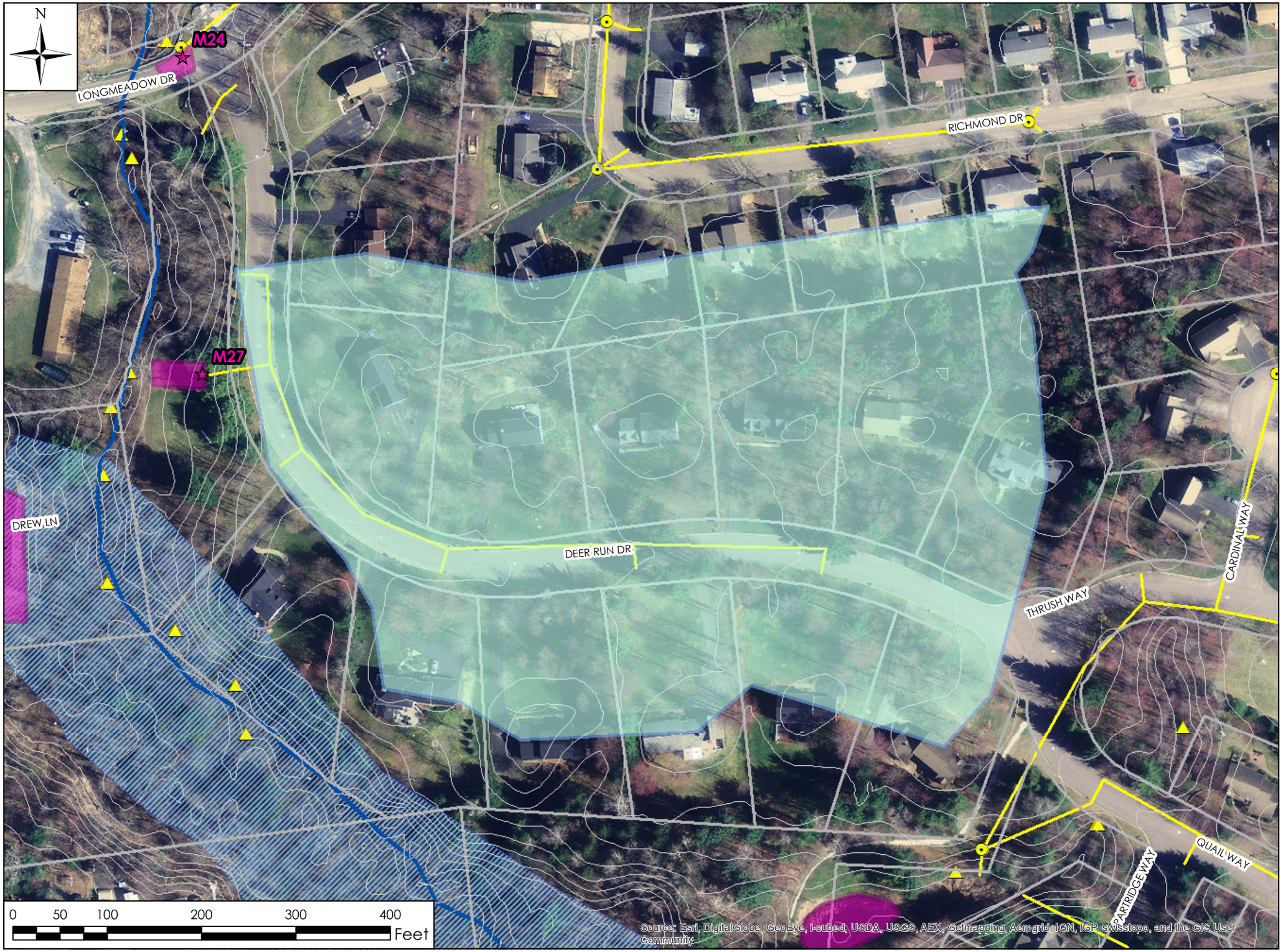
M16 - South Pointe
Shelburne, VT

Project: 14-042
Prepared By: ALD
09/23/2016
1 inch = 100 feet

ID#: M27	
Name: Deer Run	
Permit #: 1-0732	
Concept Description: Build pond in location where originally specified	
Notes/Feasibility: Proposed BMP at location indicated in permit. Existing recreation area must be demolished.	

GENERAL SITE INFORMATION	RETROFIT DETAILS	
Site Contact Info: Shelburne	Project Candidate: Tier I	
Ownership:	New or Retrofit BMP: New	
Land Use 1: Residential	Proposed Retrofit Practice: Pond	
Land Use 2:	Non-Structural Controls: N/A	
Existing BMP on site? No	Maintenance Burden: Moderate	
Is site a hotspot? No	Benefits: Storage: Yes Water Quality: Yes Recharge: No Repair: No Other: N/A	Conflicts: Soils: No Access: Yes Land Use: No Utilities: No High WT: Yes Wetlands: Yes Demo: No Other: N/A
Soils: C		
SIZING INFOMATION		
Drainage Area (ac): 8.70		
Impervious Area (ac): 1.65		
Practice Area Available(ft²): 1500		
Existing Head Available? 2-3' Est.		

Date Assessed: 10/29/2014 Assessed by: AGM/LMJ



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Project Location

Legend

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- Stormline
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- Stream

Notes

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M27 - Deer Run
Shelburne, VT

Project: 14-042
Prepared By: LMJ
12/03/2014
1 inch = 100 feet

ID#: M28A	
Name: Shelburne Camping Area	No Image Available
Permit #: N/A	
Concept Description: Two BMPs located at local low points to capture existing unpermitted impervious surface	
Notes/Feasibility: Site is relatively flat, proposed BMP located at local low point, offers little ability for treatment of Rt. 7 runoff.	

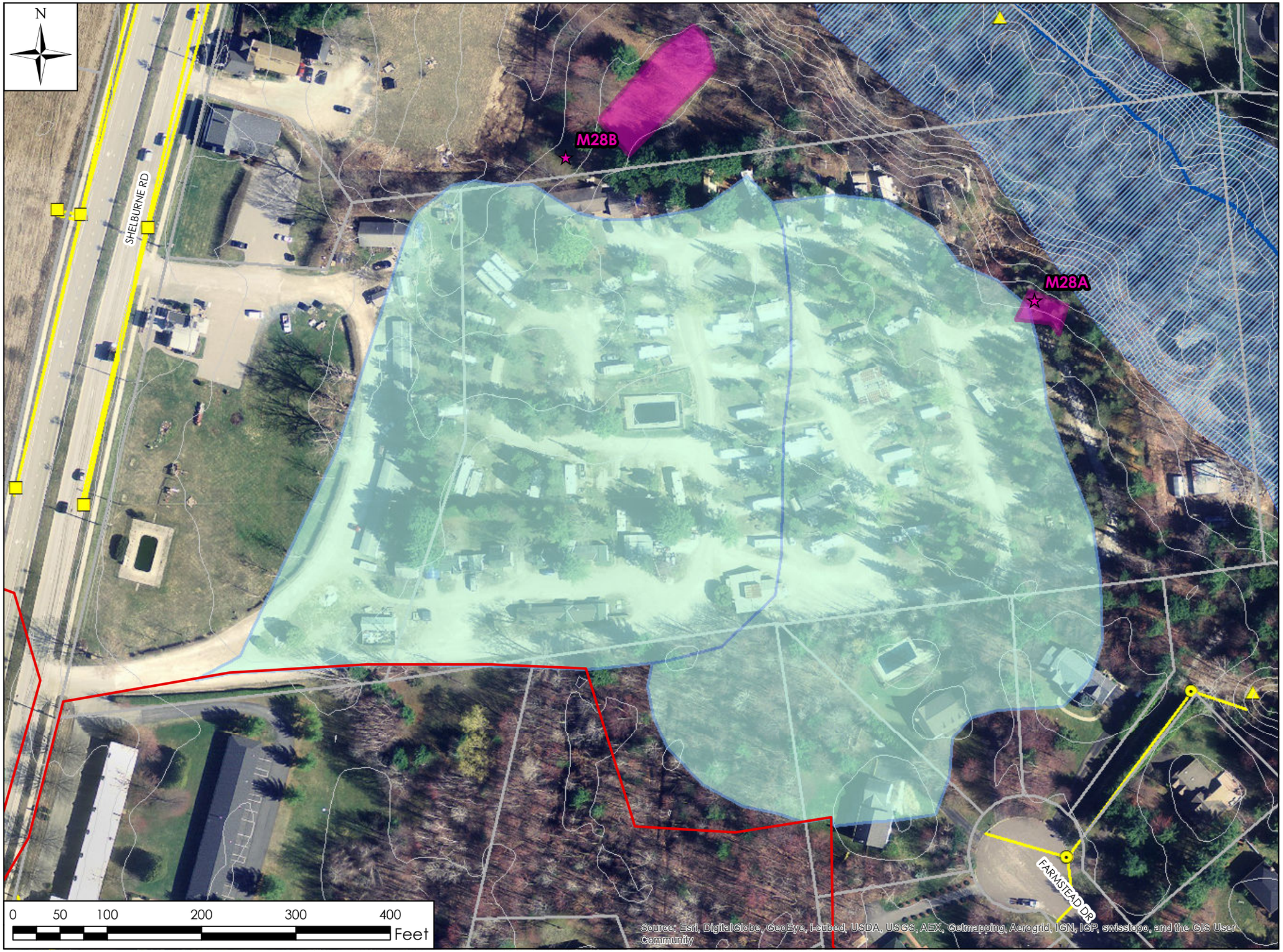
GENERAL SITE INFORMATION	RETROFIT DETAILS	
Site Contact Info: Shelburne	Project Candidate: Tier I	
Ownership:	New or Retrofit BMP: New	
Land Use 1: Commercial	Proposed Retrofit Practice: Pond	
Land Use 2:	Non-Structural Controls: N/A	
Existing BMP on site? No	Maintenance Burden: Moderate	
Is site a hotspot? No	Benefits: Storage: Yes Water Quality: Yes Recharge: No Repair: No Other: N/A	Conflicts: Soils: No Access: Yes Land Use: No Utilities: No High WT: Yes Wetlands: Yes Demo: No Other: N/A
Soils: C		
SIZING INFOMATION		
Drainage Area (ac): 4.50		
Impervious Area (ac): 1.32		
Practice Area Available(ft^2): 1300		
Existing Head Available? N/A		

Date Assessed: 10/29/2014 Assessed by: AGM/LMJ

ID#: M28B	
Name: Shelburne Camping Area	No Image Available
Permit #: N/A	
Concept Description: Two BMPs located at local low points to capture existing unpermitted impervious surface	
Notes/Feasibility: Site is relatively flat, proposed BMP located at local low point, offers little ability for treatment of Rt. 7 runoff.	

GENERAL SITE INFORMATION	RETROFIT DETAILS	
Site Contact Info: Shelburne	Project Candidate: Tier I	
Ownership:	New or Retrofit BMP: New	
Land Use 1: Commercial	Proposed Retrofit Practice: Pond	
Land Use 2:	Non-Structural Controls: N/A	
Existing BMP on site? No	Maintenance Burden: Moderate	
Is site a hotspot? No	Benefits: Storage: Yes Water Quality: Yes Recharge: Yes Repair: No Other: N/A	Conflicts: Soils: No Access: Yes Land Use: No Utilities: No High WT: Unknown Wetlands: No Demo: No Other: N/A
Soils: B		
SIZING INFOMATION		
Drainage Area (ac): 5.30		
Impervious Area (ac): 2.27		
Practice Area Available(ft²): 7500		
Existing Head Available? N/A		

Date Assessed: 10/29/2014 Assessed by: AGM/LMJ



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Project Location

Legend

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- Proposed BMP
- Practice Area
- BMP Drainage Area
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- Munroe Brook
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- Catch Basins
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- VT Significant Wetland
- Stream

Notes

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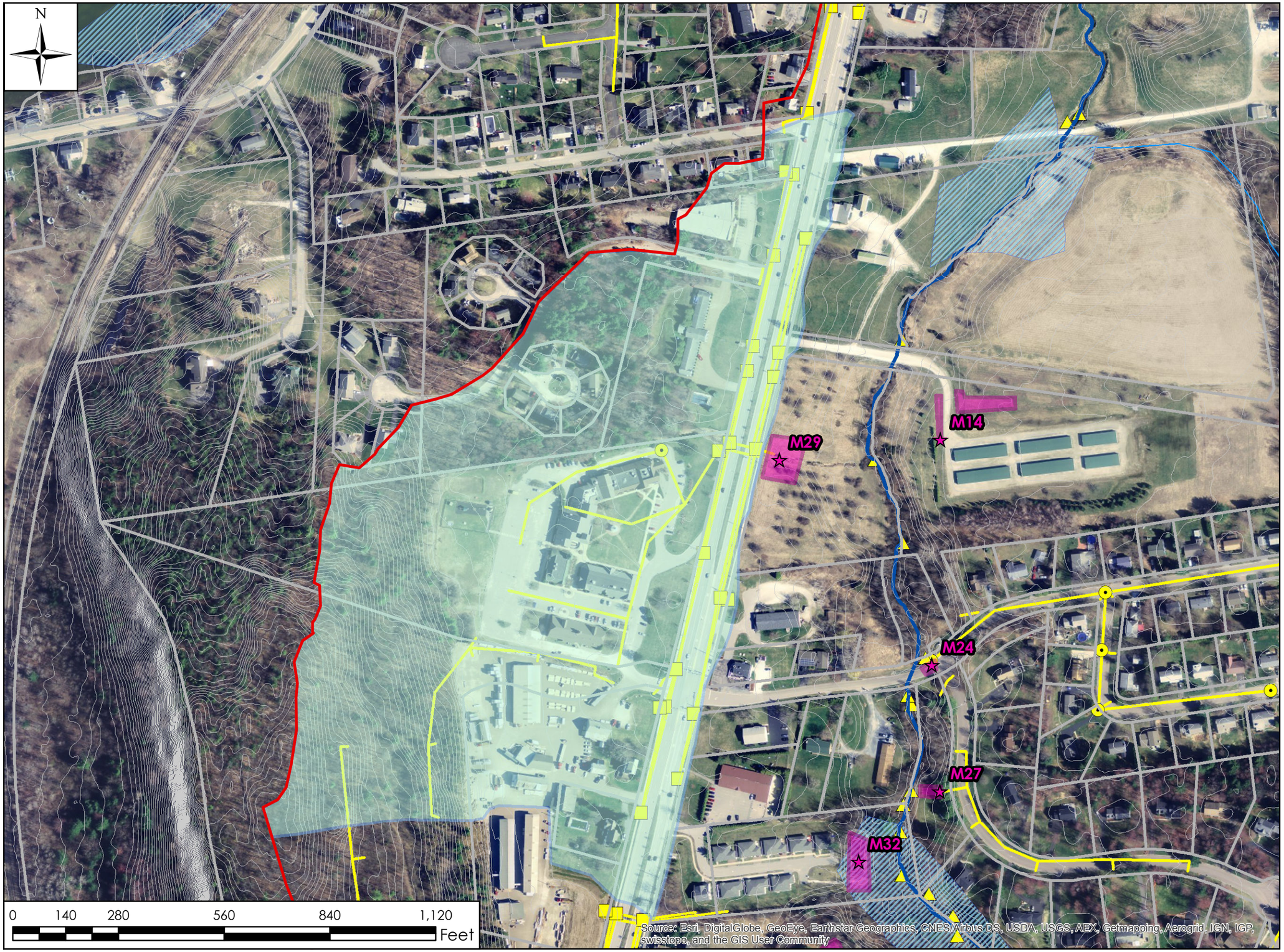
M28 A & M28 B
Shelburne Camping Area
Shelburne, VT

Project: 14-042
Prepared By: LMJ
12/03/2014
1 inch = 100 feet

ID#: M29 Option 1	
Name: Shelburne Commons/Rice Lumber	
Permit #: N/A	
Concept Description: Construct new wet pond to capture existing impervious from unpermitted site as well as Route 7	
Notes/Feasibility: Good candidate for collecting Rt. 7 runoff, significant head available.	

GENERAL SITE INFORMATION	RETROFIT DETAILS	
Site Contact Info: Shelburne/VTrans	Project Candidate: Tier I	
Ownership:	New or Retrofit BMP: New	
Land Use 1: Commercial	Proposed Retrofit Practice: Pond	
Land Use 2: Transportation	Non-Structural Controls: N/A	
Existing BMP on site? No	Maintenance Burden: Moderate	
Is site a hotspot? No	Benefits: Storage: Yes Water Quality: Yes Recharge: No Repair: No Other: N/A	Conflicts: Soils: No Access: Yes Land Use: Utilities: Yes High WT: Yes Wetlands: Yes Demo: Yes Other: N/A
Soils: D		
SIZING INFOMATION		
Drainage Area (ac): 41.10		
Impervious Area (ac): 16.40		
Practice Area Available(ft²): 10400		
Existing Head Available? N/A		

Date Assessed: 10/29/2014 Assessed by: AGM/LMJ



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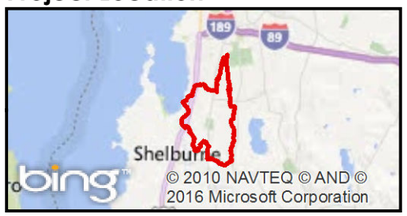

Legend

- Munroe Brook Watershed
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Notes

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M29 - Shleburne Commons
Shelburne, VT

Project: 14-042
Prepared By: ALD
09/23/2016
1 inch = 250 feet

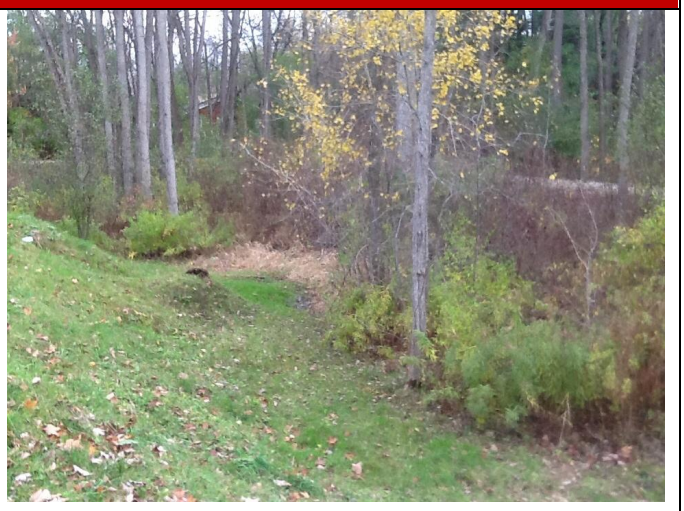
ID#: M32

Name: Drew Lane

Permit #: N/A

Concept Description: Retrofit of existing pond to 2002 standards

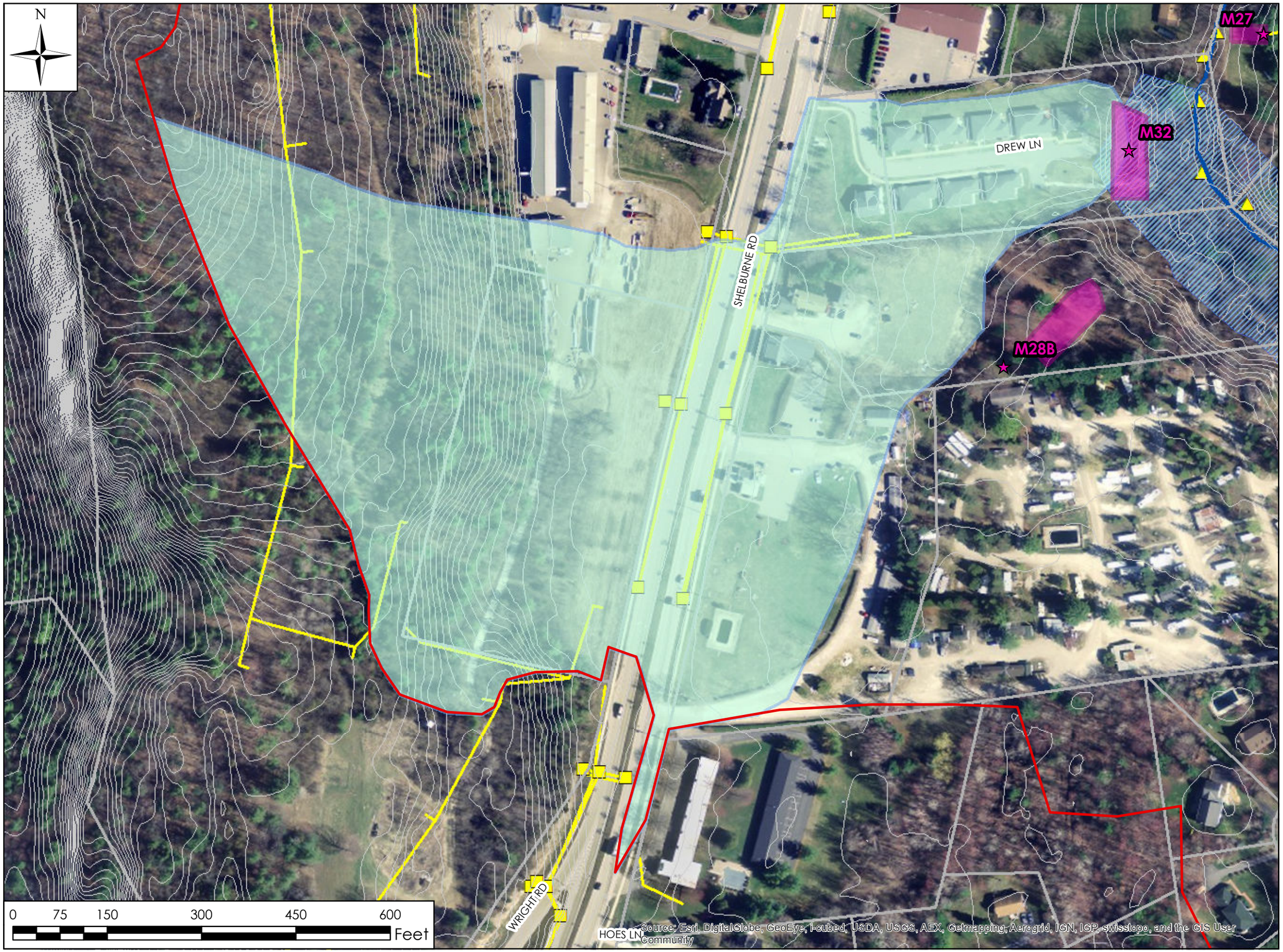
Notes/Feasibility: A pond exists in this development that does not appear to have a permit associated with it. Portion of Rt. 7 runoff runs past practice, with relatively easy ability to redirect to the practice.



GENERAL SITE INFORMATION	RETROFIT DETAILS
Site Contact Info: Shelburne/VTrans	Project Candidate: Tier I
Ownership:	New or Retrofit BMP: Retrofit
Land Use 1: Residential	Proposed Retrofit Practice: Pond
Land Use 2: Transportation	Non-Structural Controls: N/A
Existing BMP on site? Yes	Maintenance Burden: Moderate
Is site a hotspot? No	Benefits: Storage: Yes Water Quality: Yes Recharge: Yes Repair: No Other: N/A
Soils: B	
SIZING INFOMATION	
Drainage Area (ac): 19.70	
Impervious Area (ac): 4.40	
Practice Area Available(ft²): 7700	
Existing Head Available? >5'	

Conflicts:
Soils: No
Access: Yes
Land Use: No
Utilities: No
High WT: Unknown
Wetlands: No
Demo: No
Other: N/A

Date Assessed: 10/29/2014 Assessed by: AGM/LMJ



Horsley Witten Group
Sustainable Environmental Solutions
90 Route 6A • Sandwich, MA • 02563
Tel: 508-833-6600 • Fax: 508-833-3150 • www.horsleywitten.com

TRUDELL Consulting Engineers
802.879.6331 www.tcevt.com

Project Location

Legend

- Munroe Brook Watershed
- Proposed BMP
- Practice Area
- BMP Drainage Area
- Contours (2')
- Tax Parcel Boundary
- Munroe Brook
- Outfalls
- Catch Basins
- Manholes
- Stormline
- VT Significant Wetland
- Stream

Notes

Sources: Bing Aerial Photography (2012); Streams by ANR (2012); Munroe Brook Subwatersheds by ANR (Updated by TCE 2014); Drainage Areas by ANR (Updated by TCE 2014); MS4 Boundaries by ANR; BMPs by Horsley Witten Group & TCE (2014).
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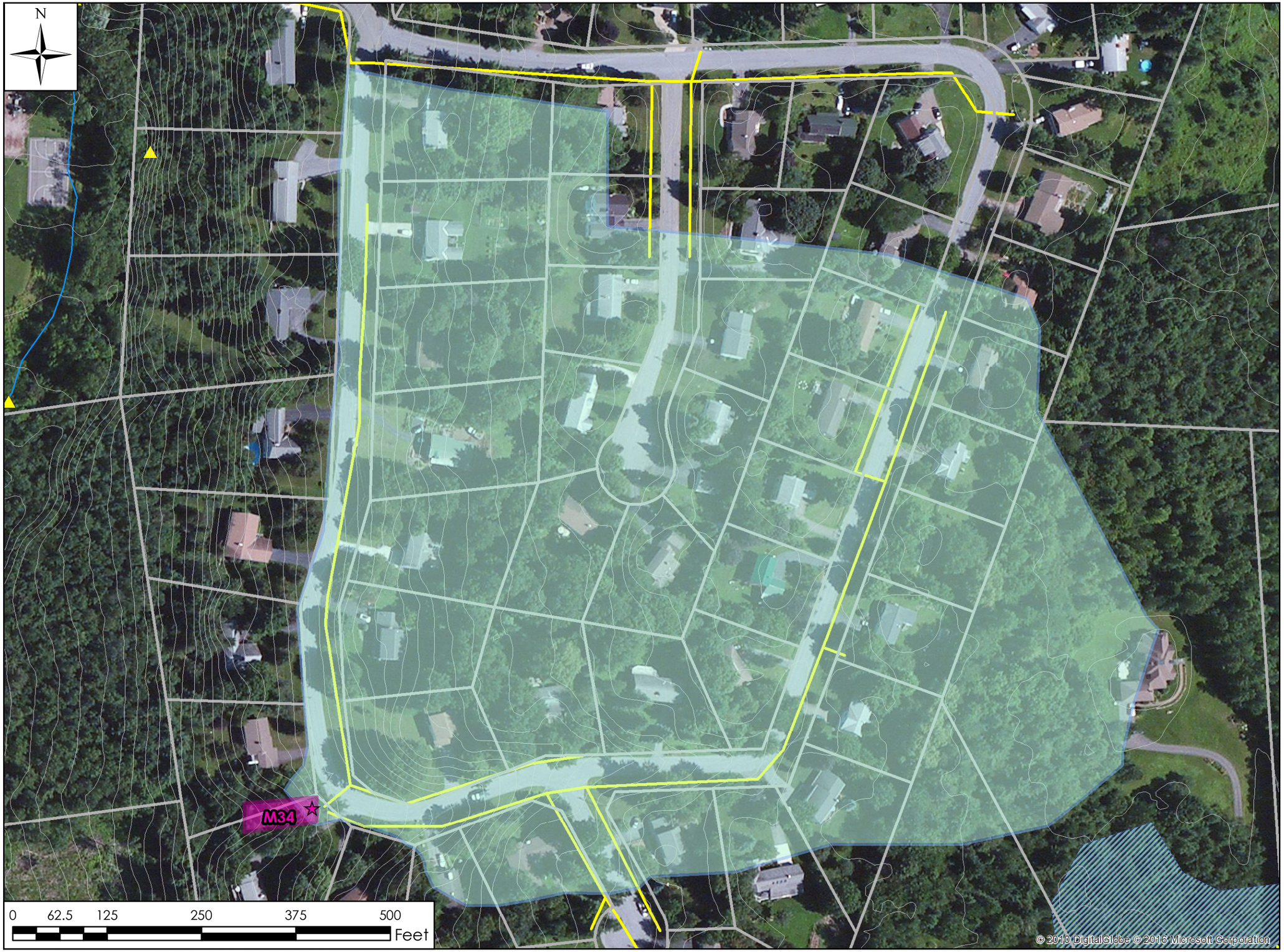
M32 - Drew Lane
Shelburne, VT

Project: 14-042
Prepared By: LMJ
12/03/2014
1 inch = 150 feet

ID#: M34	
Name: Hullcrest South	
Permit #: N/A	
Concept Description: Construction of new BMP to capture existing unpermitted impervious	
Notes/Feasibility: Area can not feasibly be drained to an existing nearby practice. Proposed practice located in wooded area along a property line.	

GENERAL SITE INFORMATION	RETROFIT DETAILS	
Site Contact Info: Shelburne	Project Candidate: Tier II	
Ownership:	New or Retrofit BMP: New	
Land Use 1: Residential	Proposed Retrofit Practice: Pond	
Land Use 2:	Non-Structural Controls: N/A	
Existing BMP on site? No	Maintenance Burden: Moderate	
Is site a hotspot? No	Benefits: Storage: Yes Water Quality: Yes Recharge: No Repair: No Other: N/A	Conflicts: Soils: No Access: Yes Land Use: No Utilities: No High WT: Unknown Wetlands: No Demo: No Other: N/A
Soils: D		
SIZING INFOMATION		
Drainage Area (ac): 20.60		
Impervious Area (ac): 4.30		
Practice Area Available(ft²): 3400		
Existing Head Available? 3-5' Est.		

Date Assessed: 10/29/2014 Assessed by: AGM/LMJ



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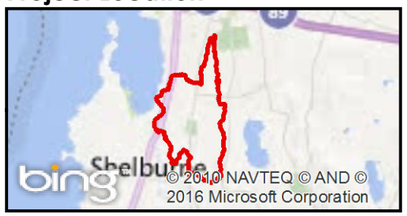
Project Location



Legend

- Munroe Brook Watershed
- Proposed BMP
- Practice Area
- BMP Drainage Area
- Contours (2')
- Tax Parcel Boundary
- Munroe Brook
- Outfalls
- Catch Basins
- Manholes
- Stormline
- VT Significant Wetland
- Stream

Notes

Sources: Bing Aerial Photography (2012); Streams by ANR (2012); Munroe Brook Subwatersheds by ANR (Updated by TCE 2014); Drainage Areas by ANR (Updated by TCE 2014); MS4 Boundaries by ANR; BMPs by Horsley Witten Group & TCE (2014).
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M34 - Hullcrest South
Shelburne, VT

Project: 14-042
Prepared By: ALD
09/23/2016
1 inch = 125 feet

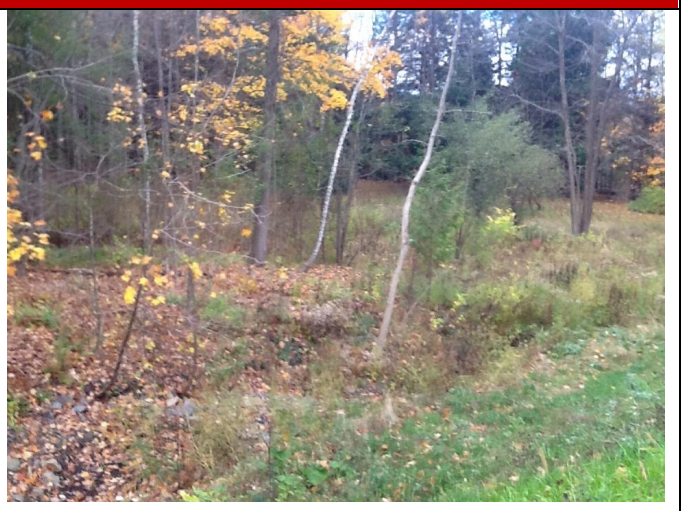
ID#: M35

Name: Morse Drive Neighborhood

Permit #: N/A

Concept Description: The existing drainage system for the proposed practice DA daylights to a single discharge adjacent to a recently constructed home. There appears to be ample area for a pond BMP at this location with good vertical relieft for discharge from the pratice.

Notes/Feasibility: Strong candidate site due to presence of existing network of ditches, culverts, and drain piping directing the majority of runoff to single point.



GENERAL SITE INFORMATION	RETROFIT DETAILS	
Site Contact Info: Shelburne	Project Candidate: Tier I	
Ownership:	New or Retrofit BMP: New	
Land Use 1: Residential	Proposed Retrofit Practice: Pond	
Land Use 2:	Non-Structural Controls: No	
Existing BMP on site? No	Maintenance Burden: Moderate	
Is site a hotspot? No	Benefits: Storage: Yes Water Quality: Yes Recharge: No Repair: No Other: N/A	Conflicts: Soils: No Access: No Land Use: Utilities: No High WT: Unknown Wetlands: No Demo: No Other: N/A
Soils: C		
SIZING INFOMATION		
Drainage Area (ac): 23.20		
Impervious Area (ac): 3.89		
Practice Area Available(ft²): 4500		
Existing Head Available? >10'		

Date Assessed: 10/30/2014 Assessed by: AGM/LMJ

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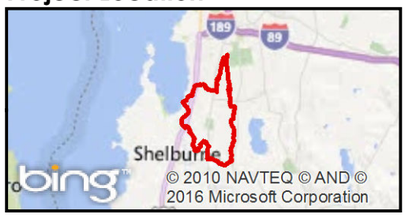
802.879.6331 www.tcevt.com

Project Location



Legend

- Munroe Brook Watershed
- Proposed BMP
- Practice Area
- BMP Drainage Area
- Contours (2')
- Tax Parcel Boundary
- Munroe Brook
- Outfalls
- Catch Basins
- Manholes
- Stormline
- VT Significant Wetland
- Stream

Notes

Sources: Bing Aerial Photography (2012); Streams by ANR (2012); Munroe Brook Subwatersheds by ANR (Updated by TCE 2014); Drainage Areas by ANR (Updated by TCE 2014); MS4 Boundaries by ANR; BMPs by Horsley Witten Group & TCE (2014).
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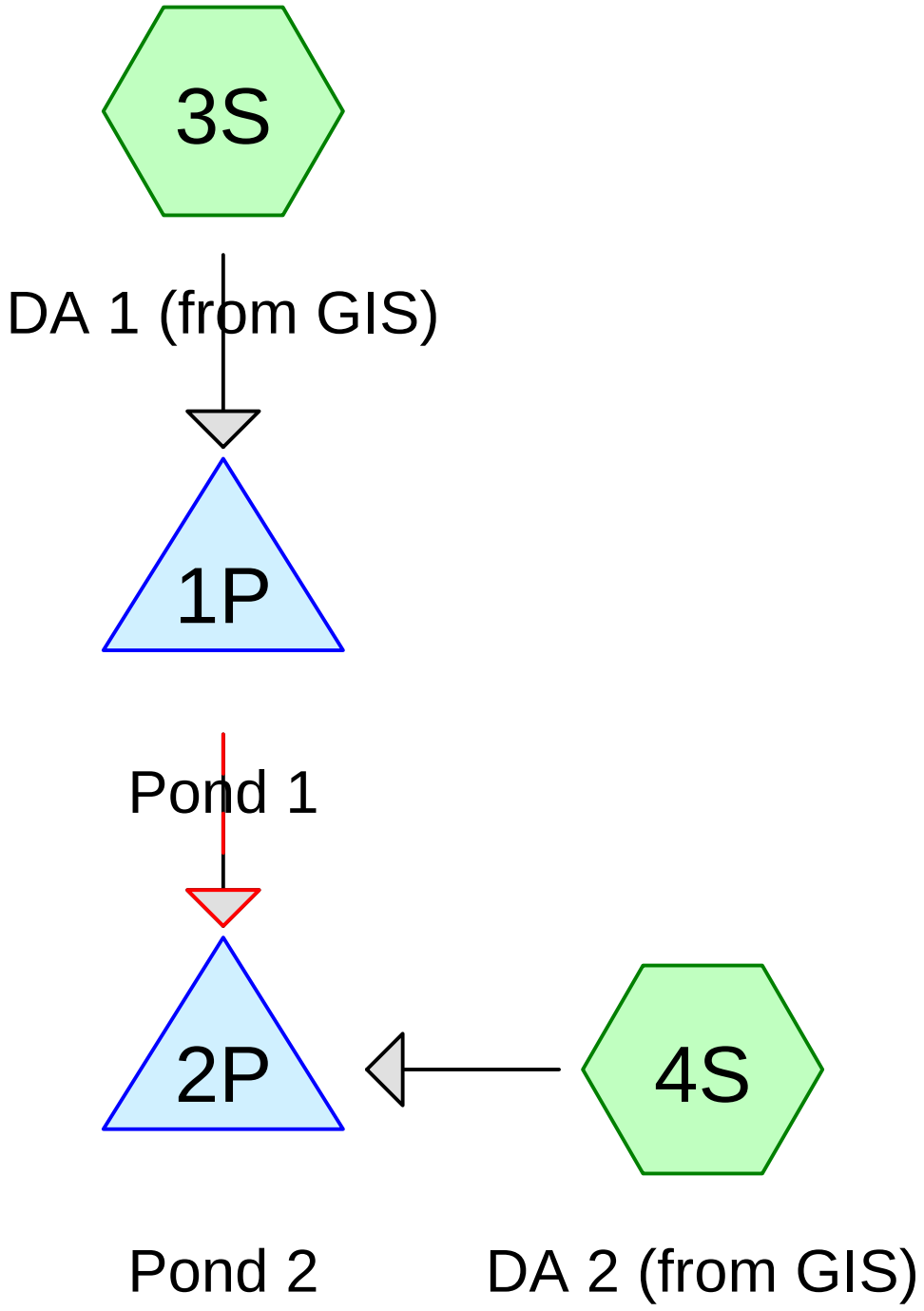
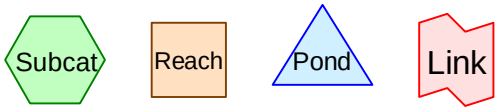
M35 - Morse Drive
Shelburne, VT

Project: 14-042
Prepared By: ALD
09/14/2016
1 inch = 200 feet

Appendix B: HydroCAD Model Outputs





Routing Diagram for M01-02 - Westview Estates Rev 2016 0401
Prepared by TCE, Printed 9/12/2016
HydroCAD® 10.00-12 s/n 02145 © 2014 HydroCAD Software Solutions LLC

Summary for Subcatchment 3S: DA 1 (from GIS)

Runoff = 2.64 cfs @ 12.22 hrs, Volume= 0.458 af, Depth= 0.18"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-100.00 hrs, dt= 0.05 hrs
Type II 24-hr 1 year Rainfall=2.10"

	Area (ac)	CN	Description
	8.902	39	>75% Grass cover, Good, HSG A
	3.208	61	>75% Grass cover, Good, HSG B
	8.290	74	>75% Grass cover, Good, HSG C
	6.382	80	>75% Grass cover, Good, HSG D
*	3.102	98	
	29.884	66	Weighted Average
	26.782		89.62% Pervious Area
	3.102		10.38% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.0					**Direct Entry,**

Summary for Subcatchment 4S: DA 2 (from GIS)

Runoff = 3.22 cfs @ 12.05 hrs, Volume= 0.263 af, Depth= 0.25"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-100.00 hrs, dt= 0.05 hrs
Type II 24-hr 1 year Rainfall=2.10"

	Area (ac)	CN	Description
	1.104	39	>75% Grass cover, Good, HSG A
	3.296	61	>75% Grass cover, Good, HSG B
	7.207	74	>75% Grass cover, Good, HSG C
*	0.833	98	
	12.440	69	Weighted Average
	11.607		93.30% Pervious Area
	0.833		6.70% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Summary for Pond 1P: Pond 1

Inflow Area = 29.884 ac, 10.38% Impervious, Inflow Depth = 0.18" for 1 year event
Inflow = 2.64 cfs @ 12.22 hrs, Volume= 0.458 af
Outflow = 0.28 cfs @ 19.18 hrs, Volume= 0.297 af, Atten= 89%, Lag= 418.1 min
Primary = 0.28 cfs @ 19.18 hrs, Volume= 0.297 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-100.00 hrs, dt= 0.05 hrs

Starting Elev= 272.50' Surf.Area= 0.494 ac Storage= 1.127 af
Peak Elev= 273.09' @ 19.18 hrs Surf.Area= 0.515 ac Storage= 1.422 af (0.295 af above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= 1,095.7 min (2,056.3 - 960.6)

Volume	Invert	Avail.Storage	Storage Description
#1	270.00'	2.478 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
270.00	0.409	0.000	0.000
271.00	0.442	0.425	0.425
272.00	0.476	0.459	0.884
273.00	0.512	0.494	1.378
274.00	0.549	0.531	1.909
275.00	0.588	0.568	2.478

Device	Routing	Invert	Outlet Devices
#1	Primary	270.00'	**12.0" Round Culvert** L= 20.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 270.00' / 269.70' S= 0.0150 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 0.79 sf
#2	Device 1	272.50'	**1.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	273.00'	**12.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#4	Secondary	274.50'	**25.0' long x 15.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=0.28 cfs @ 19.18 hrs HW=273.09' (Free Discharge)
└─**1=Culvert** (Passes 0.28 cfs of 6.08 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 0.02 cfs @ 3.55 fps)
  └─**3=Orifice/Grate** (Weir Controls 0.26 cfs @ 0.96 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=272.50' (Free Discharge)
└─**4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond 2P: Pond 2

lowered orifice elevation, increased pond footprint, raised spillway

Inflow Area =	42.324 ac,	9.30% Impervious,	Inflow Depth >	0.16" for 1 year event
Inflow =	3.22 cfs @	12.05 hrs,	Volume=	0.560 af
Outflow =	0.10 cfs @	25.80 hrs,	Volume=	0.532 af, Atten= 97%, Lag= 824.5 min
Primary =	0.10 cfs @	25.80 hrs,	Volume=	0.532 af
Secondary =	0.00 cfs @	0.00 hrs,	Volume=	0.000 af

Routing by Stor-Ind method, Time Span= 0.00-100.00 hrs, dt= 0.05 hrs
Starting Elev= 257.00' Surf.Area= 3,500 sf Storage= 3,929 cf
Peak Elev= 260.07' @ 25.80 hrs Surf.Area= 6,568 sf Storage= 19,370 cf (15,441 cf above start)
Flood Elev= 260.50' Surf.Area= 7,000 sf Storage= 22,304 cf (18,375 cf above start)

Plug-Flow detention time= 2,330.0 min calculated for 0.442 af (79% of inflow)
Center-of-Mass det. time= 1,474.1 min (3,000.7 - 1,526.6)

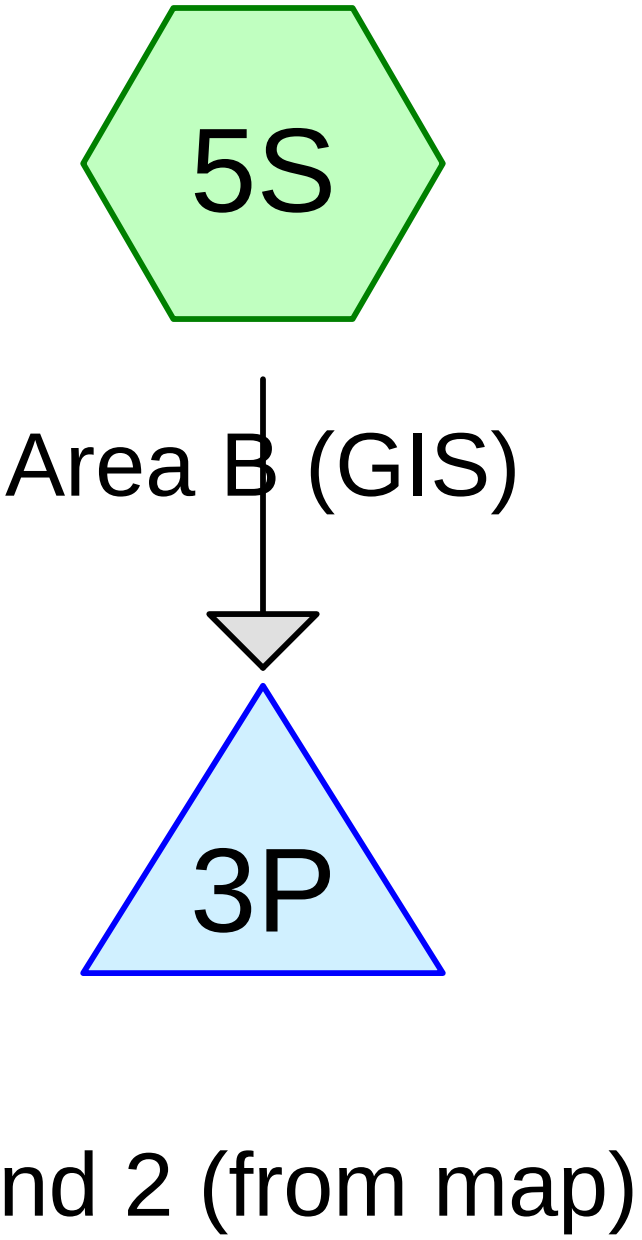
Volume	Invert	Avail.Storage	Storage Description
#1	255.00'	22,304 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

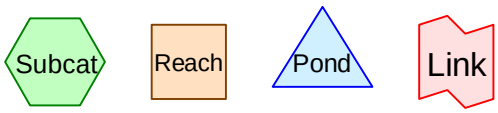
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
255.00	1,307	0	0
256.00	1,525	1,416	1,416
257.00	3,500	2,513	3,929
257.50	4,000	1,875	5,804
258.00	4,500	2,125	7,929
258.50	5,000	2,375	10,304
259.00	5,500	2,625	12,929
259.50	6,000	2,875	15,804
260.00	6,500	3,125	18,929
260.50	7,000	3,375	22,304

Device	Routing	Invert	Outlet Devices
#1	Primary	257.00'	**1.5" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Secondary	260.25'	**20.0' long x 10.0' breadth Broad-Crested Rectangular Weir**
			Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60
			Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=0.10 cfs @ 25.80 hrs HW=260.07' (Free Discharge)
└**1=Orifice/Grate** (Orifice Controls 0.10 cfs @ 8.43 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=257.00' (Free Discharge)
└**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)





Routing Diagram for M03 - 1-0732B rev 2016 0223
Prepared by TCE, Printed 9/12/2016
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Summary for Subcatchment 5S: Area B (GIS)

Runoff = 6.26 cfs @ 12.01 hrs, Volume= 0.392 af, Depth= 0.28"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-99.99 hrs, dt= 0.03 hrs
Type II 24-hr 1 year Rainfall=2.10"

Area (ac)	CN	Description
3.890	98	Paved parking & roofs
12.046	61	>75% Grass cover, Good, HSG B
0.900	74	>75% Grass cover, Good, HSG C
16.836	70	Weighted Average
12.946		76.89% Pervious Area
3.890		23.11% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.6					**Direct Entry,**

Summary for Pond 3P: Pond 2 (from map)

lowered & reduced size of control orifice, raised elevation of overflow grate

Inflow Area = 16.836 ac, 23.11% Impervious, Inflow Depth = 0.28" for 1 year event
Inflow = 6.26 cfs @ 12.01 hrs, Volume= 0.392 af
Outflow = 0.17 cfs @ 20.83 hrs, Volume= 0.343 af, Atten= 97%, Lag= 529.4 min
Primary = 0.17 cfs @ 20.83 hrs, Volume= 0.343 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-99.99 hrs, dt= 0.03 hrs
Starting Elev= 167.00' Surf.Area= 0.046 ac Storage= 0.040 af
Peak Elev= 171.03' @ 20.83 hrs Surf.Area= 0.105 ac Storage= 0.342 af (0.302 af above start)
Flood Elev= 174.00' Surf.Area= 0.155 ac Storage= 0.725 af (0.686 af above start)

Plug-Flow detention time= 2,284.1 min calculated for 0.303 af (77% of inflow)
Center-of-Mass det. time= 1,945.1 min (2,861.9 - 916.8)

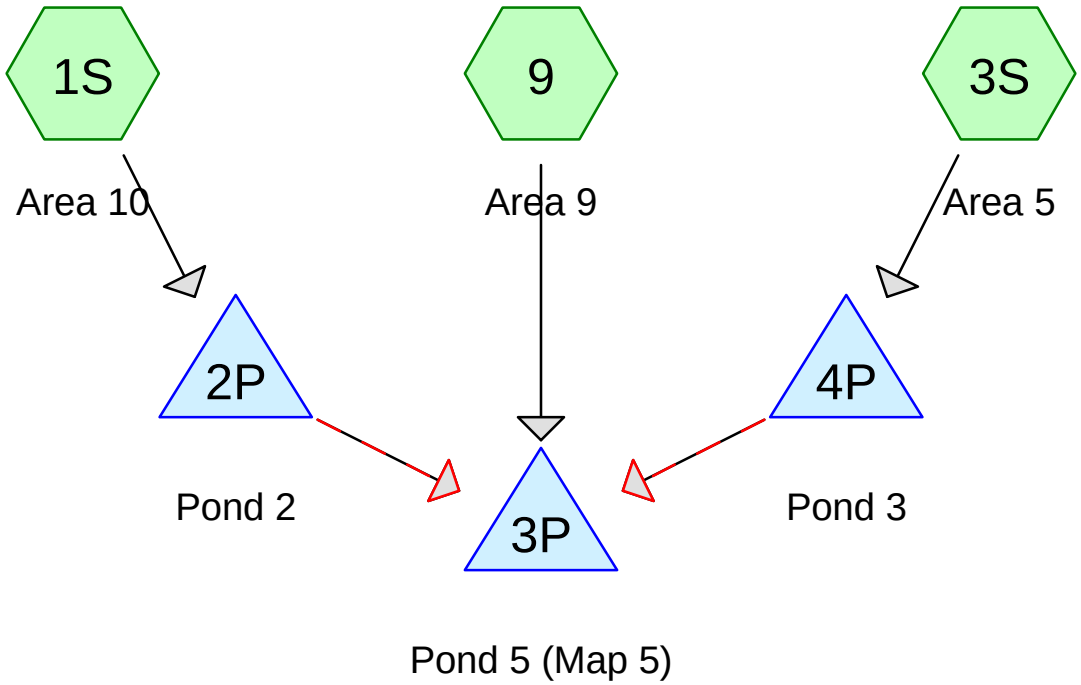
Volume	Invert	Avail.Storage	Storage Description
#1	166.00'	0.725 af	**Custom Stage Data (Irregular)** Listed below (Recalc)

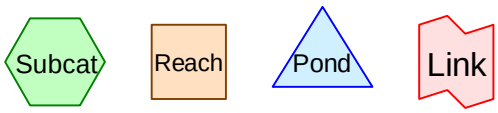
Elevation (feet)	Surf.Area (acres)	Perim. (feet)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
166.00	0.034	153.6	0.000	0.000	0.034
168.00	0.059	203.8	0.092	0.092	0.068
170.00	0.091	243.2	0.149	0.241	0.102
172.00	0.120	270.8	0.210	0.451	0.130
174.00	0.155	301.4	0.274	0.725	0.165

Device	Routing	Invert	Outlet Devices
#1	Primary	167.00'	**24.0" Round Culvert** L= 35.0' Ke= 0.500 Inlet / Outlet Invert= 167.00' / 166.50' S= 0.0143 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 3.14 sf
#2	Device 1	167.00'	**1.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	171.00'	**24.0" Horiz. overflow grate** C= 0.600 Limited to weir flow at low heads
#4	Secondary	172.00'	**60.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=0.15 cfs @ 20.83 hrs HW=171.03' (Free Discharge)
└─**1=Culvert** (Passes 0.15 cfs of 22.72 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 0.05 cfs @ 9.61 fps)
  └─**3=overflow grate** (Weir Controls 0.10 cfs @ 0.56 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=167.00' (Free Discharge)
└─**4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)





Routing Diagram for M05 - 1-1155C rev 2016 0401
Prepared by TCE, Printed 9/12/2016
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Summary for Subcatchment 1S: Area 10

Runoff = 7.19 cfs @ 12.08 hrs, Volume= 0.491 af, Depth= 0.58"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-100.00 hrs, dt= 0.05 hrs
Type II 24-hr 1 year Rainfall=2.10"

	Area (ac)	CN	Description
*	10.130	79	
	10.130		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.4					**Direct Entry,**

Summary for Subcatchment 3S: Area 5

Runoff = 7.16 cfs @ 12.11 hrs, Volume= 0.523 af, Depth= 0.62"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-100.00 hrs, dt= 0.05 hrs
Type II 24-hr 1 year Rainfall=2.10"

	Area (ac)	CN	Description
*	10.060	80	
	10.060		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
16.9					**Direct Entry,**

Summary for Subcatchment 9: Area 9

Runoff = 1.70 cfs @ 12.23 hrs, Volume= 0.194 af, Depth= 0.37"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-100.00 hrs, dt= 0.05 hrs
Type II 24-hr 1 year Rainfall=2.10"

	Area (ac)	CN	Description
*	6.360	73	
	6.360		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.5					**Direct Entry,**

Summary for Pond 2P: Pond 2

Inflow Area = 10.130 ac, 0.00% Impervious, Inflow Depth = 0.58" for 1 year event
Inflow = 7.19 cfs @ 12.08 hrs, Volume= 0.491 af
Outflow = 0.10 cfs @ 12.82 hrs, Volume= 0.225 af, Atten= 99%, Lag= 44.3 min
Primary = 0.10 cfs @ 12.82 hrs, Volume= 0.225 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-100.00 hrs, dt= 0.05 hrs
Starting Elev= 384.00' Surf.Area= 0.000 ac Storage= 0.110 af
Peak Elev= 384.98' @ 24.85 hrs Surf.Area= 0.000 ac Storage= 0.573 af (0.463 af above start)

Plug-Flow detention time= 4,609.8 min calculated for 0.115 af (23% of inflow)
Center-of-Mass det. time= 3,306.8 min (4,183.0 - 876.2)

Volume	Invert	Avail.Storage	Storage Description
#1	383.00'	2.970 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
383.00	0.000
384.00	0.110
385.00	0.580
386.00	1.090
387.00	1.660
388.00	2.280
389.00	2.970

Device	Routing	Invert	Outlet Devices
#1	Primary	383.00'	**24.0" Round Culvert** L= 60.0' Ke= 0.500 Inlet / Outlet Invert= 383.00' / 382.25' S= 0.0125 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 3.14 sf
#2	Device 1	384.00'	**2.5" Vert. Orifice/Grate** C= 0.600
#3	Secondary	388.00'	**12.6' long (Profile 1) Broad-Crested Rectangular Weir** Head (feet) 0.49 0.98 1.48 Coef. (English) 2.92 3.37 3.59
#4	Secondary	388.50'	**20.0' long (Profile 1) Broad-Crested Rectangular Weir** Head (feet) 0.49 0.98 1.48 Coef. (English) 2.92 3.37 3.59

Primary OutFlow Max=0.10 cfs @ 12.82 hrs HW=384.50' TW=384.12' (Dynamic Tailwater)
└─**1=Culvert** (Passes 0.10 cfs of 4.53 cfs potential flow)
  └─**2=Orifice/Grate** (Orifice Controls 0.10 cfs @ 2.99 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=384.00' TW=383.00' (Dynamic Tailwater)
├─**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)
└─**4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond 3P: Pond 5 (Map 5)

added control orifice

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[80] Warning: Exceeded Pond 2P by 0.08' @ 21.75 hrs (0.05 cfs 0.075 af)

Inflow Area = 26.550 ac, 0.00% Impervious, Inflow Depth > 0.42" for 1 year event
Inflow = 1.88 cfs @ 12.23 hrs, Volume= 0.937 af
Outflow = 0.12 cfs @ 25.33 hrs, Volume= 0.811 af, Atten= 94%, Lag= 786.1 min
Primary = 0.12 cfs @ 25.33 hrs, Volume= 0.811 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-100.00 hrs, dt= 0.05 hrs
Peak Elev= 385.05' @ 25.33 hrs Surf.Area= 0.250 ac Storage= 0.241 af
Flood Elev= 388.00' Surf.Area= 1.420 ac Storage= 2.357 af

Plug-Flow detention time= 1,164.5 min calculated for 0.811 af (86% of inflow)
Center-of-Mass det. time= 730.0 min (3,314.9 - 2,584.9)

Volume	Invert	Avail.Storage	Storage Description
#1	383.00'	5.197 af	**Custom Stage Data (Pyramidal)** Listed below

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
383.00	0.035	0.000	0.000	0.035
384.00	0.095	0.063	0.063	0.095
385.00	0.240	0.162	0.225	0.240
386.00	0.460	0.344	0.569	0.461
387.00	0.870	0.654	1.223	0.871
388.00	1.420	1.134	2.357	1.421
389.00	1.420	1.420	3.777	1.444
390.00	1.420	1.420	5.197	1.467

Device	Routing	Invert	Outlet Devices
#1	Primary	383.00'	**18.0" Round Culvert** L= 80.0' Ke= 0.900 Inlet / Outlet Invert= 383.00' / 382.00' S= 0.0125 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 1.77 sf
#2	Device 1	383.00'	**1.8" Vert. Orifice/Grate** C= 0.600
#3	Device 1	387.00'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#4	Primary	389.50'	**35.0' long x 1.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 Coef. (English) 2.62 2.64 2.64 2.68 2.75 2.86 2.92 3.07 3.07 3.03 3.28 3.32

Primary OutFlow Max=0.12 cfs @ 25.33 hrs HW=385.05' (Free Discharge)
- **1=Culvert** (Passes 0.12 cfs of 6.52 cfs potential flow)
  - **2=Orifice/Grate** (Orifice Controls 0.12 cfs @ 6.76 fps)
  - **3=Orifice/Grate** (Controls 0.00 cfs)
- **4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond 4P: Pond 3

Inflow Area =	10.060 ac,	0.00% Impervious,	Inflow Depth =	0.62"	for 1 year event
Inflow =	7.16 cfs @	12.11 hrs,	Volume=	0.523 af	
Outflow =	0.13 cfs @	15.48 hrs,	Volume=	0.518 af,	Atten= 98%, Lag= 202.1 min
Primary =	0.13 cfs @	15.48 hrs,	Volume=	0.518 af	
Secondary =	0.00 cfs @	0.00 hrs,	Volume=	0.000 af	

Routing by Dyn-Stor-Ind method, Time Span= 0.00-100.00 hrs, dt= 0.05 hrs
Peak Elev= 386.37' @ 24.15 hrs Surf.Area= 0.000 ac Storage= 0.396 af

Plug-Flow detention time= 1,645.3 min calculated for 0.518 af (99% of inflow)
Center-of-Mass det. time= 1,641.3 min (2,515.4 - 874.2)

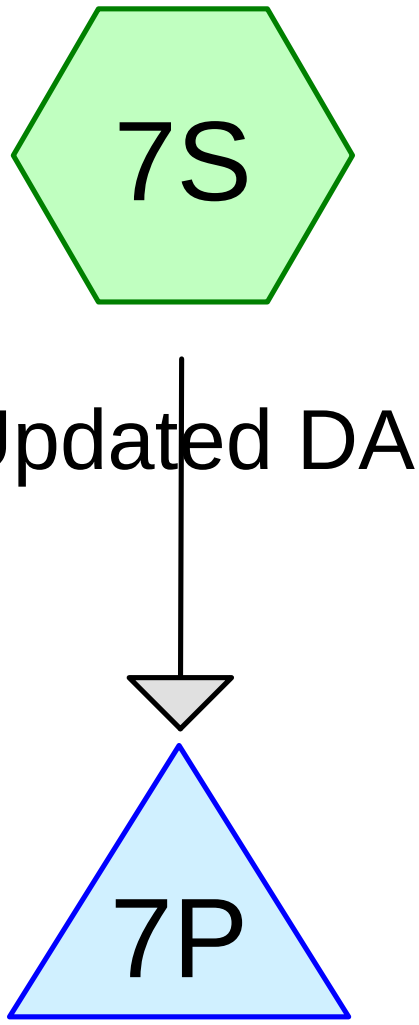
Volume	Invert	Avail.Storage	Storage Description
#1	384.50'	1.810 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
384.50	0.000
385.00	0.050
386.00	0.280
387.00	0.590
388.00	0.930
389.00	1.330
390.00	1.810

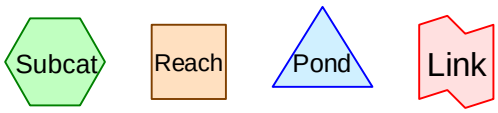
Device	Routing	Invert	Outlet Devices
#1	Primary	384.50'	**18.0" Round Culvert** L= 40.0' Ke= 0.500 Inlet / Outlet Invert= 384.50' / 383.00' S= 0.0375 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 1.77 sf
#2	Device 1	384.50'	**2.0" Vert. Orifice/Grate** C= 0.600
#3	Secondary	387.50'	**12.6' long x 1.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 Coef. (English) 2.62 2.64 2.64 2.68 2.75 2.86 2.92 3.07 3.07 3.03 3.28 3.32
#4	Secondary	389.00'	**20.0' long x 1.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 Coef. (English) 2.62 2.64 2.64 2.68 2.75 2.86 2.92 3.07 3.07 3.03 3.28 3.32

Primary OutFlow Max=0.13 cfs @ 15.48 hrs HW=386.19' TW=384.59' (Dynamic Tailwater)
└─**1=Culvert** (Passes 0.13 cfs of 8.26 cfs potential flow)
  └─**2=Orifice/Grate** (Orifice Controls 0.13 cfs @ 6.10 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=384.50' TW=383.00' (Dynamic Tailwater)
├─**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)
└─**4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)



Modified Pond



Routing Diagram for M8 - Route 7 - Updated
Prepared by TCE, Printed 9/12/2016
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Summary for Subcatchment 7S: Updated DA

Runoff = 24.33 cfs @ 12.75 hrs, Volume= 4.830 af, Depth= 0.50"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-100.00 hrs, dt= 0.01 hrs
Type II 24-hr 1 year Rainfall=2.10"

	Area (ac)	CN	Description
*	12.129	98	Impervious, HSG B
	10.499	61	>75% Grass cover, Good, HSG B
	26.260	60	Woods, Fair, HSG B
*	17.317	98	Impervious, HSG C
	8.496	74	>75% Grass cover, Good, HSG C
	19.802	73	Woods, Fair, HSG C
*	3.349	98	Impervious, HSG D
	5.493	80	>75% Grass cover, Good, HSG D
	11.910	79	Woods, Fair, HSG D
	115.255	77	Weighted Average
	82.460		71.55% Pervious Area
	32.795		28.45% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
64.8	5,331	0.0420	1.37		**Lag/CN Method,**

Summary for Pond 7P: Modified Pond

Inflow Area = 115.255 ac, 28.45% Impervious, Inflow Depth = 0.50" for 1 year event
Inflow = 24.33 cfs @ 12.75 hrs, Volume= 4.830 af
Outflow = 12.80 cfs @ 13.49 hrs, Volume= 4.794 af, Atten= 47%, Lag= 44.3 min
Primary = 12.80 cfs @ 13.49 hrs, Volume= 4.794 af

Routing by Stor-Ind method, Time Span= 0.00-100.00 hrs, dt= 0.01 hrs
Starting Elev= 146.24' Surf.Area= 0.386 ac Storage= 0.389 af
Peak Elev= 150.68' @ 13.49 hrs Surf.Area= 0.553 ac Storage= 2.168 af (1.779 af above start)

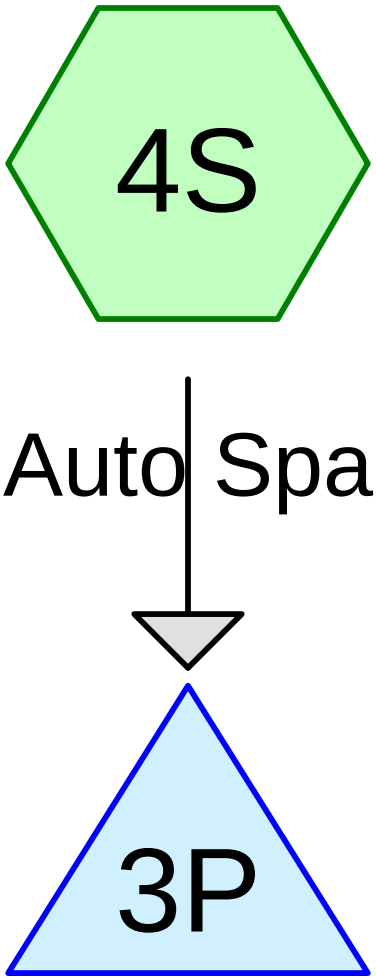
Plug-Flow detention time= 837.4 min calculated for 4.405 af (91% of inflow)
Center-of-Mass det. time= 717.5 min (1,649.4 - 931.9)

Volume	Invert	Avail.Storage	Storage Description
#1	144.50'	2.305 af	**Custom Stage Data (Irregular)** Listed below (Recalc)
#2	145.10'	1.343 af	**100.00'W x 130.00'L x 5.00'H Prismatoid**
			1.492 af Overall x 90.0% Voids
		3.648 af	Total Available Storage

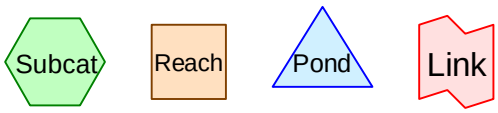
Elevation (feet)	Surf.Area (acres)	Perim. (feet)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
144.50	0.012	360.0	0.000	0.000	0.012
146.00	0.081	470.0	0.062	0.062	0.179
150.00	0.231	564.0	0.598	0.660	0.363
154.00	0.383	543.0	1.215	1.876	0.429
155.00	0.478	606.0	0.430	2.305	0.562

Device	Routing	Invert	Outlet Devices
#1	Primary	145.10'	**30.0" Round Culvert** L= 128.0' Ke= 0.500 Inlet / Outlet Invert= 145.10' / 143.82' S= 0.0100 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 4.91 sf
#2	Device 1	146.24'	**3.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	148.40'	**3.0" Vert. Orifice/Grate** C= 0.600
#4	Device 1	150.24'	**48.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=12.76 cfs @ 13.49 hrs HW=150.68' (Free Discharge)
└─**1=Culvert** (Passes 12.76 cfs of 49.17 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 0.49 cfs @ 10.00 fps)
  ├─**3=Orifice/Grate** (Orifice Controls 0.35 cfs @ 7.07 fps)
  └─**4=Orifice/Grate** (Weir Controls 11.92 cfs @ 2.16 fps)



Pond Contours from map



Routing Diagram for M09 - 1-1390 rev 2016 0224
Prepared by TCE, Printed 9/12/2016
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Summary for Subcatchment 4S: Auto Spa

Runoff = 1.93 cfs @ 12.31 hrs, Volume= 0.234 af, Depth= 0.47"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-100.00 hrs, dt= 0.05 hrs
Type II 24-hr 1 year Rainfall=2.10"

	Area (ac)	CN	Description
*	6.020	76	
	6.020		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
31.5					**Direct Entry,**

Summary for Pond 3P: Pond Contours from map

replaced 4 x 1.5" control orifices

Inflow Area = 6.020 ac, 0.00% Impervious, Inflow Depth = 0.47" for 1 year event
Inflow = 1.93 cfs @ 12.31 hrs, Volume= 0.234 af
Outflow = 0.06 cfs @ 24.31 hrs, Volume= 0.234 af, Atten= 97%, Lag= 720.1 min
Primary = 0.06 cfs @ 24.31 hrs, Volume= 0.234 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-100.00 hrs, dt= 0.05 hrs
Peak Elev= 142.95' @ 24.31 hrs Surf.Area= 0.167 ac Storage= 0.176 af
Flood Elev= 143.50' Surf.Area= 0.189 ac Storage= 0.274 af

Plug-Flow detention time= 1,402.1 min calculated for 0.234 af (100% of inflow)
Center-of-Mass det. time= 1,402.9 min (2,308.7 - 905.8)

Volume	Invert	Avail.Storage	Storage Description
#1	140.50'	0.274 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

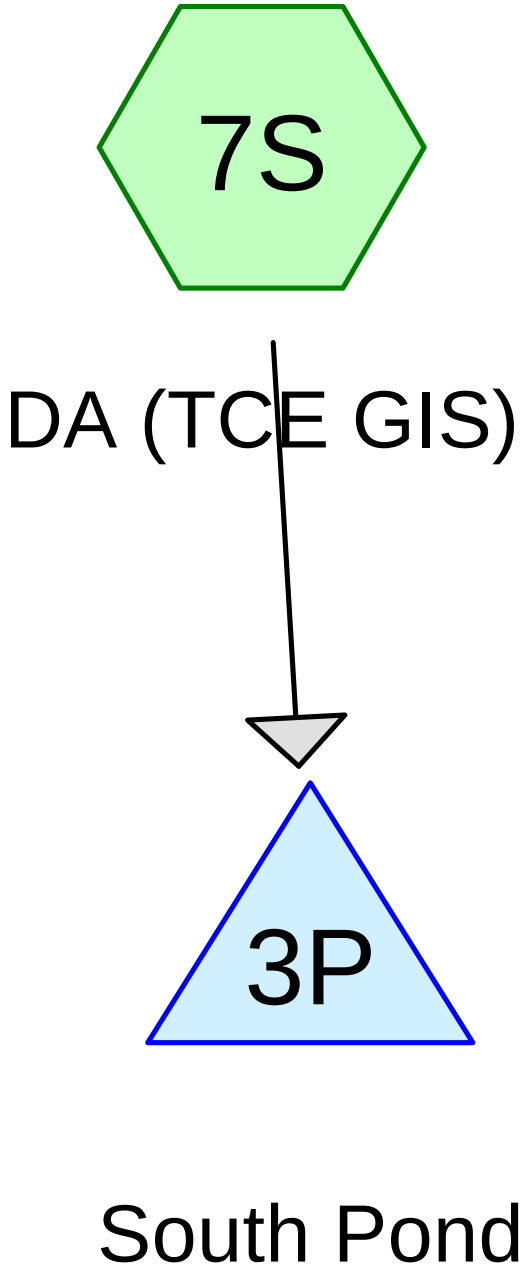
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
140.50	0.000	0.000	0.000
141.00	0.027	0.007	0.007
142.00	0.078	0.052	0.059
143.00	0.172	0.125	0.184
143.50	0.189	0.090	0.274

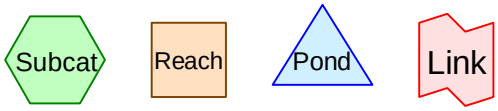
Device	Routing	Invert	Outlet Devices
#1	Primary	140.50'	**12.0" Round Culvert** L= 20.0' Ke= 0.500 Inlet / Outlet Invert= 140.50' / 140.40' S= 0.0050 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 0.79 sf
#2	Device 1	140.50'	**1.2" Vert. Orifice/Grate** C= 0.600
#3	Device 1	143.00'	**8.0" Vert. Orifice/Grate X 2.00** C= 0.600
#4	Secondary	143.00'	**10.0' long x 4.0' breadth Broad-Crested Rectangular Weir**

Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00
2.50 3.00 3.50 4.00 4.50 5.00 5.50
Coef. (English) 2.38 2.54 2.69 2.68 2.67 2.67 2.65 2.66 2.66 2.68
2.72 2.73 2.76 2.79 2.88 3.07 3.32

Primary OutFlow Max=0.06 cfs @ 24.31 hrs HW=142.95' (Free Discharge)
└─**1=Culvert** (Passes 0.06 cfs of 5.28 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 0.06 cfs @ 7.46 fps)
  └─**3=Orifice/Grate** (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=140.50' (Free Discharge)
└─**4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)





Routing Diagram for M10 - Shelb Mead So Pond (A) Rev 2016 0224
Prepared by TCE, Printed 9/12/2016
HydroCAD® 10.00-12 s/n 02145 © 2014 HydroCAD Software Solutions LLC

Summary for Subcatchment 7S: DA (TCE GIS)

Runoff = 6.75 cfs @ 12.30 hrs, Volume= 0.718 af, Depth= 0.87"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-100.00 hrs, dt= 0.05 hrs
Type II 24-hr 1 year Rainfall=2.10"

	Area (ac)	CN	Description
*	1.484	98	Impervious, HSG B
	0.113	61	>75% Grass cover, Good, HSG B
	1.762	60	Woods, Fair, HSG B
*	0.539	98	Impervious, HSG C
	0.551	74	>75% Grass cover, Good, HSG C
	0.112	73	Woods, Fair, HSG C
*	3.281	98	Impervious, HSG D
	0.164	80	>75% Grass cover, Good, HSG D
	1.904	79	Woods, Fair, HSG D
	9.910	85	Weighted Average
	4.606		46.48% Pervious Area
	5.304		53.52% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
33.4	1,082	0.0074	0.54		**Lag/CN Method,**

Summary for Pond 3P: South Pond

Inflow Area = 9.910 ac, 53.52% Impervious, Inflow Depth = 0.87" for 1 year event
Inflow = 6.75 cfs @ 12.30 hrs, Volume= 0.718 af
Outflow = 0.18 cfs @ 23.33 hrs, Volume= 0.714 af, Atten= 97%, Lag= 661.8 min
Primary = 0.18 cfs @ 23.33 hrs, Volume= 0.714 af

Routing by Stor-Ind method, Time Span= 0.00-100.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 153.72' @ 23.33 hrs Surf.Area= 8,117 sf Storage= 23,468 cf

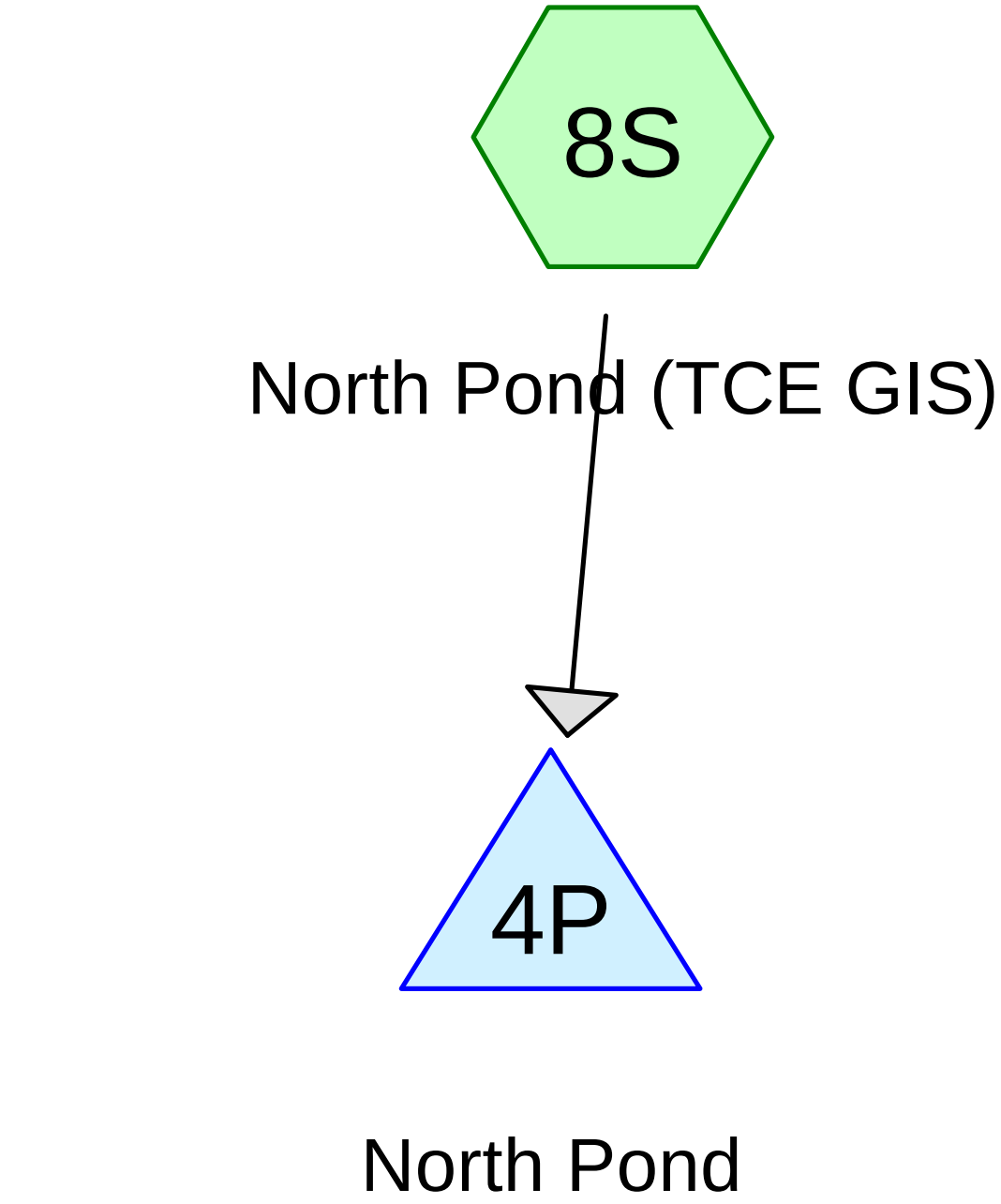
Plug-Flow detention time= 1,545.0 min calculated for 0.714 af (99% of inflow)
Center-of-Mass det. time= 1,543.5 min (2,412.2 - 868.7)

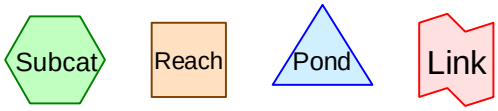
Volume	Invert	Avail.Storage	Storage Description
#1	150.00'	25,812 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
150.00	4,500	0	0
151.00	5,766	5,133	5,133
153.00	7,104	12,870	18,003
154.00	8,514	7,809	25,812

Device	Routing	Invert	Outlet Devices
#1	Primary	149.82'	**24.0" Round Culvert** L= 25.0' Ke= 0.500 Inlet / Outlet Invert= 149.82' / 149.50' S= 0.0128 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 3.14 sf
#2	Device 1	150.00'	**1.9" Vert. Orifice** C= 0.600
#3	Device 1	153.78'	**24.0" x 24.0" Horiz. Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.18 cfs @ 23.33 hrs HW=153.72' (Free Discharge)
└─**1=Culvert** (Passes 0.18 cfs of 23.06 cfs potential flow)
  ├─**2=Orifice** (Orifice Controls 0.18 cfs @ 9.19 fps)
  └─**3=Grate** (Controls 0.00 cfs)





Routing Diagram for M11 - Shelb Mead No Pond Rev 2016 0224
Prepared by TCE, Printed 9/12/2016
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Summary for Subcatchment 8S: North Pond (TCE GIS)

Runoff = 1.96 cfs @ 12.10 hrs, Volume= 0.161 af, Depth= 0.37"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-100.00 hrs, dt= 0.05 hrs
Type II 24-hr 1 year Rainfall=2.10"

Area (ac)	CN	Description
1.738	98	Paved roads w/curbs & sewers
2.627	61	>75% Grass cover, Good, HSG B
0.905	60	Woods, Fair, HSG B
5.270	73	Weighted Average
3.532		67.02% Pervious Area
1.738		32.98% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.0					**Direct Entry,**

Summary for Pond 4P: North Pond

Inflow Area = 5.270 ac, 32.98% Impervious, Inflow Depth = 0.37" for 1 year event
Inflow = 1.96 cfs @ 12.10 hrs, Volume= 0.161 af
Outflow = 0.04 cfs @ 24.18 hrs, Volume= 0.160 af, Atten= 98%, Lag= 724.4 min
Primary = 0.04 cfs @ 24.18 hrs, Volume= 0.160 af

Routing by Stor-Ind method, Time Span= 0.00-100.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 158.85' @ 24.18 hrs Surf.Area= 3,846 sf Storage= 5,446 cf

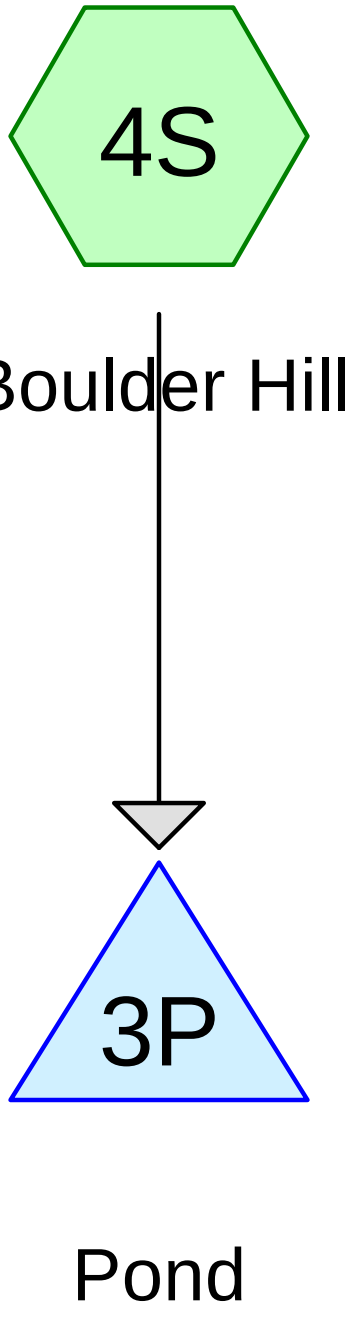
Plug-Flow detention time= 1,610.8 min calculated for 0.160 af (99% of inflow)
Center-of-Mass det. time= 1,607.8 min (2,514.0 - 906.2)

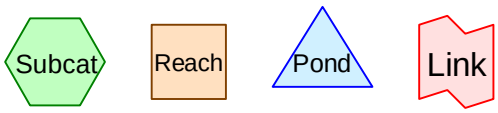
Volume	Invert	Avail.Storage	Storage Description
#1	156.75'	10,332 cf	**Custom Stage Data (Prismatic)** Listed below

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
156.75	0	0	0
158.00	3,600	2,250	2,250
159.00	3,888	3,744	5,994
160.00	4,788	4,338	10,332

Device	Routing	Invert	Outlet Devices
#1	Primary	156.75'	**24.0" Round Culvert** L= 30.0' Ke= 0.200 Inlet / Outlet Invert= 150.00' / 156.75' S= -0.2250 '/' Cc= 0.900 n= 0.009 PVC, smooth interior, Flow Area= 3.14 sf
#2	Device 1	156.75'	**1.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	159.00'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.04 cfs @ 24.18 hrs HW=158.85' (Free Discharge)
└─**1=Culvert** (Passes 0.04 cfs of 19.86 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 0.04 cfs @ 6.91 fps)
  └─**3=Orifice/Grate** (Controls 0.00 cfs)





Routing Diagram for 1-1534 rev 2014 0829
Prepared by TCE, Printed 9/12/2016
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Summary for Subcatchment 4S: Boulder Hill

Runoff = 17.15 cfs @ 12.13 hrs, Volume= 1.348 af, Depth= 0.62"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 1 year Rainfall=2.10"

	Area (ac)	CN	Description
*	25.900	80	
	25.900		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
19.0					**Direct Entry,**

Summary for Pond 3P: Pond

simplified orifices to single 2" for 1-year control

Inflow Area = 25.900 ac, 0.00% Impervious, Inflow Depth = 0.62" for 1 year event
Inflow = 17.15 cfs @ 12.13 hrs, Volume= 1.348 af
Outflow = 0.05 cfs @ 24.44 hrs, Volume= 0.153 af, Atten= 100%, Lag= 738.4 min
Primary = 0.05 cfs @ 24.44 hrs, Volume= 0.153 af
Secondary = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 197.20' @ 24.44 hrs Surf.Area= 16,793 sf Storage= 56,500 cf
Flood Elev= 200.00' Surf.Area= 21,000 sf Storage= 109,500 cf

Plug-Flow detention time= 1,106.1 min calculated for 0.153 af (11% of inflow)
Center-of-Mass det. time= 946.9 min (1,823.0 - 876.1)

Volume	Invert	Avail.Storage	Storage Description
#1	193.00'	109,500 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

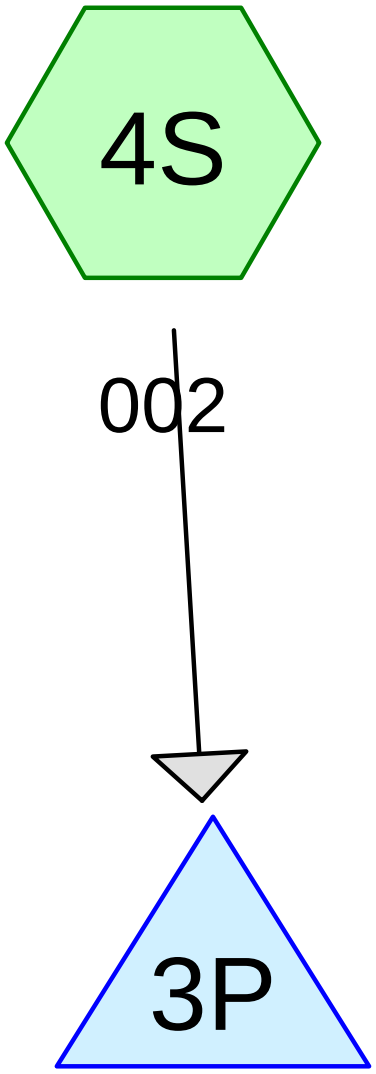
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
193.00	9,000	0	0
194.00	12,000	10,500	10,500
196.00	15,000	27,000	37,500
198.00	18,000	33,000	70,500
200.00	21,000	39,000	109,500

Device	Routing	Invert	Outlet Devices
#1	Primary	192.50'	**24.0" Round Culvert** L= 35.0' Ke= 0.500 Inlet / Outlet Invert= 192.50' / 192.00' S= 0.0143 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf
#2	Device 1	193.00'	**1.0" Vert. Orifice** C= 0.600
#3	Device 1	199.50'	**36.0" Horiz. Grate** C= 0.600 Limited to weir flow at low heads
#4	Secondary	200.00'	**8.0' long x 4.0' breadth Broad-Crested Rectangular Weir**

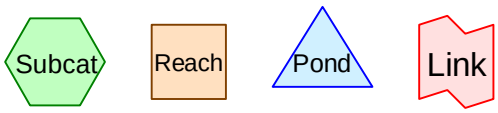
Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00
2.50 3.00 3.50 4.00 4.50 5.00 5.50
Coef. (English) 2.38 2.54 2.69 2.68 2.67 2.67 2.65 2.66 2.66 2.68
2.72 2.73 2.76 2.79 2.88 3.07 3.32

Primary OutFlow Max=0.05 cfs @ 24.44 hrs HW=197.20' (Free Discharge)
└─**1=Culvert** (Passes 0.05 cfs of 29.08 cfs potential flow)
  ├─**2=Orifice** (Orifice Controls 0.05 cfs @ 9.81 fps)
  └─**3=Grate** (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 5.00 hrs HW=193.00' (Free Discharge)
└─**4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)



Pond 2 (from site plans)



Routing Diagram for M16 - 3443-INDS Rev 2016 0426
Prepared by TCE, Printed 9/12/2016
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Summary for Subcatchment 4S: 002

Runoff = 4.58 cfs @ 12.05 hrs, Volume= 0.278 af, Depth= 0.62"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-60.00 hrs, dt= 0.01 hrs
Type II 24-hr 1 year Rainfall=2.10"

	Area (ac)	CN	Description
*	5.340	80	
	5.340		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.0					**Direct Entry,**

Summary for Pond 3P: Pond 2 (from site plans)

Inflow Area = 5.340 ac, 0.00% Impervious, Inflow Depth = 0.62" for 1 year event
Inflow = 4.58 cfs @ 12.05 hrs, Volume= 0.278 af
Outflow = 0.04 cfs @ 24.17 hrs, Volume= 0.145 af, Atten= 99%, Lag= 727.1 min
Primary = 0.04 cfs @ 24.17 hrs, Volume= 0.145 af

Routing by Stor-Ind method, Time Span= 5.00-60.00 hrs, dt= 0.01 hrs
Peak Elev= 371.89' @ 24.17 hrs Surf.Area= 0.134 ac Storage= 0.240 af

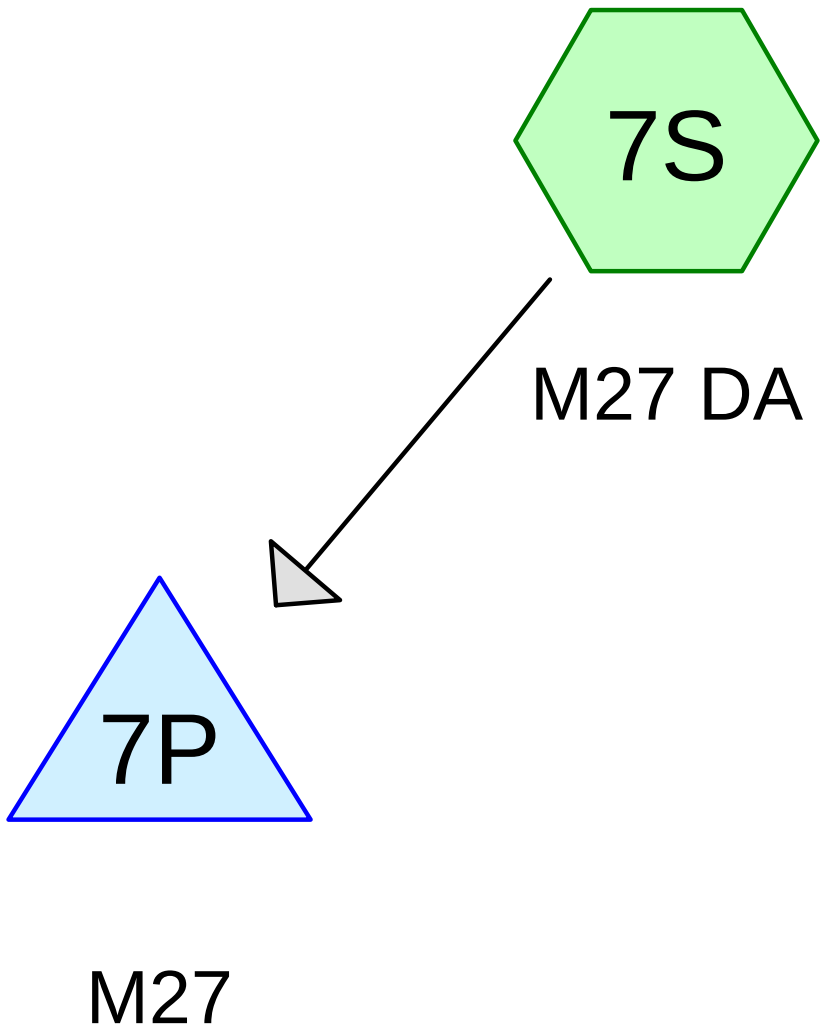
Plug-Flow detention time= 1,391.4 min calculated for 0.145 af (52% of inflow)
Center-of-Mass det. time= 1,251.4 min (2,121.0 - 869.6)

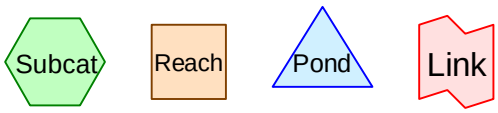
Volume	Invert	Avail.Storage	Storage Description
#1	369.50'	0.585 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
369.50	0.034	0.000	0.000
370.00	0.087	0.030	0.030
372.00	0.137	0.224	0.254
374.00	0.194	0.331	0.585

Device	Routing	Invert	Outlet Devices
#1	Primary	369.50'	**15.0" Round Culvert** L= 39.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 369.50' / 366.50' S= 0.0769 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 1.23 sf
#2	Device 1	369.50'	**1.0" Vert. Orifice/Grate** C= 0.600
#3	Primary	371.90'	**8.0" Vert. Orifice/Grate X 2.00** C= 0.600
#4	Primary	372.30'	**6.0" Vert. Orifice/Grate X 6.00** C= 0.600
#5	Device 1	373.25'	**12.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.04 cfs @ 24.17 hrs HW=371.89' (Free Discharge)
- **1=Culvert** (Passes 0.04 cfs of 7.85 cfs potential flow)
  - **2=Orifice/Grate** (Orifice Controls 0.04 cfs @ 7.38 fps)
  - **5=Orifice/Grate** (Controls 0.00 cfs)
- **3=Orifice/Grate** (Controls 0.00 cfs)
- **4=Orifice/Grate** (Controls 0.00 cfs)





Routing Diagram for M27- Deer Run Rev 2016 0225
Prepared by TCE, Printed 9/12/2016
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Summary for Subcatchment 7S: M27 DA

Runoff = 2.61 cfs @ 12.13 hrs, Volume= 0.243 af, Depth= 0.34"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-100.00 hrs, dt= 0.01 hrs
Type II 24-hr 1 year Rainfall=2.10"

	Area (ac)	CN	Description
*	0.893	98	Impervious, HSG B
	0.878	61	>75% Grass cover, Good, HSG B
	3.342	60	Woods, Fair, HSG B
*	0.765	98	Impervious, HSG C
	0.604	74	>75% Grass cover, Good, HSG C
	2.207	73	Woods, Fair, HSG C
	8.689	72	Weighted Average
	7.031		80.92% Pervious Area
	1.658		19.08% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.2	825	0.0400	0.80		**Lag/CN Method,**

Summary for Pond 7P: M27

Inflow Area = 8.689 ac, 19.08% Impervious, Inflow Depth = 0.34" for 1 year event
Inflow = 2.61 cfs @ 12.13 hrs, Volume= 0.243 af
Outflow = 0.06 cfs @ 24.19 hrs, Volume= 0.242 af, Atten= 98%, Lag= 723.2 min
Primary = 0.06 cfs @ 24.19 hrs, Volume= 0.242 af

Routing by Stor-Ind method, Time Span= 0.00-100.00 hrs, dt= 0.01 hrs
Starting Elev= 157.50' Surf.Area= 2,856 sf Storage= 1,344 cf
Peak Elev= 159.68' @ 24.19 hrs Surf.Area= 4,495 sf Storage= 9,307 cf (7,963 cf above start)

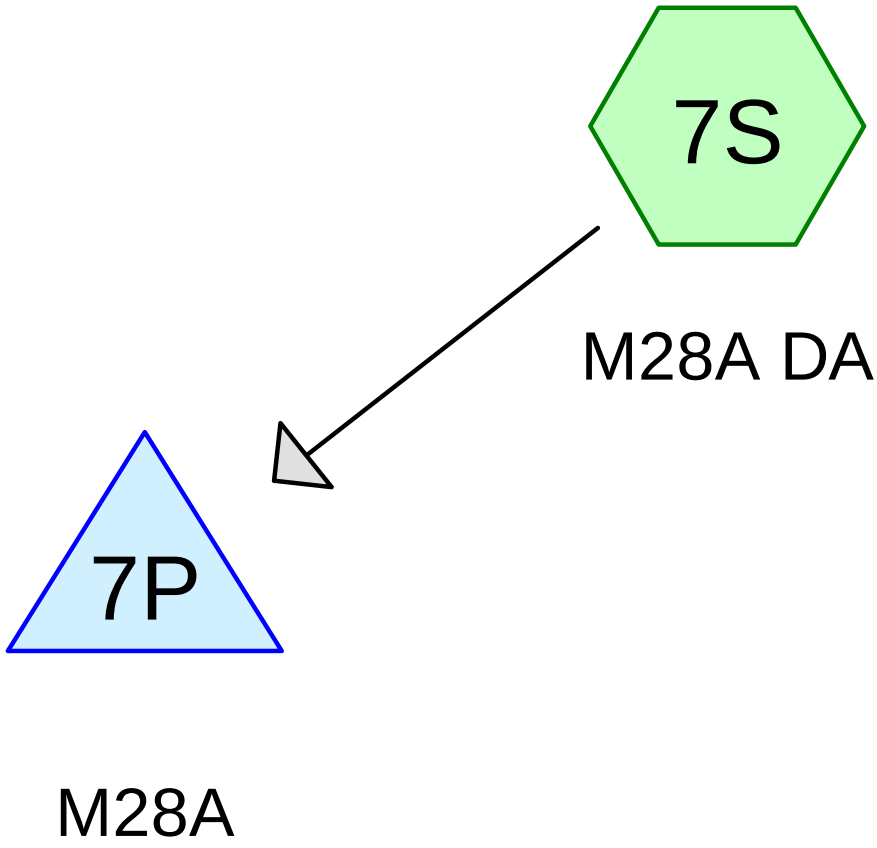
Plug-Flow detention time= 1,723.9 min calculated for 0.211 af (87% of inflow)
Center-of-Mass det. time= 1,451.7 min (2,365.7 - 914.0)

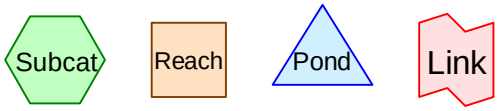
Volume	Invert	Avail.Storage	Storage Description
#1	157.00'	22,080 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
157.00	2,520	0	0
158.00	3,192	2,856	2,856
159.00	3,936	3,564	6,420
160.00	4,752	4,344	10,764
161.00	5,640	5,196	15,960
162.00	6,600	6,120	22,080

Device	Routing	Invert	Outlet Devices
#1	Primary	154.00'	**24.0" Round Culvert** L= 173.0' Ke= 0.500 Inlet / Outlet Invert= 154.00' / 52.00' S= 0.5896 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 3.14 sf
#2	Device 1	157.50'	**1.3" Vert. Orifice/Grate** C= 0.600
#3	Device 1	161.00'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.06 cfs @ 24.19 hrs HW=159.68' (Free Discharge)
└─**1=Culvert** (Passes 0.06 cfs of 32.74 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 0.06 cfs @ 7.03 fps)
  └─**3=Orifice/Grate** (Controls 0.00 cfs)





Routing Diagram for M28A - Shelb Camping Rev 2016 0225
Prepared by TCE, Printed 9/12/2016
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Summary for Subcatchment 7S: M28A DA

Runoff = 2.41 cfs @ 12.22 hrs, Volume= 0.232 af, Depth= 0.62"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-100.00 hrs, dt= 0.01 hrs
Type II 24-hr 1 year Rainfall=2.10"

	Area (ac)	CN	Description
*	1.317	98	Impervious, HSG C
	0.273	74	>75% Grass cover, Good, HSG C
	2.876	73	Woods, Fair, HSG C
	4.466	80	Weighted Average
	3.149		70.51% Pervious Area
	1.317		29.49% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.3	610	0.0066	0.39		**Lag/CN Method,**

Summary for Pond 7P: M28A

Inflow Area = 4.466 ac, 29.49% Impervious, Inflow Depth = 0.62" for 1 year event
Inflow = 2.41 cfs @ 12.22 hrs, Volume= 0.232 af
Outflow = 0.14 cfs @ 16.02 hrs, Volume= 0.230 af, Atten= 94%, Lag= 228.2 min
Primary = 0.14 cfs @ 16.02 hrs, Volume= 0.230 af

Routing by Stor-Ind method, Time Span= 0.00-100.00 hrs, dt= 0.01 hrs
Starting Elev= 172.00' Surf.Area= 2,548 sf Storage= 3,776 cf
Peak Elev= 174.02' @ 16.02 hrs Surf.Area= 4,138 sf Storage= 10,493 cf (6,717 cf above start)

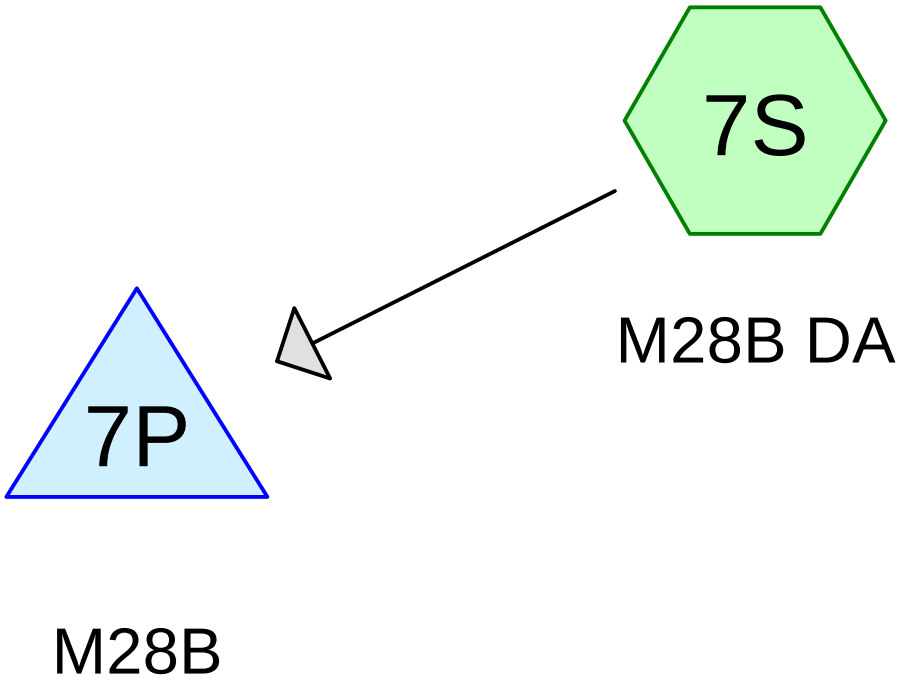
Plug-Flow detention time= 2,355.6 min calculated for 0.143 af (62% of inflow)
Center-of-Mass det. time= 1,486.4 min (2,369.3 - 882.9)

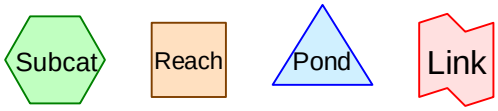
Volume	Invert	Avail.Storage	Storage Description
#1	170.00'	14,975 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
170.00	1,264	0	0
171.00	1,870	1,567	1,567
172.00	2,548	2,209	3,776
173.00	3,298	2,923	6,699
174.00	4,120	3,709	10,408
175.00	5,014	4,567	14,975

Device	Routing	Invert	Outlet Devices
#1	Primary	168.00'	**24.0" Round Culvert** L= 30.0' Ke= 0.500 Inlet / Outlet Invert= 168.00' / 166.00' S= 0.0667 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf
#2	Device 1	172.00'	**1.1" Vert. Orifice/Grate** C= 0.600
#3	Device 1	174.00'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.11 cfs @ 16.02 hrs HW=174.02' (Free Discharge)
└─**1=Culvert** (Passes 0.11 cfs of 33.89 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 0.04 cfs @ 6.77 fps)
  └─**3=Orifice/Grate** (Weir Controls 0.06 cfs @ 0.47 fps)





Routing Diagram for M28B - Shelb Camping Rev 2016 0225
Prepared by TCE, Printed 9/12/2016
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Summary for Subcatchment 7S: M28B DA

Runoff = 4.38 cfs @ 12.09 hrs, Volume= 0.297 af, Depth= 0.67"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-100.00 hrs, dt= 0.01 hrs
Type II 24-hr 1 year Rainfall=2.10"

	Area (ac)	CN	Description
*	0.523	98	Impervious, HSG B
	0.171	61	>75% Grass cover, Good, HSG B
	0.754	60	Woods, Fair, HSG B
*	1.741	98	Impervious, HSG C
	0.362	74	>75% Grass cover, Good, HSG C
	1.770	73	Woods, Fair, HSG C
	5.321	81	Weighted Average
	3.057		57.45% Pervious Area
	2.264		42.55% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.3	535	0.0149	0.58		**Lag/CN Method,**

Summary for Pond 7P: M28B

Inflow Area = 5.321 ac, 42.55% Impervious, Inflow Depth = 0.67" for 1 year event
Inflow = 4.38 cfs @ 12.09 hrs, Volume= 0.297 af
Outflow = 0.08 cfs @ 24.10 hrs, Volume= 0.293 af, Atten= 98%, Lag= 720.6 min
Primary = 0.08 cfs @ 24.10 hrs, Volume= 0.293 af

Routing by Stor-Ind method, Time Span= 0.00-100.00 hrs, dt= 0.01 hrs
Starting Elev= 171.00' Surf.Area= 4,625 sf Storage= 7,414 cf
Peak Elev= 172.75' @ 24.10 hrs Surf.Area= 6,448 sf Storage= 17,101 cf (9,687 cf above start)

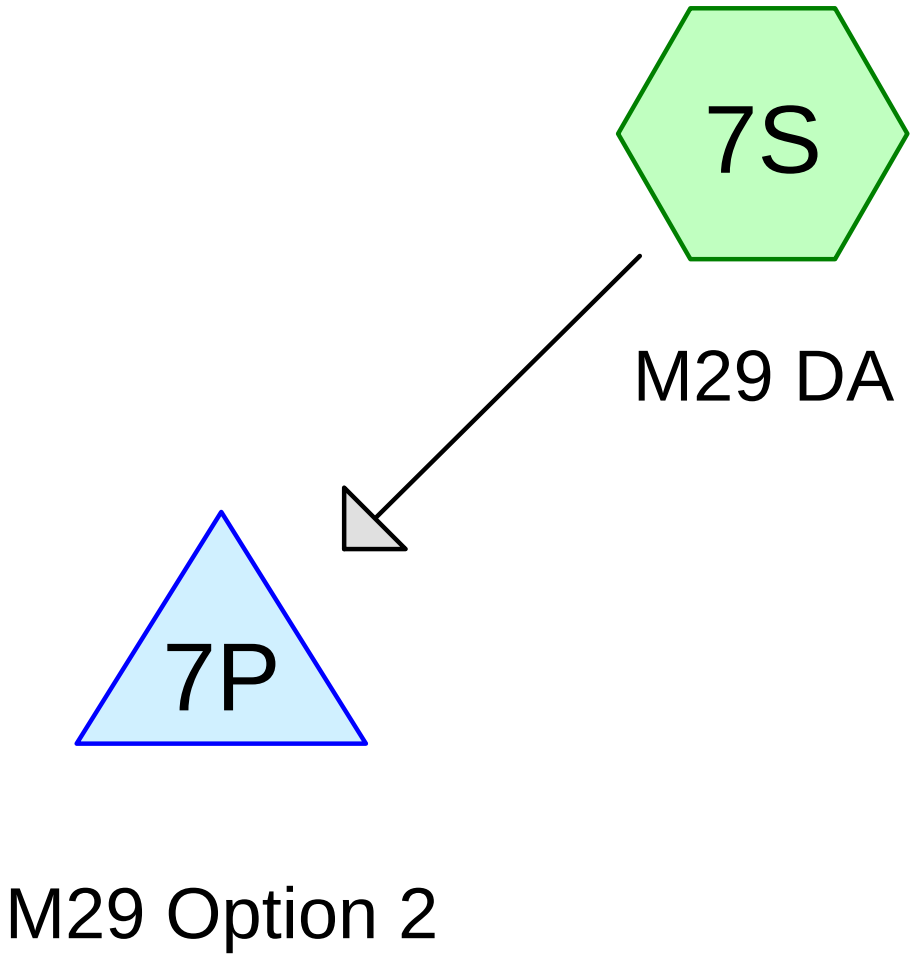
Plug-Flow detention time= 2,772.9 min calculated for 0.123 af (42% of inflow)
Center-of-Mass det. time= 1,514.3 min (2,382.8 - 868.5)

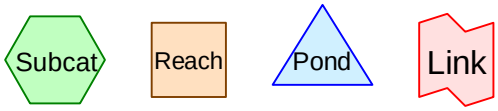
Volume	Invert	Avail.Storage	Storage Description
#1	169.00'	26,005 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
169.00	2,825	0	0
170.00	3,689	3,257	3,257
171.00	4,625	4,157	7,414
172.00	5,633	5,129	12,543
173.00	6,713	6,173	18,716
174.00	7,865	7,289	26,005

Device	Routing	Invert	Outlet Devices
#1	Primary	167.00'	**24.0" Round Culvert** L= 116.0' Ke= 0.500 Inlet / Outlet Invert= 167.00' / 166.00' S= 0.0086 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf
#2	Device 1	171.00'	**1.5" Vert. Orifice/Grate** C= 0.600
#3	Device 1	173.00'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.08 cfs @ 24.10 hrs HW=172.75' (Free Discharge)
└─**1=Culvert** (Passes 0.08 cfs of 32.03 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 0.08 cfs @ 6.26 fps)
  └─**3=Orifice/Grate** (Controls 0.00 cfs)





Routing Diagram for M29 Option 1 - Shelb Comms-Rice Rev 2016 0225
Prepared by TCE, Printed 9/12/2016
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Summary for Subcatchment 7S: M29 DA

Runoff = 32.86 cfs @ 12.15 hrs, Volume= 2.584 af, Depth= 0.82"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-100.00 hrs, dt= 0.01 hrs
Type II 24-hr 1 year Rainfall=2.10"

	Area (ac)	CN	Description
*	6.998	98	Impervious, HSG B
	1.871	61	>75% Grass cover, Good, HSG B
	0.799	60	Woods, Fair, HSG B
*	5.008	98	Impervious, HSG C
	4.200	74	>75% Grass cover, Good, HSG C
	6.328	73	Woods, Fair, HSG C
*	3.411	98	Impervious, HSG D
	0.989	80	>75% Grass cover, Good, HSG D
	8.415	79	Woods, Fair, HSG D
	38.019	84	Weighted Average
	22.602		59.45% Pervious Area
	15.417		40.55% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.9	1,942	0.0515	1.55		**Lag/CN Method,**

Summary for Pond 7P: M29 Option 2

Inflow Area = 38.019 ac, 40.55% Impervious, Inflow Depth = 0.82" for 1 year event
Inflow = 32.86 cfs @ 12.15 hrs, Volume= 2.584 af
Outflow = 1.82 cfs @ 14.73 hrs, Volume= 2.394 af, Atten= 94%, Lag= 155.1 min
Primary = 1.82 cfs @ 14.73 hrs, Volume= 2.394 af

Routing by Stor-Ind method, Time Span= 0.00-100.00 hrs, dt= 0.01 hrs
Starting Elev= 163.00' Surf.Area= 29,861 sf Storage= 55,213 cf
Peak Elev= 165.17' @ 14.73 hrs Surf.Area= 34,988 sf Storage= 125,611 cf (70,399 cf above start)

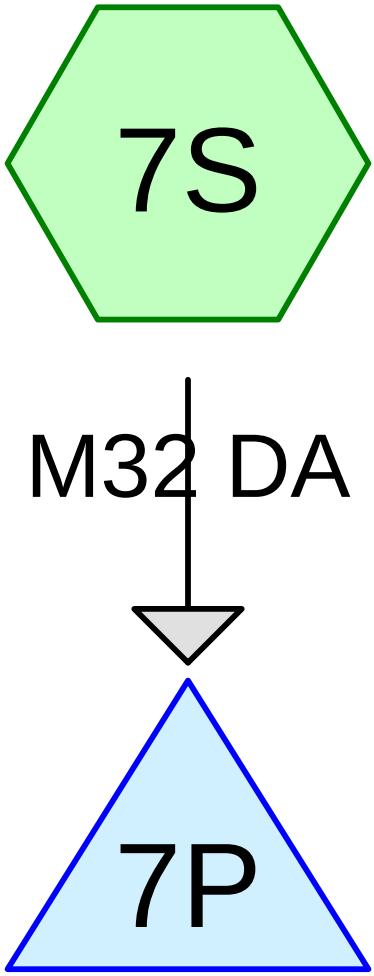
Plug-Flow detention time= 2,865.7 min calculated for 1.126 af (44% of inflow)
Center-of-Mass det. time= 1,446.4 min (2,307.7 - 861.2)

Volume	Invert	Avail.Storage	Storage Description
#1	161.00'	155,400 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

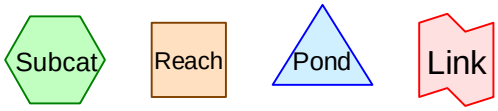
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
161.00	25,380	0	0
162.00	27,592	26,486	26,486
163.00	29,861	28,727	55,213
164.00	32,186	31,024	86,236
165.00	34,568	33,377	119,613
166.00	37,006	35,787	155,400

Device	Routing	Invert	Outlet Devices
#1	Primary	159.00'	**24.0" Round Culvert** L= 100.0' Ke= 0.500 Inlet / Outlet Invert= 159.00' / 154.00' S= 0.0500 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf
#2	Device 1	163.00'	**3.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	165.00'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=1.81 cfs @ 14.73 hrs HW=165.17' (Free Discharge)
└─**1=Culvert** (Passes 1.81 cfs of 34.40 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 0.34 cfs @ 6.89 fps)
  └─**3=Orifice/Grate** (Weir Controls 1.47 cfs @ 1.36 fps)



M32



Routing Diagram for M32- Drew Lane Rev 2016 0225
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Summary for Subcatchment 7S: M32 DA

Runoff = 15.04 cfs @ 12.11 hrs, Volume= 1.097 af, Depth= 0.67"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-100.00 hrs, dt= 0.01 hrs
Type II 24-hr 1 year Rainfall=2.10"

	Area (ac)	CN	Description
*	0.053	98	Impervious, HSG B
	0.484	61	>75% Grass cover, Good, HSG B
	0.381	60	Woods, Fair, HSG B
*	3.069	98	Impervious, HSG C
	3.930	74	>75% Grass cover, Good, HSG C
	1.538	73	Woods, Fair, HSG C
*	1.303	98	Impervious, HSG D
	1.372	80	>75% Grass cover, Good, HSG D
	7.552	79	Woods, Fair, HSG D
	19.682	81	Weighted Average
	15.257		77.52% Pervious Area
	4.425		22.48% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.4	1,504	0.0602	1.44		**Lag/CN Method,**

Summary for Pond 7P: M32

Inflow Area = 19.682 ac, 22.48% Impervious, Inflow Depth = 0.67" for 1 year event
Inflow = 15.04 cfs @ 12.11 hrs, Volume= 1.097 af
Outflow = 0.91 cfs @ 14.24 hrs, Volume= 1.051 af, Atten= 94%, Lag= 127.9 min
Primary = 0.91 cfs @ 14.24 hrs, Volume= 1.051 af

Routing by Stor-Ind method, Time Span= 0.00-100.00 hrs, dt= 0.01 hrs
Starting Elev= 161.00' Surf.Area= 5,781 sf Storage= 5,253 cf
Peak Elev= 164.61' @ 14.24 hrs Surf.Area= 10,202 sf Storage= 33,832 cf (28,579 cf above start)

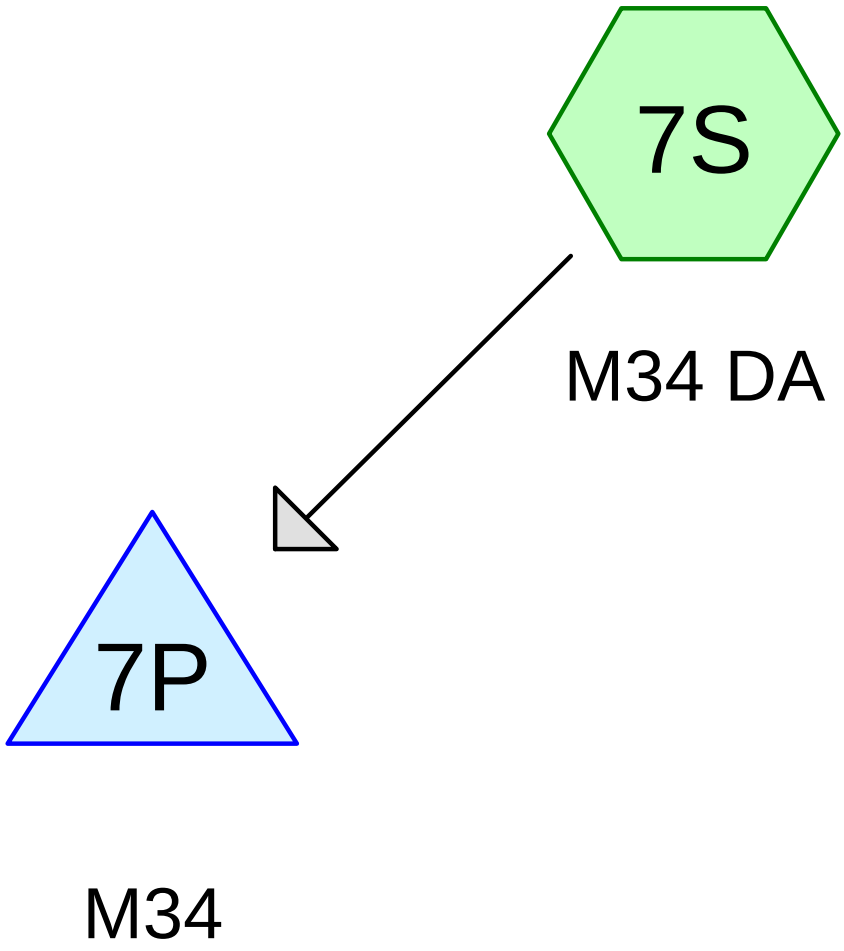
Plug-Flow detention time= 1,722.5 min calculated for 0.931 af (85% of inflow)
Center-of-Mass det. time= 1,459.5 min (2,329.9 - 870.4)

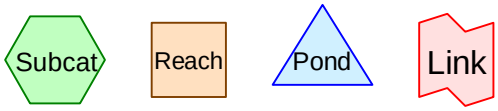
Volume	Invert	Avail.Storage	Storage Description
#1	160.00'	37,905 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
160.00	4,725	0	0
161.00	5,781	5,253	5,253
162.00	6,909	6,345	11,598
163.00	8,109	7,509	19,107
164.00	9,381	8,745	27,852
165.00	10,725	10,053	37,905

Device	Routing	Invert	Outlet Devices
#1	Primary	157.00'	**24.0" Round Culvert** L= 173.0' Ke= 0.500 Inlet / Outlet Invert= 157.00' / 55.00' S= 0.5896 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 3.14 sf
#2	Device 1	161.00'	**1.7" Vert. Orifice/Grate** C= 0.600
#3	Device 1	164.50'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.90 cfs @ 14.24 hrs HW=164.61' (Free Discharge)
└─**1=Culvert** (Passes 0.90 cfs of 38.89 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 0.14 cfs @ 9.06 fps)
  └─**3=Orifice/Grate** (Weir Controls 0.76 cfs @ 1.09 fps)





Routing Diagram for M34 - Hullcrest South - Rev 2016 0225
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Summary for Subcatchment 7S: M34 DA

Runoff = 12.03 cfs @ 12.15 hrs, Volume= 0.998 af, Depth= 0.58"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-100.00 hrs, dt= 0.01 hrs
Type II 24-hr 1 year Rainfall=2.10"

	Area (ac)	CN	Description
*	3.576	98	Impervious, HSG C
	1.915	74	>75% Grass cover, Good, HSG C
	12.495	73	Woods, Fair, HSG C
*	0.791	98	Impervious, HSG D
	0.510	80	>75% Grass cover, Good, HSG D
	1.297	79	Woods, Fair, HSG D
	20.584	79	Weighted Average
	16.217		78.78% Pervious Area
	4.367		21.22% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.4	1,290	0.0388	1.05		**Lag/CN Method,**

Summary for Pond 7P: M34

Inflow Area = 20.584 ac, 21.22% Impervious, Inflow Depth = 0.58" for 1 year event
Inflow = 12.03 cfs @ 12.15 hrs, Volume= 0.998 af
Outflow = 0.27 cfs @ 24.14 hrs, Volume= 0.984 af, Atten= 98%, Lag= 719.6 min
Primary = 0.27 cfs @ 24.14 hrs, Volume= 0.984 af

Routing by Stor-Ind method, Time Span= 0.00-100.00 hrs, dt= 0.01 hrs
Starting Elev= 194.50' Surf.Area= 11,881 sf Storage= 16,397 cf
Peak Elev= 196.89' @ 24.14 hrs Surf.Area= 15,216 sf Storage= 48,706 cf (32,309 cf above start)

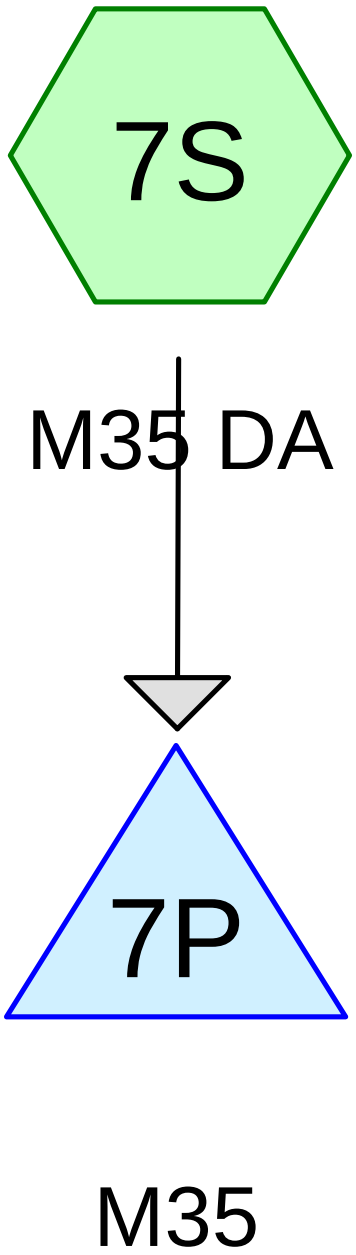
Plug-Flow detention time= 2,249.2 min calculated for 0.607 af (61% of inflow)
Center-of-Mass det. time= 1,456.4 min (2,338.2 - 881.7)

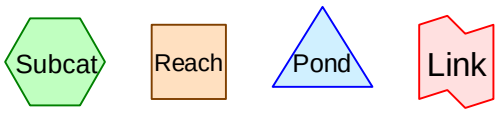
Volume	Invert	Avail.Storage	Storage Description
#1	193.00'	66,526 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
193.00	10,000	0	0
194.00	11,236	10,618	10,618
194.50	11,881	5,779	16,397
195.00	12,544	6,106	22,504
196.00	13,924	13,234	35,738
197.00	15,376	14,650	50,388
198.00	16,900	16,138	66,526

Device	Routing	Invert	Outlet Devices
#1	Primary	191.00'	**24.0" Round Culvert** L= 30.0' Ke= 0.500 Inlet / Outlet Invert= 191.00' / 186.00' S= 0.1667 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf
#2	Device 1	194.50'	**2.6" Vert. Orifice/Grate** C= 0.600
#3	Device 1	197.00'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.27 cfs @ 24.14 hrs HW=196.89' (Free Discharge)
└─**1=Culvert** (Passes 0.27 cfs of 33.45 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 0.27 cfs @ 7.27 fps)
  └─**3=Orifice/Grate** (Controls 0.00 cfs)





Routing Diagram for M35- Morse Drive Rev 2016 0225
Prepared by TCE, Printed 9/12/2016
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Summary for Subcatchment 7S: M35 DA

Runoff = 13.55 cfs @ 12.12 hrs, Volume= 1.049 af, Depth= 0.54"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-100.00 hrs, dt= 0.01 hrs
Type II 24-hr 1 year Rainfall=2.10"

	Area (ac)	CN	Description
*	0.885	98	Impervious, HSG A
	0.800	39	>75% Grass cover, Good, HSG A
	1.334	36	Woods, Fair, HSG A
*	0.011	98	Impervious, HSG C
	0.141	73	Woods, Fair, HSG C
*	3.000	98	Impervious, HSG D
	3.282	80	>75% Grass cover, Good, HSG D
	13.804	79	Woods, Fair, HSG D
	23.257	78	Weighted Average
	19.361		83.25% Pervious Area
	3.896		16.75% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.7	1,780	0.0915	1.67		**Lag/CN Method,**

Summary for Pond 7P: M35

Inflow Area = 23.257 ac, 16.75% Impervious, Inflow Depth = 0.54" for 1 year event
Inflow = 13.55 cfs @ 12.12 hrs, Volume= 1.049 af
Outflow = 0.62 cfs @ 16.16 hrs, Volume= 1.036 af, Atten= 95%, Lag= 242.1 min
Primary = 0.62 cfs @ 16.16 hrs, Volume= 1.036 af

Routing by Stor-Ind method, Time Span= 0.00-100.00 hrs, dt= 0.01 hrs
Starting Elev= 248.00' Surf.Area= 7,920 sf Storage= 7,392 cf
Peak Elev= 251.07' @ 16.16 hrs Surf.Area= 11,617 sf Storage= 37,246 cf (29,854 cf above start)

Plug-Flow detention time= 1,786.6 min calculated for 0.866 af (83% of inflow)
Center-of-Mass det. time= 1,437.3 min (2,321.0 - 883.7)

Volume	Invert	Avail.Storage	Storage Description
#1	247.00'	48,600 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
247.00	6,864	0	0
248.00	7,920	7,392	7,392
249.00	9,048	8,484	15,876
250.00	10,248	9,648	25,524
251.00	11,520	10,884	36,408
252.00	12,864	12,192	48,600

Appendix C: Tetra Tech Memorandum dated October 30, 2007

Tetra Tech, Inc.
10306 Eaton Place, Suite 340
Fairfax, VA 22030
Telephone (703) 385-6000
Fax (703) 385-6007
Water Resources Group

MEMORANUM

Date: October 30, 2007
From: Tham Saravanapavan
To: Jennifer Callahan, Vermont Department of Environmental Conservation
Re: BMP Cost Function in Vermont's BMPDSS

Defining Cost Function and Variables

When refer to the cost of stormwater best management practices (BMP), generally it includes construction cost, maintenance and inspection cost, and land opportunity cost (Wossink and Hunt, 2003). In BMPDSS (Cheng et al., 2006), a generic cost function is employed as described below.

Total Cost = Installation Cost [**I**] + Land Cost [**L**] + Fixed Cost [**F**]

Installation Cost [**I**] represents the material and labor expenses related to the construction of the BMP. Land Cost [**L**] represents the land value. It is important to note that L is negligible if the BMP were installed in small areas, such as bioretention or infiltration, and underground storages. Fixed Cost [**F**] represents the cost associated with design and permitting activities. Due to the unavailability of the cost information on maintenance and inspection, these costs were not included in the equation.

In Vermont BMPDSS, a detention BMP (assumed a wet pond) represents to control the flood flow and a bio-infiltration BMP represents to control the low flow. The following equations represent the selected BMPs.

Detention BMP:
Cost = **I** * Detention Volume (ft^3) + Detention Surface Area (acre)***L** + **F**

I = \$5 per ft^3 and **L** = \$ 217,800 per acre, were based on USEPA (1999a) similar to the Prince George's County model.
F = [\$ 2,000 **x** number of eligible parcels within a sub-watershed] (Assuming each parcel will install a separate BMP and it will cost \$ 2,000 for permitting and design of these BMPs)

Infiltraion BMP:
Cost = **I** * BMP volume (ft^3) + **F**

I = \$6 per ft^3, was based on USEPA (1999b) similar to the Prince George's County model.
F = [\$ 2,000 **x** number of eligible parcels within a sub-watershed] (Assuming each parcel will install a separate BMP and it will cost \$ 2,000 for permitting and design of these BMPs)

Discussion on Selection of Cost Function and Variables

One of the challenges to apply BMPDSS in Vermont is to identify appropriate cost variables to be input into BMPDSS that represent Vermont's site specific environment. Tetra Tech, along with Vermont Department of Environmental Conservation, has conducted a limited research on BMP cost information available for Vermont environment, including data and reports from University of Vermont (UVM) and the City of South Burlington.

The cost information available at the City of South Burlington excludes the resources that were directly provided by the City (For example, the staff time of City employees, the use of City owned equipments, etc.). Therefore, the data is not complete enough to be represented in BMPDSS. A review further revealed that the cost information available at UVM Redesigning American Neighborhood (RAN) program are based on USEPA (1999 a & b) that is the same information of the Prince George's County BMPDSS.

Due to the unavailability of the site-specific cost data for Vermont and USEPA (1999 a & b) data are presently used in UVM RAN program, Tetra Tech has employed the cost information of existing BMPDSS model. As and when more site specific information available, the variables can be easily updated in BMPDSS. Although the changes in these variables will result in changes in the total cost for implementing BMP, the optimization and other BMPDSS results, such as sizing and locations, have no impact due the changes.

Reference:

Cheng, M.S., C.A. Akinbobola, J. Zhen, J. Riverson, K. Alvi, and L. Shoemaker. 2006. BMP decision support system for evaluating watershed-based stormwater management alternatives. In *Proc. 2006 World Environmental and Water Resources Congress*, May 21-25, 2006, Omaha, Nebraska.

United States Environmental Protection Agency, 1999a. Stormwater Technology Fact Sheet: Wet Detention Pond, EPA 832-F-99-048.

United States Environmental Protection Agency, 1999b. Stormwater Technology Fact Sheet: Bioretention, EPA 832-F-99-012.

University of Vermont, Redesigning the American Neighborhood (RAN) Toolbox. http://www.uvm.edu/~ran/ran/toolbox/bmp/index.php, (accessed May 2007).

Wossink, A. and B. Hunt, 2003. An evaluation of cost and benefits of structural stormwater BMPs in North Carolina, NC State Corporative Extension.

Device	Routing	Invert	Outlet Devices
#1	Primary	244.00'	**24.0" Round Culvert** L= 173.0' Ke= 0.500 Inlet / Outlet Invert= 244.00' / 142.00' S= 0.5896 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 3.14 sf
#2	Device 1	248.00'	**2.1" Vert. Orifice/Grate** C= 0.600
#3	Device 1	251.00'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.60 cfs @ 16.16 hrs HW=251.07' (Free Discharge)
└─**1=Culvert** (Passes 0.60 cfs of 37.28 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 0.20 cfs @ 8.32 fps)
  └─**3=Orifice/Grate** (Weir Controls 0.40 cfs @ 0.88 fps)

Appendix E – Bartlett Brook Flow Restoration Plan

BARTLETT BROOK FLOW RESTORATION PLAN

City of South Burlington, Vermont

October 1, 2016

Prepared for:
City of South Burlington
104 Landfill Road, South Burlington, VT 05403

Prepared by:
Watershed Consulting Associates, LLC
P: 802.497.2367
andres@watershedca.com

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I. Disclaimer

The intent of this plan is to present the data collected, evaluations, analysis, designs, and cost estimates for the Bartlett Brook Flow Restoration Plan (FRP) Project, completed under a contract between the City of South Burlington and the hired consultant team, Watershed Consulting Associates, LLC and Aldrich & Elliott, PC. The Bartlett Brook FRP was prepared to meet the compliance requirement for the Bartlett Brook impervious surface owners (the City of South Burlington, the Vermont Agency of Transportation (VTRANS) and the Town of Shelburne) under the National Pollutant Discharge Elimination System (NPDES) General Permit 3-9014 (VTDEC 2012) for stormwater discharges to impaired waters.

1. Executive Summary

This Flow Restoration Plan (FRP) for the Bartlett Brook watershed was developed in accordance with requirements in the Municipal Separate Storm Sewer System (MS4) General Permit #3-9014 (2012). Once approved by the Vermont Department of Environmental Conservation (VTDEC) this FRP will become part of the Stormwater Management Plans (SWMP) prepared by the MS4 permittees in the Bartlett Brook watershed. This includes the City of South Burlington, the Town of Shelburne, and the Vermont Agency of Transportation (VTrans). The Bartlett Brook FRP will act as a guidance document for the MS4 entities as they implement stormwater Best Management Practices (BMP's) over a twenty (20) year timeframe, in the effort to return Bartlett Brook to its attainment condition.

Development of the Bartlett Brook FRP was an iterative process that utilized the Vermont Best Management Practice Decision Support System (BMPDSS) model maintained by VTDEC. This model was created by VTDEC and its partners as part of the initial TMDL development. The BMPDSS model allows the user to add, remove, or modify information related to the existing and proposed stormwater BMPs in the watershed. The BMPDSS then predicts the impacts that these changes will have on stream flow. In 2002, VTDEC provided a "base" condition BMPDSS model for Bartlett Brook. This version of the BMPDSS model included all stormwater BMPs that existed in the watershed prior to 2002 and provided an estimated stream flow during the 1-year storm event. The goal of the FRP is to reduce stream flow by 33.0% during this target storm event.

The first step in FRP development was to inspect all existing BMPs included in the "base" condition model (Pre-2002). Based on the results of these field inspections, revisions were made to the BMPDSS model. Once this work was complete, the BMPDSS model was updated to include all BMPs that were constructed in the watershed after 2002. This version of the model became known as the "existing" conditions, or Post-2002, model run.

Following updates to the BMPDSS for the Pre-2002 and Post-2002 model scenarios, existing Pre-2002 BMPs were evaluated to determine if they could be retrofit to provide improved treatment and detention of stormwater runoff. After an initial list of retrofit sites were identified, a preliminary field assessment was completed at each site to document any potential constructability issues and review the drainage areas for each proposed BMP. These new BMPs were then incorporated into the BMPDSS model. New BMPs were added to the BMPDSS model until the required stream flow reduction target was achieved.

In addition to the identification of stormwater controls, the Total Maximum Daily Load (TMDL) flow targets and future growth assumption developed by the VTDEC was reviewed in the context of the FRP development. In February 2014, at the request of the City of South Burlington, the Chittenden County Regional Planning Commission (CCRPC)[1] completed a study to estimate the expected non-jurisdictional impervious area growth in the Bartlett Brook watershed over the

[1] Chittenden County Regional Planning Commission (CCRPC). 2014. Non Jurisdictional Impervious Surface Analysis for the Bartlett Brook Watershed.

next 20 years. The original TMDL arbitrarily assumed a non-jurisdictional impervious growth of 50 acres, whereas the CCPRC study estimated 5.7 acres based on the actual non-jurisdictional growth rate from 2003 to 2010. The revised future growth reduced the high-flow target (Q0.3%) from 33.0% to 11.6%[2]. The modified flow target was incorporated into the FRP planning process and proposed BMP implementation scenario.

The final proposed BMPDSS model run that ultimately exceeded the required reduction in stream flow during the 1-year storm event includes a total of 18 sites—five (5) retrofits to existing BMPs, four (4) new detention systems, three (3) new infiltration systems, and six (6) green stormwater infrastructure (GSI) systems. The proposed BMPs were assessed with the BMPDSS model, and determined to address 194% of the modified TMDL high-flow target (Q0.3%). The total cost for implementation of the proposed plan is $3,408,728.

Once the final list of required BMPs was determined, these projects were then ranked using a comprehensive matrix and scheduled for construction over a 17-year period. The MS4 permit requires that the BMPs identified in the FRP be constructed within 20 years of the effective date of the MS4 permit, which results in a December 5, 2032 deadline. Therefore, 17 years remain for project implementation prior to the construction deadline. A number of the BMPs are currently covered by expired State of Vermont stormwater permits. These BMPs were included at the front of the schedule so that the associated properties could complete the required stormwater improvements and achieve permit compliance. Other BMPs involve properties containing more than 3 acres of impervious area. VTDEC is currently drafting a “3 Acre Permit” that would require stormwater retrofit of these sites. Therefore, BMPs in this situation were also placed towards the front of the implementation schedule. Other BMPs are located on land owned or controlled by the MS4 entities. These BMPs were given priority over those that were located on private property. The remaining projects were scheduled based on their ability to contribute to stream flow reductions, cost effectiveness, and constructability.

The final step in FRP development was to develop a financial plan that would allow for the construction of the BMPs included in the BMPDSS model. The MS4s involved in the Bartlett Brook FRP worked together to develop an implementation schedule for Bartlett Brook. Some MS4s have responsibility for BMP implementation as part of FRPs in multiple watersheds. For example, the City of South Burlington has the responsibility to implement BMPs as part of FRPs in five stormwater impaired watersheds: Bartlett, Englesby, Centennial, Munroe, and Potash Brook. All five FRPs were considered when developing a comprehensive and realistic D&C schedule for the City. However, the design and construction schedule presented herein contains only the projects located within the Bartlett Brook watershed.

The top four (4) projects were selected for 30% engineering including 1) Bartlett Brook Central (BBC) infiltration gallery, 2) an infiltration basin along the Overlook Dr. walking path on the UVM Horticulture Farm, 3) an expansion of the Bartlett Bay Stormwater Treatment System (BBSTS) and 4) a retrofit to an existing stormwater pond on the Irish Farm Condos property covered under

[2] See Table 1: The Modified target was calculates as: -(8.8%) + (-24.4%)*(5.7 ac/50 ac) = -11.60%

permit #1-1404. Preliminary 30% engineering plans were developed for the top four (4) priority projects with itemized planning level cost estimates. Sketch plans and spreadsheet based cost estimates were developed for all other proposed BMPs.

The City of South Burlington intends to finance the required stormwater BMPs by utilizing funds raised by stormwater utility fees, State and Federal grants, as well as low interest loan programs. Once projects were scheduled over the 17-year implementation schedule an annual 3% inflation rate was applied based on historic trends in the construction cost index. The City of South Burlington was then able to take these annual costs and insert them into their existing stormwater utility rate model. Three different scenarios were evaluated in the rate model. The first scenario assumed that grant funding would not be available and that the City would not utilize low interest loans to assist with project implementation. This scenario resulted in a stormwater billing rate of $11.25 per Equivalent Residential Unit (ERU) in FY2032. The second scenario also assumed that grant funding would not be available, but that the City would utilize low interest loans to help pay for implementation of the projects. This scenario resulted in a stormwater billing rate of $10.44 per ERU in FY2032. The third funding scenario assumed that grant funding of approximately $250,000 per year would be available starting in 2018 and that this amount would increase to $500,000 in 2030. This resulted in a stormwater billing rate of $8.79 per ERU in FY2032.

2. Background

Bartlett Brook is currently on the State of Vermont's impaired waters list (EPA 303(d)) with the primary pollutant determined to be stormwater runoff. In the effort to restore Bartlett Brook and lift its impaired designation, a flow-based Total Maximum Daily Load (TMDL) was developed for Bartlett Brook. This TMDL requires reductions in stormwater flows during high flow conditions. Increases in stream baseflow were also recommended, but are not required under the TMDL. The flow targets are the basis for the FRP, developed in accordance with the Municipal Separate Storm Sewer System (MS4) General Permit Subpart IV.C.1 as a required part of the MS4s Stormwater Management Program (SWMP).

The purpose of the FRP is to outline a plan for the retrofit of existing impervious cover with stormwater management BMPs (e.g. detention basins, bioretention filters, etc) to meet the TMDL flow targets. The TMDL set forth that watershed hydrology must be controlled in the Bartlett Brook Watershed to reduce high flow discharges and increase base flow in order to restore degraded water quality and achieve compliance with the Vermont Water Quality Standards (VWQS). Components of the FRP, as outlined in the MS4 general permit, include the identification of retrofits to existing BMPs with expired State stormwater permits, new BMP controls, a financial plan, and a regulatory analysis.

Three (3) MS4's including the City South Burlington, Town of Shelburne, and the Vermont Agency of Transportation (VTRANS) own impervious cover within the Bartlett Brook impaired watershed. The contributing MS4s agreed to prepare a joint FRP for the watershed.

2.1 TMDL Flow Targets

In response to Bartlett Brook not meeting the water quality standards set forth in Section 303(d) of the Federal Clean Water Act, the VTDEC developed TMDLs for impaired watersheds using flow as a surrogate for pollutant loading. The basis for the TMDL development was the comparison of modeled Flow Duration Curves (FDCs) between impaired and attainment watersheds. The Program for Predicting Polluting Particles Passage through Pits, Puddles, and Ponds, Urban Catchment Model (P8) was used to model gauged and ungauged watersheds in Vermont and develop Flow Duration Curves (FDCs) from which a normalized high flow and low flow per drainage area in square miles (cfs/sq.mi.) were extracted.

An FDC is a graph that displays the percentage of time during a given period where flow exceeds a certain value. For the purposes of the Bartlett Brook Stormwater TMDL, VTDEC determined that the "low" flow target would be represented by the 95th percentile (Q95%) of the curve and the "high" flow target would be represented by the 5th percentile (Q0.3%). The high and low flow values from the FDCs were then compared between "impaired" watersheds and comparable "attainment" watersheds to determine a percent change (i.e. reduction of high flow, increase of low flow). The percent change was reported in the EPA approved TMDL for each impaired watershed. The high-flow (Q0.3%) was determined to be relatively equivalent to the 1-year design storm flow (2.1 inches of rain over a 24-hour period in Chittenden County). Therefore, stormwater BMPs designed to meet the VTDEC Stormwater Management Manual's Channel Protection volume (CPv) storage standard were used to address the required high-flow reduction target.

2.1.1 Future Growth Modified Target

The TMDL flow targets and future growth assumptions used by VTDEC in development of TMDL targets were reviewed as part of the FRP development. In February 2014, at the request of the City of South Burlington, the CCRPC completed a study to estimate the additional non-jurisdictional impervious growth expected in the Bartlett Brook over the next 20 years (Appendix 1)[3]. Non-jurisdictional growth is by definition impervious area that does not require a stormwater permit, and is therefore important to account for within the 20 year management plan.

The study estimated a future growth of 5.7 acres, accounting for the maximum new impervious surfaces allowed by the zoning lot coverage for each available parcel of land within the City. Modified TMDL flow targets were determined by multiplying the portion of the TMDL target associated with future growth (FG) by a correction factor as follows:

[3] Chittenden County Regional Planning Commission (CCRPC). 2014. Non Jurisdictional Impervious Surface Analysis for the Bartlett Brook Watershed.

Modified Flow Target = $(Target\ \%\ with\ no\ FG) + (\ Target\ \%\ from\ FG) * (\frac{Revised\ FG\ acres}{Original\ FG\ acres})$

The approved original TMDL flow targets and modified flow targets with a revised future growth for Bartlett Brook are as follows:

Table 1: TMDL flow targets and modified targets with revised future growth

Flow Target	Target High Flow Q 0.3 (± %) Reduction	Target Low Flow* Q 95 (± %) Increase
TMDL Targets (Stormwater allocation only)	-8.80	8.80
TMDL Targets with **50 acres** of Non-Jurisdictional Future Growth	-33.20	13.20
TMDL Modified Targets with **5.7 acres** of Non-Jurisdictional Future Growth*	-11.60	9.30

* Modified target was calculates as: -(8.8%) + (-24.4%)*(5.7 ac/50 ac) = -11.60%
*The low flow target is not actionable under the TMDL, but is included because improving base flow in the watershed is still a water quality goal.

While the low-flow goal is important to ensure flow during the dry summer months, it is not an actionable requirement in the EPA approved TMDL, and therefore was not the primary focus of the FRP BMP identification for this study.

2.2 MS4 Permit Background and Requirements

An MS4 is a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, or man-made channels) that are designed or used for the collection or conveyance of stormwater discharged to waters of the State or waters of the United States. MS4 systems do not include combined sewer systems` that are part of publicly owned wastewater treatment facilities.

On December 5, 2012, Vermont's revised MS4 Permit was issued. This MS4 permit was the second MS4 General Permit issued by the VTDEC. The first MS4 permit was issued in 2003 and amended in 2004. Both the 2004 and 2012 permits authorize stormwater discharges within the urbanized areas of small MS4s. Small MS4s included cities, towns, counties, airports, highway departments, and universities. The City of South Burlington, Town of Shelburne, and Vermont Agency of Transportation were designated as regulated small MS4s, as were Burlington, Colchester, UVM, Essex, Essex Junction, Milton, Williston, Winooski, and Burlington International Airport.

Included in the 2012 MS4 permit issuance were new requirements for municipalities to develop FRPs to implement the stormwater TMDLs. The FRPs must be developed

for each impaired watershed within three (3) years of the date of issuance of the authorization to discharge to the permittee under the general permit, by October 1, 2016, and must include the following elements:

1) An identification of the required controls
2) A design and construction schedule
3) A financial plan
4) A regulatory analysis
5) The identification of regulatory assistance, and
6) Identification of any third party implementation.

The schedule shall provide for implementation of the required BMPs as soon as possible, but no later than 20 years from the effective date of the permit; before December 5, 2032.

3. BMPDSS Model Assessment

In an effort to implement the Vermont Stormwater TMDLs, the VTDEC worked with an external consultant (TetraTech) to develop the computer-based VT BMPDSS, a VT-specific hydrologic BMP assessment model. This modeling tool was developed by TetraTech, Inc., with considerable investment from EPA Region 3 and Prince George's County, Maryland, and was adapted for use in Vermont using funding from the Vermont Agency of Natural Resources (ANR). The purpose of the modeling tool was to predict progress toward the TMDL flow targets based on proposed BMP implementation scenarios to help MS4 communities identify different BMP options and associated costs.

In order to complete a flow target assessment, VTDEC developed three model scenarios for each impaired watershed, including a "Base" (Pre-2002), "Existing" conditions (Post-2002), and an optimized credit scenario (meeting the flow restoration target). The base scenario (Pre-2002 model) included all stormwater BMPs installed prior to issuance of the VT Stormwater Design Standards in 2002. The land use data used in this scenario was derived from 2002 Quickbird satellite imagery. An existing scenario (Post-2002 model) was then developed with all existing BMPs designed to the 2002 VT Stormwater Design Standards, providing credit toward the flow target on a percent change basis compared to the base scenario. The optimized credit run was used by VTDEC to gage the estimated cost and level of effort to reach the flow targets in each impaired watershed. During the optimized credit run, a theoretical full build-out of BMPs were placed in each subwatershed by the model with a goal of minimizing cost and maximizing flow benefit. Results from the BMPDSS model output were provided as unadjusted cubic feet per second (cfs) and normalized flow (flow per drainage area, cfs/sq. mi). The unadjusted flow was used in the determination of progress towards the TMDL targets to eliminate the effect of watershed area in the percent change comparison.

3.1 Existing Condition Review

3.1.1 Permit Review

As per subpart IV.C.1 of the approved MS4 general permit, all expired stormwater permits in the watershed were acquired and reviewed for inclusion within the BMPDSS model assessment. The expired permits were sorted into two groups: Group 1) existing stormwater systems with a CPv BMP which provides extended detention of the 1-year design storm, and Group 2) those without a CPv BMP (e.g. system of storm drains). The Group 1 list was compared to the current BMP list included in the BMPDSS models to check for omissions (Table 2 below). Only expired permit systems that include a BMP with CPv storage were included in the BMPDSS model, because only BMPs with CPv storage provide credit toward meeting the flow targets. Field assessments were then completed at each site with an existing CPv detention structure, to identify if the facility was operating according to the approved expired permit and if there was opportunity for an upgrade to the 2002 Vermont Stormwater Design Standards. Several of the expired permits are now covered under a Residual Designation Authority (RDA) permit from the state, in which the private permittee applied for a renewal of their permit with the State. A full list of the expired permits discharging to the Bartlett Brook and the type of system covered under the permit is included in Appendix 9 (Table A-9).

Table 2: Expired Permits with Stormwater BMPs in the BMPDSS Model

Permit #	Project Name	BMP Type in Model	Permit Status	RDA	Permit Issued
1-1404.9912	Irish Farms Residential Subdivision	Ponds (3)	Issued	n/a	5/31/2000
1-0523.XXXX	Champ Carwash	Pond, Swale system	Issued	6280-9030	11/3/1987
1-1155.9806	Pinnacle at Spear	Ponds (2)	Issued	n/a	4/21/1999
3121-9010	Willie Racine Jeep Isuzu	Ponds (2)	Issued	n/a	11/24/2003
1-1372.9905	Staybridge Suites & Harbor Sunset Hotel	Infiltration Trenches (2)	Issued	6296-9030	9/1/1999
	Oil n' Go	Swale	n/a		4/1/1999
2-0261.XXXX	Overlook at Spear/Summit at Spear	Ponds in series (4)	Issued	n/a	4/17/1985
1-0818	IDX headquarters	Dry Wells	Issued		6/2/2003

*Table Prepared by Emily Schelley (VT DEC 2014). Revised by WCA (2014)

3.1.2 VTDEC BMPDSS Existing Model Review

Verification of the drainage areas and design of the existing BMPs included in the Base (Pre 2002) and Credit (Existing Condition Post 2002) models was completed during

the field assessments. The result of these assessment werecompared to the DEC model inputs in order to identify any discrepancies. Updated input files for the Base and Credit models were submitted to VT DEC in order to run the updated models. Input files included revised GIS shapefiles for subwatersheds, BMP locations, BMP drainage areas, as well as HydroCAD (Version 10.0) models used to convey the BMP design parameters. Each BMP design was then converted by State DEC Stormwater Section staff to the equivalent system in the BMPDSS model, which has a slightly different interface for defining the BMP design. Adjustments were made to certain BMP designs, in cases where the design of the BMP in HydroCAD was not directly transferrable to the BMPDSS format.

The **Base (Pre 2002) model** was revised as follows:

Subwatershed Mapping:

- **Deerfield Street Walking Path:** Subwatershed boundaries were adjusted to account for a channel along the walking path, just off Deerfield St.
- **Bartlett Brook Central (Pheasant Way):** SW 12 Boundary was corrected to reflect on the ground conditions.
- **Harbor View Road:** Subwatershed boundaries along Harbor View Rd. were adjusted to reflect roof drainage and more accurate topography data.
- **Parking Lot Across from Karen Drive**: An existing parking lot and building off Karen Dr. had previously been excluded. The roof drain was confirmed to drain to Bartlett Brook.
- **Southern watershed Boundary:** The southern boundary was revised to reflect more accurate topography data and field assessment.
- **Allen Road:** An adjustment to the subwatershed was made to reflect the drainage area of the pond associated with State stormwater permit number 1-1404.
- **Bartlett Brook Central (Keari Lane):** The subwatershed boundary was corrected to reflect the roof lines and more refined topography data.
- **Brownell Way:** The subwatershed boundary was revised to better reflect more refined topography data.
- **Yandow Drive:** The subwatershed boundary from Yandow Dr. to Stonehedge Dr. was corrected to reflect on the ground conditions.

BMP Design Entries:

BMP design entries were revised to reflect field confirmed structures for State of Vermont permitted BMPs including:

- # 1-1404 detention ponds A and B at the Irish Farm Condos along Harbor View Rd.
- #1-1155 detention pond on the Pinnacle at Spear development on Spear St.
- #1-1372 detention pond at the Stay Bridge Suites on Spear St.
- #2-0261 system of 4 on-stream ponds located off Deerfield Dr.
- #1-0818 dry wells and an infiltration tank at the IDX Headquarters along Green Mountain Dr.

The **Post2002 (Credit) model** including all BMPs installed after the 2002 stormwater standards ("Post 2002") was revised as follows:

Subwatershed Mapping:

- **RDA Permits:** RDA permits with proposed changes to the existing stormwater system were added to the model by VTDEC staff (Emily Schelley) including #6280-9030 Harbor Heights Condominiums, #6281-9030/#6342-9030 Freedom Nissan, and #6294-9030.1 Bay Court Condominiums. Adjustments to the subwatershed boundaries were made to account for the proposed stormwater system changes.

BMP Design Entries:

- **6280-9030:** Champ Car Care located on Shelburne Rd. The outlet structure was field confirmed and adjusted.

4. Required Controls Identification

The process of BMP identification involved an initial assessment of the existing BMPs with expired permits that did not already meet the CPv standards in the 2002 Vermont Stormwater Management Manual (VSMM) to determine if they could be retrofit to meet the VSMM design standards (Table 2). Upon review of the existing BMPs, it was determined that additional new BMPs would be required to meet the high-flow and low-flow targets. An initial desktop assessment of the watershed was completed to identify open spaces ideal for BMP implementation. A focus of this effort was to first evaluate property owned by the MS4s where projects could be implemented more readily than on private property. In addition, the location of proposed BMPs across the watershed was taken into consideration to provide storage throughout the watershed. The effort also focused on areas with a high-percentage of impervious coverage where flows were expected

to be highest and where infiltration may be possible, as indicated by mapped Natural Resource Conservation Service Hydrologic Soil Group A[4] or B[5] soils.

After an initial list of retrofit sites were identified, a preliminary field assessment was completed at each location to document potential constructability issues and review mapped drainage areas for the proposed BMPs. The BMPs were then modeled using HydroCAD to meet the CPv storage criteria for cold water fish habitat (12-hour detention standard), and incorporated into the BMPDSS model. The initial model iteration, "Credit 1" scenario, was followed by subsequent iterations of the proposed model in which additional proposed BMPs were added to meet the flow targets.

Once the final list of proposed BMPs was determined to meet the flow targets, the projects were ranked using a comprehensive ranking matrix. In addition 30% preliminary engineering designs were developed for the top 4 projects. Orthophoto-based sketch plans for all other projects are provided in Appendix 2.

The top four projects include:

- Bartlett Bay Stormwater Treatment System (BBSTS) Expansion
- Bartlett Brook Central Infiltration Gallery
- Horticulture Farm Basin with Deerfield Dr. Dug Pond
- Irish Farm Condos Pond Retrofit

BMP feasibility was determined based on available space, mapped NRCS soils, existing 1-ft topographic elevation control derived from LIDAR, and mapped stormwater and wastewater infrastructure provided by the City and VTRANS. Supplemental topographical survey data was collected for the top 4 projects as needed. An in-depth engineering assessment will still be required at each site to confirm the presence/absence of utilities, natural resource constraints, and potential transportation impacts as part of the final design process.

4.1 BMPDSS Model Assessment Results

The final BMP scenario was developed based on an iterative assessment using the BMPDSS modeling tool. The initial model run "Credit1" included five (5) BMPs, addressing **139%** of the modified high-flow target, and **0%** of the low-flow target. The existing condition low-flow was **below** the baseline condition (pre 2002). Therefore, while the Credit1 run shows 0% of the low-flow managed, the proposed BMPs actually increased the existing condition low-flow to meet the baseline (pre 2002) condition. Seven (7) additional BMPs were identified and assessed followed by a subsequent model run "Credit2". Credit2 was estimated to manage **187%** of the modified high-flow target and

[4] Group A is sand, loamy sand or sandy loam types of soils. It has low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission.

[5] Group B is silt loam or loam. It has a moderate infiltration rate when thoroughly wetted and consists chiefly or moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.

47% of the low-flow target. Additional GSI collections were added to the final proposed scenario "Credit3_GSI" and found to manage **194%** of the modified high-flow target and **47%** of the low-flow target (Table 3). It should be noted that the groundwater component of the BMPDSS model was found to lack sensitivity based on past experience with the model for other watersheds. The estimated increase in runoff volume infiltrated for the 1-year storm by the proposed BMPs was not reflected in the estimated change in baseflow for the watershed. This general observation has been noted by the State as well as other model users. The model is not sensitive enough to detect the change in baseflow as a result of the addition of smaller GSI projects, and hence zero percent (%) change between the Credit2 and Credit3_GSI runs was observed. A final model run was completed, "Credit3", to include several additional lower-priority projects, to represent the maximum build-out of retrofit projects. A full modeling summary including all model runs completed under this contract as compared to the original TMDL and modified targets (high and low-flow targets) is included in Appendix 3 (Table A-3-1). A summary table of the proposed BMPs added to each model scenarios is also included in Appendix 3 (Table A-3-2). The table shows the model run to which the BMP was first added. The BMPs were maintained in the model for subsequent "Credit" runs.

Table 3: BMPDSS Model Runs Summary for Proposed FRP Scenario

Model Run	Description	High Flow **Reduction** (%)	BMPDSS Model Run Date
TMDL Modified Targets with 5.7 acres of Non-Jurisdictional Future Growth		-11.60	----
DEC Existing Condition Model	DEC's existing model, includes all Post2002 BMPs	-1.71	1/31/2014
WCA Revised Existing Condition Model	Model revisions to existing BMPs.	-2.54	12/9/2014
Percent of Modified Target Managed (w/ Existing 12/9/14 model)		**22%**	----
Credit3 Model with GSI ***(Proposed FRP Scenario)***	Add GSI Practices to Credit2 model scenario	-22.56	12/9/2014
Percent of Modified Target Managed (with Credit3_GSI run)		**194%**	----

4.1.1 Proposed FRP Scenario BMPDSS Model Results

The final proposed BMP list is represented in the model run "Credit3_GSI" which includes 18 proposed BMPs (Table 4). The final FRP scenario is estimated to provide a -22.56% **reduction** in the high flow ($Q_{0.3\%}$) which is a percent change between the unadjusted flow in the baseline condition and credit scenario (Table 3). This surpasses the required high-flow target of -11.60% from baseline conditions, addressing ***194%*** of the target with a significant Factor of Safety (FOS). The additional FOS is included in the recommended BMP list to provide the MS4's additional options, in the event the list has to be modified or as conditions in the watershed change from what is present today.

The individual and cumulative percent of the high-flow target mitigated is also included in Table 4, calculated based on the CPv volume storage and the BMPDSS model run results. The BMPDSS model develops a FDC from which it was determined the High-flow ($Q_{0.3\%}$ cfs) is approximately equivalent to the 1-year storm peak flowrate. The 2002 Vermont Stormwater Management Manual design standard for Channel Protection (CPv) requires mitigation of the 1-year storm event. Therefore, CPv volume storage is used as an indicator of the BMPs contribution toward the estimated high-flow reduction for detention BMPs and increase in baseflow for infiltration BMPs in the BMPDSS model. Essentially, the high-flow is directly reduced in the model by mitigating the CPv volume. The individual and cumulative percent mitigated allows for a quick understanding of the relative benefit of each BMP toward meeting the high-flow target.

Based on the "Cumulative Percent of Target" addressed, the MS4's would only need to implement the top two projects to meet the high flow target. The table is set up so that in the event one of the top projects is determined infeasible, the projects can be rearranged to determine which projects will then need to be implemented to meet 100% of the high-flow target. The ultimate determination for implementation of projects that provide benefit beyond the high-flow target (> 100%) will be made by the State based on monitoring data or other relevant information (MS4 General Permit Sec. IV.J.3). It is also possible that requirements related to existing expired State stormwater permits will necessitate improvements to some of these systems. The recommended FRP scenario is meeting the full flow restoration target, with a revised future growth of 5.7 acres, through implementation of the recommended stormwater BMPs (Table 4). For additional future growth above 5.7 acres, the City plans to manage this growth with a Low-Impact Development (LID) zoning ordinance, which will require management of new impervious that is not covered under a state stormwater permit.

5. Proposed Implementation Plan

The final proposed BMP implementation plan includes a total of 18 stormwater BMPs including five (5) retrofits to existing BMPs with expired permits, four (4) new detention systems, three (3) new infiltration systems, and six (6) green stormwater infrastructure (GSI) projects. Credit toward the flow target is also provided by nine (9) existing stormwater structures. The proposed BMPs are summarized in Table 4, including the impervious cover treated, drainage area, and CPv volume storage estimated by the HydroCAD design model. A map of the proposed BMP locations is included in Appendix 4.

Table 4: Final Proposed BMPs for the Bartlett Brook FRP

Proposed BMP ID	Owner-ship where BMP is located	BMP Type	Permit #	Runoff Area (ac)	Impervious Cover Managed (ac)	Channel Protection Volume (CPv) Storage		Percent of High-Flow Target Managed	*Cumulative* Percent of High-Flow Target Managed[2]
						CF	Ac-ft	%	%
Existing Post2002 BMPs[1]	Varies	Varies	Varies	--	--	91040	2.09	22%	22%
Bartlett Brook Central	City of S. Burlington	Infiltration Gallery	Expired #1-0202 and 2-0120	84.22	16.11	73616	1.69	46%	68%
Horticulture Farm Basin	UVM	Bioretention	Expired #1-1155	33.79	6.35	66124	1.52	42%	**110%**
Underwood Stormwater Pond	City of. S. Burlington	Detention Basin	Drains to Expired #2-2061	44.29	5.99	36590	0.84	23%	133%
Bartlett Bay Stormwater Treatment System (BBSTS) Expansion	Private Owner	BBSTS Wetland	5625-9010, 2-0180, 2-0153, 1-0734	15.86	9.51	39291	0.55	15%	148%
Laurel Hill Development	UVM	Culvert Retrofit	NP	109.47	21.13	15899	0.37	10%	158%
Holiday Inn Parking Lot	Developer -Pizzagalli	Detention Basin	6297-9030	5.03	3.20	13286	0.31	8.4%	166%
Irish Farm Condos Pond B	HOA	Pond Upgrade	Expired # 1-1404	16.30	3.38	6578	0.15	4.1%	171%
Brownell Way	City ROW	ROW Infiltration	Expired #2-0261	2.58	0.83	5445	0.13	3.4%	174%
Whatley Rd	City ROW	ROW Planter	Expired #2-0261	3.32	0.87	5227	0.12	3.3%	177%
Deerfield Dive 1	City ROW	ROW Infiltration	Expired #2-0261	2.31	0.80	5227	0.12	3.3%	181%
Pinnacle at Spear Pond B	Private Owner	Pond Upgrade	Expired #1-1155	3.45	0.22	4704	0.11	3.0%	184%
Deerfield Drive 2	City ROW	ROW Planter	Expired #2-0261	1.61	0.48	4312	0.10	2.7%	186%
Horticulture Farm Detention Pond	UVM	Detention	Expired #1-1155	7.66	1.13	3920	0.09	2.5%	189%
Allen Road	City ROW	Detention Basin	NP	6.38	1.44	3136	0.07	2.0%	191%
Windsor Court	City ROW	ROW Infiltration	Expired #2-0261	1.05	0.31	2483	0.06	1.6%	192%

1690 Shelburne Road	VTRANS/ Developer - Pizzagalli	Detention Basin	5625-9010	0.80	0.63	1873	0.04	1.2%	193%
Pinnacle at Spear Pond A	Private Owner	Pond Upgrade	Expired #1-1155	10.25	3.30	1263	0.029	0.8%	194%
Brownell Way-3	City ROW	ROW Planter	Expired #2-0261	0.96	0.08	610	0.01	0.4%	194%
				TOTAL:	**75.75**		**6.30**		

Notes:
1- Existing Post 2002 BMPs provide credit toward the TMDL flow target. Here the existing Post 2002 BMPs are lumped to show the total benefit of existing BMPs.
2- Cumulative percent of the high-flow target managed is calculated based on the CPv storage and the BMPDSS Model results from the "Credit3_GSI" and Existing Condition (12/9/14) runs. As each BMP is added the total % managed increases.

5.1 Proposed BMPs

Bartlett Bay Stormwater Treatment System (BBSTS) Expansion

The existing Bartlett Bay Stormwater Treatment System was designed in 2002 to provide WQ treatment for runoff from a portion of Route 7 as well as several buildings along Green Mountain Dr. A 15" pipe was installed with the original system to plan for future connections from Route 7. The proposed expansion of the this system would route approximately 15.86 acres of additional area from a portion of Route 7 and Harborview Road to the BBSTS system via a new stormline connection on Route 7 (Figure 1). The expansion would involve implementing a new forebay for the additional connection in front of the Oil N Go property, as well as expanding the southeast portion of the wetland. The existing access road would also be repositioned.

Figure 1: Proposed location for new connection to BBSTS from Route 7.

Bartlett Brook Central Infiltration Gallery

The proposed Bartlett Brook Central (BBC) infiltration gallery would manage runoff from 84 acres at the confluence of two existing outfalls, both of which have significant erosion issues (Figure 2). There is a larger open area, with soils mapped as Hydrologic Group "B", providing an opportunity for infiltration. The infiltration gallery would require 330 StormTech SC-740 recharge chambers, with a Downstream Defender at the confluence of the two outfall connections. The system was designed as an offline practice to mitigate just the 1-year storm volume (CPv), estimated to be 0.59 ac-ft, through the use of several flow-splitters.

Figure 2: North outfall shows evidence of significantly erosion.

A majority benefit of this project is the fact that it is on City of South Burlington property and makes use of a previously unused space, without changing the overall appearance of the area for residents. Land acquisition is not required for the project which significantly reduces the cost as well.

Horticulture Farm Bioretention (Option 1) and Detention Pond (Option 2)

The Overlook Drive walking path currently has two culverts which are directed to a swale along the path that carries significant flows downstream (Figure 3). Additionally, the mapped soil in this area is hydrologic group "B" providing opportunity for infiltration. The proposed site was identified as an excellent candidate to improve the overall aesthetics of the walking path, while also providing significant stormwater management. The project would involve a retrofit of the swale into a 0.81 ac-ft bioretention basin. A berm in the center of the basin would provide an extended flow path to improve water quality treatment.

Figure 3: Overlook Dr. Walking Path

The BMP is located on the UVM Horticulture Farm property, for which irrigation is an ever-present need. An existing pond just downstream of the proposed basin was identified as a candidate site "Horticulture Detention Pond". The 10-year storm (Qp10) overflow from the Horticulture Farm basin would be routed to the dug pond, providing a store of usable water on-site and Qp10 control for the basin.

Underwood Stormwater Pond

The confluence of the existing stormline along Spear St., just South of Nowland Farm Rd. has been the source of flooding during large storm-events. The proposed project would involve a retrofit of the existing roadside swale into a detention basin (Figure 4), designed to provide detention of the 1 year storm event for a 44.3 acre area in the upper Bartlett Brook watershed. This project is currently in the preliminary design phase under a contract between Stantec and the City of Burlington. The proposed retrofit included in the FRP analysis is a conceptual-level design for a detention basin.

Figure 4: Spear St. roadside swale.

Laurel Hill Development Culvert Retrofit

An existing 32” culvert, located on the UVM horticulture farm property, just South of the Laurel Hill Neighborhood was identified as an opportunity for retrofit to provide more storage. The proposed retrofit would involve installing a headwall at the culvert and outlet control structure to increase the CPv storage capacity, while still safely passing the larger storm events. There may be issues with alteration of an on-stream structure, as DEC has placed limitations on new on-stream structures.

Holiday Inn Parking Lot BMP

The Holiday Inn, located off Shelburne Rd, parking lot is currently covered under an RDA permit (6297-9030). However, the system does not provide any flow-control, only water quality treatment in a sedimentation tank. There is the potential to implement an underground infiltration gallery in the open space near the Holiday Inn Parking lot (Figure 5). There is also potential to route drainage from the Staybridge Hotel, which is currently routed to a detention pond that does not meet the VT CPv standard.

Figure 5: Site proposed for Holiday Inn BMP

A conceptual off-line underground infiltration basin, sized to mitigate the 1-year storm was included in the FRP analysis. Further verification of the new connections for the system will need to be completed to determine project feasibility. An alternative option would involve a retrofit of several green strips within the parking lot with dry wells and infiltration swales. The green belts provide an opportunity for a distributed green stormwater management collection system for the parking lot runoff.

Allen Road Detention Basin

The Allen Road Detention Basin was designed as a retrofit of an existing ROW swale. The basin would mitigate runoff from a 6.38 acre drainage area, providing 0.07 ac-ft of storage. The site would require a new culvert under the roadway in order to route additional runoff to the swale.

1690 Shelburne Road

An existing outfall from Shelburne Road, parallel to the Oil N Go property, was identified as a retrofit candidate site. An underground detention chamber is proposed to detain the 1-year storm volume (CPv) from the existing Route 7 stormline, via a flow splitter. The existing outfall pipe would need to be reset to make room for the chamber. The detention chamber may encroach on the flood plain for the Bartlett Brook culvert, and could also have other utility conflicts limiting the space available for the proposed system.

5.2 Expired Permit Proposed Retrofits

Overlook Drive Neighborhood (#2-0261) GSI Collection System

Currently, the neighborhood South of Deerfield Dr./Spear St is covered under an expired permit #2-0261. The site was built with four on-stream detention ponds all of which do not function according to the permit. Retrofit of these ponds is the preferred alternative for improving stormwater management. However, this may be challenging given the State's limitations for on-stream alterations. Due to lack of available open space at the end of the catch basin system, a more distributed management system is also possible. The Overlook Drive neighborhood was selected as a GSI build-out candidate area, in which opportunities for ROW planters were identified. The area has a range of soil types, some of which are Hydrologic Group "A" and "B", providing opportunity for infiltration. Candidate sites were identified in which a filter practice could be installed in the ROW and tied into the existing storm water collection system (Figure 6). Potential conflicts with trees and utilities may exist.

Figure 6: Candidate Site for detention filter in ROW along Brownell Way.

Irish Farm Condos Pond B and C (#1-1404b) Retrofit

The existing Irish Farm Condos stormwater system is currently under expired permit #1-1404. The system consists of two interconnected detention ponds. The proposed retrofit would involve converting the existing upper pond (Pond C) to an expanded gravel wetland system, while maintaining some of the native tree growth. Pond C would be designed to mitigate the 10 year storm from an additional 5.4 acres, tied into the proposed gravel wetland system via a new 18" culvert and catch basin "flow splitter". The lowest pond would also be retrofit to provide detention of the 1 year storm event. The system is on private property, owned by the condos HOA.

Pinnacle at Spear Pond B (#1-1155a and b)

The existing ponds covered under State permit #1-1155 for the Pinnacle at Spear development were assessed for retrofit. The outlet structure on Pond a (North lot) is proposed for retrofit. This would include replaceing the existing 12" culvert with a 3" low-flow orifice. The outlet structure on Pond b (along Spear St) is also proposed for retrofit. This would include the addition of two low-flow orifices, 1" at 371' and a 2" at 373.5'. The retrofits will provide 0.139 ac-ft of CPv storage.

Figure 7: #1-1155 Pond a

Figure 8: #1-1155 Pond b

5.3 Watershed-Wide Project Ranking

All proposed BMPs identified as part of FRP development in the five stormwater impaired watersheds of Potash, Bartlett, Englesby, Centennial, and Munroe Brook were ranked and a project prioritization was created. Considerations that factored into the ranking of BMP projects include the estimated benefit of a BMP towards the FRP's flow restoration targets, and the amount of impervious area treated. The comprehensive ranking matrix ranked the proposed BMP projects based on the following criteria, which were grouped into four general categories as shown in Table 5.

Table 5: Project Ranking Matrix

Category	ID	Criteria
Cost/Operations	A	Project Cost per Impervious Acre
Project Design Metrics	B	Impervious Acres Managed (ac)
	C	Channel Protection Volume (CPv) Mitigated, (ie. 1-year Storm)
	D	Volume Infiltrated (ac-ft)
Project Implementation	E	Permits
	F	Land Availability
Other Project Benefits/Constraints	G	Flood Mitigation (Is existing flooding issue mitigated by project?)
	H	TMDL Flow Target Addressed (Q03, Q95)
	I	Lake Champlain Phosphorus TMDL
	J	Other Project Benefits/Constraints

Values for each criteria were identified and assigned a relative score, so that proposed BMP projects could be ranked based on a total score. The final ranking of proposed projects is included in Table 6 below. The scoring key and full descriptions of the criteria are included in Appendix 5.

Table 6: Ranked Proposed FRP BMPs based on comprehensive ranking matrix

ID #	Site ID	BMP Type	Retrofit Description	Total Score
BB0003	Bartlett Brook Central (BBC)	Infiltration Gallery	Underground infiltration gallery at confluence of two large outfalls.	25.75
BB0010	Horticulture Farm Bioretention	Bioretention	Bioretention basin along walking path.	19.75
BB0016	Underwood Stormwater Pond	Detention Basin	Detention BMP in ROW and/or on City property. Would alleviate flooding downstream.	19.5
BB0009	Holiday Inn Parking Lot	Detention Basin	Detention BMP on private open land. Planned for design as part of 1690 Shelburne Rd. Project. Infiltration potential	18
BB0004	BBSTS Expansion	Wetland	Route CPv storm to BBSTS Wetland, and add forebay.	16.75
BB0014	Pinnacle at Spear Pond A	Pond Upgrade	Drains to proposed Hort Farm Basin. Retrofit riser and deepen.	16.75
BB00012	Irish Farm Condos Pond B	Pond Upgrade	Upgrade existing pond to gravel wetland STP, with more storage. Route additional 5.47 acres to Pond B.	16
BB0007	Deerfield Drrive 1	ROW Infiltration Trench	System of Infiltration Trenches in ROW.	16
BB0017	Whatley Rd 1-5	ROW Planter	System of Filter strips with storage in ROW.	16
BB0002	Allen Road	Detention Basin	Detention Basin in ROW. Requires new culvert under roadway.	15.5
BB0013	Laurel Hill Detention Pond at Horticulture Farm	Culvert Retrofit	Block existing culvert and add storage.	15.5
BB0005	Brownell Way	ROW Infiltration Trench	System of Infiltration Trenches in ROW.	15
BB0018	Windsor Ct-1	ROW Infiltration Trench	System of Infiltration Trenches in ROW.	15
BB0015	Pinnacle at Spear Pond B	Pond Upgrade	Drains to proposed Hort Farm Basin. Retrofit riser and deepen.	13.75
BB0011	Horticulture Farm Detention Pond	Detention	Provide irrigation pond for UVM farm	12
BB0008	Deerfield Drive 2	ROW Planter	System of Filter strips with storage in ROW.	13
BB0001	1690 Shelburne Rd.	Detention Basin	Detain unmanaged portion of Route 7 in underground detention chamber.	12
BB0011	Horticulture Farm Detention Pond	Detention	Provide irrigation pond for UVM farm	12
BB0006	Brownell Way-3	ROW Planter	System of Filter strips with storage in ROW.	10

6. Design and Construction Schedule

A Design and Construction (D&C) schedule is a required element of the final approved FRP. This schedule must show how the proposed BMPs included in the FRP can be implemented over a timeframe of less than 20 years from the date of MS4 permit issuance. This means that all BMPs associated with FRPs must be implemented prior to December 5, 2032. The City of South Burlington has impervious ownership in five impaired watersheds; Bartlett, Englesby, Centennial, Monroe, and Potash Brook. Therefore, all five impaired watersheds were considered when developing a realistic D&C schedule for the City. However, only the projects located within the Bartlett Brook watershed are presented in the D&C schedule in Appendix 6.

In addition to a project's score within the BMP ranking matrix, development of a BMP implementation schedule required the consideration of additional factors. A number of the proposed BMPs are currently covered by expired State of Vermont stormwater permits. These BMPs were included in the beginning of the schedule so that the associated properties could complete the required stormwater improvements and achieve permit compliance. Other BMPs involve property containing more than 3 acres of impervious area. VTDEC is currently drafting a "3 Acre Stormwater Permit" that would require stormwater retrofits at these sites. BMPs in this situation were also placed towards the front of the implementation schedule. In addition, some of the proposed BMPs are located on land owned or controlled by the MS4 entities. These BMPs were given priority over those that were located on private property.

The BMP schedule presented in this FRP is expected to receive updates on an annual basis. Projects will be added, modified, or removed as necessary to meet FRP flow targets and respond to actual conditions. The primary reason being that the BMPs presented in the implementation schedule have only been developed to in concept. It is reasonable to anticipate that changes will occur when these concepts are further developed. Depending on actual circumstances, the level of treatment achieved may be more or less than the level of treatment anticipated (e.g. variations in soil conditions allow for either more or less infiltration of stormwater runoff than originally anticipated). These type of modifications are common when advancing BMP plans from concept to final design. Therefore, flexibility in the schedule is necessary to accommodate these changes.

Additionally, in order for project implementation to move forward in a cost effective manner, the MS4s will need to take advantage of opportunities for stormwater improvements as they present themselves. For example, a private property owner may decide to redevelop their property on a schedule that was not anticipated in the current BMP implementation schedule. If this occurs, the MS4s may need to shift available resources from a scheduled project in order to take advantage of a cost savings opportunity.

Finally, projects may need to be shifted in the BMP schedule based on Vermont's changing regulatory system. VTDEC is currently developing an implementation plan for the Lake Champlain Phosphorous TMDL. When this document is finalized, the MS4 permit will require regulated entities to develop Phosphorus Control Plans (PCPs), similar in size and scope to the FRPs being

developed as part of stormwater TMDLs. When this occurs, the FRPs will likely need to be revised based on PCP requirements, which are yet to be defined by VTDEC.

7. Financial Plan

Subject to the requirements of the MS4 permit, a financial plan is required as part of the FRP. This plan must provide initial BMP cost estimates and demonstrate the means by which BMP implementation will be financed. The financial plan must also include the steps that each MS4 will take to implement the finance plan. Initial BMP cost estimates were arrived at using 2014 cost estimates. Once projects were scheduled over the remaining 20 year implementation schedule (17 years remaining), an annual 3% inflation rate based on the construction cost index was applied. Appendix 6 presents inflation adjusted project costs for each BMP project. Applying this inflation rate provides a more accurate annual cost for BMP construction in the later years of the schedule.

7.1 City of South Burlington Financial Plan

In 2005, the City of South Burlington created Vermont's first stormwater utility. Under the stormwater utility system, all developed properties in the City pay an impervious area-based stormwater fee using an Equivalent Residential Unit (ERU) system. These stormwater fees provide the City with a stable funding source that is used to comply with State and Federal stormwater regulations and maintain stormwater infrastructure throughout the City. The stormwater utility was created with the understanding that there would be future stormwater costs related to the five stormwater impaired watersheds located in South Burlington, as well as costs related to future implementation of projects required by the Lake Champlain Phosphorous TMDL. The City anticipates using funds generated from stormwater utility fees to fund a portion of FRP related costs.

Once the BMP cost and implementation schedule was developed, the City of South Burlington Stormwater Utility was able to incorporate this information into its existing stormwater rate model. The City evaluated three different scenarios for funding the BMPs included in the FRP. The first scenario assumed that there would be no grant funding or low interest loans available to assist with implementation. The second scenario assumed that there would be no grant funding available, but low interest loans would be available to help the City pay for implementation. This scenario included $5M in low interest loans to help pay for BMP implementation. The third funding scenario assumed no loans and that grant funding of approximately $250,000 per year would be available in 2018 through 2029, and that this amount would increase to $500,000 in 2030, 2031, and 2032. The impact that these scenarios would have on stormwater utility rates is summarized in Table 7. The resulting annual cost to a single family residential property and commercial property owner containing 1 acre of impervious area is summarized in Table 8. Calculations for "Commercial Property Containing 1 Acre Impervious Area" in Table 8 assume an Equivalent Residential Unit (ERU) rate of 17 and do not take into account the City's relative tier factors, based percent impervious cover, which would yield an ERU range of 13 to 22 ERUs.

Table 7: Stormwater Billing Rate (Cost per Equivalent Residential Unit) Under Different Flow Restoration Plan Funding Scenarios

Fiscal Year	Funding Scenario 1 Receive No Grants and No Loans	Funding Scenario 2 Receive Low Interest Loans, No Grants	Funding Scenario 3 Receive $250,000 in Grants Annually
2018	$6.69	$6.69	$6.69
2019	$6.87	$6.84	$6.84
2020	$7.05	$6.99	$6.99
2021	$7.26	$7.14	$7.14
2022	$7.50	$7.29	$7.29
2023	$7.77	$7.47	$7.44
2024	$8.07	$7.68	$7.59
2025	$8.40	$7.92	$7.74
2026	$8.76	$8.19	$7.89
2027	$9.15	$8.49	$8.04
2028	$9.57	$8.82	$8.19
2029	$9.99	$9.18	$8.34
2030	$10.41	$9.57	$8.49
2031	$10.83	$9.99	$8.64
2032	$11.25	$10.44	$8.79

Table 8: Annual Stormwater Fee Paid by Property Owners Under Different Flow Restoration Plan Funding Scenarios

Fiscal Year	Funding Scenario 1 - Receive No Grants and No Loans		Funding Scenario 2 - Receive Low Interest Loans, No Grants		Funding Scenario 3 - Receive $250,000 in Grants Annually	
	Single Family Residential Property	Commercial Property Containing 1 Acre Impervious Area	Single Family Residential Property	Commercial Property Containing 1 Acre Impervious Area	Single Family Residential Property	Commercial Property Containing 1 Acre Impervious Area
2018	$80.28	$1,364.76	$80.28	$1,364.76	$80.28	$1,364.76
2019	$82.44	$1,401.48	$82.08	$1,395.36	$82.08	$1,395.36
2020	$84.60	$1,438.20	$83.88	$1,425.96	$83.88	$1,425.96
2021	$87.12	$1,481.04	$85.68	$1,456.56	$85.68	$1,456.56
2022	$90.00	$1,530.00	$87.48	$1,487.16	$87.48	$1,487.16
2023	$93.24	$1,585.08	$89.64	$1,523.88	$89.28	$1,517.76
2024	$96.84	$1,646.28	$92.16	$1,566.72	$91.08	$1,548.36
2025	$100.80	$1,713.60	$95.04	$1,615.68	$92.88	$1,578.96
2026	$105.12	$1,787.04	$98.28	$1,670.76	$94.68	$1,609.56
2027	$109.80	$1,866.60	$101.88	$1,731.96	$96.48	$1,640.16
2028	$114.84	$1,952.28	$105.84	$1,799.28	$98.28	$1,670.76
2029	$119.88	$2,037.96	$110.16	$1,872.72	$100.08	$1,701.36
2030	$124.92	$2,123.64	$114.84	$1,952.28	$101.88	$1,731.96
2031	$129.96	$2,209.32	$119.88	$2,037.96	$103.68	$1,762.56
2032	$135.00	$2,295.00	$125.28	$2,129.76	$105.48	$1,793.16

It is the City's expectation that significant funding from the State of Vermont and other Federal sources will be available to help with the cost of stormwater TMDL implementation. The State of Vermont has already taken initial steps towards providing this funding. In 2015 the Vermont legislature created the Clean Water Fund (CWF). The CWF was provided with $2,005,000 in 2016, and $7,688,000 in 2016. While these initial investments are not at the level necessary to provide significant funding to the MS4 communities subject to stormwater TMDLs, it is our understanding that the State is working to provide additional funding to the CWF in the future. In December 2016, the State Treasurer and State agencies will be delivering a report to the Vermont legislature that provides options for raising significant money to fund the CWF. The City of South Burlington intends to work closely with our legislative representatives to ensure that this funding is made available for the stormwater improvements included in the FRPs. The City of South Burlington will also pursue funding from existing and new grant sources from other organizations including, but not limited to, VTDEC, the Vermont Agency of Transportation, and the Lake Champlain Basin Program.

7.2 Vermont Agency of Transportation Financial Plan

Planning level costs were independently estimated for each VTrans project using a consistent spreadsheet-based method for all projects. As such, some cost estimates may differ slightly from those presented in other FRP documents. VTrans will request state and federal funding for the appropriate amount to implement the BMPs as outlined in their design and construction schedule. For those projects that will require a joint effort with another municipality, VTrans will request funding for their portion of the cost share. In watersheds where VTrans is either not meeting or exceeding their allocated target there may be cost sharing between MS4s.

7.3 BMP Cost Estimates:

Itemized cost estimates were developed for the top 4 priority projects based on 30% preliminary engineering plans. For all other projects, a modified spreadsheet method was used.

7.3.1 Itemized Cost Estimates:

The itemized cost estimates for the top 4 projects are included in Appendix 7. The cost estimates are based on the following criteria:

- **Construction Cost**: The construction costs were developed based on using both VTRANS 5 year average costs, VTRANS Estimator Program, and RS Means (where applicable) and vendor estimates as necessary for each of the itemized units.
- **Construction Contingency**: The construction contingency is calculated as 15% of the construction cost.

- **Final Design Engineering**: The final design engineering cost is estimated based on the State Fee Curve Allowance as developed by VT DEC. The equations used are as follows:
  - for construction costs less than 780,000, construction cost = $1,950+(Construction cost *0.069)
  - for construction costs greater than 780,000, construction cost = (Construction cost^0.9206)*0.6788*0.30.
- **Construction Engineering**: The construction engineering cost is based on the State Fee Curve Allowance as developed by VT DEC. The equations used are as follows:
  - for construction costs less than 780,000, construction cost = $3,575+(Construction cost *0.1265)
  - for construction costs greater than 780,000, construction cost = (Construction cost^0.9206)*0.6788*0.55.
- **Other costs:** These costs are established based on simple percentages of the construction cost for the project as follows:
  - Administrative = 0.5%
  - Easement Assistance = 1.5%
  - Land Acquisition =$120,000 per acre (*Value estimated by City Assessor)
  - Legal = 5%
  - Bond Vote Assistance = 0.5%

7.3.2 Cost Estimates Using Spreadsheet Method:

A modified spreadsheet method was used to develop planning level costs for the remaining BMP projects. Horsley Witten (HW) previously completed the Centennial Brook FRP and developed cost estimates using a spreadsheet method[6] (Memorandum Provided in Appendix 8). Use of the HW spreadsheet method was originally planned. However after comparing the spreadsheet results for the top four projects with the itemized cost estimates, it appeared that modifications would improve the confidence in the spreadsheet estimates. Therefore, revisions to the HW estimates were necessary in order to be consistent with our modifications. These modifications were simple and accomplished using the available data. The following criteria and modifications were applied in the cost estimates as follows:

Design Control Volume (*Modified*): HW based the design control volume on the runoff volume from the managed site from the 1-year storm for offline CPv BMPs, and the 100-year storm + 2 ft freeboard for large aboveground basins. We found the runoff volume overestimated the cost significantly and found the storage-volume to be a preferred metric for the control volume. The storage-volume associated with the

[6] Horsley Witten Group, Inc. 2014. Centennial Brook Watershed: Flow Restoration VTBMPDSS Modeling Analysis and BMP Supporting Information. Memorandum Dated January 9th, 2014.

1-year storm was used for off-line CPv BMPs only designed to mitigate the 1-year storm, and the 100-year storm + 2 ft of freeboard for large basins.

Unit Costs and Site Adjustment Factors: We used the values developed by HW as summarized in Table 9 below:

Table 9: Retrofit unit costs and adjustment factors

BMP	Base Cost ($/ft3)
Detention Basin	$2
Infiltration Basin	$4
Underground Chamber (infiltration or detention)	$12
Bioretention	$10
Green Infrastructure/ Underground Chamber Combo	$22
Site Type	Cost Multiplier
Existing BMP retrofit	0.25
New BMP in undeveloped area	1
New BMP in partially developed area	1.5
New BMP in developed area	2
Adjustment factor for large aboveground basin projects	0.5

*Excerpt from Horsley Witten Memorandum Dated January 9th 2014 (Page 11)

Site Specific Costs: Not included in the cost estimates at this time.

Base Construction Cost: Calculated as the product of the design control volume, the unit cost, and the site adjustment factor.

Permits and Engineering Costs: Either a 20% (for largest storage volume projects) and 35% for smaller or complex projects.

Land Acquisition Costs *(Modified*): A variation from the HW method was applied. Based on an estimate from the City Assessor, the land acquisition cost was calculated as $120,000 per acre required for the BMP, applied to projects on private land.

Total Project Cost: Calculated as the sum of the base construction cost, permitting and engineering costs, and land acquisition costs.

Cost per Impervious Acre: Calculated as the construction costs plus the permitting and engineering costs divided by the impervious acres managed by the BMP.

Operation and Maintenance: The annual O&M was calculated as 3% of the base construction costs, with a maximum of $10,000.

A summary of the cost estimates is included in Table 10 below.

Table 10: Proposed BMPs Cost Estimates

BMP ID	Control	Imp acres	Design Control Volume		Base Unit Cost ($/cft)	Site Adjustment Factor	Base Construction Cost	Permits & Engineering Contingency	Land Cost	Total Project Cost	Cost/Imp Acre	Annual O&M
			(cft)	(ac-ft)								
BBSTS Combined	CPv only	9.33	0.55	30% Itemized Cost Estimate						$ 378,260	$ 40,534	$ 8,100
Bartlett Brook Central	CPv only	16.11	1.69	30% Itemized Cost Estimate						$ 853,730	$ 52,990	$ 10,000
Horticulture Farm Bioretention (Option 1)	100-yr	6.35	3.96	30% Itemized Cost Estimate						$ 267,820	$ 42,182	$ 5,700
Horticulture Farm Detention Pond (Option 2)	100-yr	1.13	0.39	30% Itemized Cost Estimate						$ 184,990	$ 163,287	$ 3,900
Irish Farm Condos Pond B	100-yr	3.38	1.06	30% Itemized Cost Estimate						$ 247,380	$ 73,198	$ 3,300
Underwood Stormwater Pond	CPv only	5.99	0.84	36721	$2	1.5	$110,163	$ 22,033	$90,000	$ 222,196	$ 22,060	$ 3,305
Laurel Hill Development	100-yr	21.13	3.20	139566	$2	0.5	$139,566	$ 27,913		$ 167,479	$ 7,927	$ 4,187
Holiday Inn Parking Lot	CPv only	3.20	0.12	5314	$12	2	$127,544	$ 25,509	$36,000	$ 189,052	$ 47,856	$ 3,826
Allen Road	100-yr	1.44	0.44	19166	$2	1.5	$57,499	$ 11,500		$ 68,999	$ 48,075	$ 1,725
1690 Shelburne Road	CPv only	0.63	0.12	5227	$12	2	$125,453	$ 43,908	$30,000	$ 199,361	$ 268,401	$ 3,764

BMP ID	Control	Imp acres	Design Control Volume	Base Unit Cost ($/cft)	Site Adjustment Factor	Base Construction Cost	Permits & Engineering Contingency	Land Cost	Total Project Cost	Cost/Imp Acre	Annual O&M	BMP ID
Windsor Ct	CPv only	0.31	0.02	1002	$10	2	$20,038	$ 7,013		$ 27,051	$ 86,748	$ 601
Brownell Way-3	CPv only	0.08	0.02	915	$10	2	$18,295	$ 6,403		$ 24,699	$ 325,063	$ 549
Brownell Way	CPv only	0.83	0.08	3354	$10	2	$67,082	$ 23,479		$ 90,561	$ 109,256	$ 2,012
Deerfield Drive 1	CPv only	0.80	0.12	5227	$10	2	$104,544	$ 36,590		$ 141,134	$ 177,069	$ 3,136
Deerfield Drive 2	CPv only	0.48	0.10	4312	$10	2	$86,249	$ 30,187		$ 116,436	$ 241,057	$ 2,587
Whatley Rd	CPv only	0.87	0.16	6752	$10	2	$135,036	$ 47,263		$ 182,299	$ 210,490	$ 4,051
Pinnacle at Spear Pond A	100-yr	3.30	0.686	29882	$2	0.25	$14,941	$ 5,229		$ 20,170	$ 6,116	$ 448
Pinnacle at Spear Pond B	100-yr	0.22	0.461	20081	$2	0.5	$20,081	$ 7,028		$ 27,110	$ 122,554	$ 602
		75.6							**Total Cost:**	**$3,408,728**		

8. Regulatory Analysis

In accordance with the MS4 permit, an FRP requires a regulatory analysis that identifies and describes what, if any additional regulatory authorities, including authority to require low impact development BMPs, that the permittees will need in order to effectively implement the FRP.

Currently, stormwater runoff within the Bartlett Brook watershed is regulated primarily by the VTDEC, City of South Burlington, Town of Shelburne, and VTrans. VTDEC regulates new developments through issuance of Stormwater Discharge Permits with technical requirements as outlined in the 2002 Vermont Stormwater Manual. The City of South Burlington and Town of Shelburne require improved stormwater practices and low impact development for new developments through their stormwater ordinances and Land Development Regulations (LDRs). VTrans regulates stormwater discharges to the state Right of Way through 19 V.S.A.§1111 "Permitted use of the right-of-way".

The City of South Burlington updated stormwater requirements in its LDRs in June 2016.[7] The revised LDRs require that any project resulting in ½ acre or more of impervious area implement stormwater controls that prioritize infiltration. The revised LDRs also contain new requirements for properties that are being redeveloped. It is the City's expectation that these changes will result in gradual improvements in stormwater management over the course of the BMP implementation schedule.

The City of South Burlington also revised its "Ordinance Regulating the Use of Public and Private Sanitary Sewerage and Stormwater Systems" in October 2015.[8] The ordinance provides a policy regarding the handling of expired VTDEC stormwater permits located in South Burlington. The City will continue to take over responsibility for exclusively residential stormwater systems that complete upgrades. In addition, the revised ordinance allows commercial properties with expired permits to obtain coverage under the City's MS4 permit if upgrades to the stormwater system are completed. These properties will still be responsible for maintaining their systems, but the permit coverage required by the State of Vermont can now be provided through the City's MS4 permit instead of obtaining coverage under one of VTDEC's other permit programs.

While the City of South Burlington has taken significant steps to alleviate the problems caused by expired State of Vermont stormwater permits within its boundaries, there is still a significant

[7] Section 12.03 – Stormwater Management Standards, "South Burlington Land Development Regulations," dated 6/27/16, can be viewed at the following link: http://www.sburl.com/vertical/Sites/%7BD1A8A14E-F9A2-40BE-A701-417111F9426B%7D/uploads/LDRs_Effective_6-27-2016__Complete_reduced_size.pdf

[8] South Burlington's "Ordinance Regulating the Use of Public and Private Sanitary Sewerage and Stormwater Systems," dated 10/5/15, can be viewed at the following link: http://www.sburl.com/vertical/sites/%7BD1A8A14E-F9A2-40BE-A701-417111F9426B%7D/uploads/Sewer_and_Stormwater_Ordinance_Final_Clean_10.5.15.pdf

role that the VTDEC needs to play in order to support these efforts. The City's revised ordinance provides the opportunity for properties to obtain their required State of Vermont stormwater permit coverage through the City's MS4 permit, but it does not require it. It is anticipated that some property owners will want to work directly with VTDEC to obtain this permit coverage. In order for South Burlington to effectively implement its FRP, VTDEC needs to update its State permit programs so that properties with expired stormwater permits in stormwater impaired watersheds can obtain permit coverage directly from VTDEC. This updated permit program should require stormwater treatment on the properties that are, at minimum, equal to the stormwater treatment requirements included in the City's LDRs and referenced in the City's Stormwater Ordinance. If VTDEC fails to take this step and creates a permit program that allows properties to obtain permits with minimal stormwater improvements, it has the strong potential to undermine the City's efforts to meet the FRP targets.

A full list of the expired State of Vermont permits with discharges to Bartlett Brook indicating the retrofits proposed under this FRP is included in Appendix 9 (Table A-9).

9. FRP Implementation

The Bartlett Brook FRP was completed to meet the requirements under Part III of the MS4 general permit for the contributing MS4's—City of South Burlington, VTRANS and the Town of Shelburne. According to Subpart IV.C.1. of the General Permit, the MS4 is required to submit a final FRP within 3 years of the permit issuance. The FRP will become a part of the permittees SWMP upon approval.

10. Appendices

Appendix 1: Future Growth Memorandum

Appendix 2: 30% Engineering Plans for the Top 4 Projects in Bartlett Brook & Orthophoto-based Sketch Plans

Appendix 3: Table A-3-1: BMPDSS Modeling Summary and A-3-2: BMP Table

Appendix 4: Map of Best Management Practices Included in the Bartlett Brook Flow Restoration Plan

Appendix 5: Table A-5-1: BMP Ranking Criteria Key, Table A-5-2: Scoring Key

Appendix 6: Bartlett Brook Watershed BMP Design and Construction Schedule

Appendix 7: Itemized Cost Estimates

Appendix 8: Horsley Witten Group Memorandum Dated January 9th, 2014.

Appendix 9: Bartlett Brook Expired Permit List

APPENDIX 1

FUTURE GROWTH MEMORANDUM

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CHITTENDEN COUNTY RPC
Communities Planning Together

Date: April 2, 2014

To: Thomas J. DiPietro Jr., Deputy Director, City of South Burlington

From: Melanie Needle, Senior Planner, CCRPC

RE: Non Jurisdictional Impervious Surface Analysis for the Bartlett Brook Watershed

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This memo documents the process used to estimate the additional non-jurisdictional impervious area that will be created in the in the Bartlett Brook Watershed over the next 20 years. The Vermont Department of Environmental Conservation (DEC) created a stormwater TMDL for the Bartlett Brook watershed. In this TMDL, non-Jurisdictional growth is defined as impervious surface growth in the watershed that is not subject to a State stormwater permit. Below is a description of the procedures developed by the Chittenden County Regional Planning Commission (CCRPC) and City of South Burlington to estimate the likely amount of non-jurisdictional impervious area growth that will occur in the watershed over the next 20 years.

Procedure

The analysis was performed in ArcGIS and Excel using the following procedure.

1. Define the study area and quantify the impervious surface for two time periods

    a. Identify parcels that do not have a state storm water permit within the Bartlett Brook Watershed study area. Parcels that do not have a state stormwater permit are potential areas for non-jurisdictional impervious area growth and are included in the analysis. Additionally, roads are excluded from the analysis and impervious area growth associated with them is addressed in step 6. The 2003 and 2010 impervious surface data was provided by South Burlington. These datasets are polygon based spatial data and identify all types of impervious surface in the watershed. The total non-jurisdictional impervious area for 2003 and 2010 are inputs to step 2 where the average annual rate of growth is calculated. To summarize the total non-jurisdictional impervious area for two periods within non-jurisdictional parcels first clip the impervious area to the parcels that do not have a state storm water permit and then total the impervious area mapped for these two time periods.

    Later in this analysis the rate of growth is applied to each parcel to determine additional impervious surface created in 2025, so the existing (2010) impervious area needs to be

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assigned to the parcel it falls within. To do this, run the dissolve tool on the 2010 non-jurisdictional impervious area. Then run the intersect tool on the dissolved impervious area and the parcel data to essentially divide the impervious area by parcel boundaries and to bring the parcel ID into the non-jurisdictional impervious area. Finally, do a join from the parcels to this newly created impervious surface data using the "parcel num" field.

2. Determine the annual rate of change for non-jurisdictional impervious area between two time periods.

    a. The total amount of non-jurisdictional impervious area for 2003 and 2010 is used in this step. The formula for calculating the growth rate is (Power((end value/start value),(1/N))-1)*100). The end value is the total impervious area for the watershed in the City for the latest year. The start value is the total impervious area for the earliest year. **According to this method, non-jurisdictional impervious area has increased 1.02% per year in the Bartlett Brook Watershed**. Later in the analysis this rate of growth will be applied to each parcel to estimate the amount of impervious area created in 2025.

Table 1: Existing Non-Jurisdictional Impervious Area, Average Annual Rate of Change

Non Jurisdictional Impervious Acres, 2003	Non Jurisdictional Impervious Acres, 2010	Number of Years	Avg. Ann Change	Change (acres) 2003 to 2010	2025 Projected Total	2025 Additional Growth
45.2	**48.5**	**7**	**1.02%**	**3.3**	**56.4**	**7.9**

3. Apply the impervious area growth rate from step 2 to each parcel within the study area to determine the acreage of non-jurisdictional impervious growth potential in 2025.

    a. Impervious area for each parcel cannot exceed the lot coverage per municipal regulations.
        - Look up the lot coverage on each parcel in the zoning regulations and assign the lot coverage based on the zoning district each parcel falls within.
        - Determine if a parcel can add more impervious area by dividing existing impervious and the total parcel acreage to get the current existing impervious percent.
        - If existing lot coverage does NOT exceed zoning lot coverage then estimate the total future impervious area in 2025. The formula for this is (1+growth rate)^(future year-recent year)* recent year's impervious area. Parcels in the GIS data are flagged as 1 in the [AddMoreImp] field if there is the potential to add more impervious cover. If parcels have exceeded the lot coverage and cannot be developed any further they received a 0 in the [AddMoreImp] field. If a parcel does not have any existing impervious area then it is assigned a 2 in [AddMoreImp] field. The future

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impervious parcels that are currently undeveloped are assumed to reach their full lot coverage potential in 2025. Therefore, the formula for estimated future impervious area is [Parcel Acres]*Lot Coverage for parcels that are classified as 2 in the [AddMoreImp] field.

b. Determine if the percent of impervious area by parcel in 2025 is greater than the lot coverage, if lot coverage is exceeded in 2025 then use the remaining lot coverage percentage to estimate the growth. The formula is

(lot coverage –(existing lot area/parcel area)* parcel + existing impervious area.

4. Use the resulting impervious values for 2025 estimated in step 3 to determine whether the parcel will be jurisdictional or non-jurisdictional. Parcels are "jurisdictional" if the sum of the existing and projected future impervious growth is greater than 1 acre. If a parcel's total future impervious area is less than 1 acre then the new impervious is considered "non-jurisdictional". The increase in new impervious area on the parcels with build out potential is shown in the table 2 below and is an estimate of the likely non-jurisdictional impervious area growth for the watershed by 2025.

Table 2: 2025 Total Projected Impervious Area by Type

	Existing[1] Impervious Area (acres)	Estimated 2025 Total Impervious Area (acres)	New Non-Jurisdictional Additional Impervious Area (acres)
Jurisdictional	9.5	13.5	4.0
Non Jurisdictional	33.8	39.5	5.7
Grand Total for Watershed	43.3	53.0	9.7

1-The existing impervious area in this table is lower than in table 1 because this table only reports existing impervious area on parcels that have development potential and have not exceeded the lot coverage standard.

5. Estimate the total impervious area potential on a parcel based on lot coverage. The formula for this is (Lot Cov – Existing % imp area)* parcel area + existing imp area. The estimate of total impervious area will assist in the identification of parcels that could become jurisdictional if a large development is planned and developed all at once. Table 3 shows the amount of impervious area possible if every parcel built out to the maximum lot coverage independent of time.

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Table 3: Total Impervious Area for Parcels that do not have an existing State Stormwater Permit

	Existing Impervious Area (acres)	Total Impervious Area (Remaining Lot Coverage)	Difference Between Total Imp Area & Existing
Jurisdictional	15.1	171.5	156.5
Non Jurisdictional	28.2	63.0	34.8
Grand Total for Watershed	43.3	234.6	191.3

6. Roads were not included in this analysis because they are not built out in the same manner as parcels and are not subject to lot coverage requirements. Any new roads in this watershed are likely to be for access to large future developments on larger parcels. Also any new expansions or sidewalk additions will likely put the impervious area threshold over 1 acre making the road subject to state stormwater standards.

Memorandum

To:
Tom Dipietro
City of South Burlington
104 Landfill Road
South Burlington, VT 05403

From: Watershed Consulting Associates, LLC

Date: May 31, 2017

Re: **Future Growth Target for Bartlett Brook Flow Restoration Plan**

1.0 Introduction

A revised future growth estimate of 5.7 acres was used for the development of the Bartlett Brook Flow Restoration Plan (FRP) as opposed to the original estimate of 50 acres. This revised estimate of non-jurisdictional future growth reduced the required high flow reduction from 33.2% to 11.6%. Watershed Consulting Associates, LCC was asked to estimate the additional impervious area that would need to be managed for the high flow reduction to meet the original 33.2% high flow reduction in the event that the original 40-acre future growth was proven accurate.

2.0 Methods and Results

The impervious cover managed by the proposed BMPs by model scenario were regressed with the unmodified high flow target met (%) by that model run. With this original TMDL high flow reduction target, 86.48% of the target is met with the currently proposed BMPs. To meet the full target, management of an additional 34.3 acres of impervious will be needed for a final managed impervious area of 140.8 acres (R^2=0.92; Figure 1).

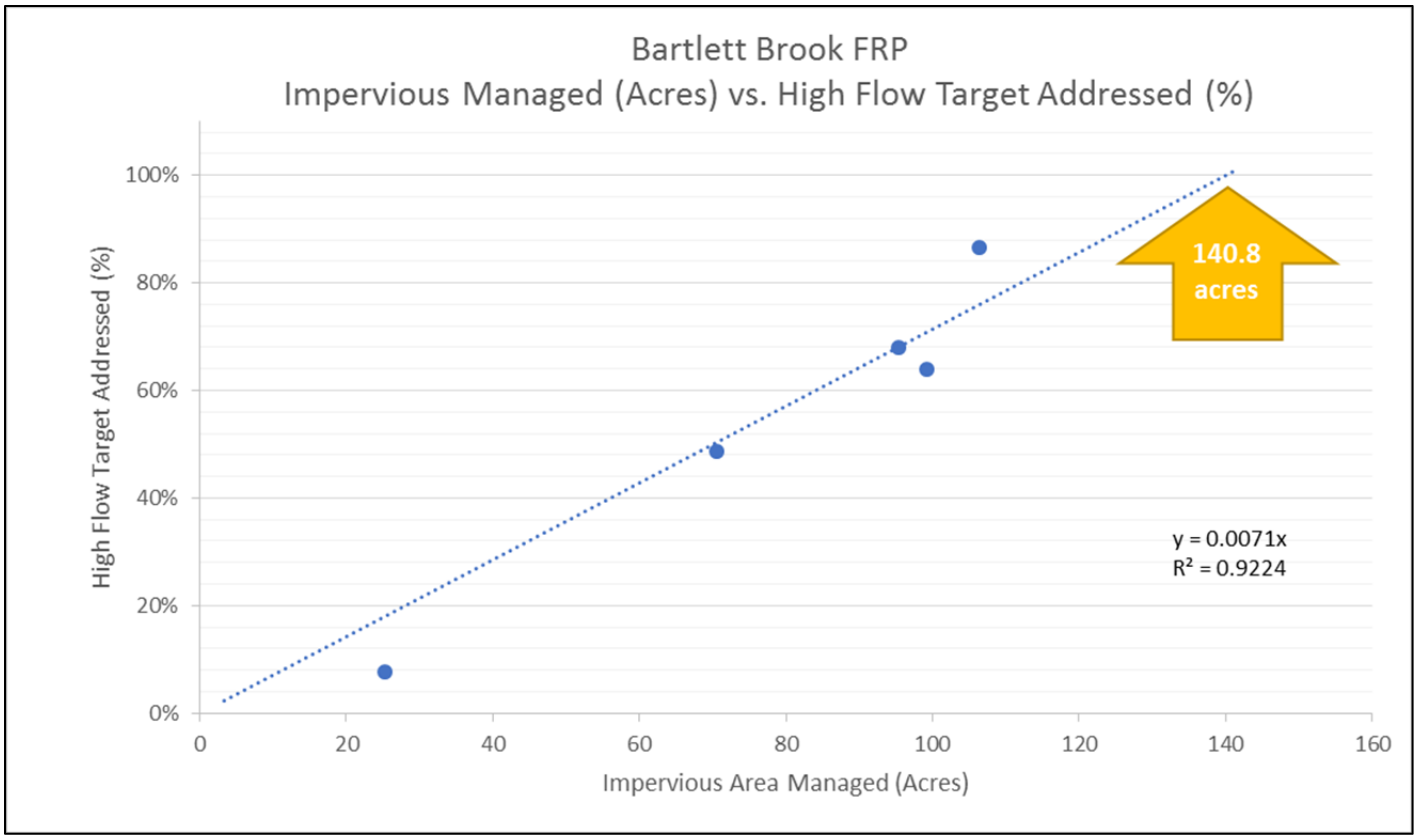


Figure 1. Regression for predicting required impervious cover to be managed to meet original TMDL high flow reduction targets.

3.0 Discussion

Currently, projects will not be developed to manage this additional 34.3 acres of impervious surfaces. Current controls do meet nearly 200% of the required high flow reduction with the modified future growth assessment. If this assumption of the modified future growth estimate is proven to be false moving forward, the MS4s will identify and construct additional controls. If this is the case, the controls will be identified near the end of the design and construction schedule. Projects would be designed and constructed in the final four years of the design and construction schedule.

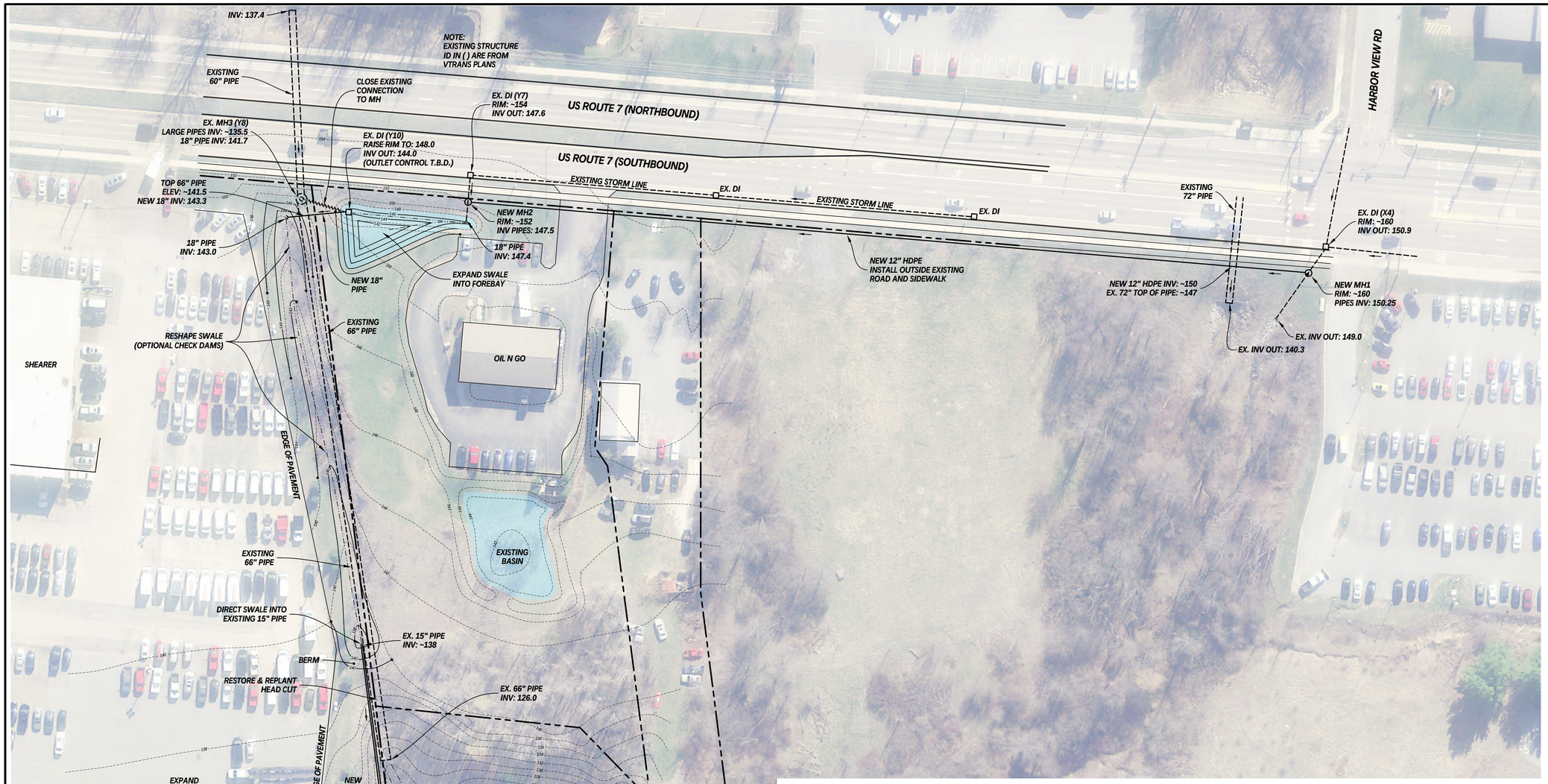
Sincerely,

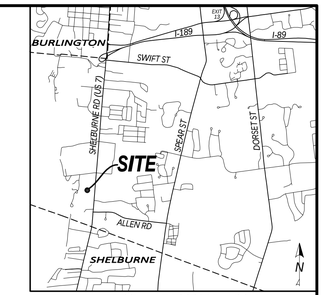
Andres Torizzo
WCA Principal

Kerrie Garvey
GIS Specialist

APPENDIX 2

30% ENGINEERING PLANS FOR THE TOP 4 PROJECTS IN BARTLETT BROOK &
ORTHOPHOTO-BASED SKETCH PLANS





SITE LOCATION

NTS

LEGEND

- PROPERTY LINE
- EXISTING CONTOUR
- FINISH GRADE CONTOUR
- SURFACE WATER

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(IN FEET)
1 inch = 40 ft.

NOTES

EXISTING LAYOUT, TOPOGRAPHY AND PROPERTY LINES ARE FROM

1. RECORD DRAWING, BARTLETT BAY ROAD STORMWATER TREATMENT SYSTEM AND STREAM CORRIDOR RESTORATION, S. BURLINGTON, VT., PROJ. 02-042, SHEET 1, LAMOUREAUX & DICKINSON CONSULTING ENGINEERS INC. 9-24-2002

2. SITE AND GRADING PLAN, OIL N GO, MARK HILL--OWNER, SHELBURNE RD., S. BURLINGTON, VT., PROJ. 7445, SHEET 2 OF 4, PINKHAM ENGINEERING ASSOCIATES, INC., 3-26-1999, LAST REV. 9-23-1999

3. RECORD PLANS, PROPOSED URBAN IMPROVEMENT, U.S. ROUTE 7, SHELBURNE/S. BURLINGTON, PLAN DRAWING NO. 5, PROJ. NH-EGC-019-4(28), SHEET 73 OF 283, STANTEC, 10-5-2006

CONCEPT

BARTLETT BROOK FLOW RESTORATION PLAN

SOUTH BURLINGTON, VERMONT

BBTS STORMWATER IMPROVEMENT PLAN

WATERSHED CONSULTING ASSOCIATES, LLC
Stormwater Management | Water Quality | Erosion Control
430 Shelburne Road P.O. Box 4413
Burlington, VT 05406
Mobile: 802.922.4871 | Main: 802.497.2367
www.watershedca.com

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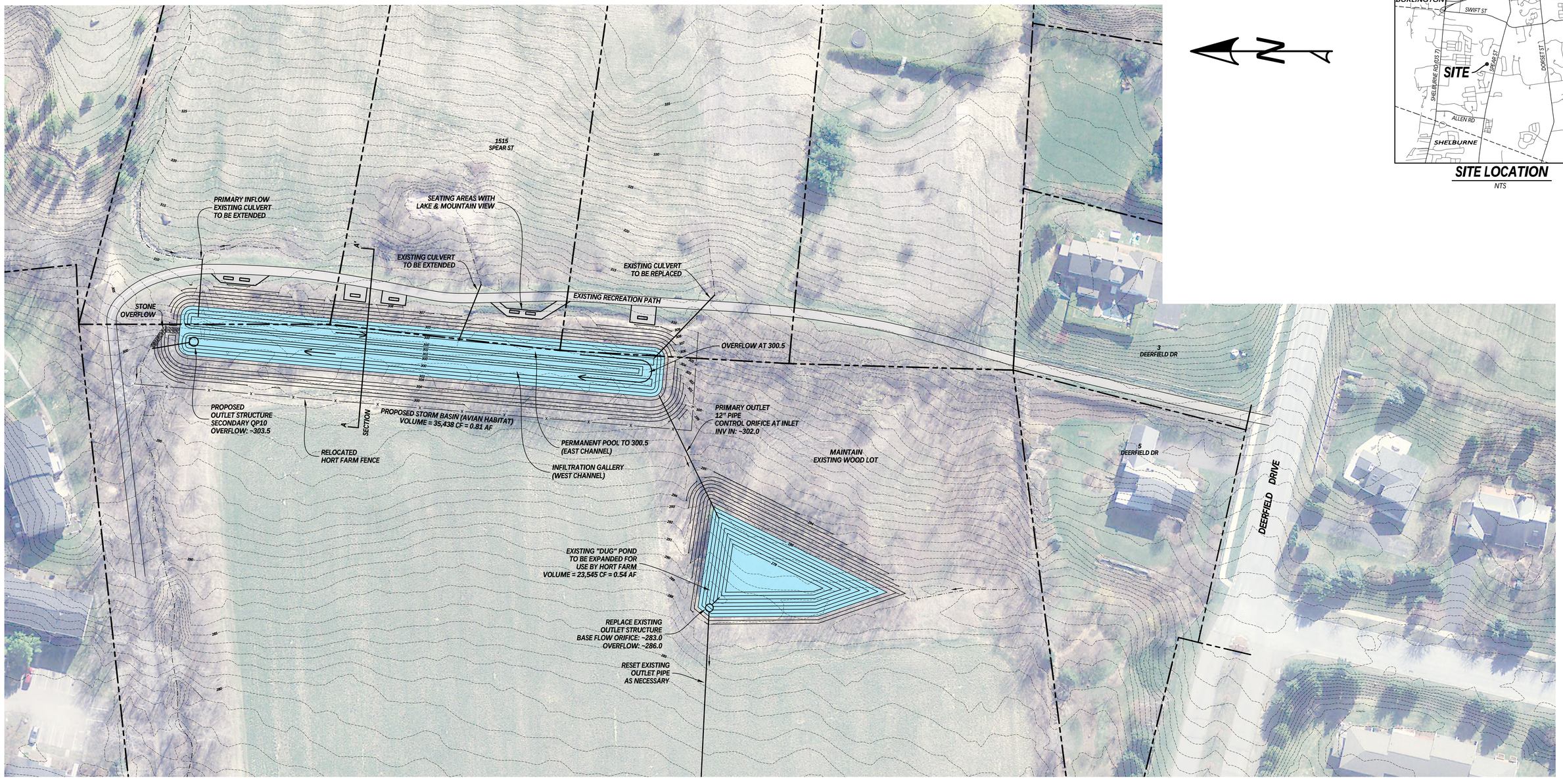
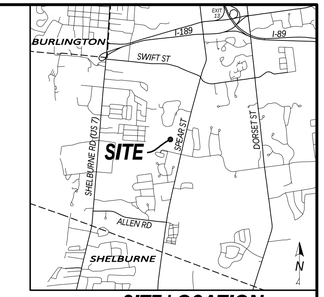
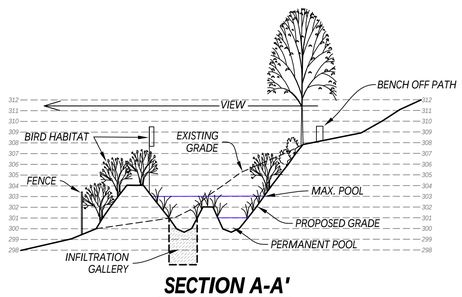
DATE:	12-15-14	CHECKED BY:	AT	SHEET:	1 OF 1





SITE LOCATION

NTS



SECTION A-A'

NTS

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(IN FEET)
1 inch = 40 ft.

LEGEND

- PROPERTY LINE
- EXISTING CONTOUR
- FINISH GRADE CONTOUR
- DRAINAGE COURSE

NOTES

1. THIS IS NOT A BOUNDARY SURVEY. BOUNDARY INFORMATION IS FROM TOWN TAX MAPS.
2. EXISTING TOPOGRAPHY WAS CREATED FROM CHITTENDEN COUNTY LiDAR (2004).

CONCEPT

BARTLETT BROOK FLOW RESTORATION PLAN

SOUTH BURLINGTON, VERMONT

HORT FARM STORMWATER IMPROVEMENT PLAN

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Stormwater Management | Water Quality | Erosion Control
430 Shelburne Road P.O. Box 4413
Burlington, VT 05406
Mobile: 802.922.4871 | Main: 802.497.2367
www.watershedca.com

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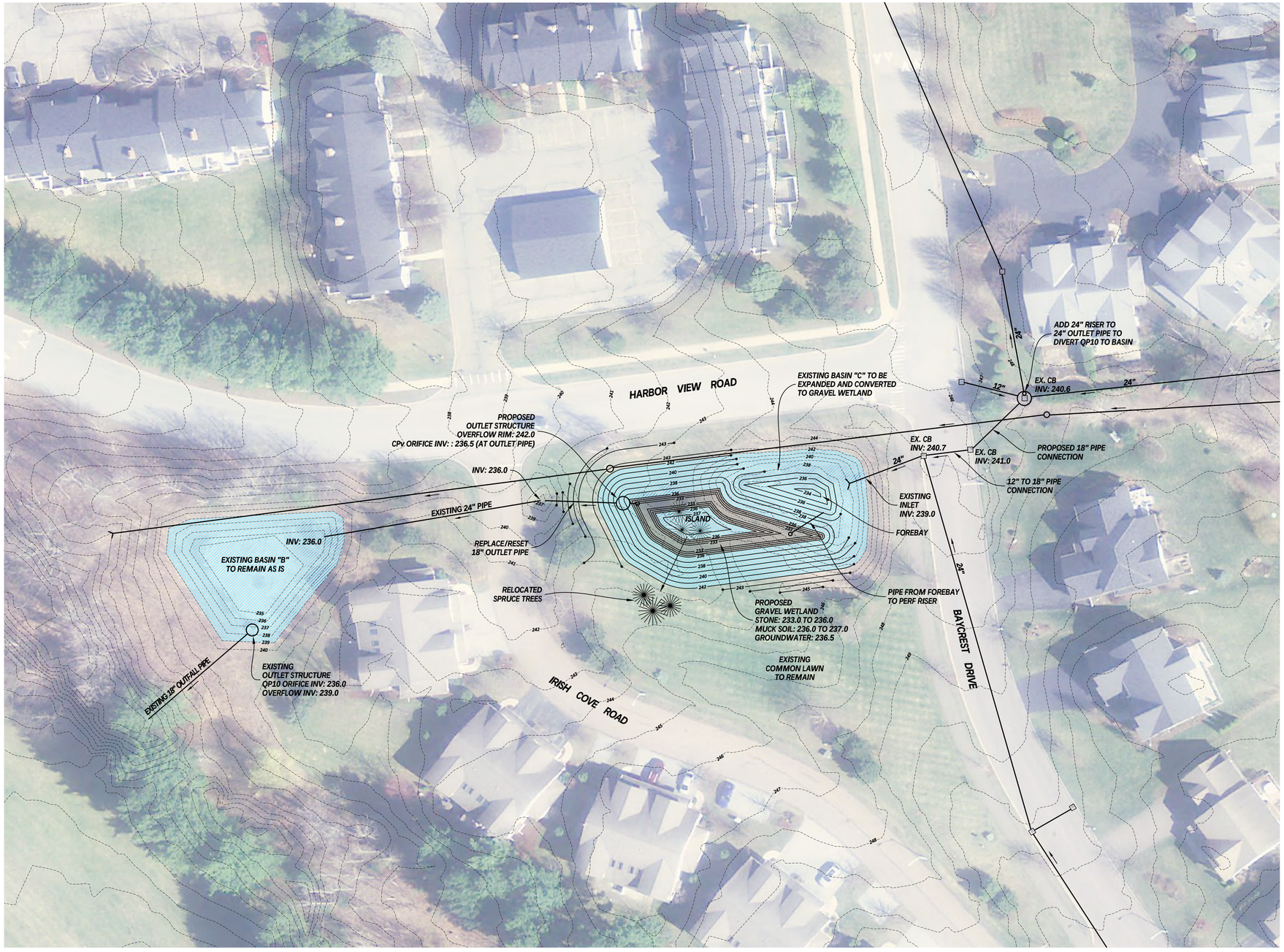

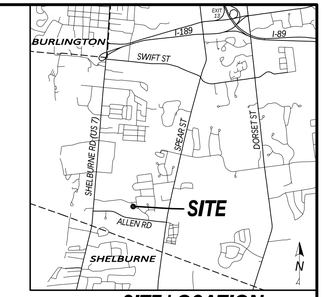

SITE LOCATION

NTS

LEGEND

- EXISTING CONTOUR
- FINISH GRADE CONTOUR

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(IN FEET)
1 inch = 30 ft.

CONCEPT

NOTE

EXISTING TOPOGRAPHY WAS CREATED FROM CHITTENDEN COUNTY LiDAR (2004).

BARTLETT BROOK FLOW RESTORATION PLAN

SOUTH BURLINGTON, VERMONT

IRISH FARM STORMWATER IMPROVEMENT PLAN

WATERSHED CONSULTING ASSOCIATES, LLC
Stormwater Management | Water Quality | Erosion Control
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Mobile: 802.922.4871 | Main: 802.497.2367
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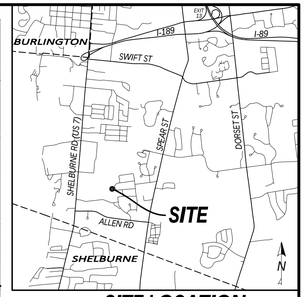

SITE LOCATION

NTS

N

LEGEND

- PROPERTY LINE
- EXISTING CONTOUR
- EXISTING STORM LINE
- PROPOSED STORM LINE

40 0 20 40 80 160

(IN FEET)
1 inch = 40 ft.

NOTES

1. THIS IS NOT A BOUNDARY SURVEY. BOUNDARY INFORMATION IS FROM TOWN TAX MAPS.
2. EXISTING TOPOGRAPHY WAS CREATED FROM CHITTENDEN COUNTY LiDAR (2004).

CONCEPT

BARTLETT BROOK FLOW RESTORATION PLAN

SOUTH BURLINGTON, VERMONT

KEARI LANE STORMWATER IMPROVEMENT PLAN

WATERSHED CONSULTING ASSOCIATES, LLC
Stormwater Management | Water Quality | Erosion Control
430 Shelburne Road P.O. Box 4413
Burlington, VT 05406
Mobile: 802.922.4871 | Main: 802.497.2367
www.watershedca.com

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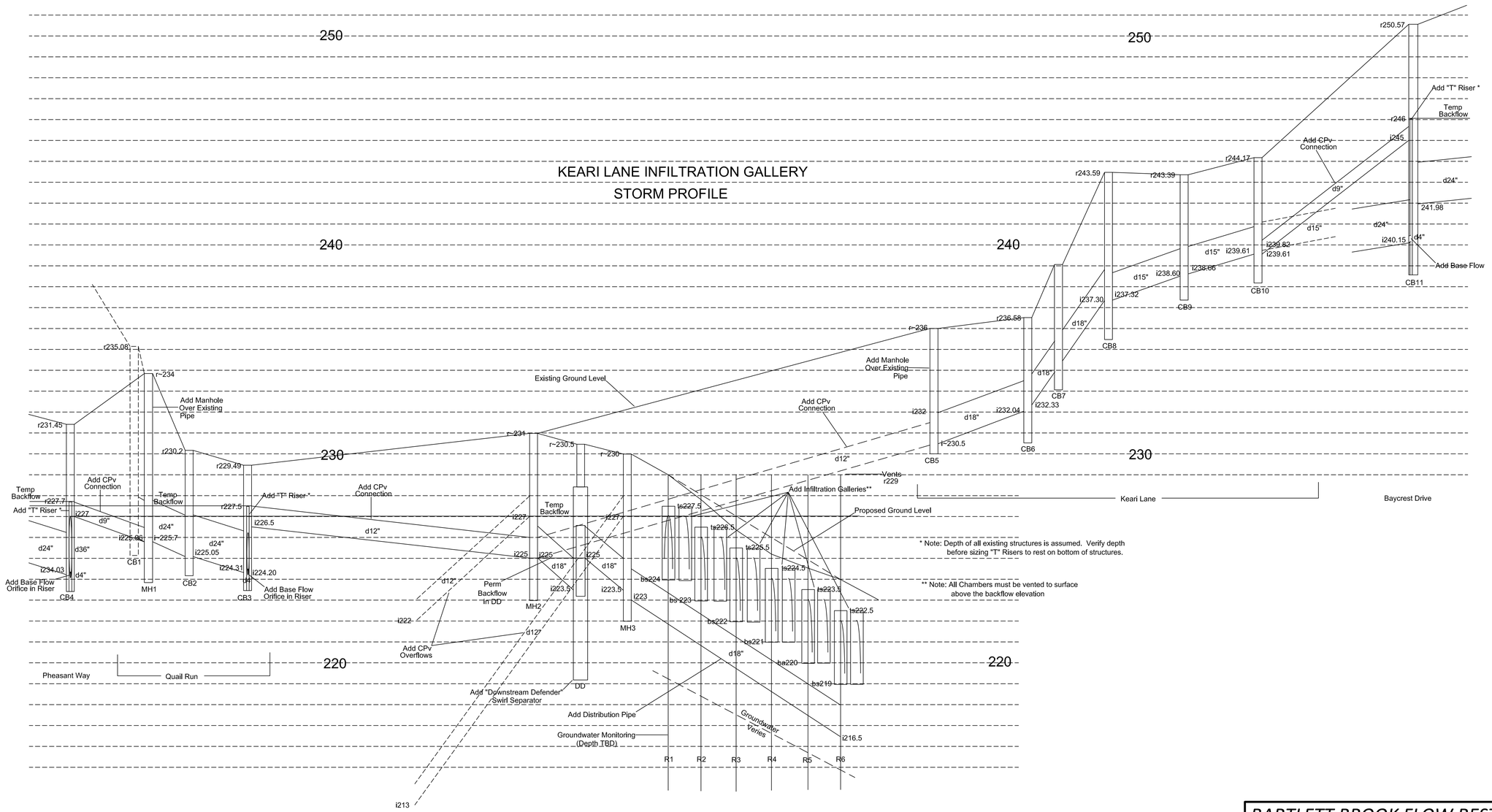

CONCEPT

BARTLETT BROOK FLOW RESTORATION PLAN

SOUTH BURLINGTON, VERMONT

KEARI LANE STORMWATER IMPROVEMENT PLAN - PROFILE

WATERSHED CONSULTING ASSOCIATES, LLC
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430 Shelburne Road P.O. Box 4413
Burlington, VT 05406
Mobile: 802.922.4871 | Main: 802.497.2367
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Remove 12" culvert at 375.5. Add 3" low flow orifice at 374.50.

Existing Detention Basin

SPEAR ST

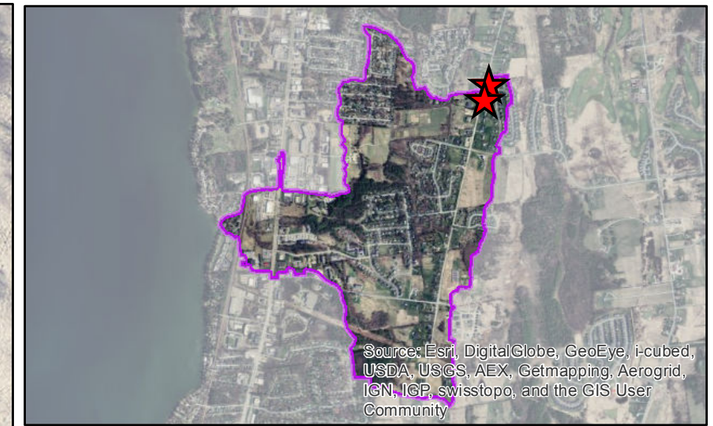
OLIVIA DR

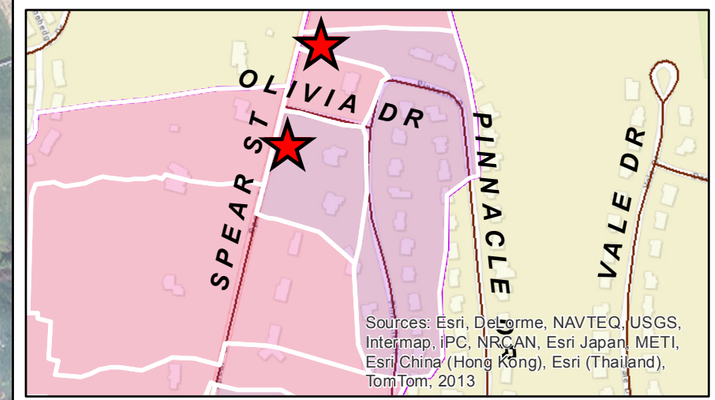
PINNACLE DR

Existing Detention Basin

Add 1" low flow orifice at 371' and 2" low flow at 373.50'.

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community





LEGEND

- PROPOSED RETROFIT SITE
- PROPOSED OUTLET
- PROPERTY LINE
- EXISTING 1' CONTOUR
- CITY BOUNDARY
- Roads

BMP DRAINAGE AREA

- Credit3
- Credit1
- Credit2
- base-r
- base
- post 2002
- bartlett_watershed_101414

WATERSHED CONSULTING ASSOCIATES, LLC

0 40 80 160 240 320 400 Feet

N S

BARTLETT BROOK FLOW RESTORATION STUDY SOUTH BURLINGTON, VERMONT		
1-1155a and 1-1155b Pond Retrofit		
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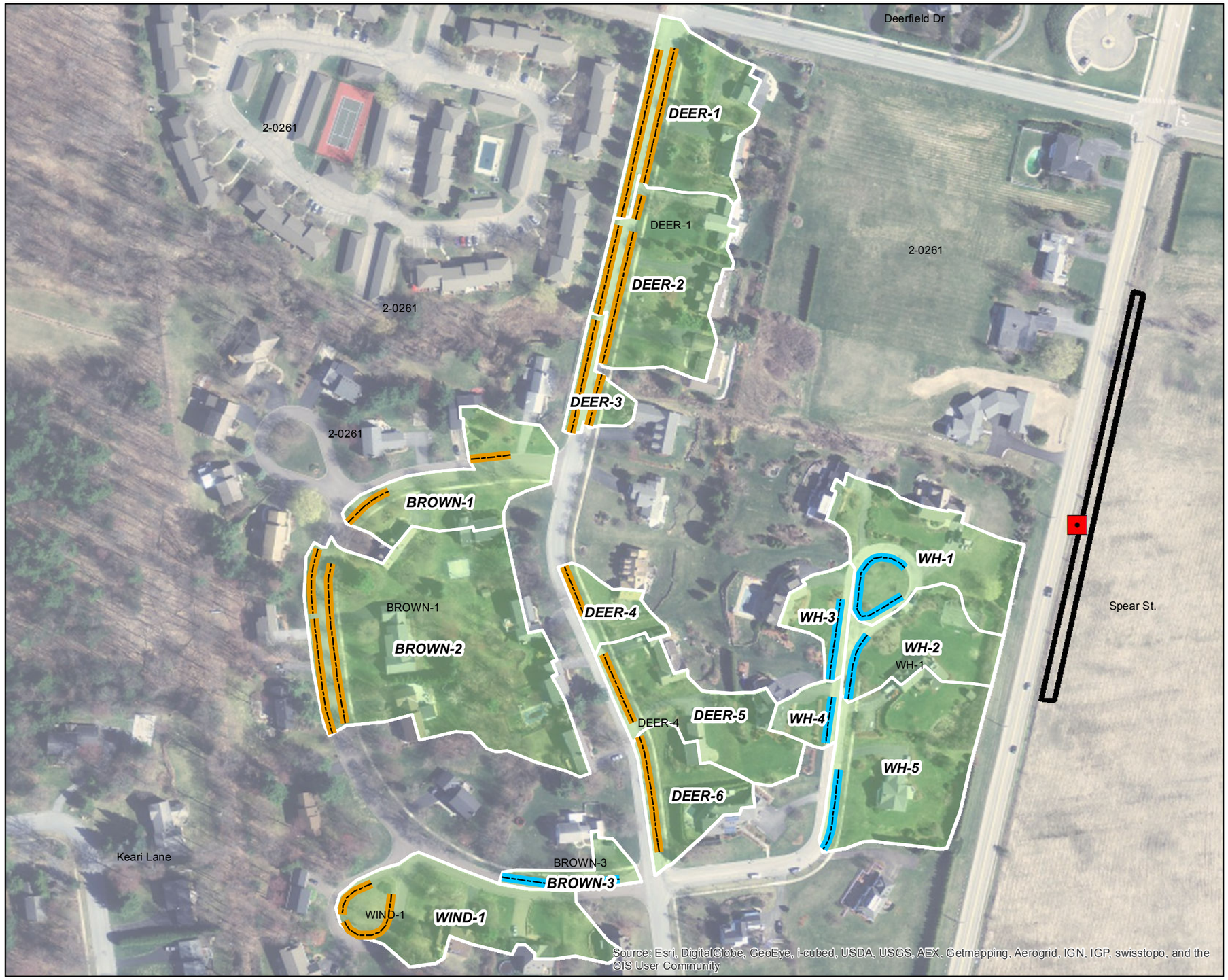

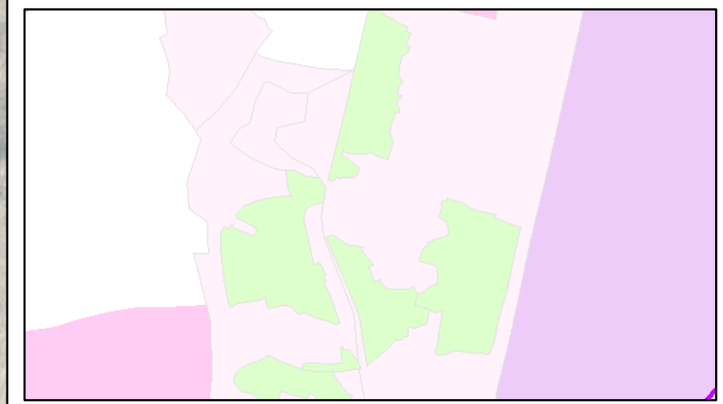

LEGEND

- ROW Detention Planter
- ROW Infiltration Planter
- PROPOSED OUTLET
- FINISH GRADE 2' CONTOUR
- GSI BMP Drainage Areas

BMP DRAINAGE AREA

- Credit3
- Credit1
- Credit2
- base-r
- base
- post 2002
- bartlett_watershed_101414
- Roads

NOTES:

Locations for proposed GSI practices are approximate. Utility and tree conflicts have not been verified. Detention BMPs were designed as biofilters and in the ROW sized to mitigate the 1-year storm (CPv) volume with underdrains and overflow outlet structures, tied to the exisiting stormwater system. Infiltration BMPs were designed as bioretention practices, sized to infiltrate the 1-year storm (CPv) volume. Ponding depth for all practices range from 6-8".

WATERSHED CONSULTING ASSOCIATES, LLC

0 40 80 160 240 320 400 480 560 640 Feet

N S

BARTLETT BROOK FLOW RESTORATION STUDY		
SOUTH BURLINGTON, VERMONT		
2-0261 Neighborhood Green Stormwater Infrastructure BMPs		
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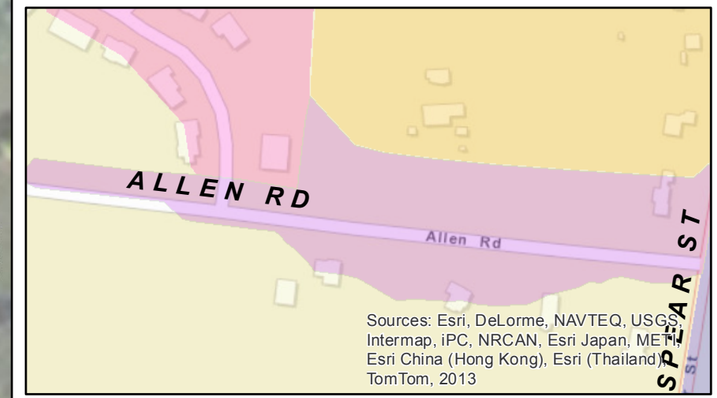


LEGEND

- PROPOSED OUTLET
- PROPOSED STORMLINE
- FINISH GRADE 2' CONTOUR
- EXISTING 1' CONTOUR
- CITY BOUNDARY
- Roads

BMP DRAINAGE AREA

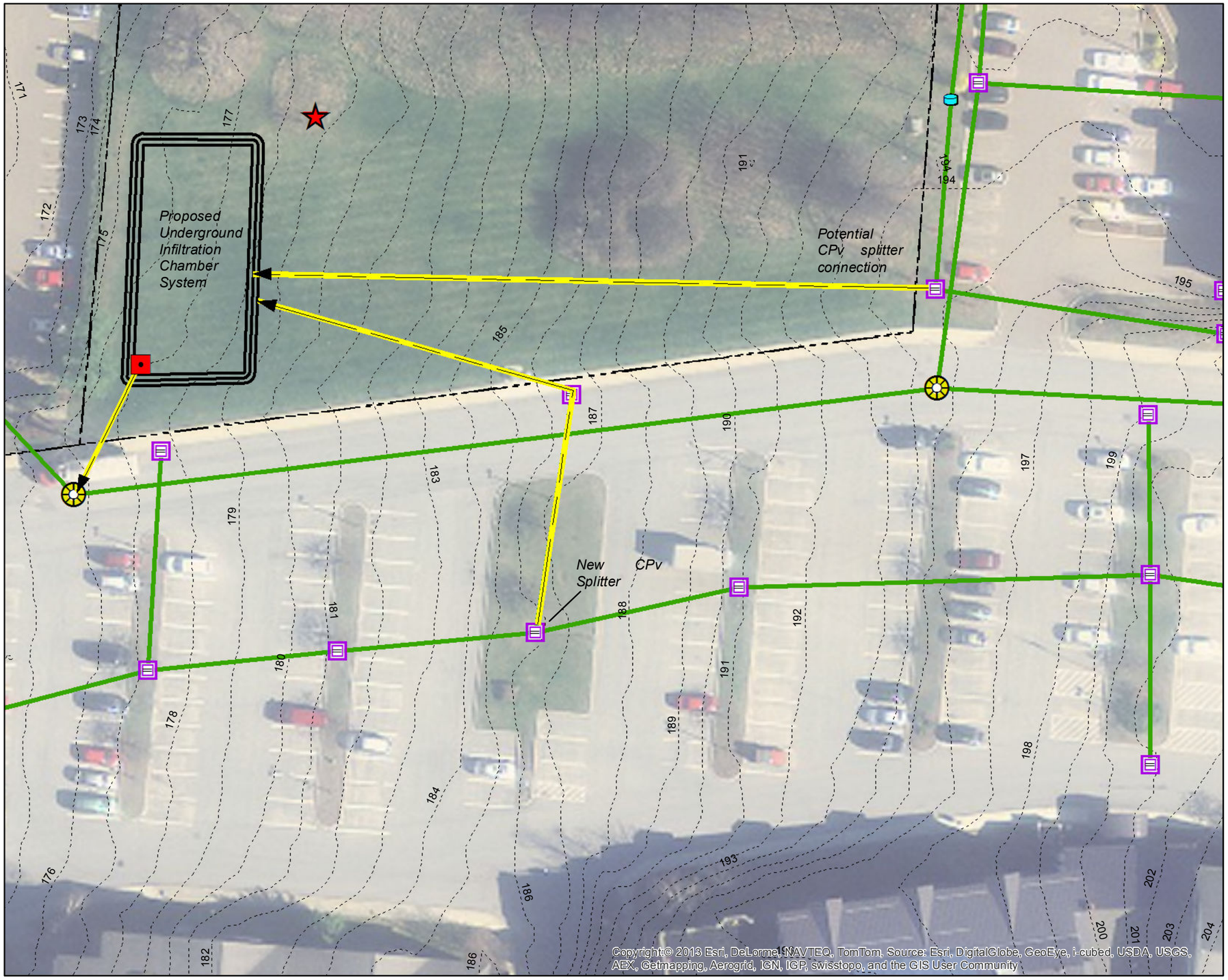
- Credit3
- Credit1
- Credit2
- base-r
- base
- post 2002
- bartlett_watershed_101414

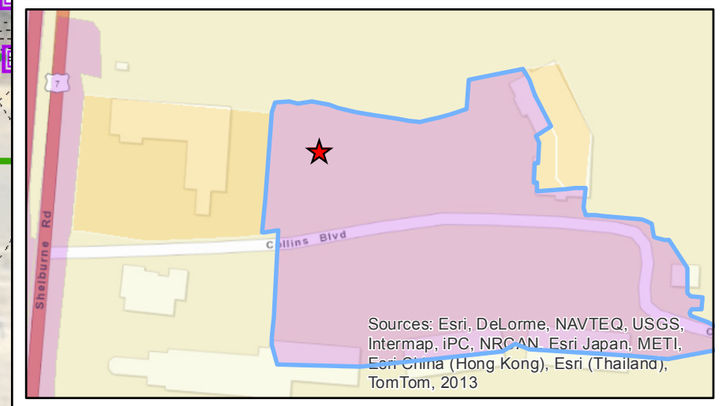
WATERSHED CONSULTING ASSOCIATES, LLC

0 40 80 160 Feet

N S

BARTLETT BROOK FLOW RESTORATION STUDY **SOUTH BURLINGTON, VERMONT**		
Allen Rd Detention Basin		
DATE: 12-12-14	**DRAWN BY:JS**	**SCALE:NOTED**





LEGEND

- PROPOSED RETROFIT SITE
- PROPOSED OUTLET
- PROPOSED STORMLINE
- PROPERTY LINE
- CITY BOUNDARY
- EXISTING 1' CONTOUR

BMP DRAINAGE AREA

- Credit3
- Credit1
- Credit2
- base-r
- base
- post 2002
- bartlett_watershed_101414

NOTES:

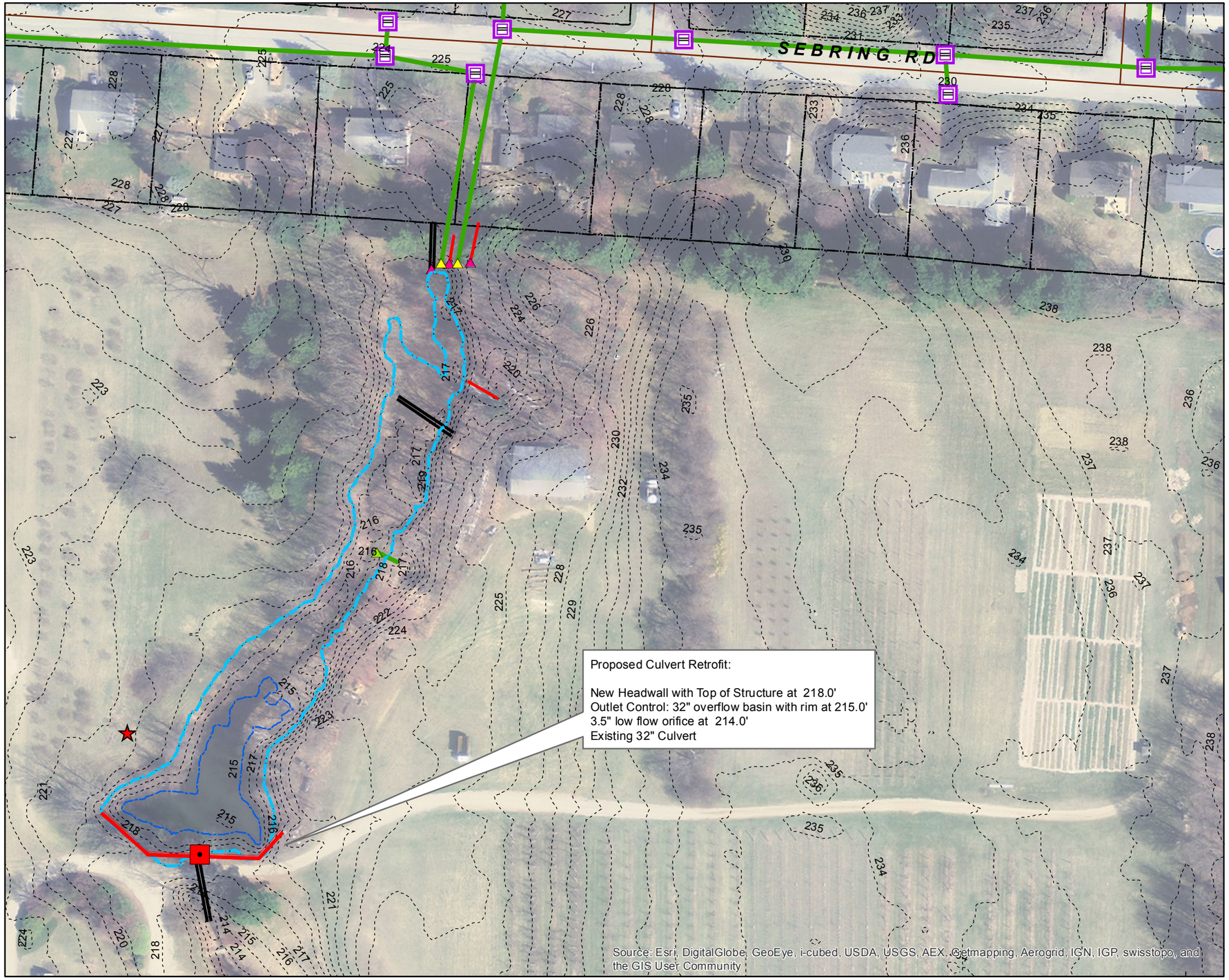
The proposed Holiday Inn Project includes an underground infiltration chamber to mitigate the 1-year storm (CPv) runoff from the Holiday Inn Parking lot. An additional CPv connection is proposed to connect the upper Staybridge runoff to the chamber system. Future design of this project should be completed in conjunction with development plans for 1690 Shelburne Rd.

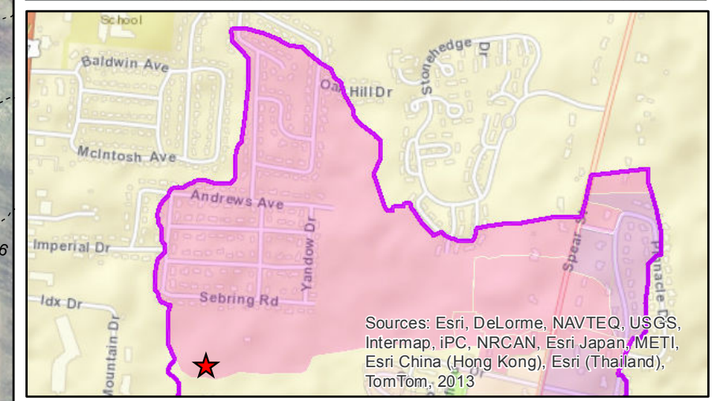
WATERSHED CONSULTING ASSOCIATES, LLC

0 40 80 160 Feet

N S

BARTLETT BROOK FLOW RESTORATION STUDY ***SOUTH BURLINGTON, VERMONT***		
Holiday Inn Lot Stormwater Improvement Plan		
DATE: 12-15-14	***DRAWN BY:JS***	***SCALE:NOTED***





LEGEND

- PROPOSED RETROFIT SITE
- PROPOSED OUTLET
- PROPOSED HEADWALL
- 1-yr (CPv) storage
- 100-yr storage
- PROPERTY LINE
- EXISTING 1' CONTOUR
- CITY BOUNDARY
- Roads

BMP DRAINAGE AREA

- Credit3
- Credit1
- Credit2
- base-r
- base
- post 2002
- bartlett_watershed_101414

NOTES:

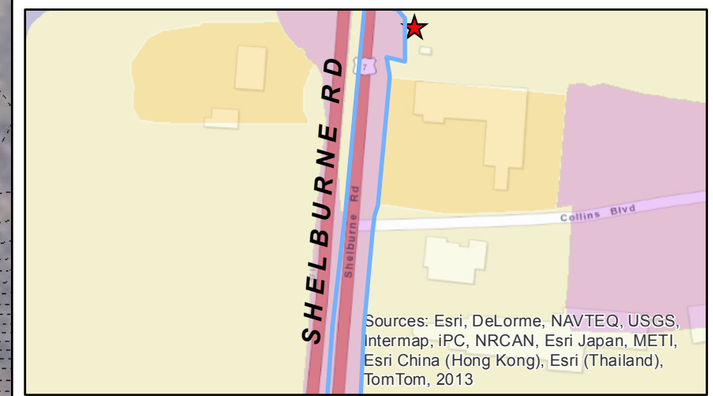
The Laurel Hill Culvert project involves a retrofit of the existing 32" culvert to provide additional storage. Proposed changes include addition of a new concrete headwall and outlet basin with a low-flow orifice and overflow for Channel Protection volume (CPv) storage.

WATERSHED CONSULTING ASSOCIATES, LLC

0 40 80 160 240 320 Feet

N S

BARTLETT BROOK FLOW RESTORATION STUDY ***SOUTH BURLINGTON, VERMONT***		
Laurel Hill Development Culvert Retrofit		
DATE: 12-12-14	***DRAWN BY:JS***	***SCALE:NOTED***



LEGEND

- PROPOSED RETROFIT SITE
- PROPOSED STORM MANHOLE
- PROPOSED OUTLET
- PROPOSED STORMLINE
- Proposed Underground Detention Chamber
- PROPERTY LINE
- EXISTING 1' CONTOUR
- CITY BOUNDARY
- Roads

BMP DRAINAGE AREA

- Credit3
- Credit1
- Credit2
- base-r
- base
- post 2002
- bartlett_watershed_101414

NOTES:

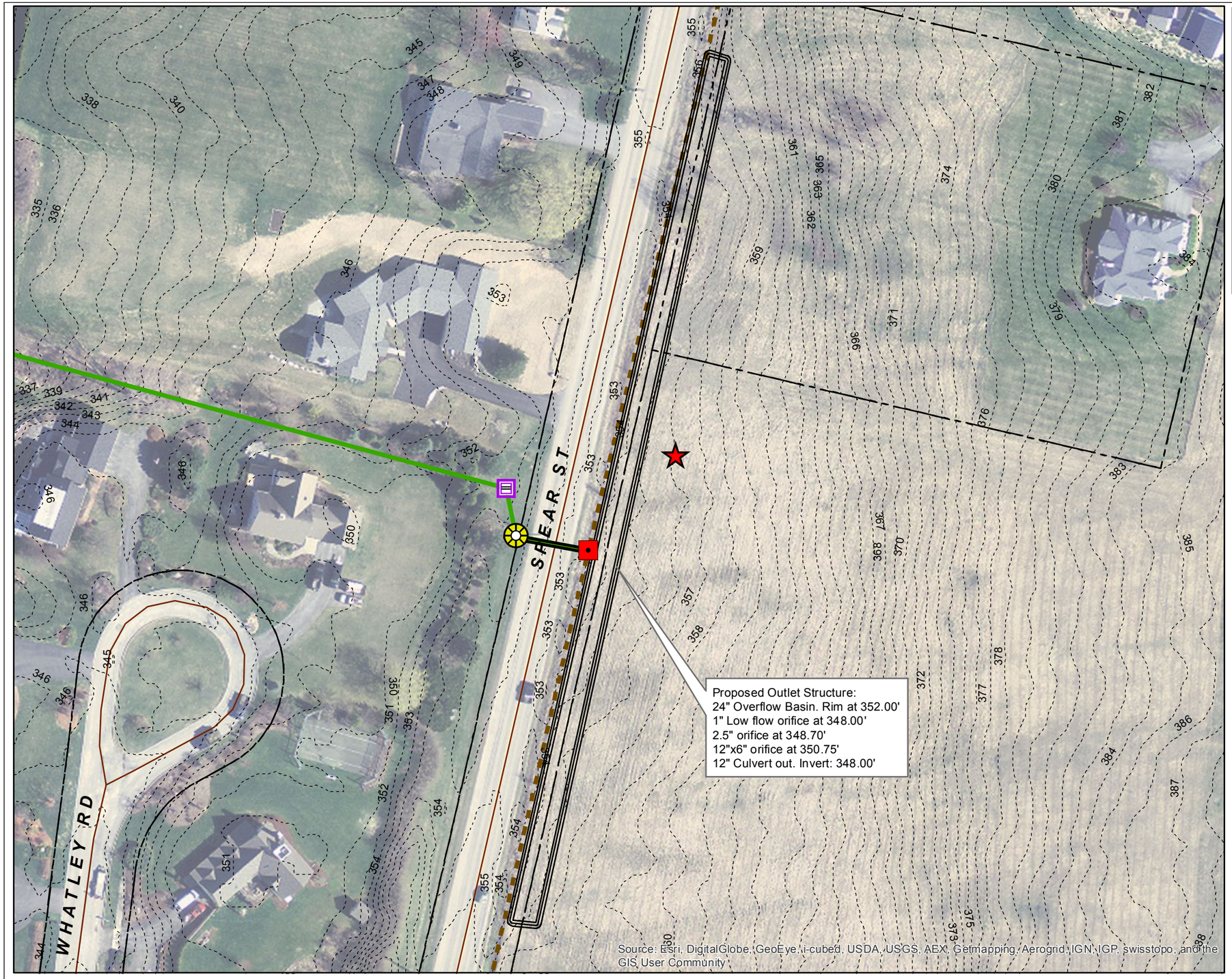
The proposed Shelburne Rd/Route 7 BMP involves an underground detention chamber to mitigate the 1-year storm (CPv) volume. The existing outfall would be reset.

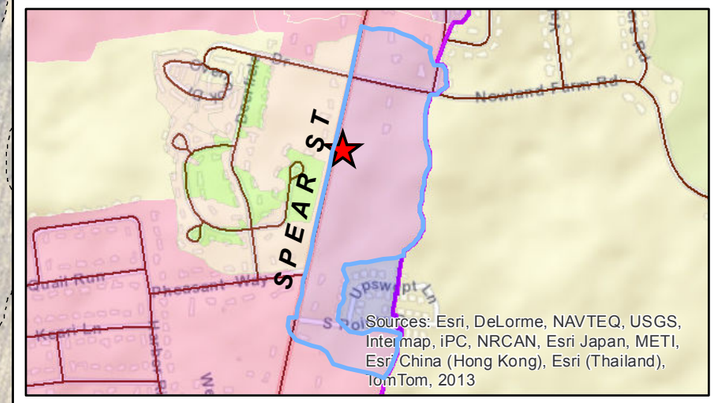
WATERSHED CONSULTING ASSOCIATES, LLC

0 40 80 Feet

N S

BARTLETT BROOK FLOW RESTORATION STUDY ***SOUTH BURLINGTON, VERMONT***		
Shelburne Rd Detention Chamber BMP		
DATE: 12-12-14	***DRAWN BY:JS***	***SCALE:NOTED***





LEGEND

- PROPOSED RETROFIT SITE
- PROPOSED OUTLET
- FINISH GRADE 2' CONTOUR
- PROPERTY LINE
- EXISTING 1' CONTOUR
- CITY BOUNDARY
- Roads

BMP DRAINAGE AREA

- Credit3
- Credit1
- Credit2
- base-r
- base
- post 2002
- bartlett_watershed_101414

NOTES:

The Spear St. Stormwater BMP project is currently being designed to final engineering by Stantec under a contract with the City of South Burlington. The BMP presented in this plan is a conceptual design included in the Flow Restoration Plan (FRP) Analysis to provide Channel Protection volume (CPv) storage.

WATERSHED CONSULTING ASSOCIATES, LLC

0 40 80 160 240 320 Feet

N S

BARTLETT BROOK FLOW RESTORATION STUDY ***SOUTH BURLINGTON, VERMONT***		
Spear St. CPv Detention Basin		
DATE: 12-12-14	***DRAWN BY:JS***	***SCALE:NOTED***

APPENDIX 3

TABLE A-3-1: BMPDSS MODELING SUMMARY

TABLE A-3-2: BMP TABLE

Bartlett Brook Flow Restoration Plan (FRP) Project
Task 4: BMPDSS Model Summary
December 30th, 2014

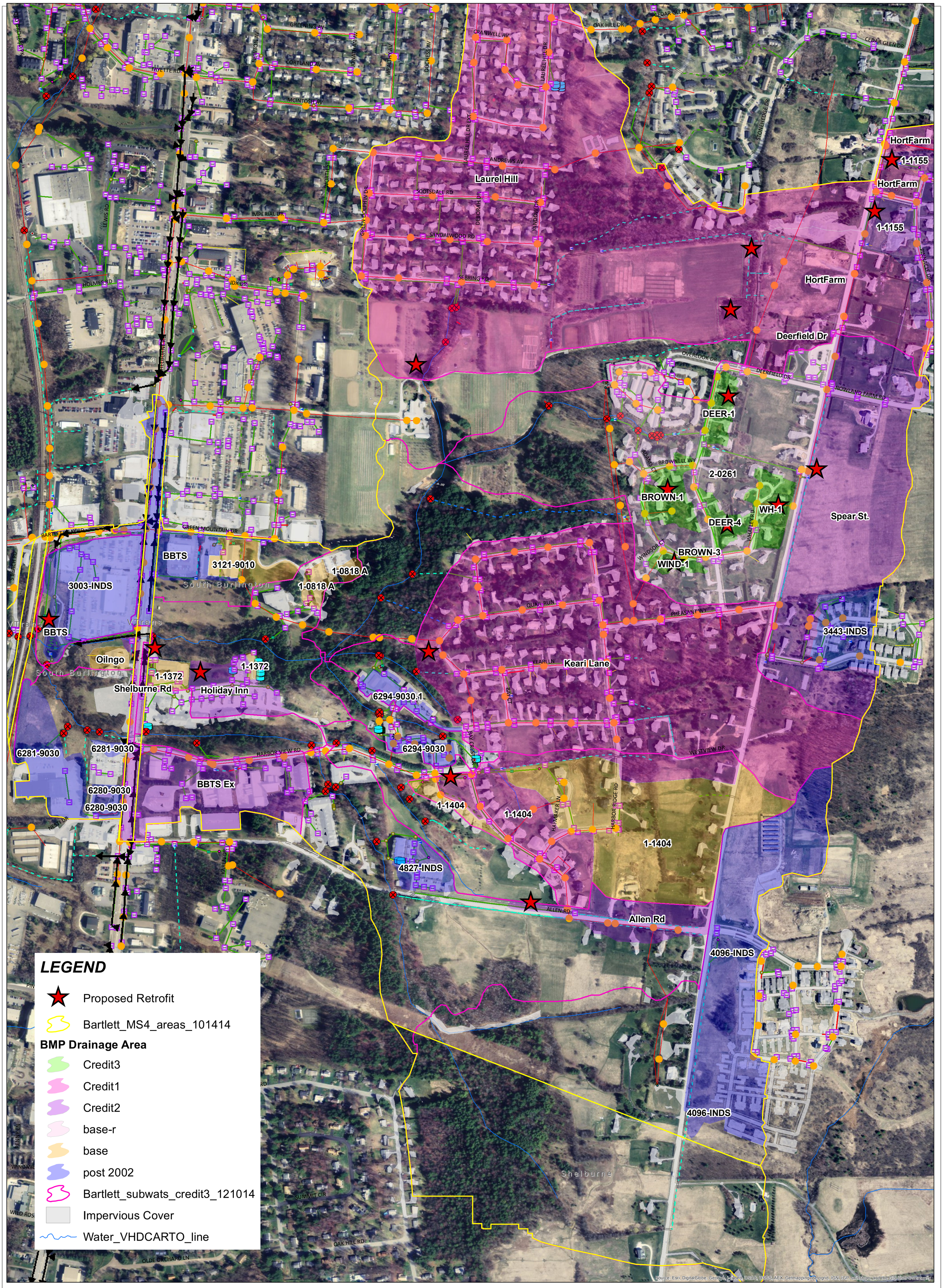
Model Run	Description	High Flow **Reduction** (%)	Low Flow **Increase** (%)	BMPDSS Model Run Date
TMDL Targets with 50 acres of Non-Jurisdictional Future Growth		-33.20	13.20	----
TMDL Modified Targets with 5.7 acres of Non-Jurisdictional Future Growth		-11.60	9.30	----
DEC Existing Condition Model	DEC's existing model, includes all Post2002 BMPs	-1.71	0.00	1/31/2014
WCA Revised Existing Condition Model	Revised subwatersheds and BMPs	-2.84	-4.35	5/16/2014
WCA Revised Existing Condition Model	Revised subwatersheds and BMPs	-2.25	-4.35	9/9/2014
WCA Revised Existing Condition Model	Added #1-0818 BMPs	-2.37	-4.35	11/14/2014
WCA Revised Existing Condition Model	Base model change to 2-0261a and drainage area.	-2.54	-4.35	12/9/2014
Percent of Original Target Managed (w/ Existing 12/9/14 model)		**8%**	**0%**	----
Percent of Modified Target Managed (w/ Existing 12/9/14 model)		**22%**	**0%**	----
Credit1 Model	Initial Proposed BMP scenario	-16.15	0.00	9/10/2014
Percent of Original Target Managed (with Credit1 run)		**49%**	**0%**	----
Percent of Modified Target Managed (with Credit1 run)		**139%**	**0%**	----
Credit2 Model	Additional BMPs added to Credit1 model scenario	-21.71	4.35	11/14/2014
Percent of Original Target Managed (with Credit2 run)		**65%**	**33%**	----
Percent of ModifiedTarget Managed (with Credit2 run)		**187%**	**47%**	----
Credit3_GSI Model (Proposed FRP Scenario)	Proposed FRP Scenario (Add GSI Planters to Credit2 model scenario)	-22.56	4.35	12/9/2014
Percent of Original Target Managed (with Credit3_GSI run)		**68%**	**33%**	----
Percent of ModifiedTarget Managed (with Credit3_GSI run)		**194%**	**47%**	----
Credit 3 Model	Add 4 additional BMPs to account for TMDL Future Growth of 50 acres	-28.71	8.70	12/11/2014
Percent of Original Target Managed (with Credit3 run)		**86%**	**66%**	----
Percent of ModifiedTarget Managed (with Credit3 run)		**248%**	**94%**	----

Table A-3-2: BMP List Sorted by BMPDSS Model Run

ID	Proposed BMP ID	MS4	Ownership where BMP is located	BMP Type	Permit #	Model Scenario BMP was first added
2	Keari Lane	South Burlington	City of S. Burlington	Infiltration Gallery	Expired #1-0202 and 2-0120	Credit1
3	Horticulture Farm Basin	UVM	UVM	Bioretention	1-1155 Pond A and B Drainage	Credit1
4	Deerfield Dr. Dug Pond	UVM	UVM	Detention	1-1155 Pond A and B Drainage	Credit1
6	Laurel Hill Development	UVM	UVM	Culvert Retrofit	NP	Credit1
16	1-1404b Irish Farm Condos Pond B,C	South Burlington	HOA	Pond Upgrade	1-1404 Pond B Upgrade	Credit1
1	BBTS Combined	South Burlington/VTRANS	Private Owner	BBTS Wetland	5625-9010,. 2-0180, 2-0153	Credit2
5	Spear St.	South Burlington	Private Owner	Detention Basin	2061	Credit2
7	Holiday Inn Parking Lot	South Burlington	Developer- Pizzagalli	Detention Basin	6297-9030	Credit2
8	Allen Rd.	South Burlington	City ROW	Detention Basin	NP	Credit2
9	1690 Shelburne Rd./ Route 7	South Burlington	VTRANS/ Developer-Pizzagalli	Detention Basin	5625-9010	Credit2
17	1-1155a Pinnacle at spear	South Burlington	Private Owner	Pond Upgrade	1-1155	Credit2
18	1-1155b Pinnacle at spear	South Burlington	Private Owner	Pond Upgrade	1-1155	Credit2
10	Windsor Ct-1	South Burlington	City ROW	ROW Infiltration	2-0261_b	Credit3_GSI
11	Brownell Way-3	South Burlington	City ROW	ROW Planter	2-0261_b	Credit3_GSI
12	Brownell Way 1-2	South Burlington	City ROW	ROW Infiltration	2-0261_b	Credit3_GSI
13	Deerfield Dr. 1-3	South Burlington	City ROW	ROW Infiltration	2-0261_d	Credit3_GSI
14	Deerfield Dr.-4-6	South Burlington	City ROW	ROW Planter	2-0261_d	Credit3_GSI
15	Whatley Rd 1-5	South Burlington	City ROW	ROW Planter	2-0261_d	Credit3_GSI
Additional BMPs in Full Built-out Scenario for Compliance with Original TMDL target (50 acres of Non-Jurisdictional Growth)						
19	1-1220 Allen Rd Community Care	South Burlington	Private	Infiltration Basin	1-1220	Credit3
20	1-0665 Pillsbury Manor	South Burlington	Private	Underground Detention Basin	1-0665	Credit3
21	Overlook Dr.	South Burlington	Private/UVM	Detention Basin	NP	Credit3
22	Option 7 Pond	South Burlington	UVM	Pond	NP	Credit3

APPENDIX 4

MAP OF BEST MANAGEMENT PRACTICES INCLUDED IN THE BARTLETT BROOK FLOW RESTORATION PLAN



0 350 700 1,400 Feet

N S

WATERSHED CONSULTING ASSOCIATES, LLC

BARTLETT BROOK FLOW RESTORATION STUDY

SOUTH BURLINGTON, VERMONT

FRP Scenario Proposed Stormwater BMP Map

DATE: 12-15-14	DRAWN BY: JS	SCALE:NOTED

APPENDIX 5

TABLE A-5-1: BMP RANKING CRITERIA KEY

TABLE A-5-2: SCORING KEY

Table A-5-1: BMP Ranking Criteria Key

Category	ID	Criteria	Technical Description	Description
Cost/Operations	A	Project Cost	The project costs were grouped into categories from >$50,000 to $1,000,000 based on the range of projects proposed. Cost estimates were developed using the latest unit costs from VTrans as well as local experience. More expensive	Project Costs include additional engineering, permitting, and construction. Transportation and utility conflicts, as well as overall constructability is also reflected in the cost.
Project Design Metrics	B	Impervious Acres Managed (ac)	Natural groupings within the range of impervious managed for the proposed projects were identified. More impervious managed receives a higher score.	The more impervious managed by a project, the higher the potential pollutant reduction. Additionally, the goal of the FRP is to manage existing impervious surfaces.
	C	Channel Protection Volume (CPv) Mitigated, (i.e.. 1-year Storm)	Groupings within the range of CPv volume storage were identified. The largest grouping receives the highest score. The CPv was estimated in HydroCAD, using local rainfall data.	The Channel Protection Volume (CPv) is the volume of stormwater runoff generated from the 1-year design storm (1.98" in Burlington). A BMP which provides CPv storage was determined to reduce the High-flow (Q0.3%), which is the flow rate exceeded 0.3% of the time (output from the State's BMPDSS model). Mitigating the CPv reduces channel erosion and excessive
	D	Volume Infiltrated (ac-ft)	Natural groupings within the range of volumes infiltrated for the BMPs were identified to which relative points were be assigned. The largest volume infiltrated was assigned the highest score. Volumes were calculated in HydroCAD.	The Volume Infiltrated indicates the amount of stormwater runoff that is infiltrated into the groundwater, and provides baseflow for the stream. The TMDL flow targets include a low-flow target, which is addressed by an infiltration-based BMP.
Project Implementation	E	Permitabilty	Permitabilty is simplified into two categories to reflect the common scenarios in permitting, as 1) minimal permitting, versus 2) Complex permitting issues. An itemized list of permits was included to inform the ranking, but was not used in the scoring.	Permitabilty is a measure of the expected level of effort to permit the project, based on knowledge that each type of permit takes varying amounts of time. Some common permits include Stormwater Construction, Local Zoning, Act 250 amendments, VTRANS ROW, etc.
	F	Land Availability	Public land is preferred, followed by regulated private land, and private land where the owners are known to be open to participate. Private land, in which participation of the owner is unknown is lower priority.	Land availability is critical for BMPs requiring open space for detention and access for the City. Properties owned by the City are ranked the highest, followed by privately owned land that has an expired permit, which provides leverage for owner participation.
Other Project Benefits	G	Flood Mitigation	Flood mitigation is categorized by the scale of the impact.	Flood mitigation is categorized by the scale of the impact. A neighborhood flooding issue is weighed more heavily than a localized drainage issue.
	H	TMDL Flow Target Addressed (Q03, Q95)	More weight is on BMPs that address both TMDL targets- the high-flow (Q0.3%) and low-flow targets (Q95%). The high-flow target is addressed by detention BMPs which storage the CP volume.	The goal of the FRP is to implement projects which address the TMDL flow targets. The high-flow target is measured as a **reduction** in the stream flow rate exceeded 0.3% of the time, while the low-flow target is an **increase** in the stream flow rate exceeded 95% of the time (baseflow). Projects which address both targets through storage or infiltration of the 1-year design storm are weighted the highest, followed by projects which address just the high-flow. Projects which do not address the full 1-year storm volume are weighted the lowest.
	I	Lake Champlain Phosphorus TMDL	Yes or no whether the proposed practice will provide benefit toward the Lake Champlain Phosphorus TMDL. This will be determined once the TMDL compliance metrics are released.	The Lake Champlain Phosphorus TMDL has been developed in the effort to reduce nutrient loading and consequential toxic algal blooms in Lake Champlain. The TMDL will require stormwater BMPs to meet a certain level of Total Phosphorus reduction. Each BMP will be evaluated against the TMDL compliance metrics, and scored yes or no if the project meets the TMDL standards.
	J	Other Project Benefits/Constraints	This criteria is to account for indirect project benefits like infrastructure improvements (e.g. aging culvert replacement, wetlands enhancement, and if it addresses an expired permit), or potential constraints (e.g. utility issues encountered during construction).	This criteria is to account for indirect project benefits like infrastructure improvements, community benefits, habitat creation, etc., as well as things that might constrain the project such as the potential of encountering utilities during construction.

Table A-5-2: Scoring Key

Category	ID	Criteria	Quality	Score
Cost/Operations	A	Relative Project Cost	$1.00 - $24,999	4
			$25,000 - $49,999	3
			$49,999 - $99,999	2
			$100,000 - $199,999	1
			$200,000 - $499,999	0
			$500,000 +	-1
Project Design Metrics	B	Impervious Acres Managed (ac)	>10 acres	6
			>5-10 acres	5
			>4-5 acres	4
			>2-4 acres	3
			>1-2 acres	2
			< 1 acre	1
			0 acres	0
	C	Channel Protection Volume (CPv) Mitigated, (ie. 1-year Storm)	0.6-1.0 ac-ft	5
			0.4-0.6 ac-ft	4
			0.2-0.4 ac-ft	3
			0.05-0.2 ac-ft	2
			>0-0.05 ac-ft	1
			0 ac-ft	0
	D	Volume Infiltrated (ac-ft)	>2 ac-ft	5
			1 - 2 ac-ft	4
			0.5-1 ac-ft	3
			0.1- 0.5 ac-ft	2
			>0.01 - 0.1 ac-ft	1
			no infiltration	0
Project Implementation	E	Permitabilty	Minimal Issues/Concerns or no permits	2
			Complex issues/Potential permit denial	0
	F	Land Availability	MS4 owned	4
			Non MS4 owned regulated (expire permit)	3
			Non MS4 owned/Participatory Owner	2
			Unknown	0
			Not MS4 owned/Non participatory owner	-2
Other Project Benefits	G	Flood Mitigation (Is existing flooding issue mitigated by project?)	Neighborhood Wide Flooding Issue	3
			Infrastructure damage (e.g. Wet Basement)	2
			Nuisance Issue (ie. ponding, puddles, etc).	1
			None	0
	H	TMDL Flow Target Addressed (Q03, Q95)	High and Low Flow Targets	3
			High Flow Target	2
			No target addressed in BMPDSS (just WQ treatment)	1
	I	Lake Champlain Phosphorus TMDL	Addressed TMDL	1
			Does not address TMDL	0
	J	Other Project Benefits	Infrastructure Improvement (e.g. Culvert Replacement)	1
			Educational/Functional Benefit	1
			Recreational Benefit	1
			Natural Habitat Creation/Protection	1
			Outfall Erosion Control	1
			Utility Issues/Uncertainty	-1

APPENDIX 6

BARTLETT BROOK WATERSHED BMP
DESIGN AND CONSTRUCTION SCHEDULE

Bartlett Brook Flow Restoration Plan
Bartlett Brook Watershed BMP Project Implementation Schedule

Project ID	Project Name	Expired Permit	MS4	BMP Type	BMP Description	Implementation Year	Project Cost (Rounded to Nearest $1,000)	Project Cost with Inflation (Rounded to Nearest $1,000)
BB0003	Bartlett Brook Central Stormwater Improvement Project (BBCSIP)	1-0202; 2-0120	South Burlington	IG/ GW	Infilatration Gallery/Gravel Wetland at confluence of two large outfalls. Outfalls curently have significant erosion issues. Land acquisition is not required for the project.	2017	$ 1,000,000	$ 1,093,000
BB0014	Pinnacle at Spear Pond A	1-1155	South Burlington	DP	The outlet structure on Pond a (North lot) is proposed for retrofit, including the removal of the existing 12" culvert, replaced with a 3" low-flow orifice.	2018	$ 20,000	$ 23,000
BB0015	Pinnacle at Spear Pond B	1-1155	South Burlington	DP	The outlet structure on Pond b (along Spear St) is proposed for retrofit including the addition of two low-flow orifices, 1" at 371' and a 2" at 373.5'. The retrofits will provide 0.139 ac-ft of CPv storage.	2018	$ 27,000	$ 30,000
BB0004	BBSTS Expansion	2-0180; 2-0153; 1-0734	South Burlington	DP	The proposed expansion of the BBTS system would be to route additional area to system via a new stormline connection on Route 7 from a portion of Route 7 and Harborview Dr. The expansion would involve adding a new forebay for the additional connection in front of the Oil N Go property, as well as expanding the southeast portion of the wetland. The existing access road would also be repositioned.	2020	$ 378,000	$ 438,000
BB0010	Horticulture Farm Bioretention	No Permit	UVM	Bio	The proposed site was identified as an excellent candidate to improve the overall aesthetics of the walking path, while also providing significant stormwater management. The project would involve a retrofit of the swale into a 0.81 ac-ft bioretention basin. A berm in the center of the basin would provide an extended flow path to improve water quality treatment.	2020	$ 268,000	$ 320,000
BB0011	Horticulture Farm Detention Pond	1-1155	UVM	DP	BMP is located on the UVM Horticulture Farm property, for which irrigation is an everpresent need. The 10-year storm (Qp10) overflow from the Horticulture Farm basin would be routed to the dug pond, providing a store of usable water on-site and Qp10 control for the basin.	2020	$ 185,000	$ 221,000
BB0007	Deerfield Drive 1	2-0261	South Burlington	IB	System of Infiltration Trenches in ROW.	2021	$ 141,000	$ 173,000
BB0012	Irish Farm Condos Pond B	1-1404	South Burlington	GW	Upgrade existing pond to gravel wetland STP, with more storage. Route additional 5.47 acres to Pond B.	2021	$ 247,000	$ 304,000
BB0017	Whatley Road	2-0261	South Burlington	Bio	System of Filter strips with storage in ROW.	2021	$ 189,000	$ 232,000
BB0005	Brownell Way	2-0261	South Burlington	IB	System of Infiltration Trenches in ROW.	2021	$ 91,000	$ 112,000
BB0018	Windsor Court	2-0261	South Burlington	IB	System of Infiltration Trenches in ROW.	2021	$ 27,000	$ 33,000
BB0008	Deerfield Drive 2	2-0261	South Burlington	Bio	System of Filter strips with storage in ROW.	2021	$ 116,000	$ 143,000
BB0006	Brownell Way-3	2-0261	South Burlington	Bio	System of Filter strips with storage in ROW.	2021	$ 25,000	$ 31,000

BB0009	Holiday Inn Parking Lot	6297-9030	South Burlington	UD	Opportunity for an underground infiltration gallery in the open space to mitigate runoff from the Holiday Inn Parking lot. Also potential to route drainage from Staybridge Hotel, which is currently routed to a detention pond not meeting the VT CPv standard. Option to provide an offset project for new development.	2023	$ 189,000	$ 247,000
BB0013	Laurel Hill Detention Pond at Horticulture Farm	No Permit	South Burlington	DP	An existing 32” culvert, located on the UVM horticulture farm property, just South of the Laurel Hill Neighborhood was identified as an opportunity for retrofit to provide more storage. The proposed retrofit would involve installing a headwall at the culvert and outlet control structure to increase the CPv storage capacity while still safely passing the larger storm events.	2024	$ 167,000	$ 224,000
BB0016	Underwood Stormwater Pond	No Permit	South Burlington	DP	The confluence of the existing stormline along Spear St, just South of Nowland Farm Rd. has been the source of flooding during large storm events. The proposed project would involve a retrofit of the existing roadside swale into a detention basin, designed to provide CPv (1-year) for a 44.3 acre area in the upper Bartlett Brook watershed.	2025	$ 222,000	$ 307,000
BB0001	1690 Shelburne Road	No Permit	VTrans	UD	Detain unmanaged portion of Route 7 in underground detention chamber.	2028	$ 199,000	$ 231,000
BB0002	Allen Road	Offset Permit	South Burlington	DP	The Allen Rd detention basin was designed as a retrofit of an existing swale in the ROW. The basin would mitigate runoff from a 6.38 acres drainage area, providing 0.07 ac-ft of volume storage. The site would require a new culvert under the roadway in order to route additional runoff to the swale.	2028	$ 69,000	$ 104,000

APPENDIX 7

ITEMIZED COST ESTIMATES

CITY OF SOUTH BURLINGTON
BARTLETT BROOK FRP

Bartlett Bay Treatment System Opinion of Probable Construction Cost (30% Design)
As of December 4, 2014

Item #		Vtrans Item	RS Means Item	Description	Estimated Quantity	Unit	Unit Cost	Total Cost (ENR 9900)[1]	Total Cost (ENR 10000)[2]
I. CONSTRUCTION COST									
1		204.20		Trench Excavation of Earth	1,560	CY	$ 12.00	$ 18,696.00	$ 18,884.85
2		204.22		Trench Excavation of Earth, Exploratory	100	CY	$ 65.00	$ 6,500.00	$ 6,565.66
3		204.25		Structure Excavation	90	CY	$ 20.00	$ 1,800.00	$ 1,818.18
4		204.30		Granular Backfill for Structures	60	CY	$ 34.00	$ 2,040.00	$ 2,060.61
5				Bituminous Pavement	280	SY	$ 74.55	$ 20,277.29	$ 20,482.11
6		601.09		CPEP (18")	1,060	LF	$ 50.00	$ 52,850.00	$ 53,383.84
7		601.09		CPEP (15")	170	LF	$ 47.00	$ 7,990.00	$ 8,070.71
8				3/4" Crushed Stone for Pipe	330	CY	$ 30.00	$ 9,900.00	$ 10,000.00
9		604.2		Precast Reinforced Concrete Catch Basin with Frame and Grate	35	VF	$ 340.00	$ 10,880.00	$ 10,989.90
10				Retrofit Existing Catch Basin	2	EA	$ 265.00	$ 530.00	$ 535.35
11		635.11		Mobilization/Demobilization	1	LS	$ 18,000.00	$ 18,000.00	$ 18,181.82
12		649.51		Geotextile for Silt Fence	400	SY	$ 5.00	$ 2,000.00	$ 2,020.20
13		651.15		Seed	10	LB	$ 10.00	$ 100.00	$ 101.01
14		651.28		Hydraulic Mulch	50	Gal	$ 12.00	$ 600.00	$ 606.06
15		651.35		Topsoil	500	CY	$ 40.00	$ 20,000.00	$ 20,202.02
16		652.10		Erosion Prevention Sediment Control Plan	1	LS	$ 1,500.00	$ 1,500.00	$ 1,515.15
17		652.20		Monitoring Erosion Prevention Sediment Control Plan	40	HR	$ 60.00	$ 2,400.00	$ 2,424.24
18		652.30		Maintenance of EPSCP	1	LS	$ 3,500.00	$ 3,500.00	$ 3,535.35
19		653.35		Vehicle Tracking Pad	150	CY	$ 42.00	$ 6,300.00	$ 6,363.64
20		653.55		Project Demarcation Fence	2,000	LF	$ 2.00	$ 4,000.00	$ 4,040.40
21				Forebay (All Inclusive)	1	LS	$ 28,676.00	$ 28,676.00	$ 28,965.66
22				Swale (All Inclusive)	380	LF	$ 11.96	$ 4,545.00	$ 4,590.91
23				Basin Expansion (All Inclusive)	1	LS	$ 31,400.33	$ 31,400.33	$ 31,717.51
24				Bonds (2.0%)	1	LS	$ 5,089.69	$ 5,089.69	$ 5,141.10
								SUBTOTAL CONSTRUCTION:	$ 262,196.28
								USE:	$ 270,000.00
II. CONSTRUCTION CONTINGENCY									
1				Construction Contingency (15%)	1		$ 40,500.00		$ 40,500.00
								SUBTOTAL CONSTRUCTION CONTINGENCY:	$ 40,500.00
III. FINAL DESIGN ENGINEERING[3]									
1				Final Design and Permitting (excluding geotechnical)	1		$ 20,580.00		$ 20,580.00
2				Geotechnical	0		$ 2,700.00		$ -
								SUBTOTAL FINAL DESIGN ENGINEERING:	$ 20,580.00
IV. CONSTRUCTION PHASE ENGINEERING[3]									
1				Construction Phase Engineering	1		$ 37,730.00		$ 37,730.00
								SUBTOTAL CONSTRUCTION PHASE ENGINEERING:	$ 37,730.00
V. OTHER COSTS									
1				Administrative	1		$ 1,350.00		$ 1,350.00
2				Easement Assistance	1		$ 4,050.00		$ 4,050.00
3				Land Acquisition		Acre	$ 120,000.00		$ -
4				Legal	1		$ 4,050.00		$ 4,050.00
5				Bond Vote Assistance			$ 1,350.000		$ -
6				Short Term Interest	0		$ 6,750.000		$ -
								SUBTOTAL OTHER COSTS:	$ 9,450.00
								TOTAL PROJECT COST:	**$ 378,260.00**
								USE:	**$ 380,000.00**

Notes:
1. ENR 9900 = November 2014
2. ENR 10,000 = June 2015
3. Engineering costs for Final Design and Construction are based on the VT DEC Facilities Engineering Fee Curve Allowance

CITY OF SOUTH BURLINGTON
BARTLETT BROOK FRP

Keari Lane Opinion of Probable Construction Cost (30% Design)
As of November 3, 2014

Item #		Vtrans Item	RS Means Item	Description	Estimated Quantity	Unit	Unit Cost	Total Cost (ENR 9900)[1]	Total Cost (ENR 10000)[2]
I. CONSTRUCTION COST									
1		204.20		Trench Excavation of Earth	420	CY	$ 12.00	$ 5,016.00	$ 5,066.67
2		204.22		Trench Excavation of Earth, Exploratory	100	CY	$ 65.00	$ 6,500.00	$ 6,565.66
3		204.25		Structure Excavation	90	CY	$ 20.00	$ 1,640.00	$ 1,656.57
4		204.30		Granular Backfill for Structures	40	CY	$ 34.00	$ 1,258.00	$ 1,270.71
5				Bituminous Pavement	1,330	SY	$ 74.55	$ 99,150.00	$ 100,151.52
6		601.09		CPEP (24")	1,200	LF	$ 52.00	$ 62,244.00	$ 62,872.73
7				3/4" Crushed Stone for Pipe	330	CY	$ 30.00	$ 9,780.00	$ 9,878.79
8		604.21		Precast Reinforced Concrete Catch Basin with Cast Iron Cover	30	VF	$ 340.00	$ 8,160.00	$ 8,242.42
9				Retrofit Existing Catch Basin	2	EA	$ 265.00	$ 530.00	$ 535.35
10		635.11		Mobilization/Demobilization	10	LS	$ 25,000.00	$ 25,000.00	$ 25,252.53
11		649.51		Geotextile for Silt Fence	100	SY	$ 5.00	$ 500.00	$ 505.05
12		651.15		Seed	10	LB	$ 10.00	$ 100.00	$ 101.01
13		651.28		Hydraulic Mulch	50	Gal	$ 12.00	$ 600.00	$ 606.06
14		651.35		Topsoil	500	CY	$ 40.00	$ 20,000.00	$ 20,202.02
15		652.10		Erosion Prevention Sediment Control Plan	1	LS	$ 1,500.00	$ 1,500.00	$ 1,515.15
16		652.20		Monitoring Erosion Prevention Sediment Control Plan	60	HR	$ 60.00	$ 3,600.00	$ 3,636.36
17		652.30		Maintenance of EPSCP	1	LS	$ 4,000.00	$ 4,000.00	$ 4,040.40
18		653.20		Temporary Erosion Matting	1,000	SY	$ 7.50	$ 7,500.00	$ 7,575.76
19		653.35		Vehicle Tracking Pad	20	CY	$ 42.00	$ 630.00	$ 636.36
20		653.55		Project Demarcation Fence	200	LF	$ 2.00	$ 400.00	$ 404.04
21				Pre-treatment Downstream Defender	1	LS	$ 22,249.84	$ 22,249.84	$ 22,474.59
22				Manifold (All Inclusive)	260	LF	$ 67.58	$ 17,029.00	$ 17,201.01
23				StormTech Chambers (All Inclusive)	25,600	CF	$ 11.17	$ 285,776.55	$ 288,663.18
24				Bonds (2.0%)	1	LS	$ 11,663.27	$ 11,663.27	$ 11,781.08
								SUBTOTAL CONSTRUCTION:	$ 600,835.01
								USE:	$ 610,000.00
II. CONSTRUCTION CONTINGENCY									
1				Construction Contingency (15%)	1		$ 91,500.00		$ 91,500.00
								SUBTOTAL CONSTRUCTION CONTINGENCY:	$ 91,500.00
III. FINAL DESIGN ENGINEERING[3]									
1				Final Design and Permitting (excluding geotechnical)	1		$ 44,040.00		$ 44,040.00
2				Geotechnical	1		$ 6,100.00		$ 6,100.00
								SUBTOTAL FINAL DESIGN ENGINEERING:	$ 50,140.00
IV. CONSTRUCTION PHASE ENGINEERING[3]									
1				Construction Phase Engineering	1		$ 80,740.00		$ 80,740.00
								SUBTOTAL CONSTRUCTION PHASE ENGINEERING:	$ 80,740.00
V. OTHER COSTS									
1				Administrative	1		$ 3,050.00		$ 3,050.00
2				Easement Assistance	1		$ 9,150.00		$ 9,150.00
3				Land Acquisition	0	Acre	$ 120,000.00		$ -
4				Legal	1		$ 9,150.00		$ 9,150.00
5				Bond Vote Assistance			$ 3,050.000		$ -
6				Short Term Interest			$ 15,250.000		$ -
								SUBTOTAL OTHER COSTS:	$ 21,350.00
								TOTAL PROJECT COST:	**$ 853,730.00**
								USE:	**$ 860,000.00**

Notes:
1. ENR 9900 = November 2014
2. ENR 10,000 = June 2015
3. Engineering costs for Final Design and Construction are based on the VT DEC Facilities Engineering Fee Curve Allowance

CITY OF SOUTH BURLINGTON
BARTLETT BROOK FRP

Irish Farm Opinion of Probable Construction Cost (30% Design)
As of December 4, 2014

Item #		Vtrans Item	RS Means Item	Description	Estimated Quantity	Unit	Unit Cost	Total Cost (ENR 9900)[1]	Total Cost (ENR 10000)[2]
I. CONSTRUCTION COST									
1				Gravel Wetland (Existing Upper Pond Expansion)	1	LS	$ 71,977.60	$ 71,977.60	$ 72,704.65
2				Lower Pond	1	LS	$ 10,020.00	$ 10,020.00	$ 10,121.21
3		635.11		Mobilization/Demobilization	1	LS	$ 6,000.00	$ 6,000.00	$ 6,060.61
4		652.10		Erosion Prevention Sediment Control Plan	1	LS	$ 1,500.00	$ 1,500.00	$ 1,515.15
5		652.20		Monitoring Erosion Prevention Sediment Control Plan	20	HR	$ 60.00	$ 1,200.00	$ 1,212.12
6		652.30		Maintenance of EPSCP	1	LS	$ 2,500.00	$ 2,500.00	$ 2,525.25
7		653.35		Vehicle Tracking Pad	150	CY	$ 42.00	$ 6,300.00	$ 6,363.64
8		653.55		Project Demarcation Fence	1,000	LF	$ 2.00	$ 2,000.00	$ 2,020.20
9				Bonds (2.0%)	1	LS	$ 2,029.95	$ 2,029.95	$ 2,050.46
								SUBTOTAL CONSTRUCTION:	$ 104,573.29
								USE:	$ 110,000.00
II. CONSTRUCTION CONTINGENCY									
1				Construction Contingency (15%)	1		$ 16,500.00		$ 16,500.00
								SUBTOTAL CONSTRUCTION CONTINGENCY:	$ 16,500.00
III. FINAL DESIGN ENGINEERING[3]									
1				Final Design and Permitting (excluding geotechnical)	1		$ 9,540.00		$ 9,540.00
2				Geotechnical	0		$ 1,100.00		$ -
								SUBTOTAL FINAL DESIGN ENGINEERING:	$ 9,540.00
IV. CONSTRUCTION PHASE ENGINEERING[3]									
1				Construction Phase Engineering	1		$ 17,490.00		$ 17,490.00
								SUBTOTAL CONSTRUCTION PHASE ENGINEERING:	$ 17,490.00
V. OTHER COSTS									
1				Administrative	1		$ 550.00		$ 550.00
2				Easement Assistance	1		$ 1,650.00		$ 1,650.00
3				Land Acquisition	0.75	Acre	$ 120,000.00		$ 90,000.00
4				Legal	1		$ 1,650.00		$ 1,650.00
5				Bond Vote Assistance			$ 550.000		$ -
6				Short Term Interest			$ 2,750.000		$ -
								SUBTOTAL OTHER COSTS:	$ 93,850.00
								TOTAL PROJECT COST:	**$ 247,380.00**
								USE:	**$ 250,000.00**

Notes:
1. ENR 9900 = November 2014
2. ENR 10,000 = June 2015
3. Engineering costs for Final Design and Construction are based on the VT DEC Facilities Engineering Fee Curve Allowance

CITY OF SOUTH BURLINGTON
BARTLETT BROOK FRP

UVM Horticulture Farm Option 1 System Opinion of Probable Construction Cost (30% Design)
As of December 4, 2014

Item #		Vtrans Item	RS Means Item	Description	Estimated Quantity	Unit	Unit Cost	Total Cost (ENR 9900)[1]	Total Cost (ENR 10000)[2]
I. CONSTRUCTION COST									
1				Recreational Path Basin	1	LS	$ 144,574.00	$ 144,574.00	$ 146,034.34
2		635.11		Mobilization/Demobilization	1	LS	$ 12,000.00	$ 12,000.00	$ 12,121.21
3		652.10		Erosion Prevention Sediment Control Plan	1	LS	$ 1,500.00	$ 1,500.00	$ 1,515.15
4		652.20		Monitoring Erosion Prevention Sediment Control Plan	60	HR	$ 60.00	$ 3,600.00	$ 3,636.36
5		652.30		Maintenance of EPSCP	1	LS	$ 2,500.00	$ 2,500.00	$ 2,525.25
6		653.35		Vehicle Tracking Pad	150	CY	$ 42.00	$ 6,300.00	$ 6,363.64
7		649.51		Geotextile for Silt Fence (Double Row)	500	SY	$ 5.00	$ 2,500.00	$ 2,525.25
8		653.55		Project Demarcation Fence	1,000	LF	$ 2.00	$ 2,000.00	$ 2,020.20
9				Bonds (2.0%)	1	LS	$ 3,499.48	$ 3,499.48	$ 3,534.83
								SUBTOTAL CONSTRUCTION:	$ 180,276.24
								USE:	$ 190,000.00
II. CONSTRUCTION CONTINGENCY									
1				Construction Contingency (15%)	1		$ 28,500.00		$ 28,500.00
								SUBTOTAL CONSTRUCTION CONTINGENCY:	$ 28,500.00
III. FINAL DESIGN ENGINEERING[3]									
1				Final Design and Permitting (excluding geotechnical)	1		$ 15,060.00		$ 15,060.00
2				Geotechnical	0		$ 1,900.00		$ -
								SUBTOTAL FINAL DESIGN ENGINEERING:	$ 15,060.00
IV. CONSTRUCTION PHASE ENGINEERING[3]									
1				Construction Phase Engineering	1		$ 27,610.00		$ 27,610.00
								SUBTOTAL CONSTRUCTION PHASE ENGINEERING:	$ 27,610.00
V. OTHER COSTS									
1				Administrative	1		$ 950.00		$ 950.00
2				Easement Assistance	1		$ 2,850.00		$ 2,850.00
3				Land Acquisition	0	Acre	$ 120,000.00		$ -
4				Legal	1		$ 2,850.00		$ 2,850.00
5				Bond Vote Assistance			$ 950.000		$ -
6				Short Term Interest			$ 4,750.000		$ -
								SUBTOTAL OTHER COSTS:	$ 6,650.00
								TOTAL PROJECT COST:	**$ 267,820.00**
								USE:	**$ 270,000.00**

Notes:
1. ENR 9900 = November 2014
2. ENR 10,000 = June 2015
3. Engineering costs for Final Design and Construction are based on the VT DEC Facilities Engineering Fee Curve Allowance

CITY OF SOUTH BURLINGTON
BARTLETT BROOK FRP

Deerfield Dr-UVM Horticulture Farm Option 2 System Opinion of Probable Construction Cost (30% Design)
As of December 4, 2014

Item #		Vtrans Item	RS Means Item	Description	Estimated Quantity	Unit	Unit Cost	Total Cost (ENR 9900)[1]	Total Cost (ENR 10000)[2]
I. CONSTRUCTION COST									
1				Pond Option 2 (Middle Pond)	1	LS	$ 100,299.00	$ 100,299.00	$ 101,312.12
2		635.11		Mobilization/Demobilization	1	LS	$ 7,000.00	$ 7,000.00	$ 7,070.71
3		652.10		Erosion Prevention Sediment Control Plan	1	LS	$ 1,500.00	$ 1,500.00	$ 1,515.15
4		652.20		Monitoring Erosion Prevention Sediment Control Plan	40	HR	$ 60.00	$ 2,400.00	$ 2,424.24
5		652.30		Maintenance of EPSCP	1	LS	$ 2,000.00	$ 2,000.00	$ 2,020.20
6		653.35		Vehicle Tracking Pad	150	CY	$ 42.00	$ 6,300.00	$ 6,363.64
7		653.55		Project Demarcation Fence	500	LF	$ 3.50	$ 1,750.00	$ 1,767.68
8				Bonds (2.0%)	1	LS	$ 2,424.98	$ 2,424.98	$ 2,449.47
								SUBTOTAL CONSTRUCTION:	$ 124,923.21
								USE:	$ 130,000.00
II. CONSTRUCTION CONTINGENCY									
1				Construction Contingency (15%)	1		$ 19,500.00		$ 19,500.00
								SUBTOTAL CONSTRUCTION CONTINGENCY:	$ 19,500.00
III. FINAL DESIGN ENGINEERING[3]									
1				Final Design and Permitting (excluding geotechnical)	1		$ 10,920.00		$ 10,920.00
2				Geotechnical	0		$ 1,300.00		$ -
								SUBTOTAL FINAL DESIGN ENGINEERING:	$ 10,920.00
IV. CONSTRUCTION PHASE ENGINEERING[3]									
1				Construction Phase Engineering	1		$ 20,020.00		$ 20,020.00
								SUBTOTAL CONSTRUCTION PHASE ENGINEERING:	$ 20,020.00
V. OTHER COSTS									
1				Administrative	1		$ 650.00		$ 650.00
2				Easement Assistance	1		$ 1,950.00		$ 1,950.00
3				Land Acquisition	0	Acre	$ 120,000.00		$ -
4				Legal	1		$ 1,950.00		$ 1,950.00
5				Bond Vote Assistance			$ 650.000		$ -
6				Short Term Interest			$ 3,250.000		$ -
								SUBTOTAL OTHER COSTS:	$ 4,550.00
								TOTAL PROJECT COST:	**$ 184,990.00**
								USE:	**$ 190,000.00**

Notes:
1. ENR 9900 = November 2014
2. ENR 10,000 = June 2015
3. Engineering costs for Final Design and Construction are based on the VT DEC Facilities Engineering Fee Curve Allowance

APPENDIX 8

HORSLEY WITTEN GROUP MEMORANDUM
DATED JANUARY 9, 2014

Horsley Witten Group
Sustainable Environmental Solutions
90 Route 6A • Sandwich, MA • 02563
Tel: 508-833-6600 • Fax: 508-833-3150 • www.horsleywitten.com

tce TRUDELL CONSULTING ENGINEERS

MEMORANDUM

DATE: January 9, 2014

TO: Dan Albrecht; Megan Moir; Tom DiPietro; Jennifer Callahan; Bill Nedde, Linda Seavey, and Lani Ravin

FROM: Horsley Witten Group, Inc.

RE: Centennial Brook Watershed: Flow Restoration VTBMPDSS Modeling Analysis and BMP Supporting Information

This memorandum describes the basic approach used to model potential stormwater retrofits for the Centennial Brook Flow Restoration Plan (FRP) using the VT BMPDSS model. Modeling efforts have proven that is it difficult to meet the **63.0%** high flow reduction target required by the Centennial Brook TMDL. In fact, the percent flow reduction achieved under the proposed restoration scenario is **44.2%**. This reduction reflects management of 90% of the watershed impervious cover using all retrofits identified in the field and vetted with the MS4s. Under this scenario, UVM's existing Main St. and North Campus ponds would be modified from their current configuration to improve performance while maintaining 12-hr detention times and storage capacity for future development activities (only the proposed Colchester Ave. watershed expansion is incorporated into the model at this time).

Table 1 summarizes high flow reduction targets established by the TMDL, a revised target based on an analysis of future impervious cover, and the percent reduction achieved under the currently modeled VTBMPDSS restoration scenario. Figures 1-3 show impervious cover and drainage area maps for the proposed restoration scenario, including a zoom in of the proposed Colchester Avenue expansion.

Table 1. Summary of Percent Flow Reductions Achieved

Description		% High Flow Reduction	Managed IA (acres)	Planning Level Cost[5]
TMDL Reduction Targets	TMDL baseline with no agriculture.	49.9	--	--
	TMDL with no agriculture and 40 acres future, unmanaged impervious cover.	63.0	--	--
	TMDL with no agriculture and revised 5 acres of future, unmanaged impervious cover.[1]	51.5[2]	--	--
Current Conditions	All existing BMPs (revised ANR BMPDSS Credit Model)	14.8	106.1[3]	--
Proposed Flow Restoration Scenario	All primary and secondary retrofits; existing UVM facilities meeting 12-hr detention criteria and maintaining future use allocations; Colchester Ave watershed expansion included.[4]	44.2	243.7	$9,740,000

[1] Based on 2013 analysis conducted by CCRPC for Burlington and South Burlington.
[2] 51.5% = 49.9% baseline target + 5/40 acres future IA * 13.1% reduction target associated with future IA
[3] IA managed by post-2002 BMPs, which does not include Main Street and Queensbury ponds (based on most recently available GIS)
[4] One surface detention facility proposed in the VTrans right-of-way is designed to exceed 24-hr detention time.
[5] See cost section for more detail on planning level assumptions and costing analysis.

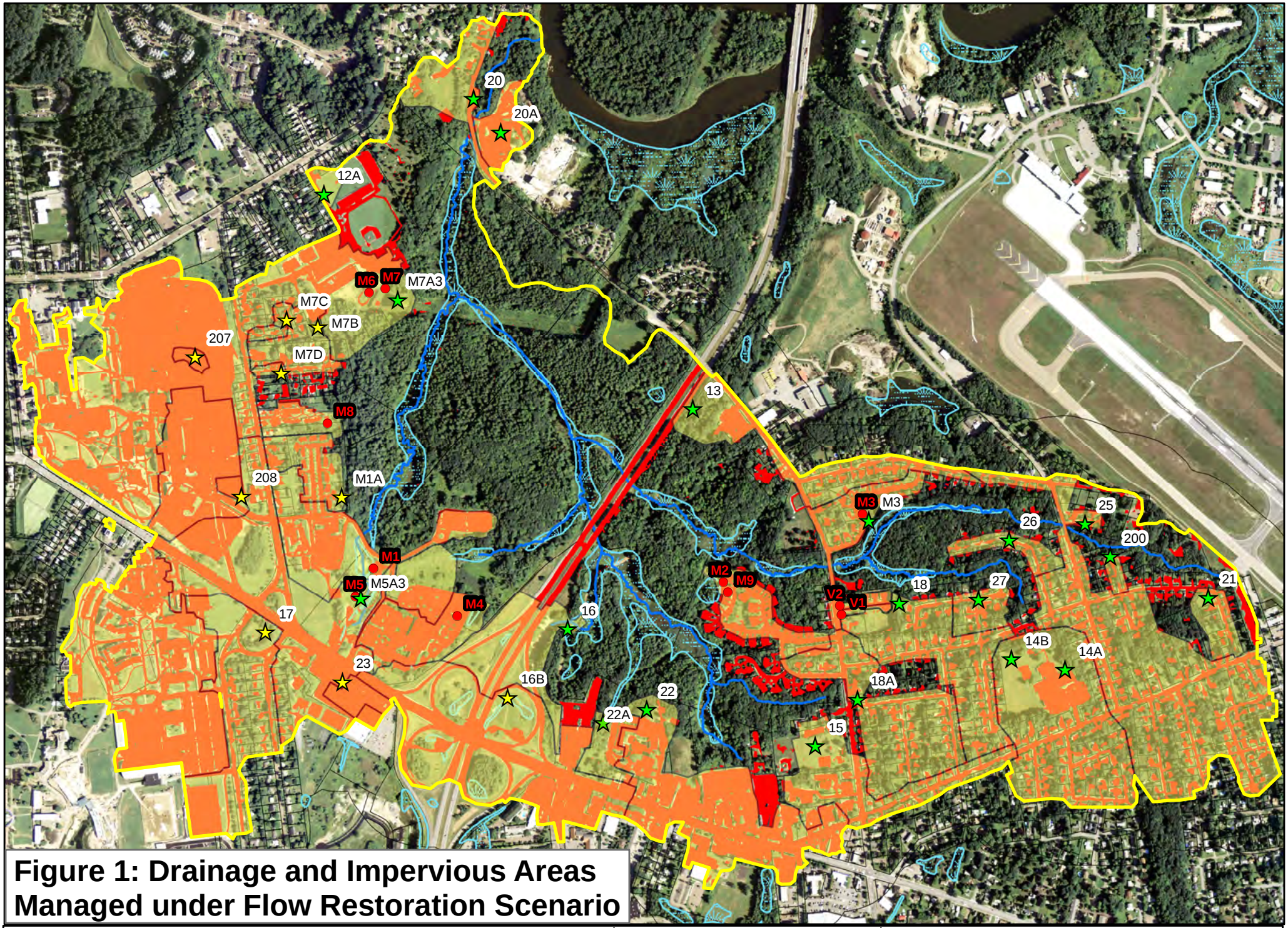


Figure 1: Drainage and Impervious Areas Managed under Flow Restoration Scenario

Legend

- Primary Retrofit
- Secondary Retrofit
- Retrofit DA
- Existing BMP
- stream
- Watershed
- Wetlands_SoBu
- Impervious Cover

N

Feet

1,000

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Horsley Witten Group
Sustainable Environmental Solutions

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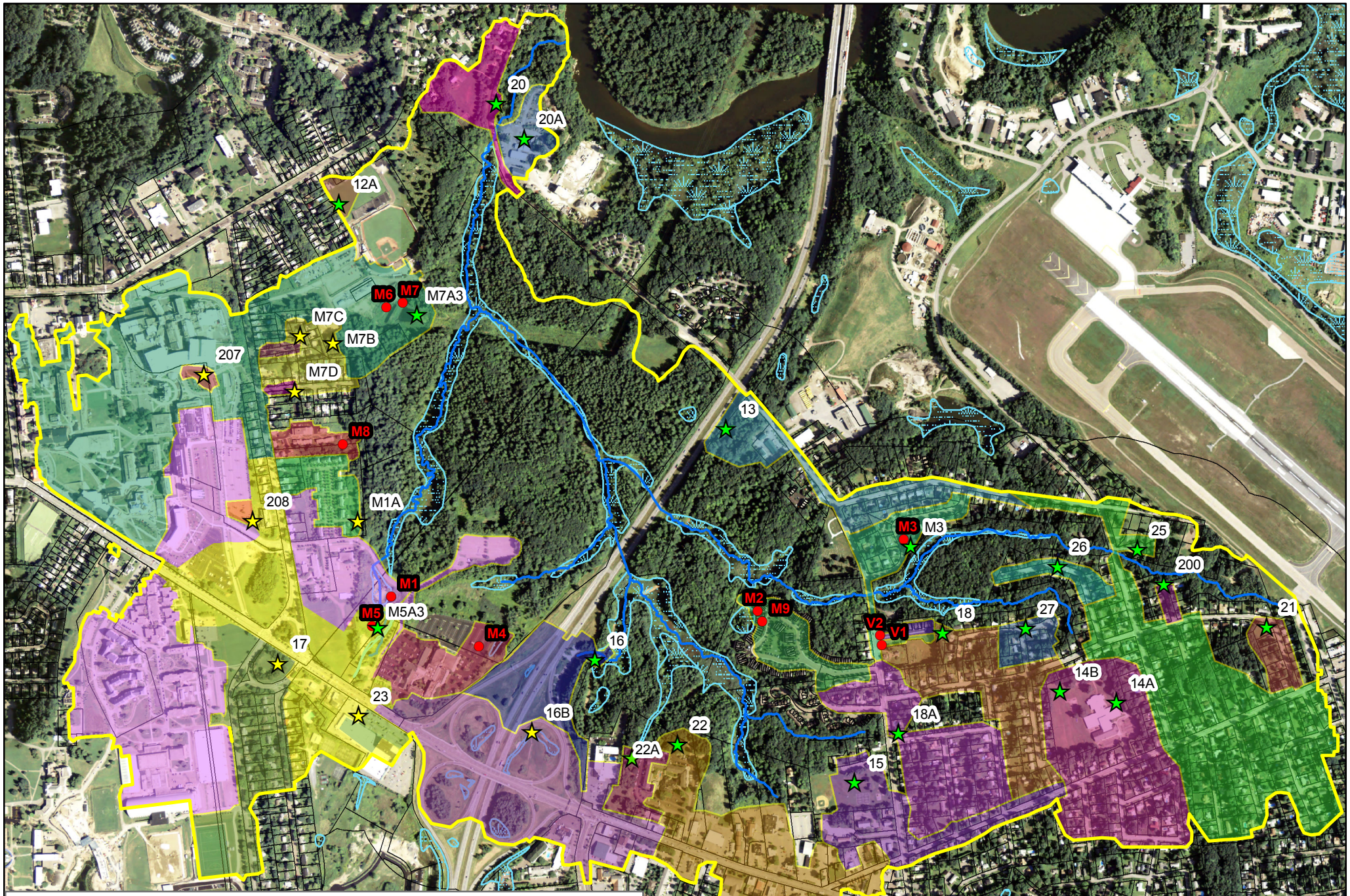

Figure 2: BMP Drainage Areas Managed under Flow Restoration Scenario

Legend

- Primary Retrofit
- Secondary Retrofit
- Retrofit DA
- Existing BMP
- stream
- Watershed
- Wetlands_SoBu
- Parcels

N

Feet

1,000

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Path: H:\Projects\2012\12106 Chittenden County-Centennial Brook WS\GIS\Maps\140108_FlowRestorationPlan.mxd

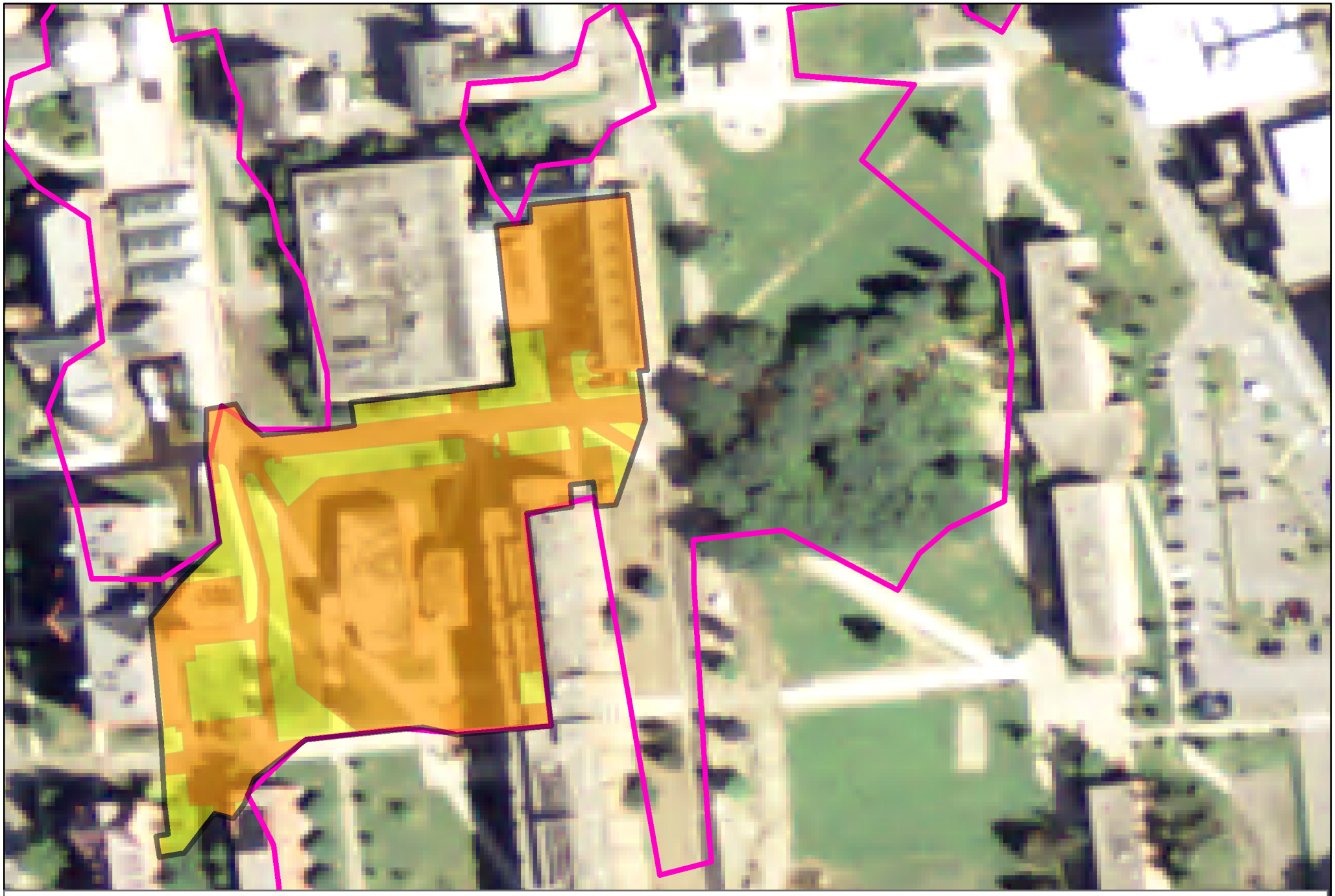

Figure 3. Colchester Ave. Proposed Watershed Expansion

Legend

- Colchester Ave Area
- Impervious Cover
- Existing Watershed Boundary

N

100 Feet

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General Conclusions

The restoration scenario presented here is not intended to represent the optimal implementation scenario proposed by the MS4s, rather it represents the maximum reduction all MS4s agree is achievable, regardless of cost considerations. Prior to moving forward with finalizing the flow restoration plan for Centennial Brook, the MS4s and the VT Agency of Natural Resources (ANR) may want to consider the following:

1. A detailed analysis was conducted by Chittenden County Regional Planning Commission in July, 2013 that refined the estimate of future, unregulated impervious cover to a more realistic estimate of 5 acres, rather than the 40 acres assumed in the TMDL. This change, if approved by ANR, would lower the high flow TMDL target from 63.0% to 51.5%.
2. Restoration activities other than the implementation of structural stormwater retrofits, such as tree planting, buffer enhancement, impervious cover reduction, or more stringent development requirements could potentially bridge the remaining gap for meeting the reduction target if a crediting mechanism was established.
3. Higher flow reductions are possible if surface detention time (center of mass) are relaxed in Centennial Brook; although modeling suggests that detention times >24 hrs for retrofits of existing and new ponds still cannot meet the 63% reduction target. If increased detentions times were allowed, future permitting of proposed development projects draining to those retrofitted facilities would also need to be considered.
4. The proposed retrofits with the most influence on flow reduction modeled at the watershed outlet include: Best Western (#22 at 13.6% relative reduction); North Campus Pond (M7A3 at 7.7%); Chamberlain School (#14 at 5.9%); and Picard Circle (#25 at 4.3%). The East Campus Pond (M1) contributes to 13.4% of the achieved flow reduction, though no retrofit of this facility is proposed. The Main St. pond retrofit's (M5A3) relative reduction was 3.4%. These "regional" storage facilities manage more impervious cover than the smaller on-site BMPs, which have less of an individual influence on reductions measured at the watershed outlet. Based on the results of the VTBMPDSS, the revised 51.5% flow reduction target can be met by extending detention times of the UVM ponds beyond 24 hours; however, since over-detention in these existing facilities was reported by Krebs and Lansing to significantly reduce UVM's future development opportunities, this retrofit option is not considered practical. Regardless, the 63% target was not reached under any modeling scenarios.
5. A number of secondary BMPs (practices within the drainage areas of primary sites) were identified as backup options in case primary sites become infeasible or are down-sized. None of the secondary practices are able to completely replace the relevant primary practice, however. The I-89 clover-leaf (16B) comes the closest, but is about ½ as effective as the primary BMP proposed at I-89 outfall (16). Currently, these secondary practices are included in the proposed restoration scenario in addition to the primary facilities to show the maximum amount of flow reduction deemed achievable, regardless of cost. Removing the secondary facilities from the restoration scenario will likely result in a very modest change the flow reduction at significant cost savings.
6. The VTBMPDSS model runs for Centennial Brook do not fully depict expected increases in low flow despite a substantial increase in annual infiltration volumes from the proposed infiltration BMPs. Under the proposed restoration scenario, 94 acres of impervious cover are directed to infiltration practices designed to infiltrate the 1-year storm. Using the Burlington rainfall record, a rough analysis of recharge from the impervious area runoff should yield approximately 22 inches/year.

This recharge should augment streamflow by approximately 0.24 cfs across the entire flow duration curve; however, the model predictions of increase in low flow from infiltration practices are only 0.02 cfs (an 8% increase over baseline conditions).

7. The planning level estimate of overall capital costs for the proposed flow restoration scenario modeled is $9,740,000.

The remainder of this memorandum provides more detailed information on the modeling analyses, BMP input information, and estimated construction costs. Additional supporting information submitted separately from, but in conjunction with, this memo includes:

- VTBMPDSS model runs for the revised baseline, the revised credit, and the proposed restoration scenario.
- GIS shapefiles used in each scenario, including updated impervious cover layer, BMP footprints, and other shapefiles created during this effort.
- HydroCAD models—created for all of the revised Credit BMPs and potential retrofits using HydroCAD version 10.00 for calibrating VTBMPDSS input;
- Spreadsheets—summarizing reductions, input variables, and cost estimates.

VTBMPDSS Modeling Analysis

The VTBMPDSS model is a continuous hydrological simulation model that estimates the effect of land use changes and stormwater BMPs on streamflow. This model was applied to the Centennial Brook watershed, which has a drainage area of about 1.4 square miles. The most important inputs to the model for this study are the GIS layers of land use, impervious cover, and soil, as well as the locations, configuration, and connections of the BMPs themselves.

Establishing Baseline Conditions

The ANR Baseline Scenario represents the watershed condition prior to the Centennial TMDL (2002), which in this case reflects six existing BMPs. In coordination with ANR, a Revised Baseline Scenario was created to address an issue discovered during subsequent modeling runs involving the application of BMPs with small drainage areas. Each time one of these on-site BMPs is added, the model creates a new routing connection that increases downstream flow and reduces times of concentration in the drainage area. This phenomenon can cause the VTBMPDSS model to underestimate the reduction potential of smaller green infrastructure (GI) practices and negates some of the potential benefits of BMP treatment trains. To accurately account for this effect, the Baseline Scenario was revised to incorporate virtual outlets (VOs) and drainage areas with “dummy” connections in the same manner as in the subsequently modeled flow restoration scenario. This adjustment did not alter flow paths in the Baseline Scenario, but did slightly increase Q03 base flows. Thus, slight increases in percent reductions over baseline conditions were achieved in the restoration scenarios.

FDC Statistics and Flow Reductions

The VTBMPDSS model outputs both summary files and complete records of hourly flows for any specified control points. The outlet is the primary control point (number 16 for this model). The outlet summary file (Init_Eval.out) provides a quick way to see the control point flows for Q95 and Q03 flows (cfsm) from the current scenario. These numbers were used as a quick guide on performance.

For the final FDC flow numbers, ANR recommends that a separate FDC analysis be performed using only the last 10 years of the 12 year output record for the desired control point (Init_VirtualOutlet_16.out). The FDC spreadsheet was used to provide these numbers for all current scenarios. Only these FDC numbers are reported in this memo.

Additionally, ANR requires computation of the flow reductions percentages based on flow in cubic feet per second (cfs) not cubic feet per second per square mile (cfsm). The logic is that additional watershed area would increase flow (in cfs) and require instream morphological changes that could be detrimental, like augmenting sediment load. The flow per square mile (cfsm) might be unchanged and not reflect this impact. Only flows in cfs were reported in this memo.

Current Condition (Credit) Models

The ANR Credit Scenario reflects upgrades to four of the six ponds included in the baseline model to meet 2002 VT Stormwater Manual criteria. Updated ponds include: the East Campus Pond (M1), Sheraton Pond (M4); the North Campus Pond (M6) with sediment forebay (M7); and the Quarry Ridge Pond (M9) with sediment forebay (M2). The Queensbury Rd. Pond (M3) and the Main St. Pond (M5) remained unchanged from the baseline model. The ANR Credit Scenario was reviewed and revised to account for: 1) an error discovered in the HydroCAD and VTBMPDSS setup for the East Campus pond (M1), and 2) recent construction at Patchen Woods that added two vegetated swales (V1 and V2), increased impervious cover, and required slight changes to sub-watershed boundaries.

HydroCAD modeling of BMPs

HydroCAD models were set up for most of the proposed retrofits identified during field investigations in May, 2013. The Field Findings Memorandum (dated June 13, 2013) that documented procedures and feasible retrofit concepts has been revised to reflect subsequent changes to some of the retrofit concepts (see Revised Field Summaries Memorandum, dated October, 2013). The HydroCAD runs were saved as PDF files, marked up to show the relevant VTBMPDSS parameters used, and then the selected parameters were saved in a model input spreadsheet, thus providing full documentation of each VTBMPDSS model run. All HydroCAD models and the input spreadsheet are available for review. The following two modeling adjustments should be noted:

- HydroCAD models were based on the most updated impervious cover and soils data, which may differ slightly from what is being used in the VTBMPDSS model. ANR requested consistency in the GIS layers used for running model scenarios to ensure that results are comparable to baseline conditions; however, they agreed that the BMPs should be adequately designed using the latest data.
- Because of the differing methods that HydroCAD and the VTBMPDSS models aggregate runoff from soils and impervious areas and deal with flow lag times (time of concentration), the size of the HydroCAD designs for some infiltration practices (e.g., Jaycee Park (15) and Patchen Rd. (18A)) had to be increased to achieve maximum infiltration in the VTBMPDSS.

Flow Restoration Scenario

A number of restoration scenarios were modeled to compare various implementation options using 39 stormwater BMPs. In these scenarios, primary BMPs are defined as having an outlet directly to a stream while secondary BMPs drain to a downstream BMP. More details of the BMP concept summaries, based on GIS and field data, can be found in the revised “Centennial Brook Watershed: Retrofit Field Findings Summary Memorandum” (dated October, 2013). A few key model parameters used during the restoration scenarios include:

- The revised impervious cover used in the Revised Credit Scenario was updated slightly to account for new parking lots and buildings recently constructed/removed based on a visual inspection of the latest satellite images. Even though more recent impervious cover GIS layers were available, this approach was recommended by ANR since it allows direct comparison with the baseline scenarios without introducing differences between remote sensing technology used to develop the old and new impervious cover layers.
- The watershed boundary was changed in a few locations based on MS4 input and field verification. For example, the area north of University Avenue and west of the baseball diamond was removed because it is now connected to the combined sewer system. The UVM proposed expansion on the corner of Colchester Avenue and University Place was modeled as part of the restoration scenario presented here.
- All the stormwater practices, except for vegetated swales, were modeled as multistage ponds. The multistage pond allows the volume-stage relationship to be well represented, has more options for outlet control structures, and has all the controls represented in other model BMPs like infiltration or biofiltration. The multi-stage pond also has the added advantage in that it can be turned on/off or scaled with a multiplier (normally set to 1.0). The parameter allows the same network to be preserved for all flow restoration scenarios and is extremely useful for evaluating different scenarios and individual BMP performance.

Table 2 summarizes the base, credit, and restoration scenarios discussed above. Table 3 provides an accounting of some of the key input parameters of each proposed BMP used in the proposed restoration scenario.

Table 2. Summary of Modeling Scenarios

Model Scenario			Purpose	Q03 High Flow		Conclusion
				(cfs)	% Red.	
Pre-TMDL	ANR Base	Six pre-2002 BMPs, 2002 land use and IA GIS layers	What were the flows at the time the TMDL was established? These flows are the baseline from which restoration/treatment is measured.	27.2	--	We were able to successfully replicate ANR's model.
	Revised Base	ANR Base + virtual outlets, DAs, and network	Add "dummy" BMP connections to allow for more accurate comparison with restoration scenarios.	27.9	--	This is the new baseline to measure achieved flow reductions.
Current	ANR Credit	ANR Base + upgrades to some existing BMPs	What is the change in baseline flow with the retrofit of 4 of 6 existing BMPs to 2002 standards?	23.1	15.2%	We were able to replicate ANR's model.
	Revised Credit	ANR Credit + BMP revisions/addition	Revise current conditions by correcting model inputs on East Campus Pond (M1) and adding the Patchen Woods development.	23.2	14.8%	Corrections result in a slight decrease from ANR's prediction of the current reductions.
Proposed Restoration Scenario		All primary and secondary retrofits (see Table 3)	What is the max. flow reduction achievable if all feasible retrofits are implemented with UVM-designed retrofits of the Main St. (M5A3) and North Campus (M7A3) ponds and the Colchester Ave. expansion.	15.6	44.2%	Does not meet the revised 51.5%% TMDL reduction target, and benefit of secondary practices probably not worth the additional cost.

Table 3. BMPs used in Flow Restoration Scenarios

Site ID	Site Name	BMP Type[1]	Class[2]	DA (ac)	IA (ac)[3]	% Difference in Q03[4]		Design Notes
						BMP Outlet	Watershed Outlet	
12A	University soccer field	IB	E	1.41	0.33	-100.0	0.0	--
13	Patchen Rd. depression	URC	P	14.06	5.07	-100.0	-1.2	Max. ponding depth=7'; Exfiltration = 2.41 in/hr
14A/B	Chamberlin School	URC	P	31.49	10.12	-100.0	-5.9	Field size: 97'(w) x 167'(l) x 3.5'(h); Exf. = 0.52 in/hr
15	Jaycee Park	DB	P	15.73	6.28	-100.0	-2.7	Field size: 87'(w) x 60'(l) x 3.5'(h); Exf. = 2.41 in/hr
16	I-89 outfall	DB	P	52.25	18.88	-26.4[4]	-2.1	Max det. time= 46.6 hr; max. ponding depth=12'
16B	I-89 cloverleaf (NE)	UDC	S	39.17	16.14	-83.0	-0.9	Max det. time=48.8 hrs; max. ponding depth=8'
17	Jug handle @ Spear & Main St. (east)	UDC	S	22.01	7.28	-74.9	-0.3	Field size: 144'(w) x 231'(l) x 3.5'(h)
18	Fielding Lane Condos	URC	P	18.74	5.48	-100.0	-2.3	Max. ponding depth=4'; Exf. = 2.41 in/hr
18A	Patchen Rd & Pine St	URC	P	20.41	6.00	-100.0	-1.8	Field size: 49'(w) x 81'(l) x 3.5'(h); Exf. = 2.41 in/hr
20	Grove St Parking Lot	URC	P	8.82	2.54	-100.0	-0.3	Field size: 30'(w) x 74'(l) x 3.5'(h); Exf. = 2.41 in/hr
20A	SD Ireland Property	URC	P	4.66	3.82	-100.0	-0.2	--
21	Dumont Ave (south)	URC	P	3.93	1.20	-100.0	-0.1	Field size: 21'(w) x 24'(l) x 3.5'(h); Exf. = 2.41 in/hr
22	Best Western Windjammer (N)	IB	P	29.25	21.68	-100.0	-13.6	Max. ponding depth=12'; Exf. = 2.41 in/hr
22A	Best Western Windjammer (W)	IB	P	4.09	1.24	-100.0	-0.5	Max. ponding depth=3'; Exf. = 2.41 in/hr
23A/B	Staples Plaza	UDC	S	2.50	2.43	-67.7	-0.2	Field size: 35'(w) x 259'(l) x 2.33'(h)
25	Picard Circle	URC	P	51.85	17.11	-86.7	-4.3	Field size: 49'(w) x 138'(l) x 3.5'(h); Exf. = 2.41 in/hr
26	Duval St	URC	P	3.57	1.18	-100.0	-0.1	Field size: 21'(w) x 24'(l) x 3.5'(h); Exf. = 2.41 in/hr
27	Clover St	URC	P	3.82	1.43	-100.0	0.0	Field size: 26'(w) x 31'(l) x 3.5'(h); Exf. = 2.41 in/hr
200	N Henry Court	URC	P	1.03	0.45	-100.0	0.0	Field size: 11'(w) x 24'(l) x 3.5'(h); Exf. = 2.41 in/hr
207	Fletcher Allen green space	Bio	S	0.89	0.85	-100.0	0.0	Bio surface area: 3,200 sf
208	Fletcher Allen parking lot	Bio	S	0.83	0.53	-100.0	-0.1	Bio surface area: 2,300 sf
M1A	Centennial Crt Apartments	IB	S	6.54	3.03	-100.0	-0.6	Max. ponding depth=4'; Exfiltration=0.52 in/hr

Site ID	Site Name	BMP Type[1]	Class[2]	DA (ac)	IA (ac)[3]	% Difference in Q03[4]		Design Notes
						BMP Outlet	Watershed Outlet	
M1	East Campus Pond	DB	E	80.30	49.34	-58.1	-13.4	Existing UVM design. Max. det. time= < 12 hrs. Stor. Vol. = 11.3 ac-ft
M2/ M9	Quarry Ridge	DB	E	7.44	4.2	-59.7	-1.1	Max det. time= 12.5 hrs
M3A	Queensbury Pond (modified)	IB	P	8.99	4.17	-86.5	-0.8	Max. ponding depth=10'; Exfiltration=2.41 in/hr
M4	Sheraton	DB	E	9.81	6.70	-52.4	-0.2	Max det. time= 9.9 hrs
M5A3	Main St (UVM modified)	DB	P	64.15	26.59	-39.0	-3.4	UVM design. Max. det. time= < 12 hrs. Stor. Vol. =8.5 ac-ft; with smaller low flow orifice of 5.8" than existing
M6 / M7A3	North Campus (UVM modified)	DB	P	86.36	48.22	-46.3	-7.7	UVM design. Max. det. time= < 12 hrs. Stor. Vol. =21.5 ac-ft.; perm pool elevation 236.0, with smaller low flow orifice of 7.3" than existing and raised to 9-ft embankment
M7B	Open area east of Case Pkwy	URC	S	7.04	3.19	-100.0	-0.1	Field size: 40'(w) x 74'(l) x 3.5'(h); Exf. = 2.41 in/hr
M7C	Case Pkwy center island	Bio	S	0.86	0.50	-100.0	0.1	Bio surface area: 700 sf
M7D	140 East Ave residence	Bio	S	0.63	0.36	0.0	0.0	Bio surface area: 1,550 sf
M8	Burlington COOP	DB	E	3.73	1.62	-100.0	-0.4	Max det. time= 2hrs
V1	Patchen Woods	VS	E	0.48	0.32	-50.0	-0.3	
V2	Patchen Woods	VS	E	0.91	0.81	-100.0	-0.11	

[1] Bio=bioretention; DB=detention basin, IB= infiltration basin; UDC= underground detention chamber; URC=underground recharge chambers; and VS=vegetated swale

[2] P=Primary BMP; S= Secondary BMP that drains to a primary BMP; E=Existing practice (no modification)

[3] Impervious area shown here is based on the most recent/ accurate information that was used to size potential retrofits and may not correspond exactly with GIS layers used in the VTBMPDSS model

[4] Percent difference in high flows is negative when showing a reduction. The model was run with all BMPs turned on and then with individual BMPs turned off, one at a time, to quantify differences in flow and relative performance at the outlet of individual BMPs. Differences at each BMP outlet were determined by comparing the inflows and outflows. 100% represents no surface discharge; BMPS with less than 50% at the BMP outlet could be opportunities to enhance performance. Differences in flow at the watershed outlet are intended as a relative comparison of BMP effectiveness, but are not absolute or additive. Individual BMP values do not add up to corresponding total watershed reductions due to other losses in the system.

[4] Relative performance for #16 appears low because #16B is already managing a large portion of the drainage area.

Estimated Project Costs

This section provides estimates of construction costs for the various stormwater retrofit facilities based on volume managed, the type of BMP, and the type of project site. The total cost for implementation of the restoration scenario presented here is $9,740,000.

The cost estimates were developed based on the following assumptions and design decisions:

1. **Design Control Volumes** are based on the estimated runoff volume associated with the one-year storm event for underground systems or green infrastructure-type practices. Control volumes for large, above-ground infiltration or detention basins are based on the estimated runoff associated with the one hundred year storm event plus approximately two feet of freeboard volume. Underground systems and green infrastructure-type practices were conceptually designed as off-line practices that only accept runoff from the one-year event. Runoff volumes for all storm events were determined based on HydroCAD® model results that rely on the Soil Conservation Service (SCS) TR-55 and TR-20 hydrologic methods.
2. Table 4 summarizes **Unit Costs** for each BMP and **Site Adjustment Factors** that were derived from research by the Charles River Watershed Association and Center for Watershed Protection, as well as from our experience with actual construction. Underground detention chambers (UDC) and underground recharge chamber (URC) systems were typically designed using Stormtech SC-740™ chamber systems. A Stormtech SC-310™ system was used at Site 23A/B due to a shallow existing drainage system. Cost estimates for the retrofit sites described as "GI/URC" were calculated as bioretention treatment systems followed by Stormtech SC-740™ chambers for recharge benefits. The cost adjustment factors were used to account for site-specific differences typically related to project size, location, and complexity. Retrofits of existing BMPs, for example, generally cost less than new installations.

Table 4. Retrofit unit costs and adjustment factors

BMP	Base Cost ($/ft^3)
Detention Basin	$2
Infiltration Basin	$4
Underground Chamber (infiltration or detention)	$12
Bioretention	$10
Green Infrastructure/ Underground Chamber Combo	$22
Site Type	**Cost Multiplier**
Existing BMP retrofit	0.25
New BMP in undeveloped area	1.00
New BMP in partially developed area	1.50
New BMP in developed area	2.00
Adjustment factor for large aboveground basin projects	0.50

3. For certain retrofit locations, additional **Site-Specific Costs** were added to the construction costs. For example, Sites #13, #22, and M3A will require significant drainage or utility reconstruction. Site M5A3 will require ledge removal if constructed. Site M7A3 will require elevating the existing electric transmission lines to provide adequate clearance for the basin berm construction. Site-specific construction items are described in detail in the Retrofit

Summary Sheets provided as part of the Revised Field Findings Memo (dated October 14), except for the most recent retrofit concepts by UVM for M5A3 and M7A3, which were updated after submittal of the Revised Field Findings Memo. Table 3 provides information on the key design elements of M5A3 and M7A3.

4. **Base Construction Cost** is the product of the design control volume, the unit cost, and the site adjustment factor. Site-specific costs were added to this result for the applicable retrofit sites.
5. **Permits & Engineering Costs** were estimated at either 20% or 35% of the construction cost depending on the scale of the project. The largest projects (in terms of control volume) were estimated at 20% and the smaller projects at 35%. Certain large-scale projects that are likely to include high levels of engineering or permitting effort were assigned a 35% fee, despite their overall size.
6. **Land Acquisition Cost** was added to the total costs for facilities located on private, non-UVM properties. Retrofits that may require partial land acquisition fees were marked up by $150,000; retrofits possibly requiring total land acquisition were marked up by $300,000. These land acquisition estimates are considered to be place-holders at this time and may require adjustments based on current land values and the willingness of land owners to grant easements for the proposed drainage improvements. It was assumed that no land acquisition fees would be necessary for privately owned Sites 22, 22B, and 23A/B due to possible Residual Designation Authority (RDA) applicability. Site M1A was also not assigned a land acquisition fee due to possible existing agreements between UVM and the Centennial Court Apartments property management; however additional refinement of costs for UVM property may require inclusion of a land acquisition cost.
7. **Total Project Cost** is the sum of the base construction cost, permitting & engineering costs, and land acquisitions costs; it does not include operation & maintenance costs.
8. **Relative Cost** is described in terms of total project costs and represented by dollar signs. A project costing less than $100,000 is given $; a project between $100,000 and $250,000 is given $$; a project between $250,000 and $500,000 is given $$$; and a project greater than $500,000 is given $$$$.
9. **Costs per Impervious Acre** treated was calculated by dividing the sum of the construction costs and the permitting & engineering costs by the total impervious area directed to each BMP. Impervious areas used in this calculation are displayed in Table 3. Land acquisition costs and operation & maintenance costs are not included as part of this calculation.
10. **Operation & Maintenance** costs were estimated separately for each BMP, but are <u>not</u> included in the total construction costs. We assume that annual O&M is approximately 3% of project construction costs, with a cap at $10,000.

Each of the numbered descriptions above provides clarification to the corresponding columns in Table 5. The spreadsheet used to develop Table 5 is provided separately as supporting information.

Table 5. BMP Cost Summary Table

Site ID	Site Name	BMP Type	Class	Design Control Volume[1] (ft3)	Base Unit Cost[2] ($/cu.ft.)	Site Adjust. Factor[2]	Site Specific Cost[3]	Base Constr. Cost[4]	Permits & Eng.[5]	Land Cost[6]	Total Project Cost[7]	Relative Cost[8]	Cost/ Imp. Acre[9]	O&M[10]
12A	University soccer field	IB	E	2,700	-	-	-	-	-	-	-	-	-	-
13	Patchen Rd depression	URC	P	66,800	$4	0.25	$25,000	$91,800	$33,000	$150,000	$280,000	$$$	$25,000	$2,800
14A/B	Chamberlin School	URC	P	35,200	$12	1.50	$0	$633,600	$127,000	$0	$770,000	$$$$	$76,000	$10,000
15	Jaycee Park	DB	P	11,300	$12	1.50	$0	$203,400	$72,000	$0	$280,000	$$$	$48,000	$6,200
16	I-89 outfall	DB	P	566,000	$2	1.00	$0	$1,132,000	$227,000	$150,000	$1,510,000	$$$$	$72,000	$10,000
16B	I-89 cloverleaf (NE)	UDC	S	320,000	$2	0.50	$0	$320,000	$112,000	$0	$440,000	$$$	$27,000	$9,600
17	Jug handle @ Spear & Main St.	UDC	S	73,000	$12	1.50	$0	$1,314,000	$263,000	$0	$1,580,000	$$$$	$217,000	$10,000
18	Fielding Lane Condos	URC	P	21,700	$4	1.00	$0	$86,800	$31,000	$300,000	$420,000	$$$	$23,000	$2,700
18A	Patchen Rd & Pine St	URC	P	8,600	$12	1.50	$0	$154,800	$55,000	$150,000	$360,000	$$$	$35,000	$4,700
20	Grove St Parking Lot	URC	P	4,800	$12	2.00	$0	$115,200	$41,000	$0	$160,000	$$	$62,000	$3,500
20A	SD Ireland Property	URC	P	28,700	-	-	-	-	-	-	-	-	-	-
21	Dumont Ave (south)	URC	P	1,100	$12	1.50	$0	$19,800	$7,000	$0	$30,000	$	$23,000	$600
22	Best West.(N)	IB	P	181,000	$4	0.50	$50,000	$412,000	$145,000	$0	$560,000	$$$$	$26,000	$10,000
22A	Best West. (W)	IB	P	30,000	$4	0.50	$0	$60,000	$21,000	$0	$90,000	$	$75,000	$1,800
23A/B	Staples Plaza	UDC	S	11,600	$12	2.00	$0	$278,400	$56,000	$0	$340,000	$$$	$139,000	$8,400
25	Picard Circle	URC	P	14,700	$12	1.50	$0	$264,600	$53,000	$0	$320,000	$$$	$20,000	$8,000
26	Duval St	URC	P	1,100	$22	1.50	$0	$36,300	$13,000	$150,000	$200,000	$$	$42,000	$1,100
27	Clover St	URC	P	1,700	$12	1.50	$0	$30,600	$11,000	$150,000	$200,000	$$	$30,000	$1,000

Site ID	Site Name	BMP Type	Class	Design Control Volume[1] (ft3)	Base Unit Cost[2] ($/cu.ft.)	Site Adjust. Factor[2]	Site Specific Cost[3]	Base Constr. Cost[4]	Permits & Eng.[5]	Land Cost[6]	Total Project Cost[7]	Relative Cost[8]	Cost/ Imp. Acre[9]	O&M[10]
200	N Henry Court	URC	P	600	$22	1.50	$0	$19,800	$7,000	$0	$30,000	$	$60,000	$600
207	Fletcher Allen green space	Bio	S	3,700	$10	1.00	$0	$37,000	$13,000	$0	$50,000	$	$59,000	$1,200
208	Fletcher Allen parking lot	Bio	S	2,700	$10	1.00	$0	$27,000	$10,000	$0	$40,000	$	$70,000	$900
M1A	Centennial Court Apts.	IB	S	30,800	$4	1.00	$0	$123,200	$44,000	$0	$170,000	$$	$59,000	$3,700
M3A	Queensbury (modified)	IB	P	26,700	$4	0.25	$25,000	$51,700	$19,000	$150,000	$230,000	$$	$24,000	$1,600
M5A3	Main St (UVM modified)	DB	P	370,900	$2	0.50	$100,000	$470,900	$95,000	$0	$570,000	$$$$	$22,000	$10,000
M7A3	North Campus (with extra DA)	DB	P	1,008,000	$2	0.25	$100,000	$604,000	$121,000	$0	$730,000	$$$$	$16,000	$10,000
M7B	Open area east of Case Pkwy	URC	S	6,300	$12	1.50	$0	$113,400	$40,000	$0	$160,000	$$	$38,000	$3,500
M7C	Case Pkwy center island	Bio	S	1,000	$10	1.50	$0	$15,000	$6,000	$0	$30,000	$	$42,000	$500
M7D	140 East Ave residence	Bio	S	1,800	$10	1.50	$0	$27,000	$10,000	$150,000	$190,000	$$	$103,000	$900

See preceding text for footnotes.

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APPENDIX 9

BARTLETT BROOK EXPIRED PERMITS LIST

Table A-9: Bartlett Brook Expired Permit Discharges and Proposed Retrofits

BMP in BMPDSS Model	Permit Number	Project Name	RDA/Other[1]	Permit Issued	Existing Manner of Discharge[2]	Proposed System Upgrades under FRP[3]
No Channel Protection Volume (CPv) BMP covered under Permit	1-0202.XXXX	Meadowwood at Spear	n/a	6/1/1976	CB	Drains to proposed Keari Lane BMP (Infiltration Gallery)
	1-0665.XXXX	Pillsbury Manor	n/a	9/30/1988	GS, RS, ST	Proposed Underground detention chamber assessed. Determined not necessary to meet FRP targets.
	1-0705.XXXX	Freedom Nissan	6342-9030	5/23/1988	CB, GS	No retrofit proposed. System currently covered under RDA permit.
	1-0734	Champ Car Care	n/a	11/29/1988	CB, GS	Drains to proposed BBTS Expansion Project (Wetland Pond)
	1-1134.XXXX	Freedom Nissan	6342-9030	5/10/1993	OF	No retrofit proposed. System currently covered under RDA permit.
	1-1220.9908	Allen Rd Community Care	n/a	5/12/1996	CB, (2)ST	Proposed Infiltration Basin assessed. Determined not necessary to meet FRP
	1-1291.0112	US Route 7 Expansion	5625-9010	12/20/2002	CB, OF	Covered under 5625-9010. Portion of coverage area drains to proposed BBTS Expansion Project (Wetland Pond), and a portion drains to proposed Shelburne Rd. Project (Detention Chamber)
	2-0153.XXXX	WESCO Distributors	n/a	4/26/1983	CB	Drains to proposed BBTS Expansion Project (Wetland Pond)
	2-0180.XXXX	Shelburne Plastics	n/a	9/26/1983	GS	Drains to proposed BBTS Expansion Project (Wetland Pond)
Channel Protection Volume (CPv) BMP covered under Permit	3121-9010	Willie Racine Jeep Isuzu	n/a	11/24/2003	GS, (2)DP, CB	Drains to proposed BBTS Expansion Project (Wetland Pond). Limited space to manage on-site.
	3017-9010	IDX Headquarters - 25 GMD	n/a	6/2/2003	IB	No retrofit proposed. Current system meeting VT 2002 SWMM standard for CPv.
	1-1404.9912	Irish Farms Residential Subdivision	n/a	5/31/2000	CB, (3)DP, GS	Irish Farms Pond Retrofit: Upgrade Pond B to gravel wetland, and new outlet control for Pond C.
	1-1372.9905	Staybridge Suites & Harbor Sunset Hotel	6296-9030	9/1/1999	CB, ST, DP, (2) IG	Proposed alternative option to route upper portion of Staybridge runoff to the Holiday Inn BMP rather than upgrade exisiting detention pond.
	1-1155.9806	Pinnacle at Spear	n/a	4/21/1999	CB, (2)DP, OF	Upgrade Pond A and B with new outlet control and increase storage.
	1-0949.XXXX	Bouyea-Fassetts Building	6281-9030	6/6/1990	OF, IB	No retrofit proposed. System currently covered under RDA permit.
	1-0523.XXXX	Champ Carwash	6280-9030	11/3/1987	GS, OF, DP	No retrofit proposed. System currently covered under RDA permit.
	2-1073.XXXX	Howard Johnson's	6297-9030	12/20/1985	DW, CB, OF, ST	Portion of coverage area drains to proposed Holiday Inn Project (Infiltration Gallery)
	2-0261.XXXX	Overlook at Spear/Summit at Spear	n/a	4/17/1985	CB, GS, (4)DP	Neighborhood GSI Retrofit: Propose 6 collections of biofilters or infiltration basins in the ROW, within the drainage area for the 4 on-stream ponds covered under #2-0261. Retrofit of on-stream ponds determined less feasible than distributed GSI retrofit.
	2-0120.XXXX	Bay Court/Harbor Heights/Keari Rd	6294-9030 & 6294-9030.1	8/11/1982	CB, (4)SF	Drains to proposed Keari Lane BMP (Infiltration Gallery)

* Table Originally Prepared by Emily Schelley (VT DEC, last revised 1-31-14), Revised by WCA (2014).

[1] RDA: Residual Designation Authority- Private Permittees requests to have their expired stormwater system covered under an RDA permit, which overwrites their expired permit

[2] Manner of Discharge: CB: Catch Basin, GS: Grass Swale, RS: Retention Swale, ST: Settling Tank, OF: Control orifice, IB: Infiltration Basin, DP: Detention Pond, DW: Dry Well, IG: Infiltration Gallery, SF: Sand Filter

[3] Expired permit retrofits were determined based on direct benefit to the Flow Restoration Targets. Expired pemits with a CPv(extended detention of the 1-year design storm) BMP were assesed for retrofit opportunity, and if the flow reduction benefit was determined neglible, a retrofit was not proposed. It was determined beneficial to route several expired permit systems to a larger retrofit project, rather than retrofit the existing system on-site.

Appendix F – Summary of Amendments to SWMP