



MUNROE BROOK FLOW RESTORATION PLAN

TCE# 14-042
Shelburne, Vermont

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Prepared For:

Town of Shelburne

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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 stream 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 required 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 stream 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:

$$\text{Total Cost} = \text{Installation Cost (I)} + \text{Land Cost (L)} + \text{Fixed Cost (F)}$$

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 VTTrans 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

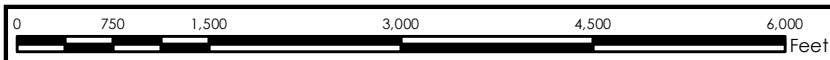
The MS4 permit requires the identification of any party, other than the MS4 permittees, that is responsible for implementing any portion of the FRP. There are several properties in the Munroe Brook watershed that are covered by expired State of Vermont stormwater permits. Some of these sites are located 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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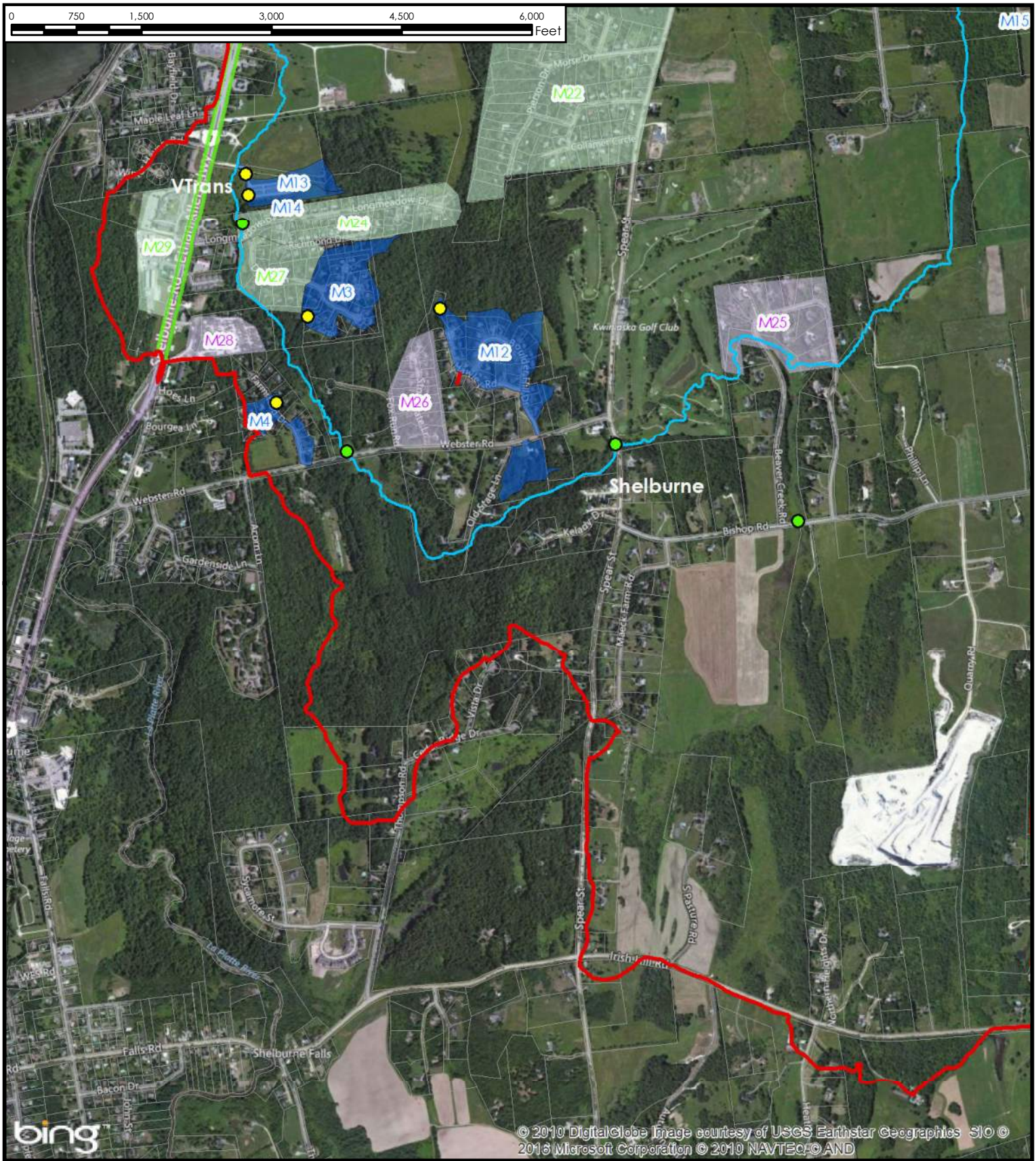
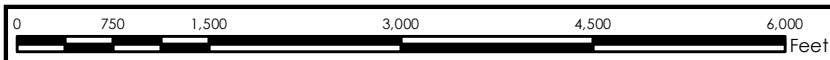


Munroe Brook Watershed Northern Section - FRP BMPs Shelburne & South Burlington, VT

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); M54 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); M24 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 INFORMATION		
Drainage Area (ac): 29.90		
Impervious Area (ac): 4.01		
Practice Area Available(ft²): 20700		
Existing Head Available? 4-5' Est.		

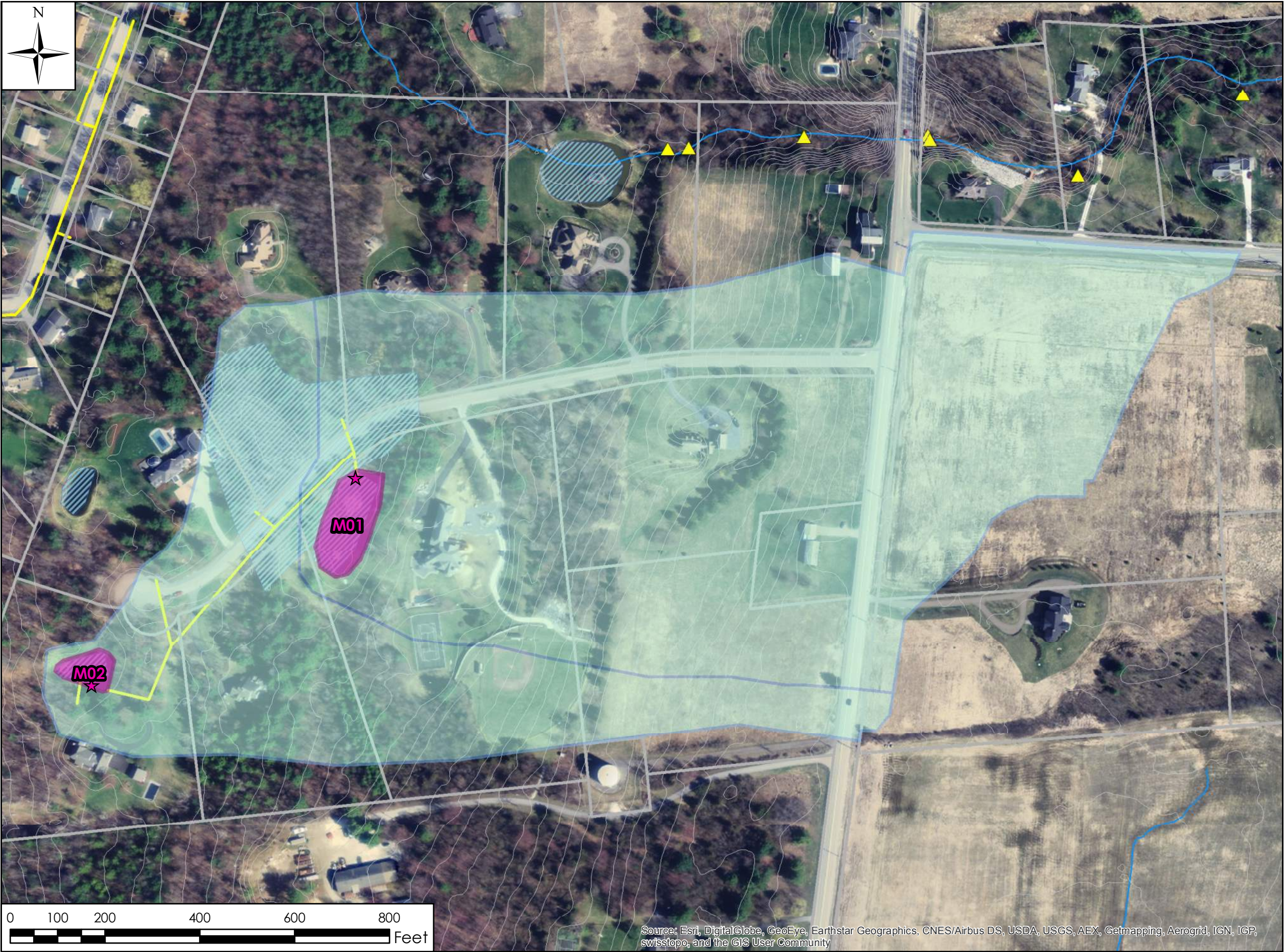
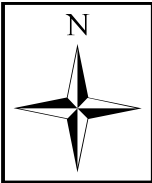
Date Assessed: 10/30/2014

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 INFORMATION		
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



Horsley Witten Group
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90 Route 5A • Shelburne, MA • 02563
Tel: 508-833-6800 • Fax: 508-833-3150 • www.horsleywitten.com

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Project Location

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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).

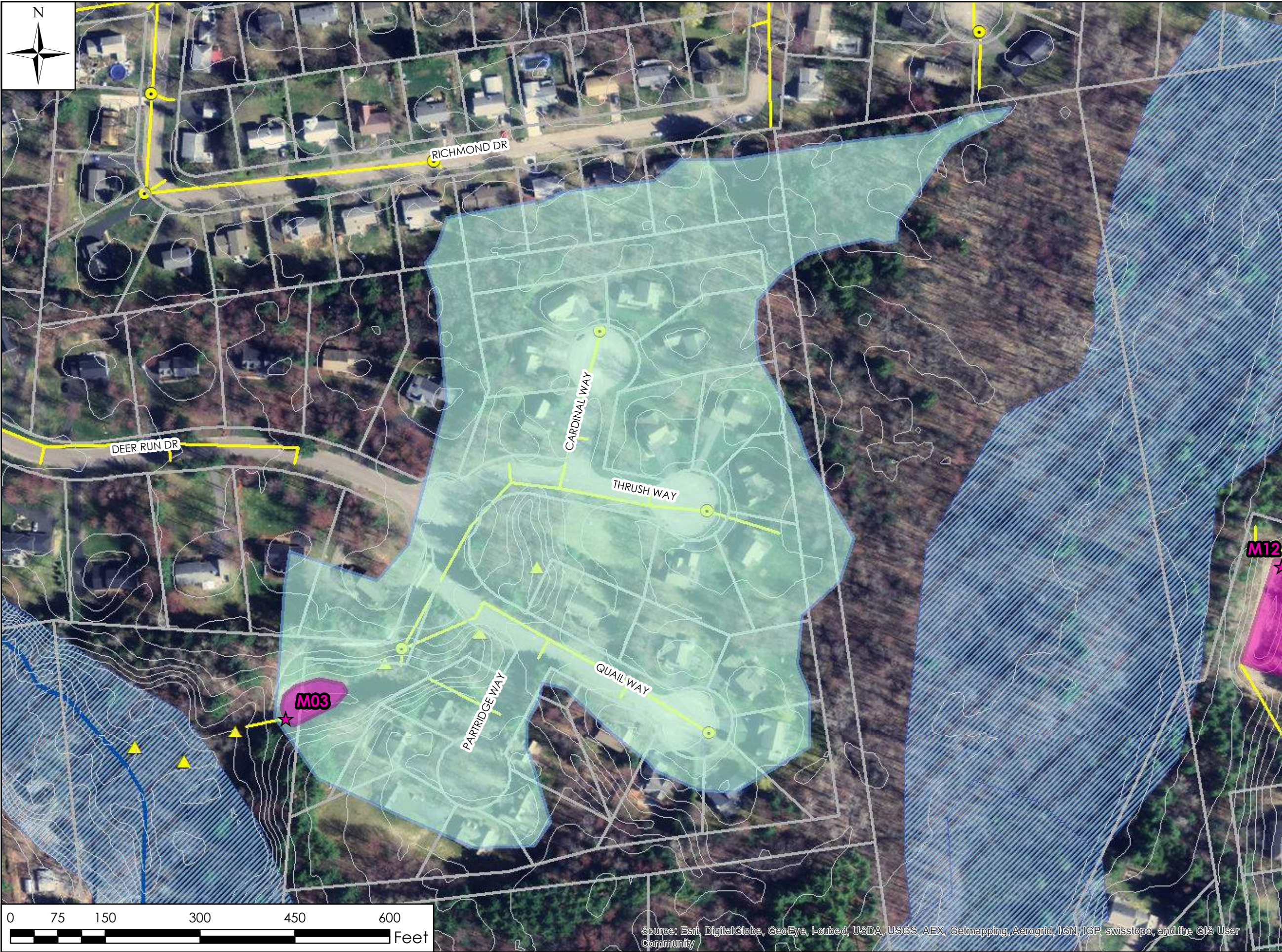
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M1 & M2 - Westview Est
Shelburne, VT
Project: 14-042
Prepared By: ALD
09/14/2016
1 inch = 200 feet

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 INFORMATION		
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



- 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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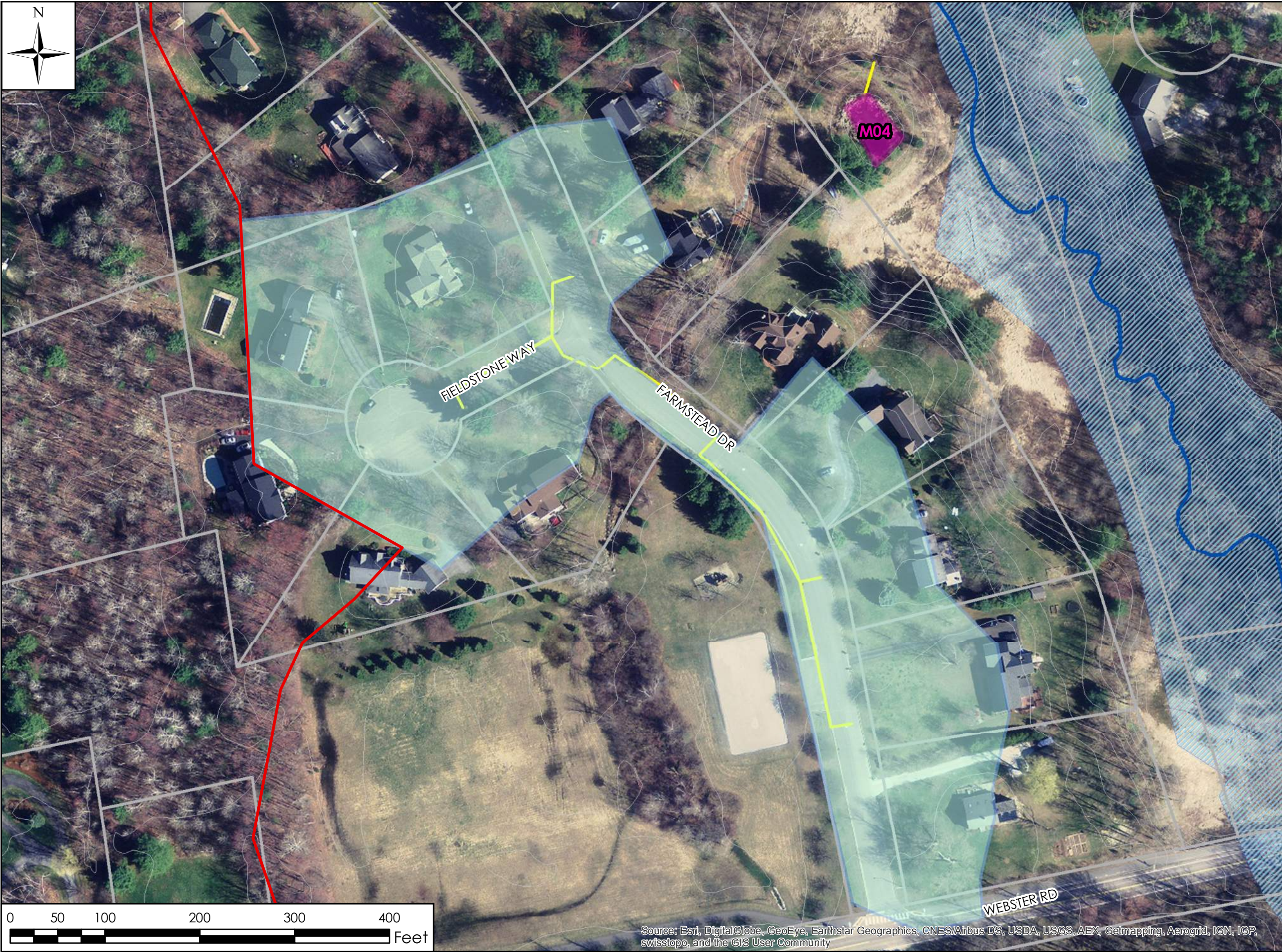
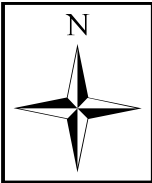
**M03 - Deer Run
Shelburne, VT**

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 INFORMATION		
Drainage Area (ac): 5.60		
Impervious Area (ac): 1.83		
Practice Area Available(ft²): 2200		
Existing Head Available? 3' Est.		

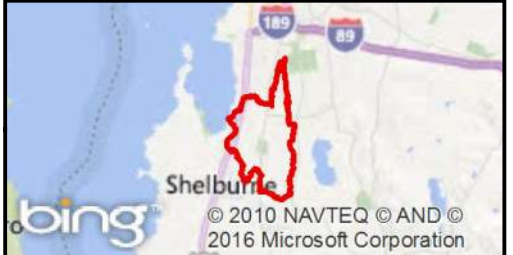
Date Assessed: 10/29/2014

Assessed by: AGM/LMJ



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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 INFORMATION			
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 INFORMATION			
Drainage Area (ac): 1.76			
Impervious Area (ac): 0.06			
Practice Area Available(ft²): 11700			
Existing Head Available? N/A			

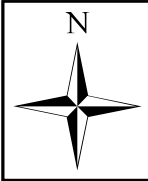
Date Assessed: 10/30/2014

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 INFORMATION		
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



Project Location



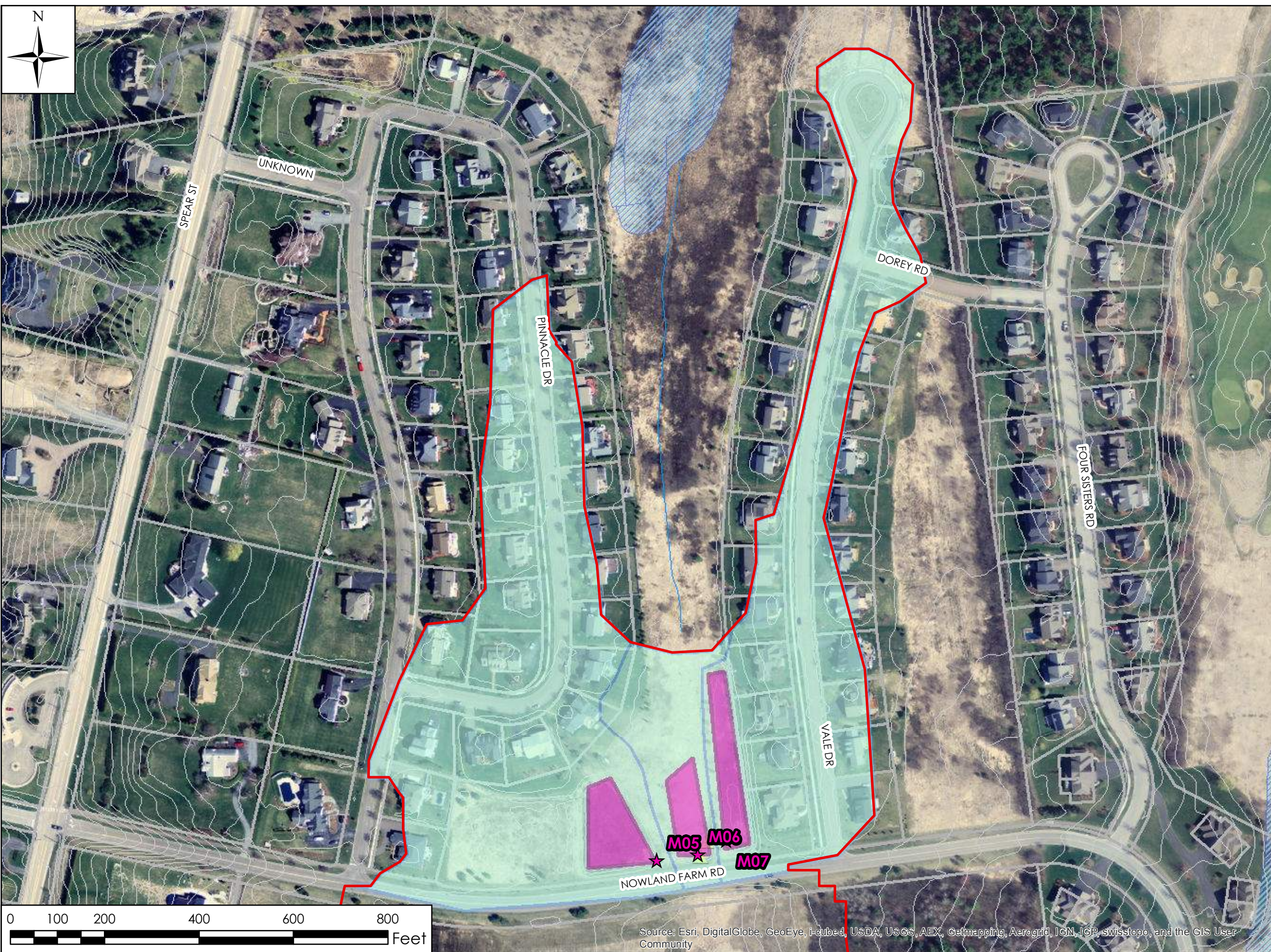
Legend


- 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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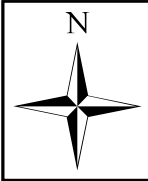
M05, M06, M07
Pinnacle at Spear
South Burlington, VT
Project: 14-042
Prepared By: LMJ
12/03/2014
1 inch = 200 feet



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 INFORMATION			
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



- 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**

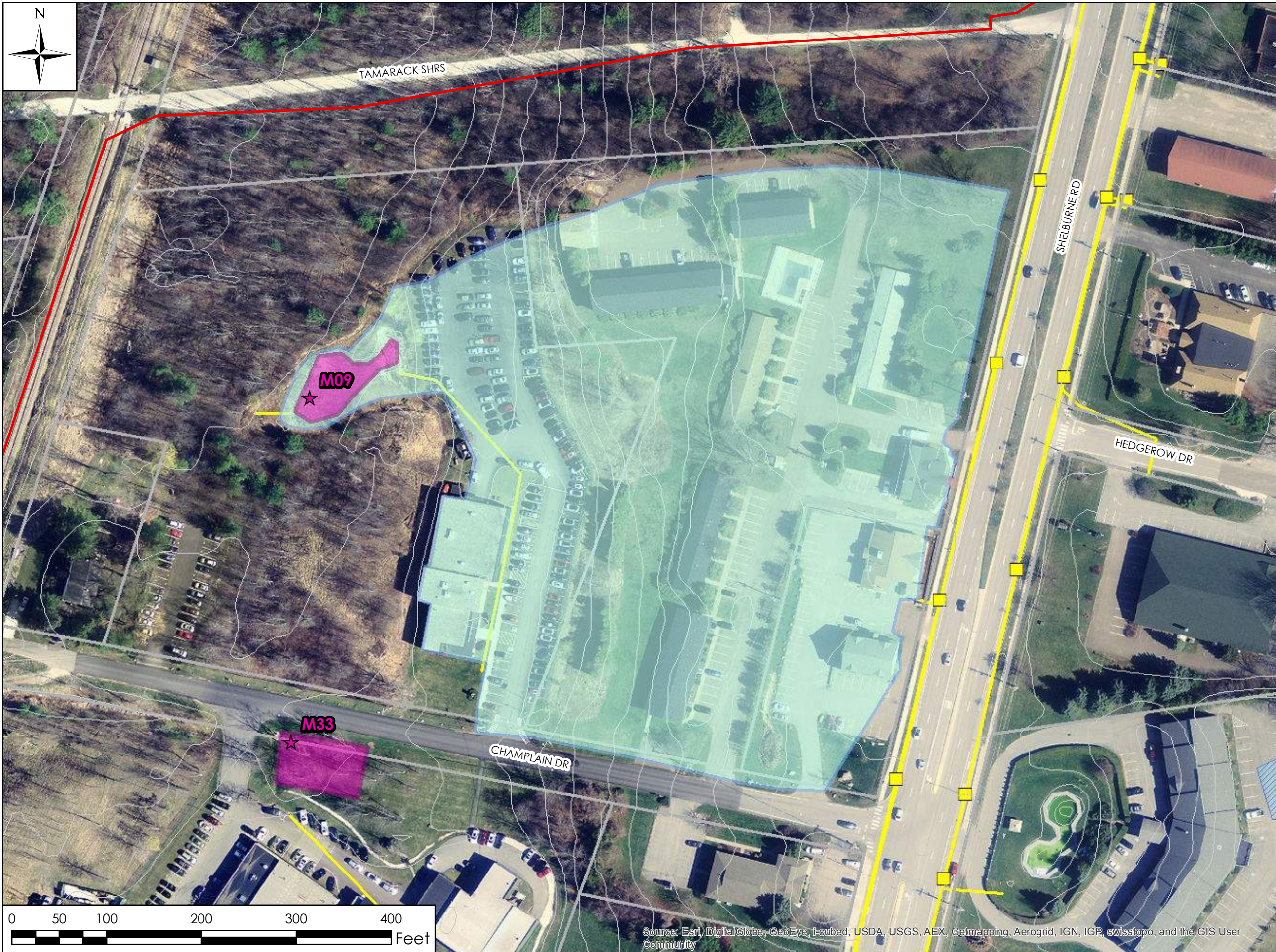
Project: 14-042
Prepared By: LMJ
12/03/2014
1 inch = 500 feet



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 INFORMATION		
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



- 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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**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 INFORMATION		
Drainage Area (ac): 1.80		
Impervious Area (ac): 0.74		
Practice Area Available(ft²): 2100		
Existing Head Available? 2' Est.		

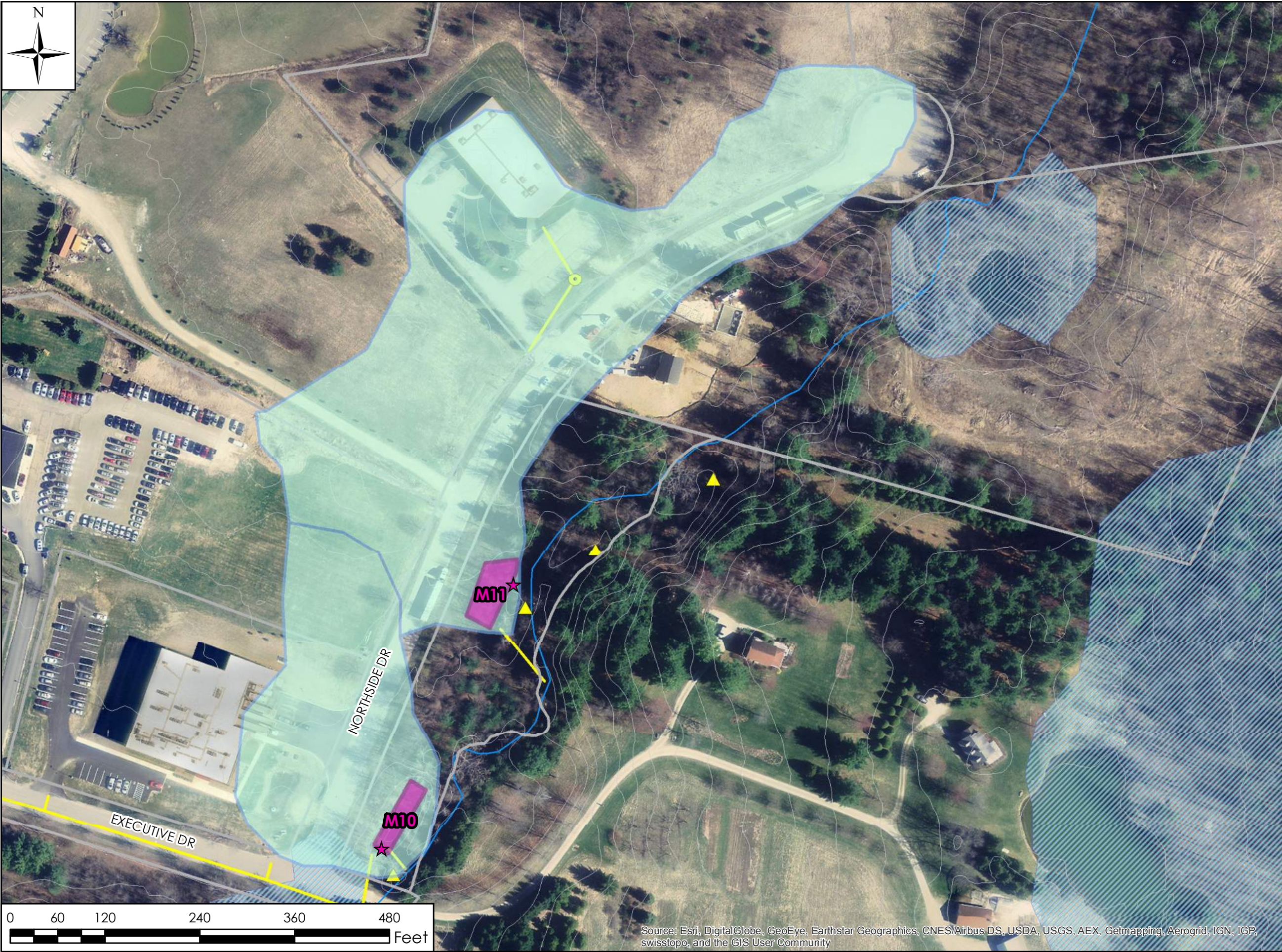
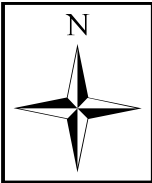
Date Assessed: 10/30/2014

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 INFORMATION		
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



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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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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 INFORMATION		
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



Project Location



Legend

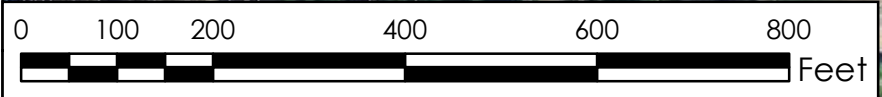
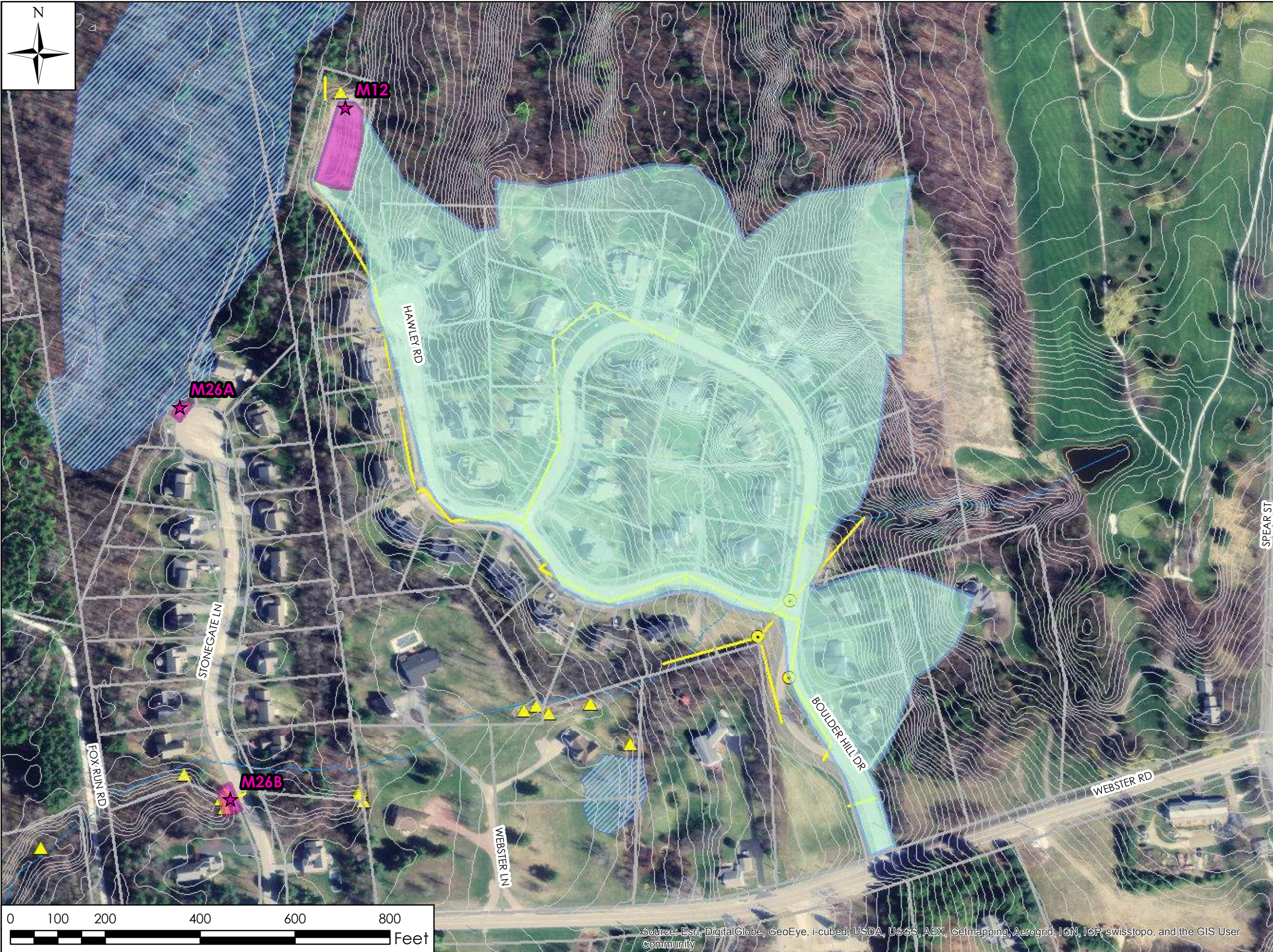
- Munroe Brook Watershed
- Proposed BMP
- Practice Area
- BMP Drainage Area
- Contours (2')
- Tax Parcel Boundary
- Munroe Brook
- Outfalls
- Catch Basins
- Manholes
- Stormline
- VT Significant Wetland
- Stream

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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**M12 - Boulder Hill Drive
Shelburne, VT**

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

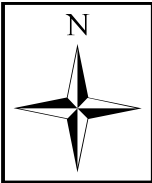


Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

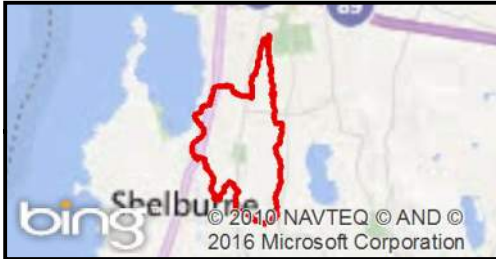
ID#: M16		
Name: South Pointe		
Permit #: 3443-INDS M1		
Concept Description: Retrofit Outlet Structure		
Notes/Feasibility: While designed to 2002 standards, there was benefit to retrofitting the outlet structure		
GENERAL SITE INFORMATION		RETROFIT DETAILS
Site Contact Info: South Burlington		Project 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 INFORMATION		
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



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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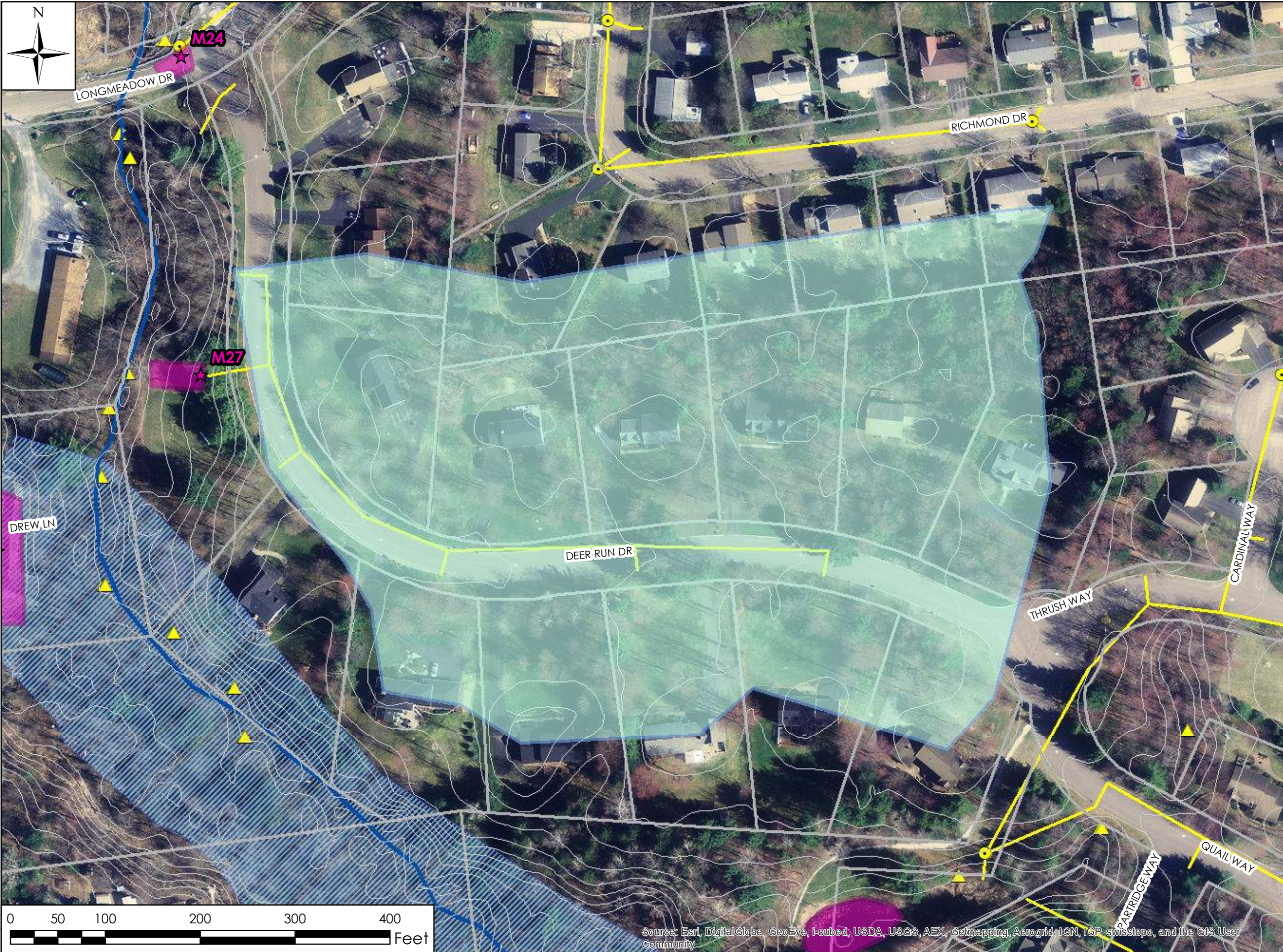
**M16 - South Pointe
Shelburne, VT**

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 INFORMATION		
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



- 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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**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 INFORMATION		
Drainage Area (ac): 4.50		
Impervious Area (ac): 1.32		
Practice Area Available(ft²): 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 INFORMATION		
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



- 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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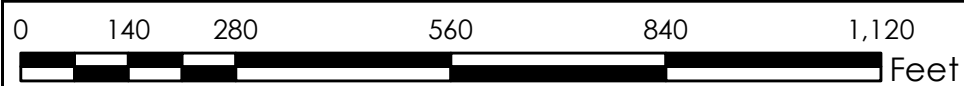
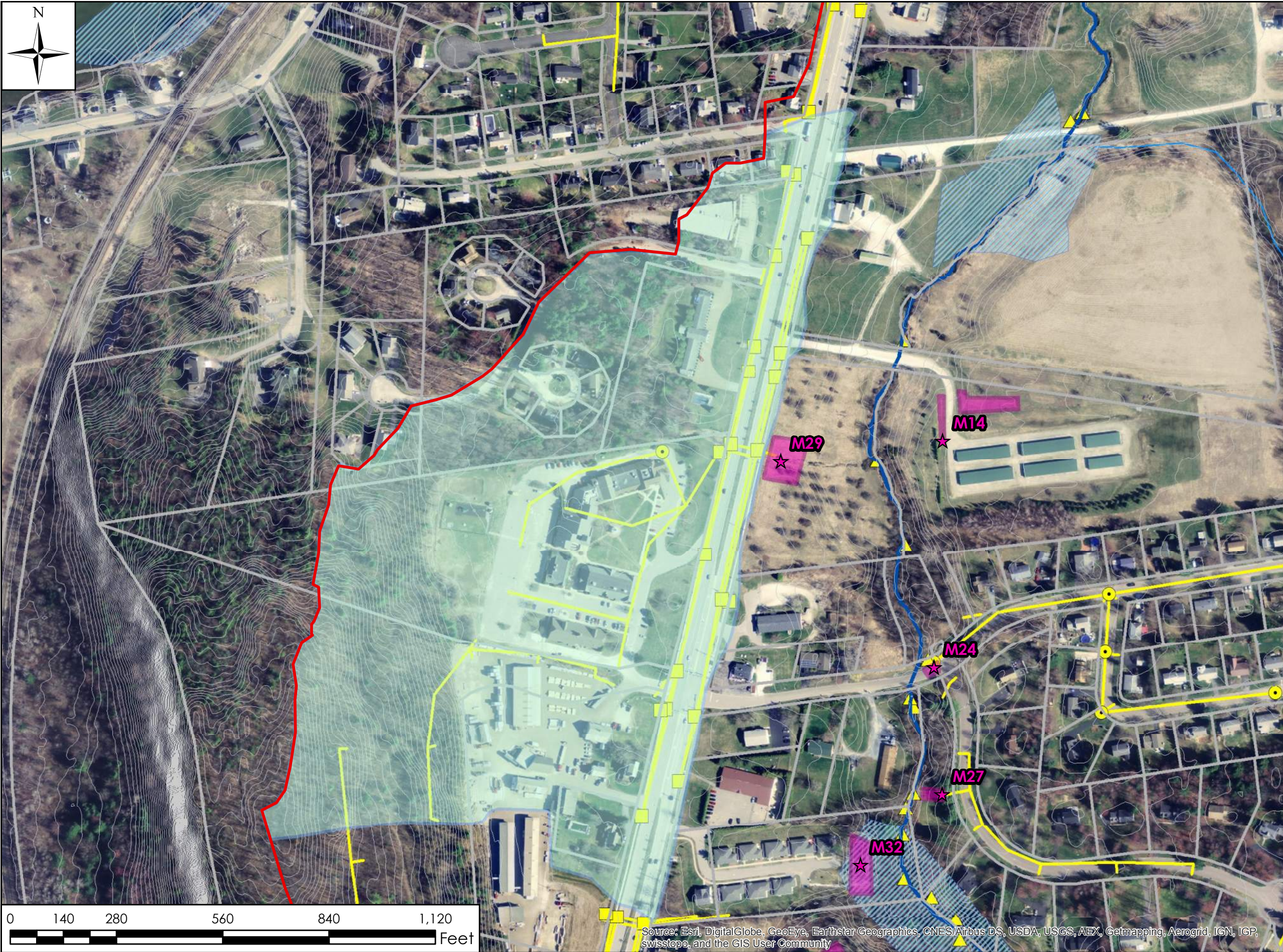
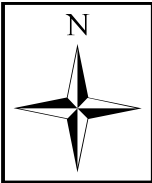
**M28 A & M28 B
Shelburne Camping Area
Shelburne, VT**

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

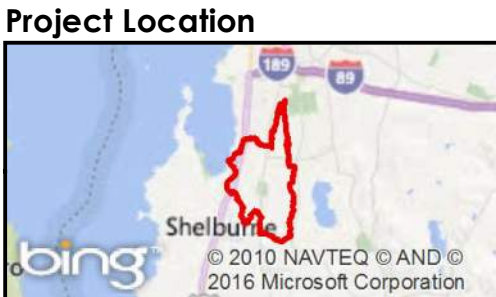
ID#: M29 Option 1		
Name: Shelburne Commons/Rice Lumber		
Permit #: N/A		
Concept Description: Construct new wet pond to capture existing impervious from unpermitted site as well as Route 7		
Notes/Feasibility: Good candidate for collecting Rt. 7 runoff, significant head available.		
GENERAL SITE INFORMATION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



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community




- 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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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	Conflicts: Soils: No Access: Yes Land Use: No Utilities: No High WT: Unknown Wetlands: No Demo: No Other: N/A
Soils: B		
SIZING INFORMATION		
Drainage Area (ac): 19.70		
Impervious Area (ac): 4.40		
Practice Area Available(ft²): 7700		
Existing Head Available? >5'		

Date Assessed: 10/29/2014

Assessed by: AGM/LMJ



- 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

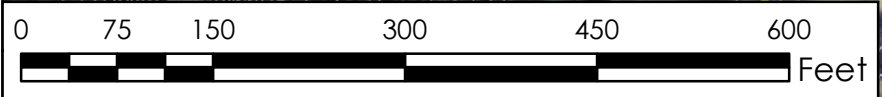
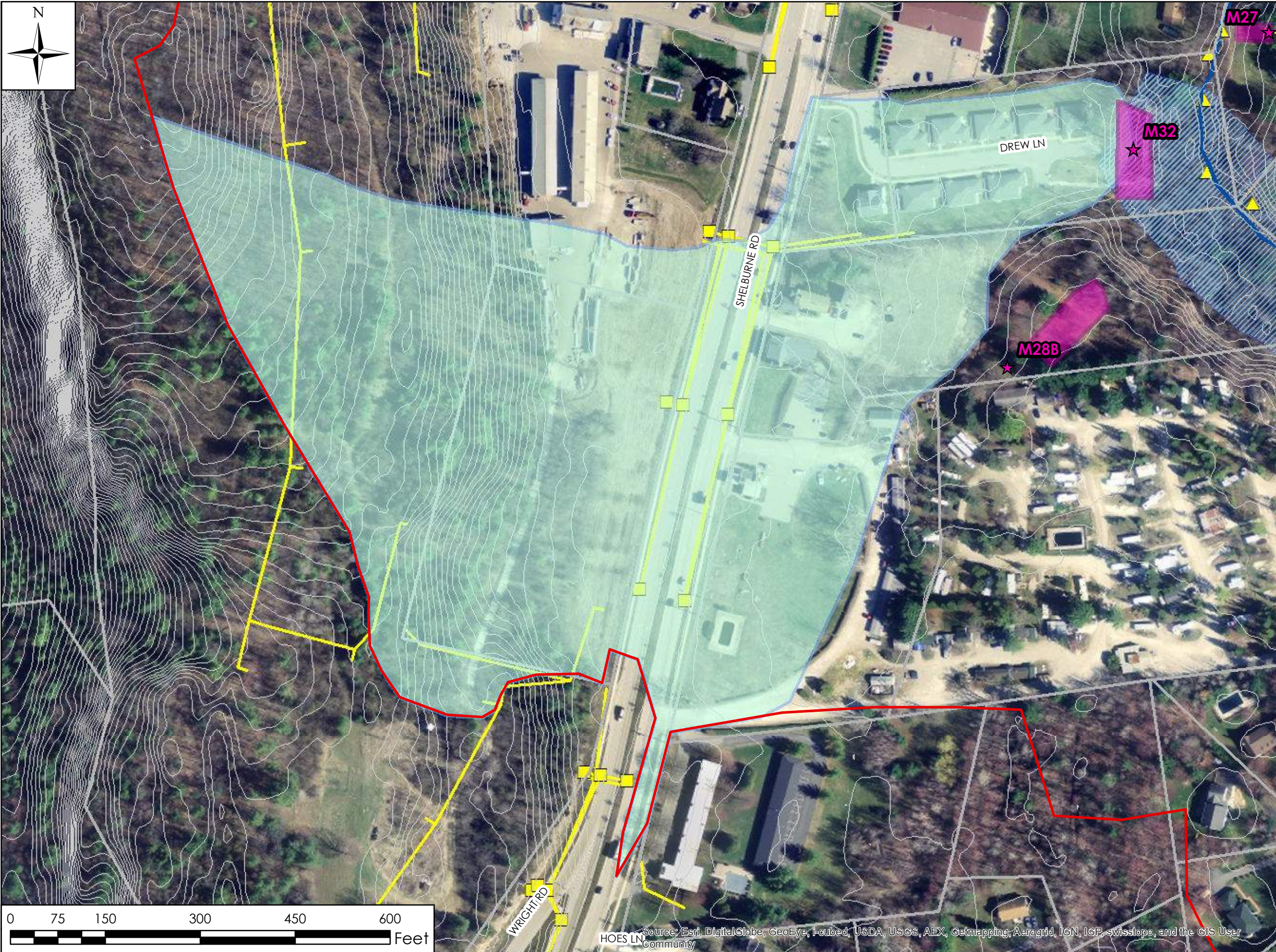
Notes

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

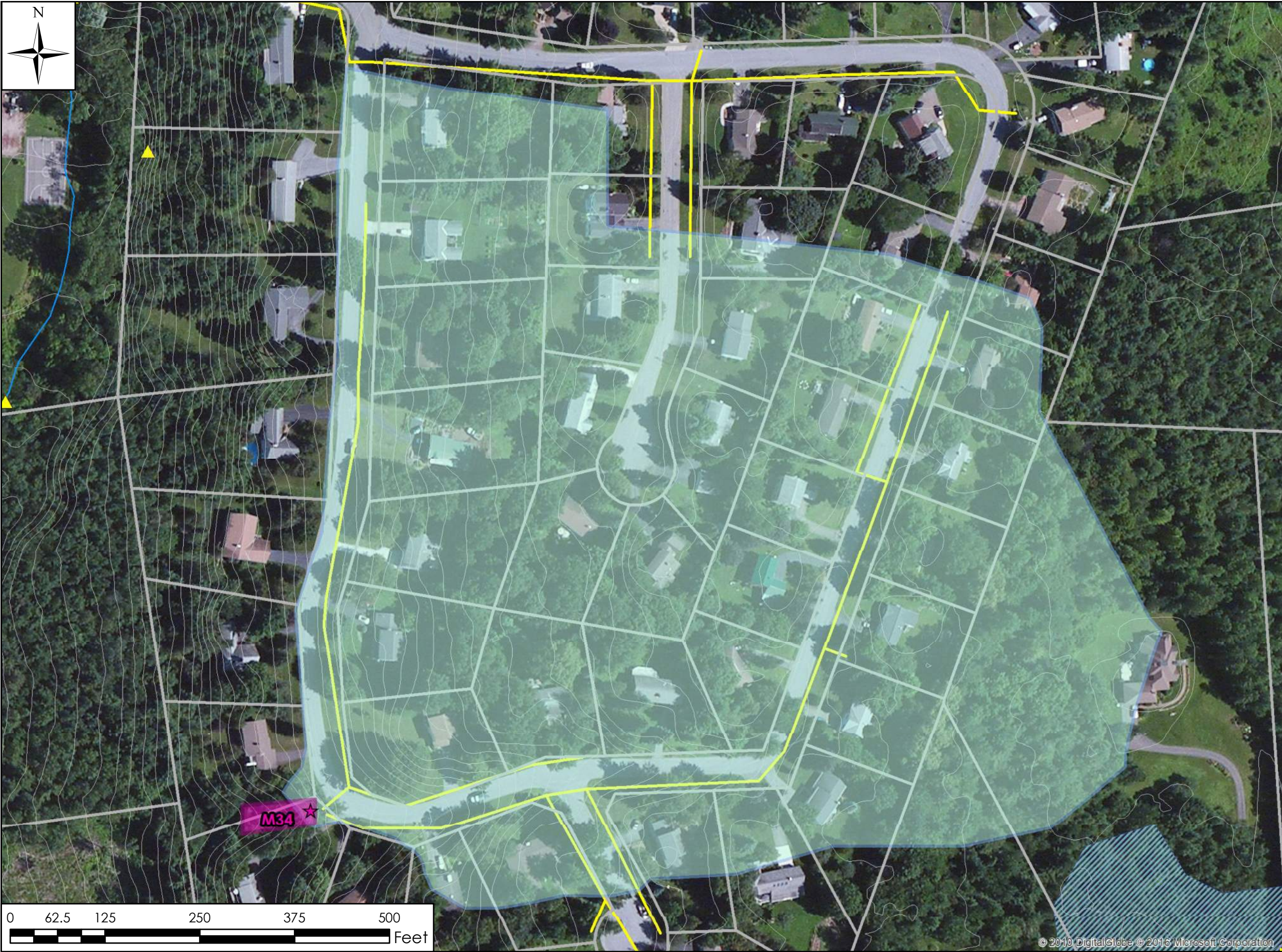
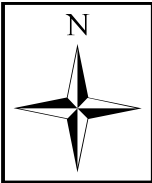


Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community


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 INFORMATION		
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

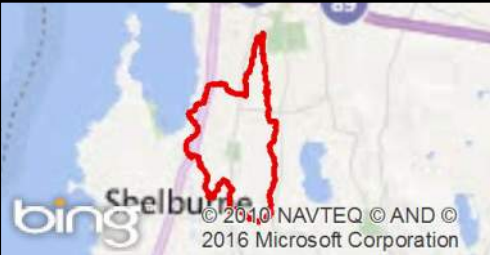
Assessed by: AGM/LMJ
















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Sustainable Environmental Solutions
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Tel: 508-833-6800 • Fax: 508-833-3150 • www.horsleywitten.com



**TRUDELL**
Consulting Engineers
802.879.6331 www.tcevt.com

Project Location

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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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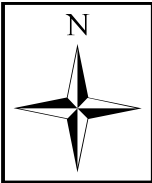
**M34 - Hullcrest South
Shelburne, VT**

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 relief for discharge from the practice.		
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		<div>Benefits:</div> <div>Storage: Yes</div> <div>Water Quality: Yes</div> <div>Recharge: No</div> <div>Repair: No</div> <div>Other: N/A</div> <div>Conflicts:</div> <div>Soils: No</div> <div>Access: No</div> <div>Land Use:</div> <div>Utilities: No</div> <div>High WT: Unknown</div> <div>Wetlands: No</div> <div>Demo: No</div> <div>Other: N/A</div>
Soils: C		
SIZING INFORMATION		
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




Horsley Witten Group
Sustainable Environmental Solutions
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Project Location

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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

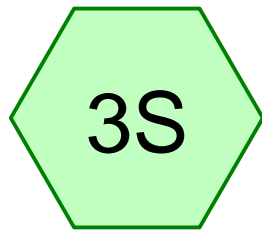
Notes

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).

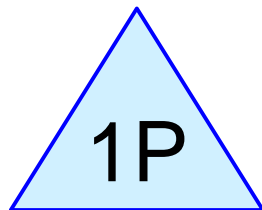
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M35 - Morse Drive
Shelburne, VT
Project: 14-042
Prepared By: ALD
09/14/2016
1 inch = 200 feet

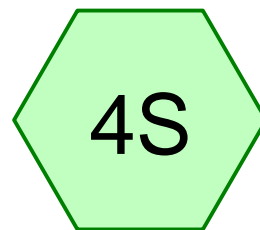
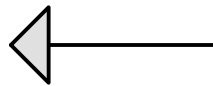
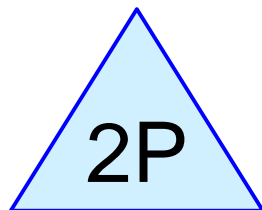
Appendix B: HydroCAD Model Outputs



DA 1 (from GIS)

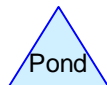
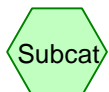


Pond 1



Pond 2

DA 2 (from GIS)



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

M01-02 - Westview Estates Rev 2016 0401

Type II 24-hr 1 year Rainfall=2.10"

Prepared by TCE

Printed 9/12/2016

HydroCAD® 10.00-12 s/n 02145 © 2014 HydroCAD Software Solutions LLC

Page 3

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)

M01-02 - Westview Estates Rev 2016 0401

Type II 24-hr 1 year Rainfall=2.10"

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Page 4

Plug-Flow detention time= 2,330.0 min calculated for 0.442 af (79% of inflow)

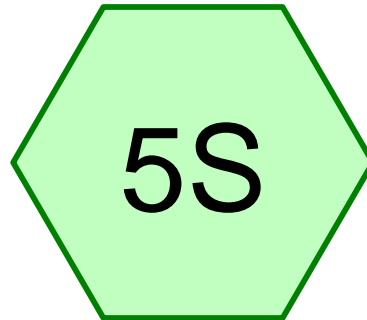
Center-of-Mass det. time= 1,474.1 min (3,000.7 - 1,526.6)

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

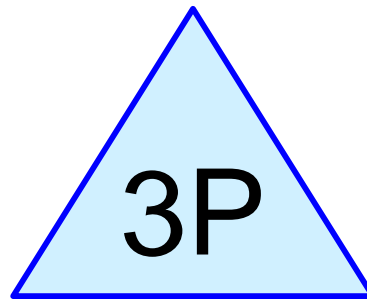
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
255.00	1,307	0	0
256.00	1,525	1,416	1,416
257.00	3,500	2,513	3,929
257.50	4,000	1,875	5,804
258.00	4,500	2,125	7,929
258.50	5,000	2,375	10,304
259.00	5,500	2,625	12,929
259.50	6,000	2,875	15,804
260.00	6,500	3,125	18,929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

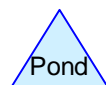
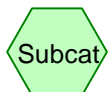
Primary OutFlow Max=0.10 cfs @ 25.80 hrs HW=260.07' (Free Discharge)↑ **1=Orifice/Grate** (Orifice Controls 0.10 cfs @ 8.43 fps)**Secondary OutFlow** Max=0.00 cfs @ 0.00 hrs HW=257.00' (Free Discharge)↑ **2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)



Area B (GIS)



Pond 2 (from map)



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

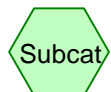
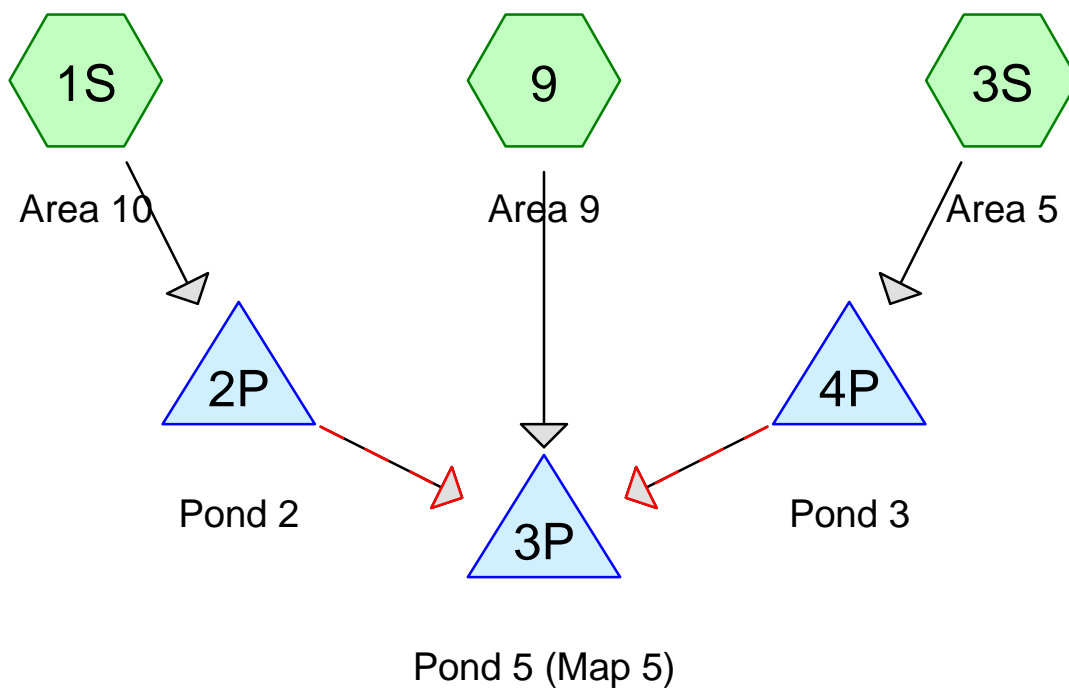
Device	Routing	Invert	Outlet Devices
#1	Primary	167.00'	24.0" Round Culvert L= 35.0' Ke= 0.500 Inlet / Outlet Invert= 167.00' / 166.50' S= 0.0143 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 3.14 sf
#2	Device 1	167.00'	1.0" Vert. Orifice/Grate C= 0.600
#3	Device 1	171.00'	24.0" Horiz. overflow 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)

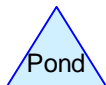
↑ **4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)



Subcat



Reach



Pond



Link

Routing Diagram for M05 - 1-1155C rev 2016 0401
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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

[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

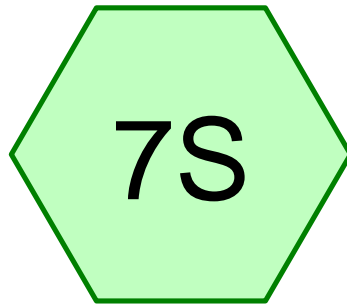
Device	Routing	Invert	Outlet Devices
#1	Primary	384.50'	18.0" Round Culvert L= 40.0' Ke= 0.500 Inlet / Outlet Invert= 384.50' / 383.00' S= 0.0375 ' /' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 1.77 sf
#2	Device 1	384.50'	2.0" Vert. Orifice/Grate C= 0.600
#3	Secondary	387.50'	12.6' long x 1.5' breadth 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)

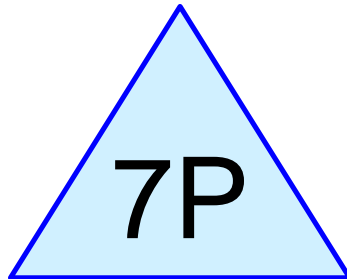
↑ **1=Culvert** (Passes 0.13 cfs of 8.26 cfs potential flow)
 ↑ **2=Orifice/Grate** (Orifice Controls 0.13 cfs @ 6.10 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=384.50' TW=383.00' (Dynamic Tailwater)

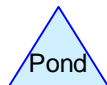
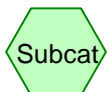
↑ **3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)
 ↑ **4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)



Updated DA



Modified Pond



Routing Diagram for M8 - Route 7 - Updated

Prepared by TCE, Printed 9/12/2016

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M8 - Route 7 - Updated

Prepared by TCE

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Type II 24-hr 1 year Rainfall=2.10"

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Page 2

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) 100.00'W x 130.00'L x 5.00'H Prismaoid 1.492 af Overall x 90.0% Voids
#2	145.10'	1.343 af	
		3.648 af	
			Total Available Storage

M8 - Route 7 - Updated

Type II 24-hr 1 year Rainfall=2.10"

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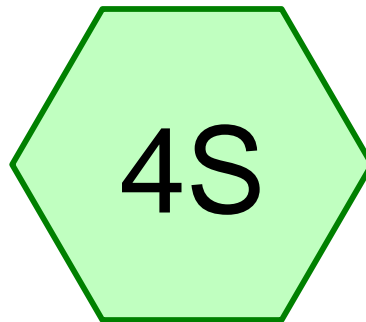
Page 3

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

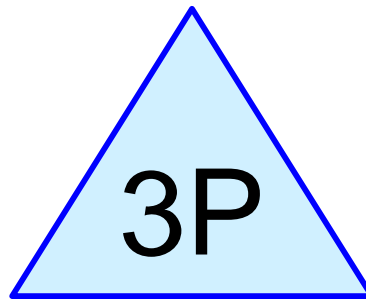
Device	Routing	Invert	Outlet Devices
#1	Primary	145.10'	30.0" Round Culvert L= 128.0' Ke= 0.500 Inlet / Outlet Invert= 145.10' / 143.82' S= 0.0100 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 4.91 sf
#2	Device 1	146.24'	3.0" Vert. Orifice/Grate C= 0.600
#3	Device 1	148.40'	3.0" Vert. Orifice/Grate 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)

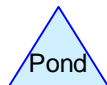
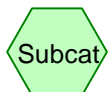
- ↑ **1=Culvert** (Passes 12.76 cfs of 49.17 cfs potential flow)
- ↑ **2=Orifice/Grate** (Orifice Controls 0.49 cfs @ 10.00 fps)
- ↑ **3=Orifice/Grate** (Orifice Controls 0.35 cfs @ 7.07 fps)
- ↑ **4=Orifice/Grate** (Weir Controls 11.92 cfs @ 2.16 fps)



Auto Spa



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

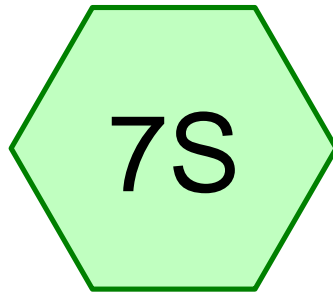
Head (feet)	0.20	0.40	0.60	0.80	1.00	1.20	1.40	1.60	1.80	2.00
	2.50	3.00	3.50	4.00	4.50	5.00	5.50			
Coef. (English)	2.38	2.54	2.69	2.68	2.67	2.67	2.65	2.66	2.66	2.68
	2.72	2.73	2.76	2.79	2.88	3.07	3.32			

Primary OutFlow Max=0.06 cfs @ 24.31 hrs HW=142.95' (Free Discharge)

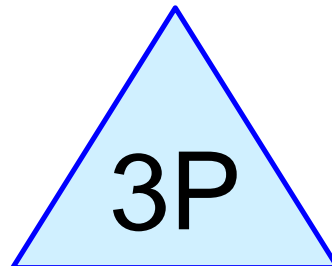
- ↑ **1=Culvert** (Passes 0.06 cfs of 5.28 cfs potential flow)
 - ↑ **2=Orifice/Grate** (Orifice Controls 0.06 cfs @ 7.46 fps)
 - ↑ **3=Orifice/Grate** (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=140.50' (Free Discharge)

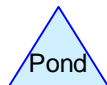
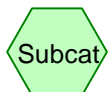
- ↑ **4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)



DA (TCE GIS)



South Pond



Routing Diagram for M10 - Shelb Mead So Pond (A) Rev 2016 0224

Prepared by TCE, Printed 9/12/2016

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M10 - Shelb Mead So Pond (A) Rev 2016 0224

Type II 24-hr 1 year Rainfall=2.10"

Prepared by TCE

Printed 9/12/2016

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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

M10 - Shelb Mead So Pond (A) Rev 2016 0224*Type II 24-hr 1 year Rainfall=2.10"*

Prepared by TCE

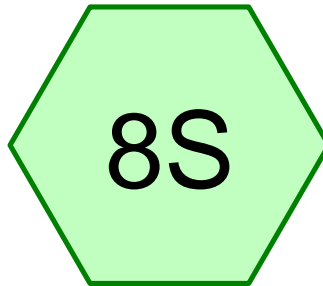
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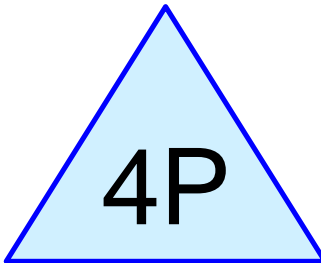
Page 3

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

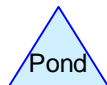
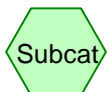
Primary OutFlow Max=0.18 cfs @ 23.33 hrs HW=153.72' (Free Discharge)↑ **1=Culvert** (Passes 0.18 cfs of 23.06 cfs potential flow)↑ **2=Orifice** (Orifice Controls 0.18 cfs @ 9.19 fps)↑ **3=Grate** (Controls 0.00 cfs)



North Pond (TCE GIS)



North Pond



Routing Diagram for M11 - Shelb Mead No Pond Rev 2016 0224

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M11 - Shelb Mead No Pond Rev 2016 0224

Type II 24-hr 1 year Rainfall=2.10"

Prepared by TCE

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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

M11 - Shelb Mead No Pond Rev 2016 0224

Type II 24-hr 1 year Rainfall=2.10"

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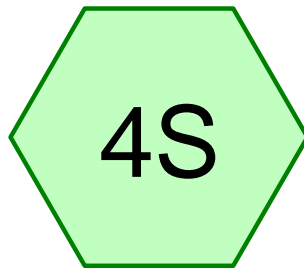
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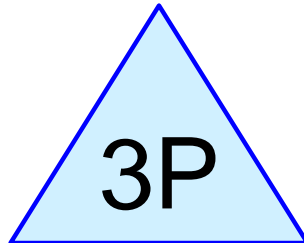
Page 3

Primary OutFlow Max=0.04 cfs @ 24.18 hrs HW=158.85' (Free Discharge)

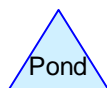
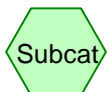
- ↑ **1=Culvert** (Passes 0.04 cfs of 19.86 cfs potential flow)
- ↑ **2=Orifice/Grate** (Orifice Controls 0.04 cfs @ 6.91 fps)
- ↑ **3=Orifice/Grate** (Controls 0.00 cfs)



Boulder Hill



Pond



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)

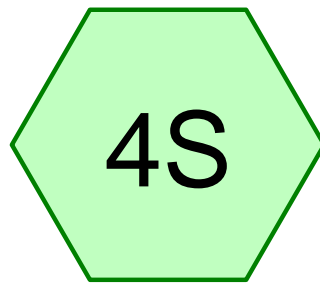
↑ **1=Culvert** (Passes 0.05 cfs of 29.08 cfs potential flow)

↑ **2=Orifice** (Orifice Controls 0.05 cfs @ 9.81 fps)

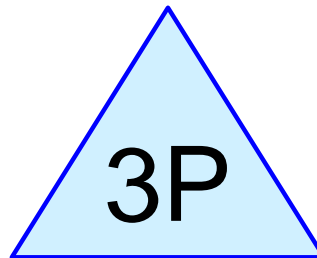
↑ **3=Grate** (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 5.00 hrs HW=193.00' (Free Discharge)

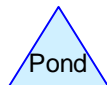
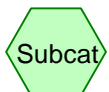
↑ **4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)



002



Pond 2 (from site plans)



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)

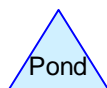
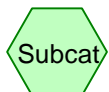
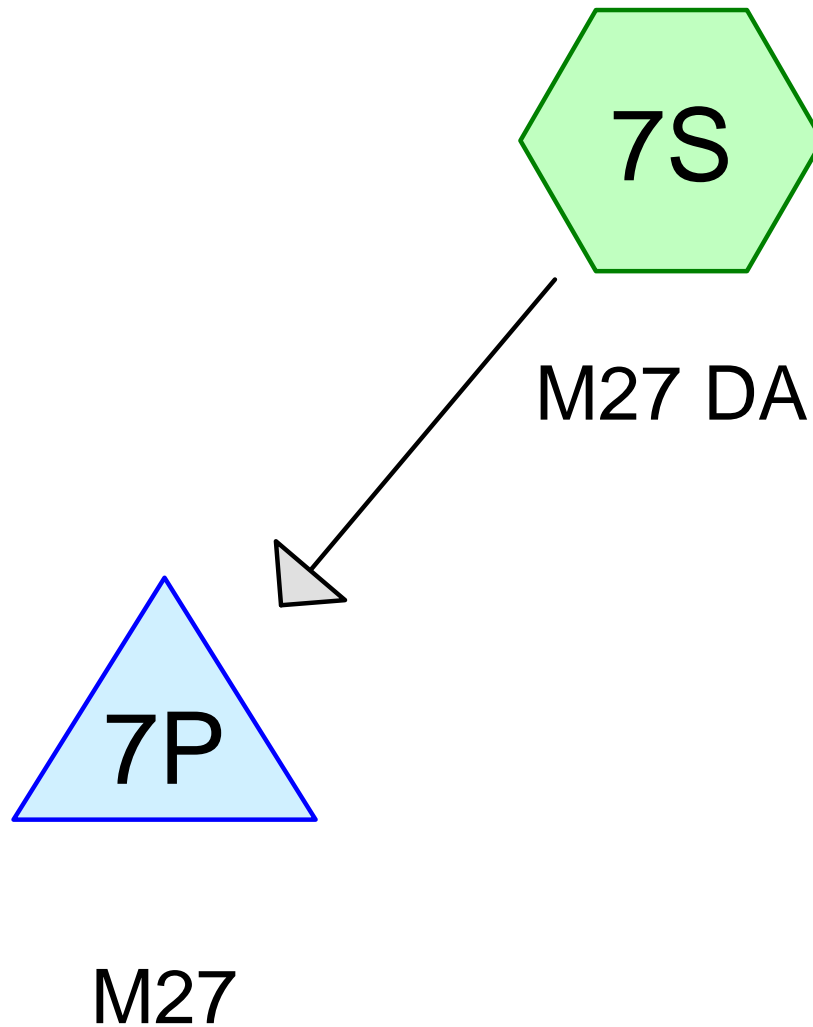
Volume	Invert	Avail.Storage	Storage Description
#1	369.50'	0.585 af	Custom Stage Data (Prismatic) Listed below (Recalc)

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)



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

M27- Deer Run Rev 2016 0225*Type II 24-hr 1 year Rainfall=2.10"*

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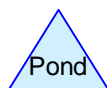
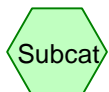
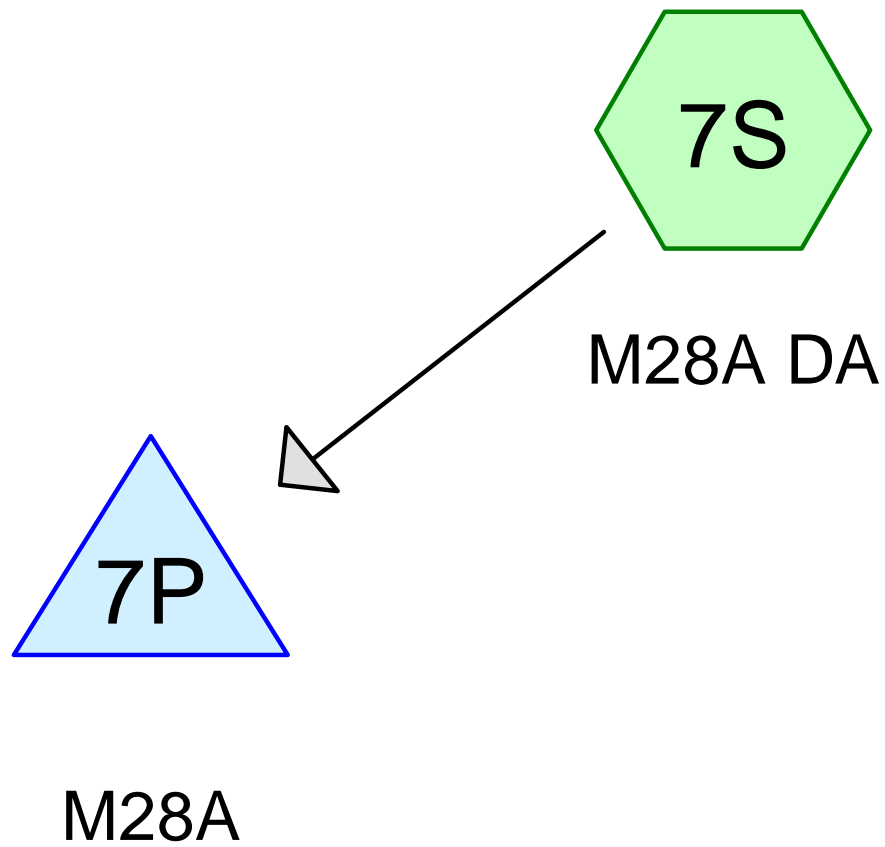
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Device	Routing	Invert	Outlet Devices
#1	Primary	154.00'	24.0" Round Culvert L= 173.0' Ke= 0.500 Inlet / Outlet Invert= 154.00' / 52.00' S= 0.5896 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 3.14 sf
#2	Device 1	157.50'	1.3" Vert. Orifice/Grate 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)



M28A - Shelb Camping Rev 2016 0225

Type II 24-hr 1 year Rainfall=2.10"

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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

M28A - Shelb Camping Rev 2016 0225

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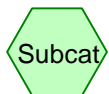
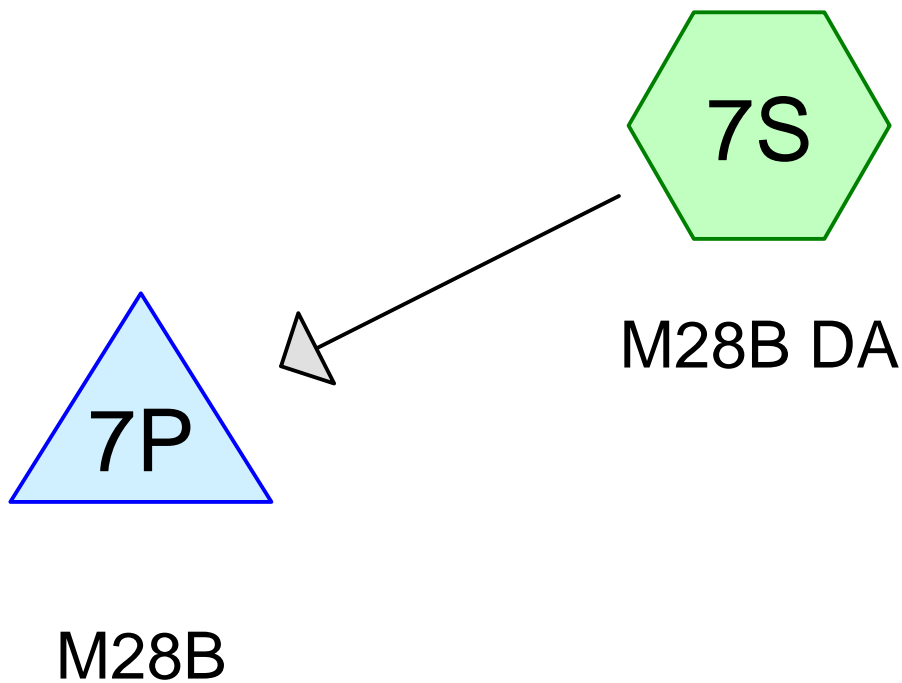
Type II 24-hr 1 year Rainfall=2.10"

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Primary OutFlow Max=0.11 cfs @ 16.02 hrs HW=174.02' (Free Discharge)

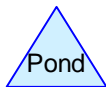
- ↑ 1=Culvert (Passes 0.11 cfs of 33.89 cfs potential flow)
- ↑ 2=Orifice/Grate (Orifice Controls 0.04 cfs @ 6.77 fps)
- ↑ 3=Orifice/Grate (Weir Controls 0.06 cfs @ 0.47 fps)



Subcat



Reach



Pond



Link

Routing Diagram for M28B - Shelb Camping Rev 2016 0225

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M28B - Shelb Camping Rev 2016 0225

Type II 24-hr 1 year Rainfall=2.10"

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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

M28B - Shelb Camping Rev 2016 0225*Type II 24-hr 1 year Rainfall=2.10"*

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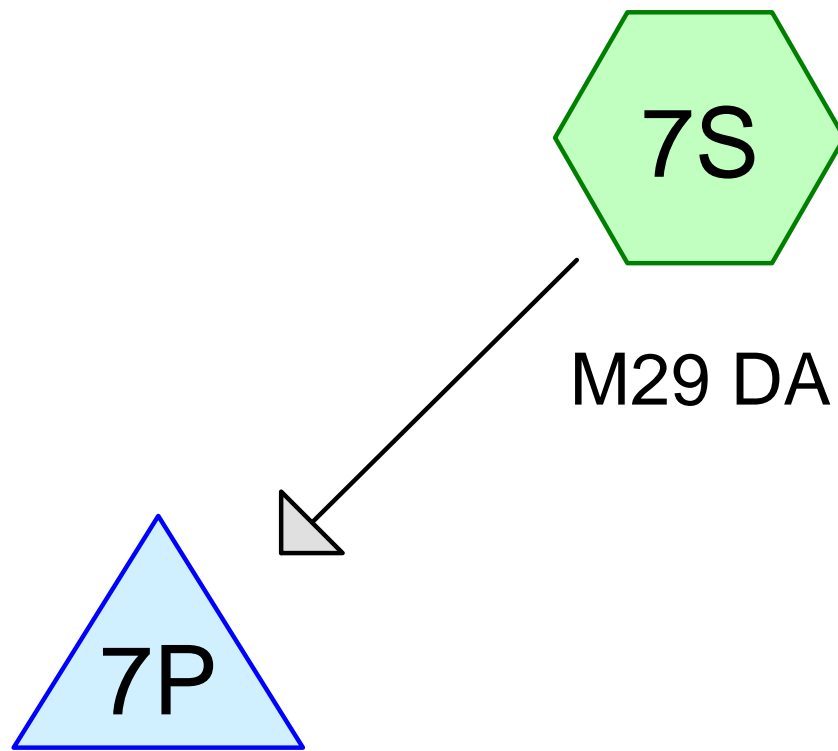
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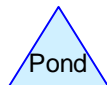
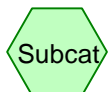
Device	Routing	Invert	Outlet Devices
#1	Primary	167.00'	24.0" Round Culvert L= 116.0' Ke= 0.500 Inlet / Outlet Invert= 167.00' / 166.00' S= 0.0086 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf
#2	Device 1	171.00'	1.5" Vert. Orifice/Grate C= 0.600
#3	Device 1	173.00'	24.0"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



M29 Option 2



Routing Diagram for M29 Option 1 - Shelb Comms-Rice Rev 2016 0225

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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

M29 Option 1 - Shelb Comms-Rice Rev 2016 0225*Type II 24-hr 1 year Rainfall=2.10"*

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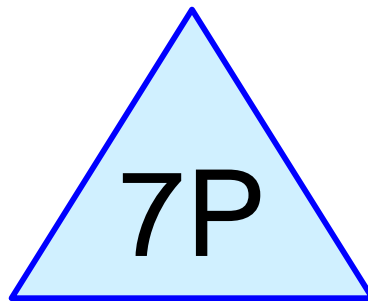
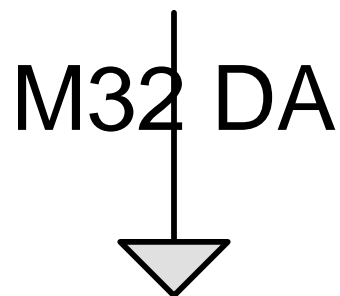
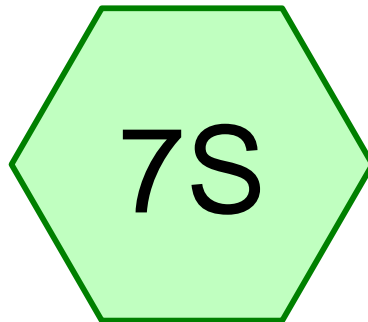
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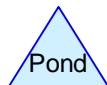
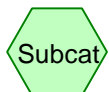
Device	Routing	Invert	Outlet Devices
#1	Primary	159.00'	24.0" Round Culvert L= 100.0' Ke= 0.500 Inlet / Outlet Invert= 159.00' / 154.00' S= 0.0500 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf
#2	Device 1	163.00'	3.0" Vert. Orifice/Grate C= 0.600
#3	Device 1	165.00'	24.0"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



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

M32- Drew Lane Rev 2016 0225*Type II 24-hr 1 year Rainfall=2.10"*

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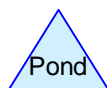
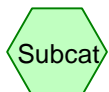
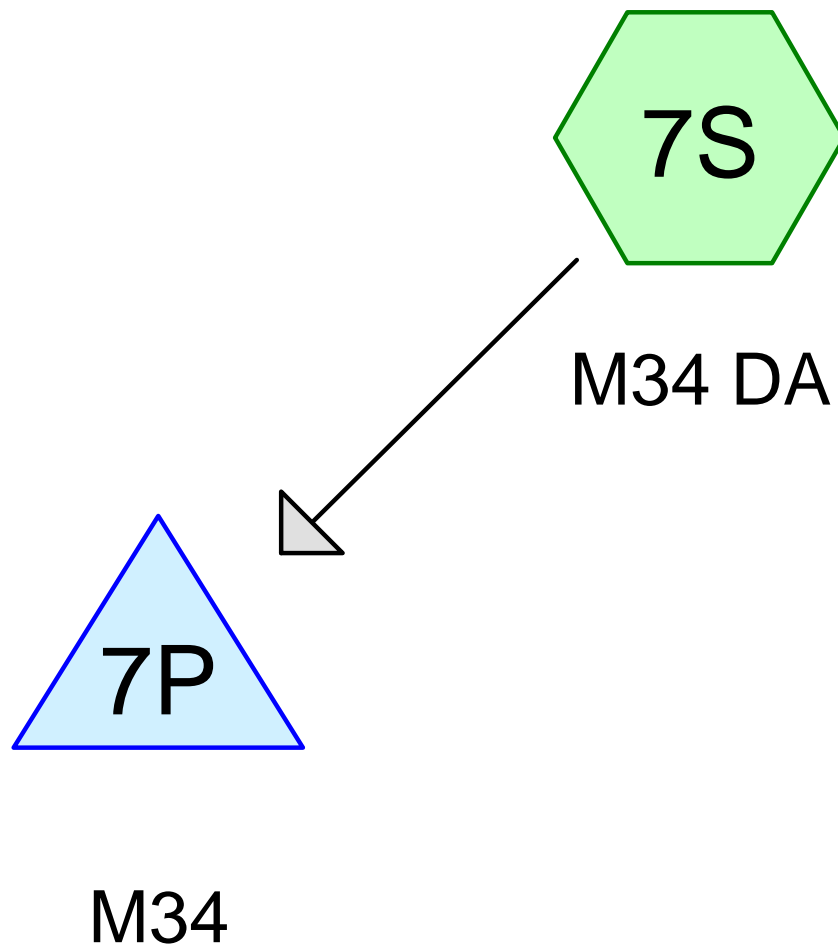
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Device	Routing	Invert	Outlet Devices
#1	Primary	157.00'	24.0" Round Culvert L= 173.0' Ke= 0.500 Inlet / Outlet Invert= 157.00' / 55.00' S= 0.5896 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 3.14 sf
#2	Device 1	161.00'	1.7" Vert. Orifice/Grate 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)



M34 - Hullcrest South - Rev 2016 0225

Type II 24-hr 1 year Rainfall=2.10"

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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

M34 - Hullcrest South - Rev 2016 0225*Type II 24-hr 1 year Rainfall=2.10"*

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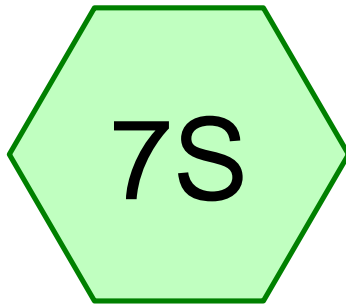
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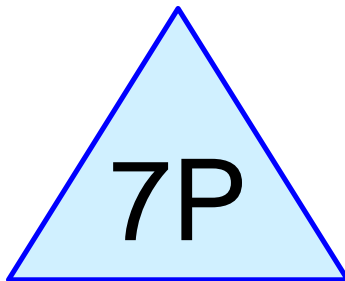
Device	Routing	Invert	Outlet Devices
#1	Primary	191.00'	24.0" Round Culvert L= 30.0' Ke= 0.500 Inlet / Outlet Invert= 191.00' / 186.00' S= 0.1667 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf
#2	Device 1	194.50'	2.6" Vert. Orifice/Grate C= 0.600
#3	Device 1	197.00'	24.0" Horiz.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

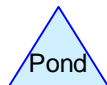
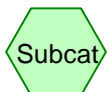
- ↑ **1=Culvert** (Passes 0.27 cfs of 33.45 cfs potential flow)
- ↑ **2=Orifice/Grate** (Orifice Controls 0.27 cfs @ 7.27 fps)
- ↑ **3=Orifice/Grate** (Controls 0.00 cfs)



M35 DA



M35



Routing Diagram for M35- Morse Drive Rev 2016 0225

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M35- Morse Drive Rev 2016 0225

Type II 24-hr 1 year Rainfall=2.10"

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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.
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Fairfax, VA 22030
Telephone (703) 385-6000
Fax (703) 385-6007
Water Resources Group

MEMORANDUM

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.

$$\text{Total Cost} = \text{Installation Cost [I]} + \text{Land Cost [L]} + \text{Fixed Cost [F]}$$

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:

$$\text{Cost} = \text{I} * \text{Detention Volume (ft}^3\text{)} + \text{Detention Surface Area (acre)} * \text{L} + \text{F}$$

I = \$5 per ft³ 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)

Infiltration BMP:

$$\text{Cost} = \text{I} * \text{BMP volume (ft}^3\text{)} + \text{F}$$

I = \$6 per ft³, 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.

M35- Morse Drive Rev 2016 0225*Type II 24-hr 1 year Rainfall=2.10"*

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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)