Rugg Brook
Flow Restoration Plan

MS4 GENERAL PERMIT REQUIREMENT (IV.C.1)

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I. Disclaimer

The intent of this plan is to present the data collected, evaluations, analysis, designs, and cost estimates for the Rugg Brook Flow Restoration Plan (FRP) Project, completed under a contract between the Northwest Regional Planning Commission and the hired consultant team, Watershed Consulting Associates, LLC and Aldrich & Elliott, PC. The Rugg Brook FRP was prepared to meet the compliance requirement for the Rugg Brook impervious surface owners—the Town of St. Albans, City of St. Albans, and the Vermont Agency of Transportation (VTRANS) under the National Pollutant Discharge Elimination System (NPDES) General Permit 3-9014 (VTDEC 2012) for stormwater discharges to impaired waters. The presented plan is in draft form, and will be revised by the MS4 partners, as needed. **At this time, the MS4s are not bound in any way to the proposed BMP list.**

1 Executive Summary

Watershed Consulting Associates, LLC, and partners Aldrich and Elliott, PC (A+E) were commissioned to develop the following Flow Restoration Plan (FRP) for the Rugg Brook watershed under contract with the Northwest Regional Planning Commission (NWRPC), in partnership with the Town of St. Albans, the City of S. Albans, and the Vermont Department of Transportation (VTRANS). The plan was developed in accordance with the MS4 General Permit #3-9014 Subpart IV.C.1 as a part of the participating MS4's Stormwater Management Program (SWMP). The purpose of the FRP is to provide a planning tool for the MS4 entities to implement stormwater BMP's over a twenty (20) year timeframe, in the effort to return Rugg Brook to its attainment condition.

As a part of the FRP development, an assessment was completed to determine to what extent current stormwater controls have reduced high flows (flows occurring less than 0.3% of the time, equivalent to greater than the 1-year design storm) from the pre 2002 condition, as required by the Rugg Brook Total Maximum Daily Load (TMDL) for stormwater. The Vermont Best Management Practice Decision Support System (BMPDSS) model, a GIS-based hydrologic model used to assess the impact of various stormwater Best Management Practice (BMP) scenarios, was used for the assessment. The BMPDSS estimated **45%** of the high-flow target was met with existing BMPs designed to meet the Vermont 2002 Stormwater Design Standards, when compared to the condition before 2002. Therefore, additional BMPs are required to meet 100% of the actionable flow target.

In addition to the identification of stormwater controls, the Total Maximum Daily Load (TMDL) flow targets and future growth assumption developed by the Vermont (VT) Department of Environmental Conservation (DEC) was reviewed in the context of the FRP development. Specifically, the expected non-jurisdictional impervious area growth in the Rugg Brook watershed over the next 20 years was determined using a GIS analysis. An assumed 15 acres of non-jurisdictional impervious growth was used to develop the original TMDL future growth factor. A new estimate of 4.54 acres was estimated based on the actual non-jurisdictional growth rate from 2003 to 2014. The revised future growth reduced the high-flow target (Q0.3%) from 16.0% to **15.30%[1].** The modified flow target was incorporated into the FRP planning process and assessment of the proposed BMP implementation scenario.

Development of the FRP involved field inspection of all existing BMPs with an expired stormwater permit, followed by review and revision of the existing BMPDSS model scenarios. Several revisions to existing BMP drainage areas and BMP design configurations were identified during field inspection and accounted for in the revised models. After the existing model scenarios were reviewed, new BMPs were identified, inspected, and assessed in the BMPDSS.

The final evaluated BMP list includes 31 projects—nine(9) retrofits to existing ponds with expired permits, five(5) new detention practices in the Town, one (1) new infiltration basin in the Town,

[1] See Table 1: The Modified target was calculates as: -(15.0%) + (-1.0%)*(4.54 ac/15 ac) = -15.30%

four(4) new underground infiltration systems along Route 7 in the City, four (4) new detention practices to mitigate runoff from primarily VTRANS owned impervious, and eight(8) new sand filters in the I-89 median. The proposed BMPs were assessed with the BMPDSS model, and determined to provide a –17.46% reduction in the high-flow which addresses **114%** of the TMDL high-flow target (Q0.3%), through reduction of runoff from the 1-year design storm. While not an actionable target, the low-flow (baseflow) was estimated to increase by 9% over the existing condition, however the low-flow in the proposed scenario was still below the pre 2002 condition. The percent target mitigated by each project and cumulative percent addressed, was determined for the projects and determined that all but one of the 31 projects are required to meet 100% of the TMDL high-flow target. The planning level cost for implementation of the FRP is **$3,416,540.** Preliminary 30% engineering plans were developed for the new projects with planning level cost estimates.

A comprehensive ranking matrix was developed to prioritize the proposed projects based on a multitude of criteria including considerations for the cost, design, aesthetics, and other project benefits and constraints. The ranking is a tool for the MS4's to use as they prioritize projects with available financial resources. The prioritization was also used to develop a Design and Construction Schedule (D&C), for implementation of the plan over a 20 year time frame.

2 Background

Rugg Brook, is currently on the State of Vermont's impaired waters (EPA 303(d)) list, determined to be primarily a result of stormwater runoff. In the effort to restore Rugg Brook and lift its impaired designation, a flow-based Total Maximum Daily Load (TMDL) was developed for Rugg Brook, which outlines required reductions in stormwater high flows and increase in baseflow. The flow targets are the basis for the Flow Restoration Plan (FRP), developed in accordance with the MS4 General Permit Subpart IV.C.1 as a required part of the MS4s Stormwater Management Program (SWMP).

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

Each MS4 is required to prepare an FRP for impaired waters. The three MS4's contributing impervious cover runoff to Rugg Brook, including the Town St. Albans, City of St. Albans, and VTRANS agreed to prepare a joint FRP for the watershed, with consideration of the individual MS4s flow-target allocation based on impervious ownership.

2.1 TMDL Flow Targets

Vermont developed TMDLs for impaired watersheds using flow as a surrogate for pollutant loading. The basis for the TMDL development was the comparison of modeled Flow Duration Curves (FDCs) between impaired and attainment watersheds. The Program for Predicting Polluting Particles Passage through Pits, Puddles, and Ponds, Urban Catchment Model (P8) was used to model gauged and ungauged watersheds in Vermont and develop Flow Duration Curves (FDC) from which a normalized high flow and low flow per drainage area in square miles (cfs/sqmi) were extracted. An FDC is a curve displaying the percentage of time during a period that flow exceeds a certain value, with the “low” flow represented by the 95th percentile ($Q_{95\%}$) of the curve and the “high” flow represented by the 5th percentile ($Q_{0.3\%}$). The high and low flow values from the FDCs were then compared between “impaired” watersheds and comparable “attainment” watersheds to determine a percent change (i.e. reduction of high flow, increase of low flow). The percent change was reported in the EPA approved TMDL for each impaired watershed. The high-flow ($Q_{0.3\%}$) was determined to be relatively equivalent to the 1-year Design storm flow, therefore BMPs designed to the Channel Protection volume (CP_v) Storage standard address the high-flow reduction target.

2.1.1 Future Growth Modified Target:

The VT DEC added a future growth factor to the TMDL flow targets to account for future non-jurisdictional impervious growth. Non-jurisdictional growth is by definition impervious area that does not require a stormwater permit and is not managed by a stormwater BMP. Therefore this type of growth is important to account for within the 20 year stormwater management plan. VT DEC estimated a future growth of 15 acres based on local development and projected growth. A GIS-based exercise was completed to verify VT DEC’s assumption and to develop a revised estimate for the impervious growth, as well as revised TMDL flow targets.

The revised future growth estimate was determined through a GIS exercise. The impervious cover mapping from 2003, extracted from Quickbird Satellite Imagery, was compared to revised imperious cover mapping from 2014. The 2014 impervious was cut from the 2003 impervious layer to find the net change over 11 years. Impervious within the drainage area of a Post 2002 Stormwater BMP was cut from the layer. The remaining impervious cover was considered the non-jurisdictional growth over 11 years. A growth rate was then calculated using the 2003 and 2014 non-jurisdictional impervious cover areas (below). The revised non-jurisdictional future growth over the next 20 years was estimated to be 4.54 acres versus the VT DEC estimate of 15 acres.

$$\text{Growth Rate} = \left(\left(\frac{Non-Jurisdictional\ Impervious\ ,2014}{Non-Jurisdictional\ Impervious,2003}\right)^{\left(\frac{1}{years}\right)} - 1\right) * 100$$

Modified TMDL flow targets were determined by multiplying the portion of the TMDL target associated with future growth (FG) by a correction factor as follows:

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

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

Table 1: TMDL Flow Restoration Targets

Flow Target	Target High Flow Q 0.3 (± %) **Reduction**	Target Low Flow* Q 95 (± %) **Increase**
TMDL Targets (Stormwater allocation only)	-15.0	16.8
Approved TMDL Targets with **15 acres** of Non-Jurisdictional Future Growth	-16.0	16.8
Modified TMDL Targets with **4.54 acres** of Non-Jurisdictional Future Growth	-15.30	NA
*The low flow target is not actionable under the TMDL, but is included because improving base flow in the watershed is still a water quality goal. NA= Not applicable. No change in low flow TMDL target due to future growth.		

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

2.2 MS4 Allocation of Flow Targets

Allocation of the high-flow flow target by MS4 was approximated based on relative impervious ownership and impervious cover currently managed with a BMP which meets the Channel Protection Volume (CPv) design standard. This includes BMPs which detain the 1-year storm for 12-hours in cold-water fish habitat and 24-hours in warm-water fish habitat. However, there are limitations to this method because the BMPDSS model is an aggregate model, in which upstream BMPs affect downstream flow and runoff doesn't necessarily follow political boundaries. A correction factor was applied based on the flow target to account for the relative error in separation of the BMPDSS results by MS4.

Approximately 71.6% of the impervious cover in the Rugg Brook watershed is within the Town, of St. Albans, 8.2% within the City of S. Albans, and about 20.2% in the VTRANS Right-of-Way (ROW) (Table 2). The TMDL flow targets were then re-allocated to each MS4 based on their impervious ownership, for the original 15 acres of non-jurisdictional growth and modified target with 4.54 acres (Table 3).

Table 2: MS4 Impervious Ownership Breakdown

MS4 Impervious Owner	Total Area w/in Watershed (acres)	Impervious Cover (acres)	% of Watershed Impervious Cover
St. Albans City	70.50	18.54	8.2%
St. Albans Town	1556.69	162.36	71.6%
VTrans	131.83	45.72	20.2%
Watershed Total	**1759.02**	**226.62**	

Table 3: Rugg Brook TMDL Flow Target Allocation by MS4 Impervious Owner

Impervious Owner	Approved TMDL With 15 acres Future Growth		Modified TMDL With 4.54 acres Future Growth	
	Target High Flow **Reduction** (%) [1]	Target Low Flow **Increase** (%) [2]	Target High Flow **Reduction** (%)	Target Low Flow **Increase** (%) [3]
St. Albans City	-1.31	1.37	-1.25%	1.37%
St. Albans Town	-11.46	12.04	-10.96%	12.04%
VTrans	-3.23	3.39	-3.09%	3.39%
Watershed Total	**-16.00**	**16.80**	**-15.30%**	**16.8%**

1- The High Flow target is negative (-), indicating there needs to be a reduction in high flow from the baseline condition. The Low Flow target is positive (+), indicating there needs to be an increase in low flow from the baseline condition.
2 - The low flow target is not actionable under the TMDL, but is included in the summary because improving base flow in the watershed is still a water quality goal.
3- The Low Flow Target was not modified due to future growth

3 BMPDSS Model Assessment

The Vermont DEC worked with an external consultant to develop a VT-specific hydrologic model, the VT BMPDSS, to predict progress toward the TMDL flow targets based on proposed BMP implementation scenarios. The BMPDSS model is used to predict peak flows at the watershed outlet for a base condition (pre 2002), existing condition (Post 2002), and a BMP implementation scenario, all compared on a percent change basis.

In order to complete the assessment, VT DEC developed “Base” condition models for all impaired watersheds. The base scenario includes all stormwater BMPs installed prior to issuance of the VT Stormwater Standards in 2002, and impervious cover extracted from Quickbird high-resolution satellite imagery. A “Post 2002” model scenario was then developed with all existing BMPs designed to the VT Stormwater standards, providing credit toward the flow target. Results from the BMPDSS model output are provided as unadjusted (cfs) and normalized flow (flow per drainage area, cfs/sq.mi). The unadjusted flow is used in the determination of progress towards the TMDL targets to eliminate the effect of watershed area in the percent change comparison.

3.1 Existing Condition Review

3.1.1 Permit Review

As per subpart IV.C.1 of the approved MS4 general permit, all expired stormwater permits in the watershed were acquired and reviewed for inclusion within the BMPDSS model assessment. The expired permits were sorted into two groups- Group 1) existing stormwater systems with a CPv BMP which provides extended detention of the 1-year design storm (Table 4), and Group 2) those without a CPv BMP (ie. system of catchbasins with no outfall management). The Group 1 list was compared to the current BMP list included in the BMPDSS models to check for omissions. Only expired permit systems that include a BMP with CPv storage were included in the BMPDSS model, because only BMPs with CPv storage provide credit toward meeting the flow targets. Field assessments were then completed at each site with an existing CPv detention structure, to determine if the practice was operating according to the approved expired permit and if there was opportunity for an upgrade to the 2002 Vermont Stormwater Design Standards. A full list of expired permits within the Rugg Brook watershed, and a description of their existing stormwater system, and proposed retrofit (if applicable) is included in Appendix 2 (A-2-1).

Table 4: "Group 1" Expired Permit Stormwater BMPs

Permit #	Permittee	MS4 Draining to Practice	Project Name	Associated Permits	BMP Type in Model
1-1428b	Private	VTRANS/ Town	St Albans Milk and Maple		Detention Pond
1-0908	HOA	VTRANS/ Town	Tanglewoods		Detention Pond
1-1563 P1	HOA	VTRANS/ Town	Pineview Estates		Detention Pond
1-1563 P2	HOA	Town	Pineview Estates		Detention Pond
1-1563 P3	HOA	Town	Pineview Estates		Detention Pond
1-1563 P4	HOA	VTRANS/ Town	Pineview Estates		Detention Pond
1-1563 P5	HOA	VTRANS/ Town	Pineview Estates		Detention Pond
2-0291	Town	Town	Collins-Perley Athletic Complex	#5961-9010 upgrades	Detention Pond
1-1428c	Private	VTRANS/ Town	St Albans Milk and Maple		Detention Pond
1-1428a	Private	Town	St Albans Milk and Maple		Detention Pond
1-0930	Private	Town	Church of the Rock		Detention Pond
1-1442	HOA	Town	Sunset Terrace Phase 3		Detention Pond
3567-9010	Private	Town	Barry Callebaut Inc	# 2-0142	Detention Pond

*Prepared by Emily Schelley (VT DEC, Jan. 2014). Revised by WCA (2015)

3.1.2 VTDEC BMPDSS Existing Model Review

Figure 1 WCA Staff inspect existing stormwater swales in the St. Albans

On July 2nd, 2014 as well as August 20th, staff from WCA conducted site visits of permitted sites (Figure 1). A follow up field visit was completed on September 11th 2014. The team field verified the drainage areas and design of the BMPs included in the Base and Post2002 model scenarios and compared the field observations to the DEC model inputs. Updated input files for the Base and Post2002 models were submitted to VT DEC to run the updated model scenarios. Input files included revised GIS shapefiles for subwatersheds, BMP locations, BMP drainage areas, as well as HydroCAD® (Version 10.0) model outputs used to model detention times and peak flows. Each BMP design was then converted to the equivalent system in the BMPDSS model, which has a slightly different interface for defining the BMP design, than HydroCAD®. Adjustments were made to certain BMP designs, if the BMP design in HydroCAD® was not directly transferrable to the BMPDSS format. A full list of existing BMPS in the base and Post2002 model scenarios is included in Appendix 2 (Table A-2-2).

3.1.2.1 Base model (Pre 2002 condition) Revisions

Subwatershed boundaries around the Superior Ceramics pond, permitted under #3410-9010, and the SASH highway were adjusted to reflect field observations.

BMP model entries were adjusted for the following BMPs after comparison between the existing model data and field measurements:

- #1-1428 Ponds 2 and 3: St. Albans Milk and Maple
- #1-0908 Tanglewoods Pond
- #1-1563 Pond 1, 2 and 3: Pine View Estates
- #1-0930, Church of the Rock
- #1-1442, Sunset Terrace
- #3567-9010, Barry Callebaut
- #4197-9010, Superior Ceramics Lot

Figure 2: WCA and Town Public Works Director Inspect #3410-9010 Outlet structure to verify pond routing.

3.1.2.2 Existing Condition (Post 2002) Model Revisions

New development projects previously omitted from the model were added including permit #5577-INDS the Harborview development on Main Street and #6375-INDS, the AFB Subdivision along Bellevue Carriage Road. It was confirmed that both projects have initiated construction, and therefore were added to the model. Both subdivisions include conventional catch basin and pipe conveyance systems routed to stormwater detention ponds. Subwatershed boundaries around the new Harborview Subdivision were adjusted to account for changes in the pond routing to a different tributary compared to the pre-development condition.

The proposed rain garden and gravel swale on the Barry-Callebaut property was not added to the model due to limitations of the BMPDSS model resolution. The scale of the project is too small to be accounted for by the model, and actually caused an error when included in the model input.

3.1.2.3 Diversion Structure Considerations

The Stevens-Rugg diversion structure, first built in 1957, is a historic structure designed to address flooding issues in the City of St. Albans by diverting stream flow from Stevens Brook to Rugg Brook. After an extensive study of the diversion in the early 2000's, a new water quality and flood equalization system was constructed at the diversion to minimize increases stormwater flows to Rugg Brook and provide enhanced water quality treatment.

The diversion structure has posed some difficulties for modeling the Rugg Brook watershed in the BMPDSS model. VT DEC developed an alternative method to simulate the interaction between Stevens and Rugg Brook, by use of a "regulator" device. The regulator design was calibrated to the BMP design, and effectively splits the flow. The flow from the Stevens Brook watershed model is added to the Rugg Brook watershed by using the time series output file from the Stevens Brook model as an input file for Rugg Brook. The Stevens models used for the Rugg analysis coorespond to the scenario modeled. For the base condition, the latest "Base" scenario model is used. For the Rugg "Credit" scenario, the proposed FRP "Credit" scenario for Stevens Brook (developed under the Stevens Brook FRP Project in 2012) is used to account for future flow reductions. A memo prepared by Emily Schelley, of VT DEC, is provided which details the procedure utilized for the diversion structure in the BMPDSS (Appendix 2).

3.1.2.4 Existing Conditions Model Results

The existing condition (Post 2002) model was revised with three iterations resulting in an overall ***slight increase*** in progress toward the high-flow target from the previous model prepared by VT DEC (Table 5). This is primarily due to changes in the base condition model, improving the modeled condition from the previous model iterations. A full list of the existing BMPs in the Base and Post2002 models is included in Appendix 2 (Table A-2-1). The existing condition scenario includes 31 individual BMPs, each managing the 1-year design storm, and 5 of which also provide recharge to groundwater. The most up to date existing condition model scenario (as of

1/30/2015) was estimated to provide a -2.5% reduction in high flow, calculated as a percent change between the unadjusted flow in the baseline condition (pre 2002) and Post 2002 scenario, addressing **16.0%** of the TMDL high-flow(Q0.3%) target. The low-flow was estimated to decrease by -2.99% below the baseline scenario, not addressing the non-actionable Q95% flow target. Based on the model results, additional CPv stormwater controls will be required to meet the required TMDL high-flow target. Biomonitoring of the streams will ultimately determine if the Rugg Brook has reached attainment conditions in compliance with the Vermont Water Quality Standards.

Table 5: Existing Condition BMPDSS Model Assessment Results

Model Run	Description	High Flow **Reduction** (%)	Low Flow **Increase** (%) [1]	BMPDSS Model Run Date
TMDL Targets for Rugg Brook with 15 ac Non-Jurisdictional Growth		-16.00%	16.8%	----
Modified TMDL Target for Rugg Brook with **4.54** ac Non-Jurisdictional Future Growth		-15.30%		
DEC Existing Condition Model	DEC's existing model, includes all Post2002 BMPs	-2.49%	0.0%	9/18/2013
WCA Revised Existing Condition Model (8/21/2014)	Addition of 5577-INDS and 6375-INDS Projects.	-2.82%	-1.5%	8/21/2014
WCA Revised Existing Condition Model (10/10/2014)	WCA revised additional subwatersheds and existing BMP designs.	-2.65%	-4.5%	10/10/2014
WCA Revised Existing Condition Model (1/30/2015)	Revised Subwatersheds.	-2.50%	-2.99%	1/30/2015
Percent of Target Managed (with Existing Condition Run on 1/30/2015)		**16%**	-27%	----
1 - The low flow target is not actionable under the TMDL, but is included in the summary because improving base flow in the watershed is still a water quality goal.				

4 Required Controls Identification

The process of BMP identification was initiated with a field assessment on August 20th, September 11th, and October 22nd 2014, of existing CPv BMPs covered by an expired permit to assess the opportunity for upgrade potential to VT 2002 design standards. Prior to the initial field visit, the team conducted a desktop assessment of the watershed to identify open spaces ideal for BMP implementation with priority on municipally owned land. The distribution of BMPs was considered to provide storage throughout the watershed. Potential site selection focused on areas with a high-percentage of impervious coverage where flows were expected to be highest and where infiltration was possible as indicated by mapped Hydrologic Group A or B soils.

After an initial list of retrofits was identified, a follow-up field assessment was completed at each site documenting the preliminary engineering feasibility of each retrofit and mapped drainage area for the proposed BMPs. The BMPs were then designed using the HydroCAD® model to meet the CPv storage criteria for cold waters (12-hour detention standard).

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

Once the final list of proposed BMPs was determined to meet the flow targets, the projects were ranked using a comprehensive ranking matrix, as detailed below in section 5-6. The team prepared 30% preliminary engineering conceptual designs for the new projects provided in Appendix 1.

4.1 BMPDSS Model Assessment Results

The final proposed BMP list was developed based on an iterative assessment using the BMPDSS model as follows; The first proposed "Credit" scenario (Credit1), included nine(9) retrofits to existing ponds with expired permits, five(5) new detention practices in the Town, one (1) new infiltration basin in the Town, one(1) new underground infiltration system along Route 7 in the City, three (3) new detention practices to mitigate runoff from primarily VTRANS owned impervious, and eight(8) new sand filters in the I-89 median. A separate model run was done with just the 9 existing BMP retrofits, "Credits_EX". The "Credits_EX" scenario estimated a decrease in high flow of -6.85%, addressing **45%** of the target (Table 6). The low flow did not increase. The 1st proposed scenario, "Credit 1" estimated a decrease in high flow of -17.97%, addressing **117%** of the target (Table 6). The low flow did not increase.

Additional field work was completed at several sites and a few revisions were made to the Credit1 BMPs. A large infiltration basin on the J+L service lot was removed, and replaced with four new infiltration BMPs in the ROW of S. Main St. In addition, a new gravel wetland was added to mitigate runoff from the SASH. These revisions and additions constitute the Credit 2 model. The "Credit 2" scenario estimated a slightly decreased reduction of -17.46 % decrease in the high-flow from the base condition, addressing **114%** of the high-flow and no increase in baseflow. A few subwatershed boundaries were adjusted in the existing condition model scenario, which effected the percent difference comparison for the Credit 2 run. A full modeling summary including all the model run results completed for Rugg Brook with results compared to the original and modified target, is provided in Appendix 3 (Table A-3-1), as well as a Table of BMPs sorted by the model run to which the BMP was first added (Table A-3-2). BMPs were maintained in each subsequent run.

Table 6: BMPDSS Model Runs Summary for Proposed FRP Scenario

Model Run	Description	High Flow **Reduction** (%)	BMPDSS Model Run Date
Modified TMDL Target for Rugg Brook with 4.54 ac Non-Jurisdictional Future Growth		-15.30%	
DEC Existing Condition Model	DEC's existing model, includes all Post2002 BMPs	-2.49%	9/18/2013
WCA Revised Existing Condition Model (1/30/2015)	Revised Subwatersheds.	-2.50%	1/30/2015
Percent of Target Managed (with Credit_ run on 1/30/2015)		**16%**	----
Credit_EX Model	Proposed BMP scenario with only retrofits to existing BMPs with expired permits (9 projects).	-6.85%	10/10/2014
Percent of Target Managed (with Credit_EX run on 10/10/14)		**45%**	----
Credit1 Model	Proposed BMP scenario with all proposed retrofits.	-17.97%	10/13/2014
Percent of Target Managed (with Credit1 run on 10/13/14)		**117%**	----
Credit2 Model	Revised S. Main St Practices, Nason St, and Twin Ct. Add new SASH BMP.	-17.46%	1/30/2015
Percent of Target Managed (with Credit2 run on 1/30/2015)		**114%**	----

4.2 Proposed FRP Model Scenario

The final recommended BMP list is represented in the "Credit2" model run, which includes 31 proposed BMPs (Table 7). The proposed FRP scenario addresses ***114%*** of the modified high-flow target providing a 14% factor of safety (FOS). The additional FOS is included in the recommended BMP list to provide the MS4's additional options, in the event the list has to be modified or as conditions in the watershed change from what is present today.

The individual and cumulative percent of the high-flow target mitigated is also included in Table 7, calculated based on the CPv volume storage and the BMPDSS model run result (Credit 2 run). The individual and cumulative percent mitigated allows for a quick understanding of the relative benefit of each BMP toward meeting the high-flow target. The CPv volume is used as an indicator of the percent mitigated because it was determined by VT DEC that the high-flow (Q0.3%) is approximately equivalent to the 1-year storm peak discharge. Essentially, the high-flow is directly reduced in the model by mitigating the CPv volume.

The "Cumulative Percent of Target" addressed allows the MS4's flexibility in the event one of the top projects is determined infeasible and the projects need to be rearranged. The TMDL requires that 100% of the high-flow target be addressed. The ultimate determination for implementation of projects providing benefit beyond the high-flow target (> 100%) will be made by the State based on monitoring data or other relevant information (MS4 General Permit Sec. IV.J.3). Progress toward the TMDL flow targets with the proposed FRP scenario was allocated by MS4 to determine the extent to which the proposed BMPs addressed each **MS4's allocated responsibility** of the flow targets, summarized in Table A-3-3 (Appendix 3).

5 Proposed Implementation Plan

The proposed BMPs are summarized in Table 7, including the impervious cover treated, drainage area, and CPv volume storage estimated by the HydroCAD® model. A map of the proposed BMP locations is included in Appendix 4. The **individual and cumulative percent of the high-flow target mitigated** is also included in Table 7. An additional table is included in Appendix A-3-2, which separates the projects by the model run to which the project was first added (Credit 1 or Credit 2).

Table 7: Final Proposed BMPs for the Rugg Brook FRP

Site Name	Ownership of Land where BMP is located	BMP Type*	Permit #	Drainage Area (acres)	Impervious Acres Managed (ac)	Runoff Channel Protection Volume (CPv) Storage		Percent of High-Flow Target Managed	*Cumulative* Percent of High-Flow Target Managed
						cft	ac-ft	%	%
Existing Post 2002 BMPs	Varies	Varies	Varies	---	---	---	---	**16%[1]**	**16%**
Industrial Park Pond	Town	Detention	3348-9010/ 1-1268	38.64	18.49	49713	1.141	10%	**27%**
Tanglewoods	Private	Detention	1-0908	27.69	7.70	28140	0.646	5.9%	**33%**
S. Main St. Infiltration	Private/ Cadillac Motel	Infiltration	NP	6.55	3.14	15769	0.362	3.3%	**36%**
SASH/Nason St Connector	City/ VTRANS/Town	Detention	NP	21.12	4.26	15682	0.360	3.3%	**39%**
Twin Court	Private	Detention	1-0658	17.64	4.20	15682	0.360	3.3%	**42%**
Barry Callebaut Inc	Private	Detention	3567-9010	10.37	7.01	8364	0.192	1.8%	**44%**
Nason St./ Green Mountain Dr.	Private	Detention	1-0577	7.76	1.47	8189	0.188	1.7%	**46%**

[1] See Table 6. The existing BMPDSS model run estimated 16% of the flow target is addressed with existing BMPs.

Site Name	Ownership of Land where BMP is located	BMP Type*	Permit #	Drainage Area (acres)	Impervious Acres Managed (ac)	Runoff Channel Protection Volume (CPv) Storage		Percent of High-Flow Target Managed	*Cumulative* Percent of High-Flow Target Managed
						cft	ac-ft	%	%
Clyde Allen Dr.	Private	Detention	2-1168	11.00	2.43	8015	0.184	1.7%	**47.8%**
St Albans Milk and Maple (P3)	Private/Public Road	Detention	1-1428c (P3)	3.08	1.30	6447	0.148	1.4%	**49.2%**
South Main St.-2	City	Infiltration	NP	4.13	1.08	4792	0.110	1.0%	**50.2%**
St Albans Milk and Maple (P2)	Private	Detention	1-1428a (P2)	1.66	1.41	4095	0.094	0.9%	**51.1%**
Freeborn St.	Private/ Public Road	Undergroun d Infiltration	NP	2.94	1.08	3572	0.082	0.7%	**51.8%**
South Main St.-3	City	Infiltration	NP	0.98	0.41	2526	0.058	0.5%	**52.4%**
Church of the Rock	Private	Detention	1-0930	3.24	1.42	2483	0.057	0.5%	**52.9%**
Pineview Estates (P2)	Private	Detention	1-1563	5.52	1.69	2047	0.047	0.4%	**53.3%**
Pineview Estates (P3)	Private	Detention	1-1563	4.90	0.54	1437	0.033	0.3%	**53.6%**
Sunset Terrace Phase 3	Private	Detention	1-1442	1.75	0.26	958	0.022	0.2%	**53.8%**
Pineview Estates (P1)	Private	Detention	1-1563	1.02	0.23	697	0.016	0.1%	**54.0%**
South Main St.-1	City	Infiltration	NP	0.90	0.22	1394	0.032	0.3%	**54.3%**
Exit 19 South_CN	VTRANS	Detention	NP	62.11	6.93	90169	2.070	19.0%	**73.2%**
Access Rd. East	VTRANS/Priv	Detention	NP	103.1	10.16	79279	1.820	16.7%	**89.9%**

Site Name	Ownership of Land where BMP is located	BMP Type*	Permit #	Drainage Area (acres)	Impervious Acres Managed (ac)	Runoff Channel Protection Volume (CPv) Storage		Percent of High-Flow Target Managed	*Cumulative* Percent of High-Flow Target Managed
						cft	ac-ft	%	%
Access Rd. West	VTRANS/Priv	Detention	Portion of 1-1428	13.7	0.57	28401	0.652	6.0%	**95.9%**
SDC87	VTRANS	Median Filter	NP	3.80	1.90	5579	0.128	1.2%	**97.1%**
SDC83b	VTRANS	Median Filter	NP	1.80	0.58	3339	0.077	0.7%	**97.8%**
SDC27	VTRANS	Median Filter	NP	1.61	0.64	2762	0.063	0.6%	**98.4%**
SDC280	VTRANS	Median Filter	NP	2.13	0.40	2741	0.063	0.6%	**99.0%**
SDC347	VTRANS	Median Filter	NP	1.40	0.43	2608	0.060	0.5%	**99.5%**
SDC83a	VTRANS	Median Filter	NP	1.71	0.52	2534	0.058	0.5%	**100.0%**
SDC342	VTRANS	Median Filter	NP	1.60	0.45	2358	0.054	0.5%	**100.5%**
SDC29	VTRANS	Median Filter	NP	2.25	0.67	2358	0.054	0.5%	**101.0%**
I-89/Holyoke Farm	Private	Infiltration	NP	61.87	2.68	62117	1.426	13.1%	**114.1%**
				Totals:	**84.3**		**10.66**		

* NP = No permit

*BMP Type: Detention= Stormwater Pond designed to detain the 1-yr design storm (1.94"). Underground Infiltration= Storage Tank under pavement or grass which infiltrates runoff into the subsurface soils.

5.1 Proposed Retrofits to Existing BMPs

Each existing BMP with an expired stormwater permit providing CPv volume storage was assessed for retrofit to meet Vermont 2002 Stormwater Design Standards. Nine(9) of the existing detention ponds were not providing full detention of the CPv volume for 12 hours. For most of the ponds either a new low-flow or reduced size orifice was proposed to provide full CPv detention. Expansion of several of the ponds was also proposed. The following retrofits were proposed for the existing BMPs:

Table 8: Proposed Retrofits to Existing BMPs

Permit #	Project Name	Address	Managed Impervious (ac)	Existing System	Proposed Retrofit
1-0908	Tanglewoods	Tanglewoods Dr.	7.70	Shallow detention pond. Flooding issues in upstream conveyance.	Regrade pond, add outlet structure, add two forbays and improve drainage swales to reduce flooding.
3567-9010	Barry Callebaut Inc	Industrial Park Rd.	7.01	Detention Pond	Reduce 8" low flow orifice to 2.5".
1-1428a	St Albans Milk and Maple/ Mobil (P2)	Fairfax Rd. /SASH	1.41	Detention area in Mobil Station parking lot (North)	Regrade and expand existing detention area.
1-1428c	St Albans Milk and Maple/ Mobil (P3)	Fairfax Rd. /SASH	1.30	Detention Pond in Mobil Station parking lot (West)	Reduce low flow orifice from 4" to 2".
1-0930	Church of the Rock	Fairfax Rd. / Garden Dr.	1.42	Detention Pond in back parking lot.	Remove 4" low flow orifice. Expand Pond.
1-1563	Pineview Estates (P1)	Fairfax Rd. / Allaire Dr.	0.23	1 of 5 ponds built for Pineview Estates Subdivision.	Add 2" low flow orifice at 518.75'.
1-1563	Pineview Estates (P2)	Fairfax Rd. / Allaire Dr.	1.69	1 of 5 ponds built for Pineview Estates Subdivision.	Reduce 3" low flow orifice to 2".
1-1563	Pineview Estates (P3)	Fairfax Rd. / Allaire Dr.	0.54	3 of 5 ponds built for Pineview Estates Subdivision.	Add 2" low flow orifice. Needs Maintenance.
1-1442	Sunset Terrace Phase 3	Sunset Terrace Rd.	0.26	Existing pond, built for portion of Sunset Terrace subdivision.	Reduce 2" low flow to 1.5". Expand and clear overgrowth.

5.2 Town of St. Albans Proposed New BMPs

Industrial Park Pond (#3348-9010/ #1-1268)

In 2008, Cross Engineering, of St. Albans, developed a Stormwater Enhancements Study for the Industrial Park, under a contract with the Franklin County Industrial Development Corp (Appendix 1-Plans). The study was tabled at the time. The focus of the study was an existing stormwater lagoon, that since has been abandoned (Figure 3). In 2012, a part of the proposed enhancements were implemented including several engineered check dams within the median strip along Industrial Park road. The improvements were observed to be functioning as designed on a site visit in September, 2014.

Figure 3: Industrial Park median swales, which drain to the area of the proposed new detention pond.

The initial design involved an expanded detention pond extending from the existing stormwater pond at the end of Industrial Park Rd., to the south onto Mylan Technologies (MTI) Property. A new inlet pipe would route runoff from 38.64 acres of the Industrial Park to the pond. This design would meet the water quality, CPv, overbank flood control, and extreme flood control. However Mylan Technologies, and the neighboring property owner (Lapierre) were not willing to provide land for the project. Therefore, an alternative smaller pond design was developed in 2009 by Cross Engineering, which includes a revised detention pond layout all within the Town owned parcel at the end of Industrial Park Rd. This design doesn't provide full overbank flood protection or extreme flood control. The Cross Engineering design for this pond and corresponding Report are included in Appendix 1. The Cross design was used as the design for the BMP in the BMPDSS modeling assessment. A revised cost estimate was developed for the project as well.

Twin Court Pond (#1-0658)

Twin Court has a history of flooding issues along the roadway. Ruggiano Engineering has developed plans to increase the size of the stormwater conveyance along Twin Court. In addition, a detention pond is proposed at the end of the conveyance system, located along the stream on North side of the stream crossing (Figure 4).

Figure 4: Rugg Brook crossing at end of Twin Court.

The Town has discussed accepting ownership of a portion of the roadway, currently owned by the HOA of the condominiums on the West side of the Rugg Brook crossing. However, there have been easement issues with the HOA, slowing progress on this project. The pond was included in the project list and FRP assessment.

Clyde Allen Dr. Gravel Wetland (#2-1168)

Clyde Allen Dr. is a neighborhood off Fairfax St. with a system of catch basins and swales permitted under expired permit #2-1168. The existing drainage system drains directly to the stream. The open grass lawn, just south of the Vermont Housing Authority owned homes, was identified as an ideal location for a detention retrofit due to the open space, proximity to the stream, and ability to help mitigate an existing flooding issue (Figure 5).

Figure 5: Grassed lawn proposed for retrofit with new gravel wetland.

Across the road from the BMP site, there is an area of low ground in the backyard of two homes (Figure 6). The homeowners have brought the issue of standing water to the attention of the town before, and have reported wet basements.

The proposed retrofit involves installing a new footing drain and stone swale between the two homes backyards. The footing drain would then connect to a new storm pipe, which would be routed to the proposed gravel wetland. Two new 18" culverts would also be needed to provide the necessary drain improvements. A flow splitter will route the 1-year storm to the proposed gravel wetland, while all high-flows are routed to existing discharge, with additional buffer improvements. The proposed gravel wetland will be a large open basin, with vegetation on the surface. Beneath the vegetation is 2 feet of stone, which provides additional storage and filtering of sediment and other pollutants from the stormwater prior to discharge out a low-flow orifice.

Figure 6: Low area between homes along Clyde Allen Dr. with history of flooding. New footing drain and outlet proposed to drain area.

Freeborn St. Infiltration Basin

Figure 7: Open lawn area on Freeborn St. identified for stormwater retrofit.

An area east of South Main St, at the intersection of Freeborn St. and Potter Ave was identified as a potential site for an infiltration basin. There is a pocket of soils mapped as Hydrologic Group B, which is suitable for infiltration. Upon field inspection, it appeared the existing stormwater outfall, just to the left of the open green space in Figure 7 (RIGHT) was severely eroded. In addition, an exposed PVC sewer pipe was observed within the existing channel. The sewer pipe was covered with stone shortly after observation in the field (Figure 8). The work revealed there are sandy soils in this area.

The proposed retrofit would involve installation of an underground infiltration basin at the edge of an existing open grass lawn. The existing stormwater conveyance system would be routed to the new basin, with a high-flow bypass (> 10 year storm) to a new outfall. The infiltration basin would consist of a 15’x 50’ chamber with 6 feet of drainage stone. A Downstream Defender® (D4GA) pretreatment hydrodynamic separator will be placed at the inlet for ease of maintenance, and to ensure longevity of the infiltration. The Downstream Defender can be vacuumed like a typical catch basin.

Figure 8: New stone cover in existing drainage swale, near location of proposed infiltration basin.

Nason St./Green Mt. Drive (#1-0577) Detention

The neighborhood along Green Mountain Dr. is currently covered under an expired stormwater permit (#1-0577). It was determined that the northern portion of the neighborhood, North of Victoria Dr. drains to a collection system on the West side of Green Mt. Dr. The East side of Green Mt. Dr. drains to a bowl-shaped area with a 24" culvert to the brook (Figure 9).

Figure 9: Nason St. / Green Mt. Dr. Right-of-Way

The bowl-shaped area in the ROW was identified as a retrofit site to provide detention and improved water quality. The project would involve regrading the existing depressed area to a detention basin, with a low-flow orifice and high-flow bypass to the existing culvert. In addition, the swale on the east side of the roadway would be regraded to create a series of detention area, with lateral check dams. The bowl would be grassed for ease of maintenance.

5.3 City of S. Albans Proposed BMPs

South Main St. Infiltration Basins

Along South Main St/Route 7, between the intersection with the SASH to Freeborn St, there is an area of Hydrologic Group B soils, which have potential for infiltration. Therefore, the Right-of-Way (ROW) was inspected for opportunities for green stormwater infrastructure practices, like stormwater planters, curb extensions, underground infiltration basins, dry wells, etc.

South Main St. Infiltration Basin:

A large open grass area in front of the Cadillac Motel was identified as the location for a proposed 840 sq-ft underground infiltration basin (Figure 10). An underground infiltration chamber system was selected as the best option because this type of practice requires limited maintenance and will not interfere with road maintenance operations. The chamber would be offline, tied into the existing stormwater conveyance system along Route 7, sized to mitigate the 1-year design storm. Flows above the 1-year storm would bypass

Figure 10: Entrance to Cadillac Motel. Site of proposed underground infiltration basin.

the system. Potential water line conflicts are still to be determined. The town would need to acquire an easement for the practice, from the Motel property owners.

South Main St. M1, M3, M3:

Along Route 7, three stormwater curb extensions with infiltration basins were proposed in the ROW, designed as offline practices to detain and infiltrate up to the 1-year design storm volume (Figure 11, 12, 13). An example of a stormwater curb extension is provided in Figure 14, below. The practices would be tied into the existing stormwater conveyance system. Curb cuts would be installed to increase catchment of surface runoff from the roadway. The current roadway width is approximately 25 feet, which is wider than the minimum 13 feet for shared use. The proposed practices would extend a maximum of 4 feet into the existing roadway, maintaining the required road width. Practices could be left with a pea gravel surface to reduce maintenance.

Figure 12 Site for "M3" Stormwater Curb Extension along Route 7.

Figure 11: Site for "M2" Stormwater Curb Extension along Route 7.

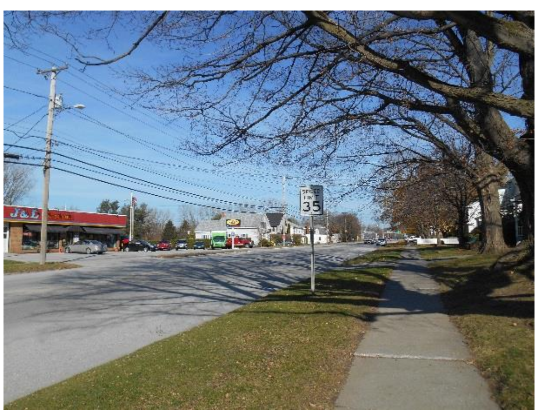

Figure 13: Site for "M1" Stormwater Curb Extension along Route 7.

Figure 14: Example of a stormwater curb extension for the Route 7 ROW (Credit- VA DRC Stormwater Design Manual 2013).

5.4 VTRANS Proposed BMPs

Exit 19 South Detention Basin

Figure 15: Exit 19 center median. Site of proposed stormwater basin.

The center median between the Exit 19 South on-ramp and Interstate Access Rd is presently contoured and piped to collect drainage from three segments of I-89, as well as a large portion of the upper watershed east of I-89, which makes this site a feasible candidate for stormwater improvements (Figure 15). The land is within the VTRANS ROW and would only treat VTRANS-owned impervious, with the exception of a small amount of private impervious area at the top of the upstream watershed. The proposed BMP is a stormwater detention pond designed to VTRANS standards for structures within the ROW, with approximately 2.0 ac-ft of storage. Water quality components such as a sand or stone bed, forebay, and/or micro pool could be integrated into the design if necessary. The site was screened for natural resources and found to contain dense *Phragmities australis* growth, which will need to be considered in the excavation process. It is recommended that excavated materials are re-used on-site to minimize the spread of invasive species off-site.

Access Rd. East (SASH/Fairfax Rd).

There is a privately owned open space located between Rugg Brook and the NW corner of Fairfax Road and the St. Albans Interstate Access Road (SASH) that is a candidate site for implementation of a new stormwater detention basin (Figure 16). A stone bed and micropool are proposed to improve water quality benefits of the project. The proposed basin would collect and store drainage from a segment of an existing mapped tributary which takes drainage from an expired permit site (#1-1428), a segment of I-89, as well as a large area of the upper watershed East of I-89.

Figure 16: Site of proposed Access Rd. East project.

The location of the proposed BMP is on land that is currently owned by a local farmer, and within the VTRANS ROW. The section of land which is proposed for BMP implementation appears to be devoid of farming practices likely due to the presence of the existing tributary dividing the field. The project could be an opportunity for the Town to acquire open space to address their MS4 permit requirements and for the landowner to sell a potentially unprofitable section of farmland. This BMP would be a shared system that would require Town management and cost sharing with VTRANS as well as private permittees. This project has the potential to provide very significant benefit toward the flow target in the watershed, therefore it would be worth the effort approach the landowner.

Access Rd West (SASH)

The Access Road West Basin would be located along the northern (Westbound) side of a section of the Interstate Access Rd. The BMP was designed as a median sand filter which would collect drainage from the roadway as well as the upslope field, before draining to a culvert under the Access Rd. The BMP could be designed to provide CPv storage as well as water quality treatment. This project would be located within the VTRANS ROW, but has potential for cost-sharing with the Town, as the BMP would treat drainage from Privately-owned land cropland within the Town. Additionally, a portion of the highway which currently drains to the Tanglewood Subdivison basin under expired permit #1-0908 would drain to the proposed BMP.

Figure 17: Site of proposed "Access Rd. East Basin" at intersection of Fairfax Rd. and the SASH.

Median Sites

Eight median sites were identified which would detain and treat runoff from I-89 in the existing highway median. The structures would be considered equivalent to Dry Swales as defined in the 2002 Vermont Stormwater Management Manual. The structures would be located in existing vegetated stormwater conveyances in the I-89 median. Key features of the structures include earthen check dams designed to create up to 1.5’ of ponding depth behind each dam, amended soils consisting of a 50/50 blend of sand and native soil at the surface, and a pure sand filter below (Figure 18). A perforated underdrain wrapped in stone would be located below the sand filter, which would be connected to the outlet structure or day lighted. A plan for SDC 280 is provided to demonstrate the typical layout of the median sand filter BMP, which would be consistent for the other median sites (Appendix 1). The proposed sand filters are consistent with the three filter systems constructed in the Exit 19 ROW in 2013—existing BMPs VTRANS 138, 75c, and 80b (See Map in Appendix A-4).

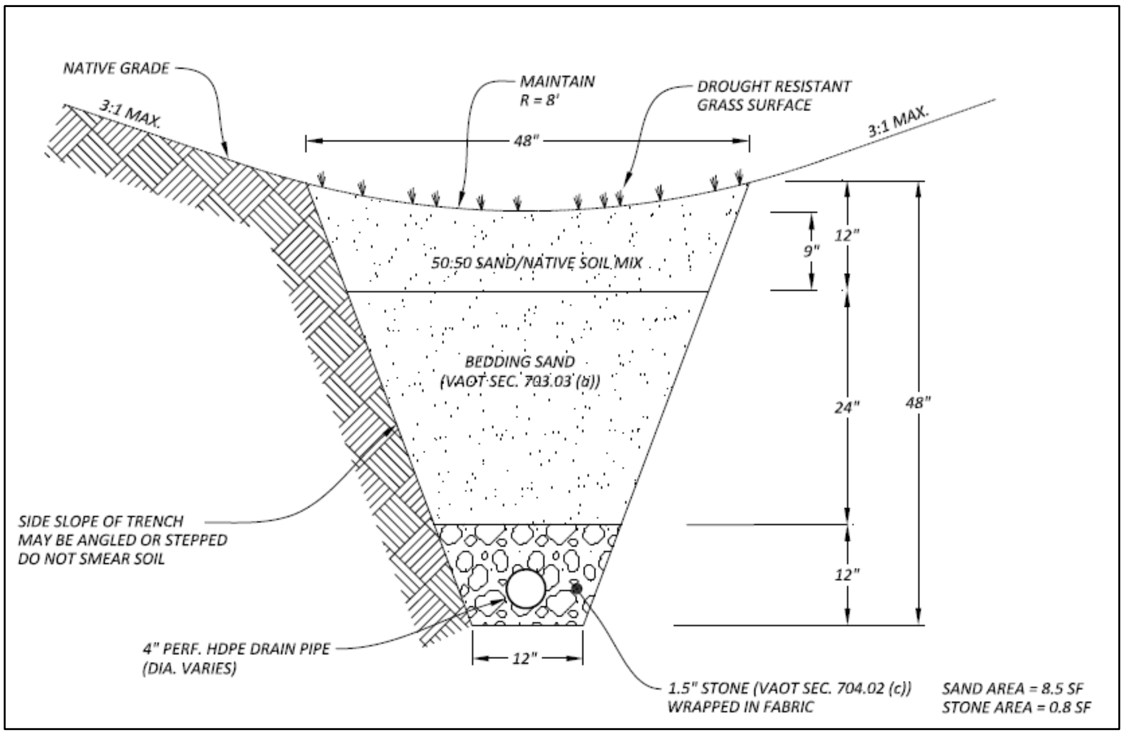

Figure 18: Median Filter Section View (Credit- WCA)

5.5 Joint MS4 Proposed BMPs

I-89/ Holyoke Farm Infiltration Basin

On the southern border of the impaired watershed boundary there is an area with Hydrologic Group A mapped soils, which have potential for infiltration. The area was identified as a potential site for an infiltration BMP to treat runoff from an I-89 culvert. The proposed BMP would located on land owned by an active farm, adjacent to I-89, located off Holyoke Farm Rd. This project is one of five BMPs that have the potential to increase baseflow to the stream, via infiltration, which addresses both the high-flow and low-flow TMDL targets.

The proposed BMP would be a 15,000 sq-ft infiltration basin (Figure 19). The surface would be reseeded with grass for ease of maintenance. Below the surface would be 3 feet of drain stone on top of the native soil. The basin would detain and filter the 1-year design storm volume (CPv), to reduced Total Suspended Solids (TSS) and Total Phosphorus (TP). New surface flow paths draining to the proposed BMP would be constructed as well as a new discharge pipe to direct runoff from the southern VTRANS culvert to the practice (Figure 19). The proposed placement of the BMP was based on optimizing catchment of runoff from two I-89 culverts and the flat terrain. The existing use of the open space for farm operations would need to be verified to limit disturbance to the owner's ongoing use of the land.

Figure 19: Proposed infiltration basin on farm land, located off Holyoke Farm Rd.

The proposed project is on land owned by an active farm. As of now, agriculture lands are exempt from the MS4 permit. There is potential the farm may need to implement BMPs for compliance with the Lake Champlain Phosphorus TMDL. This proposed project has potential to also address runoff from the farm to mitigate phosphorus runoff, which could provide VTRANS with a joint opportunity to address runoff from a portion of I-89.

SASH/Route 7 Gravel Wetland

The culvert under Route 7 (South Main St), at the West end of the St. Albans State Highway (also known as the SASH or Interstate Access Rd) was identified as a priority stormwater drainage to manage. The existing drainage area for the culvert includes a majority of impervious cover from the SASH, which is owned by VTRANS, as well as a minor portion of the St. Albans Education Center back parking lot, as well as the portion of the SASH owned by the City (Figure 20). There is no VTRANS owned land available to manage the SASH runoff. A city-owned parcel, located across Route 7 from the SASH, and set back approximately 500 feet from the culvert outlet, was identified as a potential location for a gravel wetland, to provide storage and filtration of the 1-year storm runoff volume.

Nason St. Connector Project: Plans developed by VHB Engineering to add a new road connection from Route 7 to Lemnah Dr. were considered when developing the plan for this project. As of now, the project is at the 60% design phase. Based on plans as of January, 2015, a water quality basin was proposed between the railroad and new road, potentially leaving space for an additional BMP. The Nason St. Project is still in the design phase, and is subject to change. Therefore, this project may need to revised and/or could be prohibited due to lack of available space.

Figure 20: Drainage area for SASH/Route 7 culvert, with MS4 boundaries. The proposed plan as of January 2015 for the Nason St. Connector road was included in this map (NW corner).

5.6 Watershed-Wide Project Ranking

A comprehensive ranking matrix was developed in order to rank the proposed projects based on a multitude of criteria grouped into four general categories. The purpose of the ranking matrix is to provide the MS4's with a tool to prioritize projects on a number of criteria, rather than just on flow benefit. The matrix is set up for use in the future as new information for the proposed BMPS is developed and/or BMPs are added/removed from the list. The criteria and categories included as follows:

Category	ID	Criteria
Cost/Operations	A	Relative Project Cost
	B	Ease of O/M
Project Design Metrics	C	Impervious Acres Managed (ac)
	D	Channel Protection Volume (CPv) Mitigated, (ie. 1-year Storm)
	E	Volume Infiltrated (ac-ft)
	F	Water Quality (WQ) Volume Control
	G	Primary or Secondary BMP
Project Implementation	H	Permitabilty
	I	Land Availability
Other Project Benefits	J	Flood Mitigation (Is existing flooding issue mitigated by project?)
	K	TMDL Flow Target Addressed (Q03, Q95)
	L	Lake Champlain Phosphorus TMDL Metrics Met*
	M	Other Project Benefits/Constraints (Educational, Infrastructure Improvement, Unknown Feasibility)
*For now the Lake Champlain Phosphorus TMDL criteria is a placeholder, until the final TMDL is approved and the compliance metrics are outlined.		

Values for each criteria were identified and assigned a relative score so the projects could be ranked based on a total score. A secondary set of Water Quality criteria were added to the matrix, to rank the BMPs on water quality benefits, using the Source Loading & Management Model (WinSLAMM). WinSLAMM is a very robust, field verified and calibrated model that will accurately predict pollutant loading and BMP effectiveness. WCA modeled the BMPs within WinSLAMM and quantified the annual total suspended solids (TSS) and total phosphorus (TP) reductions in loads of pollutant per year. Ranges for the TSS and TP removals were identified, and assigned a score of 0-6 points, 6 being the greatest benefit. The final ranking of proposed projects is included in Table 9 below. The criteria key (Table A-5-1), scoring key (Table A-5-2) and the full matrix spreadsheet (A-5-3) are included in Appendix 5. A separate table with the phosphorus and TSS loading reductions for each proposed BMP is provided in Appendix A-5-4.

Table 9: Ranked Proposed FRP BMPs based on comprehensive ranking matrix

Rank	Site ID	MS4	Retrofit Description	Total Score
1	Tanglewoods	Town	Expand and retrofit Detention Basin	25.00
2	Industrial Park Pond	Town	Expand abandoned pond and redirect parking lot/road runoff to pond.	25.00
3	Exit 19 South	VTRANS	Detention Basin	22.00
4	Barry Callebaut Inc	Town	Reduce 8" low flow orifice to 2.5".	21.00
5	S. Main St. Infiltration	City	Underground Infiltration gallery in open space at Cadillac Motel Entrance	20.50
6	S. Main St.-2	City	Dry well system in ROW	20.25
7	SASH/Federal St Connector	VTRANS/City	Incorporate detention of SASH runoff with Federal St. Connector Project	20.00
8	Clyde Allen Dr.	Town	Gravel Wetland	19.00
9	Access Rd. East	VTRANS	Gravel Wetland	19.00
10	SDC83b	VTRANS	Median Filter	19.00
11	SDC27	VTRANS	Median Filter	19.00
12	SDC83a	VTRANS	Median Filter	19.00
13	SDC342	VTRANS	Median Filter	19.00
14	SDC29	VTRANS	Median Filter	19.00
15	S. Main St.-1	City	Dry well system in ROW	18.25
16	S. Main St.-3	City	Dry well system in ROW	18.25
17	Freeborn St.	Town	Dry Well adjacent to parking lot.	18.25
18	SDC87	VTRANS	Median Filter	18.00
19	SDC280	VTRANS	Median Filter	18.00
20	Nason St./ Green Mountain Dr.	Town	Bioretention with underdrain along roadway.	18.00
21	St Albans Milk and Maple (P2)	Town	Regrade and expand pond.	18.00
22	St Albans Milk and Maple (P3)	Town	Reduce low flow orifice.	18.00
23	Church of the Rock	Town	Remove 4" low flow orifice. Expand Pond.	18.00
24	SDC347	VTRANS	Median Filter	18.00
25	Pineview Estates (P2)	Town	Reduce 3" low flow orifice to 2".	17.00
26	I-89/Holyoke Farm	Town	Infiltration Basin	16.00
27	Pineview Estates (P1)	Town	Add 2" low flow orifice at 518.75'.	16.00
28	Pineview Estates (P3)	Town	Add 2" low flow orifice.	16.00
29	Sunset Terrace Phase 3	Town	Reduce 2" low flow to 1.5".	16.00
30	Twin Court	Town	Detention Basin.	16.00
31	Access Rd. West	VTRANS	Gravel Wetland	13.00

5.7 Critical Source Area Study for St. Albans

A Critical Source Area (CSA) Study was completed by the NRPC to quantify phosphorus loading in the St. Albans City and Town in order to identify critical areas for phosphorus pollution control. The proposed FRP scenario was overlaid onto the CSA study results, to show for the most part, the proposed BMPS are focused in areas with higher TP loading (Appendix 8). There are also areas where an existing BMP could potentially decrease the estimated TP loadings for some subwatersheds. As the Lake Champlain Phosphorus TMDL is finalized, it is evermore important to try to address both the Stormwater Flow TMDL and Phosphorus TMDL goals at the same time. In addition to flow control, which is the most effective way to address the Stormwater TMDL, considerations for improved water quality benefits by the proposed stormwater control BMPs were incorporated into the design alternatives. For example, by choosing a gravel wetland design alternative versus a detention pond Phosphorus loading reductions were improved.

6 Design and Construction Schedule

A Design and Construction (D&C) schedule is a required element of the final approved Flow Restoration Plan, providing an outline for the implementation of the proposed FRP over a 20-year timeframe. A D&C was prepared, with the 31 projects grouped by MS4, and spaced out over the timeframe in four separate 5 year phases. The timeline considered effort for design, acquisition of necessary permits and/or regulatory approvals. The estimated total cost by MS4 and Phase is summarized in Table 10, and graphically in Figure 21. The total costs in Table 10 were calculated using individual cost estimates for each project (Section 7 below) with a cost-share allocation applied for projects with joint-MS4 contribution. The D&C is included in Appendix A-6. Note, the flow restoration targets are subject to adjustment by the Secretary, as specified in section IV.C.1.e.3 of the MS4 permit, based on biological monitoring data and/or other confounding information concerning flow reduction progress. Adjustments to the flow targets may impact the schedule and full implementation of the proposed projects. Additionally, the D&C is a working document and will be revised based on new information about the projects and/or stream conditions.

Cost-Share Allocation

A cost-share was applied for projects with multiple MS4 jurisdictions (e.g. VTRANS and the Town) based on a percentage factor, which combined the percent runoff contribution and percent impervious surface ownership within the BMP drainage area into an overall percent allocation. The percent runoff contribution was determined using site-specific HydroCAD models for each BMP drainage area. The percent impervious was determined through a GIS exercise, using 2011 impervious cover mapping prepared by the Lake Champlain Basin Program. The cost-share allocation applied provides one example for how the MS4's can share the financial responsibility for projects with contributing area from multiple jurisdictions. The cost breakdown, percent runoff volume and percent impervious area are summarized in Appendix A-10 for the following projects; I-89 Holyoke Farm infiltration gallery, Access Rd East detention basin, Access Rd West detention basin, Exit 19 South basin, and the SASH/Nason St Connector project.

Table 10: Total FRP Implementation Costs by MS4 for each Implementation Phase

MS4	Total FRP Cost	FRP Implementation Cost $				
		Phase 1 (Yr 1-4)	Phase 2 (Yr- 5-8)	Phase 3 (Yr 9-12)	Phase 4 (Yr 13-16)	Phase 5 (Yr 17-20)
Town of St. Albans	$1,864,922.30	$411,726.25	$350,622.60	$632,903.39	$325,000.00	$144,670.06
City of St. Albans	$419,849.01	$310,103.95	$109,745.06			
VTRANS	$1,131,769.23	$309,285.68	$57,967.00	$535,000.00	$52,721.50	$176,795.06

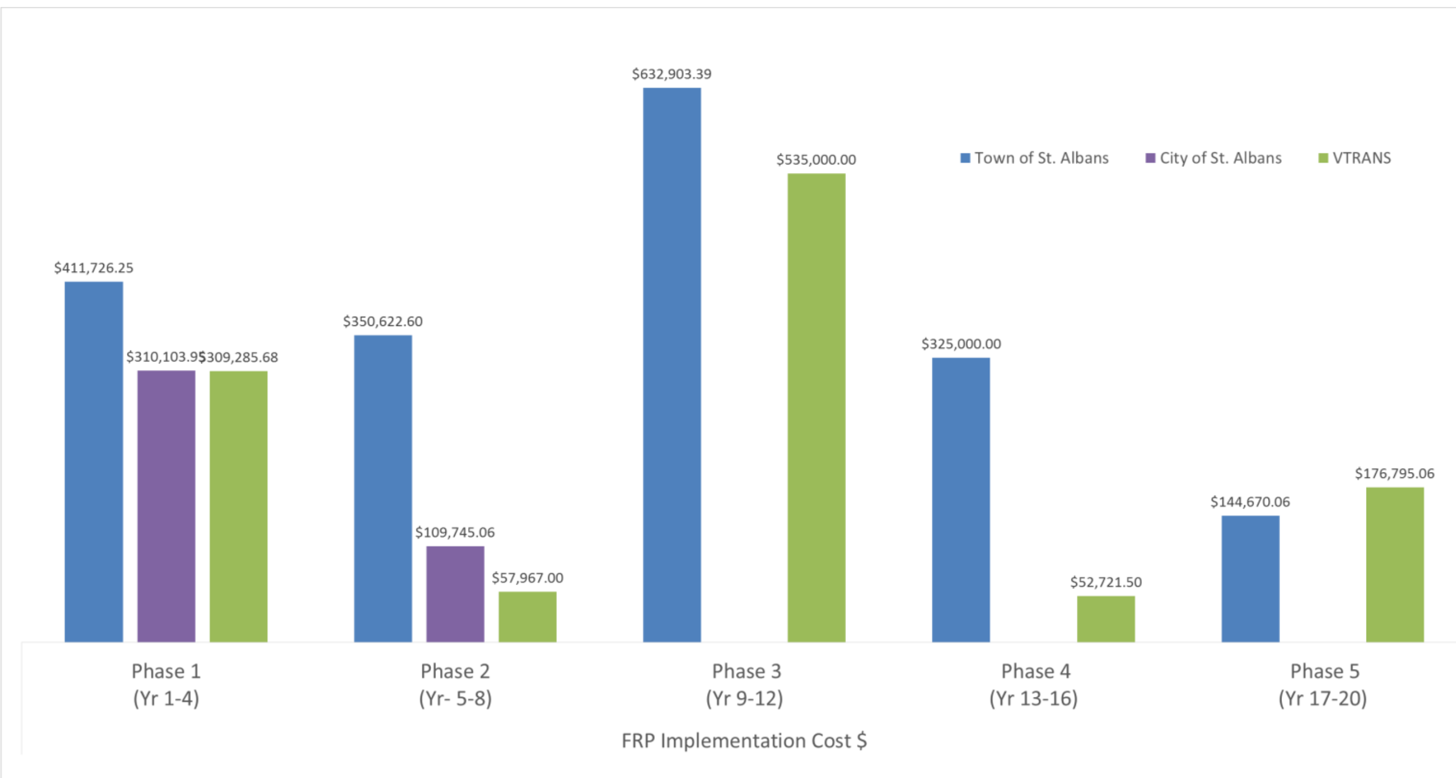

Figure 21: Total Cost by MS4 for each phase of FRP implementation (as of 4-28-2015). For joint MS4 projects, allocations of the total cost were developed for each project based on the breakdown of impervious acreage and flow data.

7 Financial Plan

Subject to the requirements of the MS4 permit, a financial plan is required as a part of the FRP which demonstrates the means by which the plan will be financed as well as initial BMP cost estimates. The TMDL is a watershed-wide reduction in the high-flow, and therefore the proposed BMP's are located throughout the watershed. MS4 permittee ownership was considered and the plan preparers attempted to identify BMPs with a sole MS4 owner. However optimal BMP locations did not always follow property boundaries. For joint ownership projects, the funding responsibility will be negotiated between the involved MS4's. The challenges with cost-sharing will be considered in the final FRP proposed financial plan, and may dictate the recommended strategy.

Funding Sources: As of now, St. Albans City or Town does not have a separate funding source for stormwater related costs. The stormwater program is funded from the general tax, which is pooled for the City and Town's respective Public Works departments. The City and Town are in the process of developing their stormwater program and regulations in the upcoming year, which will determine how they will fund the FRP projects. VTRANS will utilize their stormwater project budget funds for the FRP projects. Several additional funding sources that may be available for larger projects, which may need to be phased over several years, include the Clean Water State Revolving Fund (CWSRF) program and Municipal Bond bank funds.

7.1 BMP Cost Estimates:

Itemized cost estimates were developed for the VTRANS Exit 19 South Basin, as well as the Clyde Allen Dr. projects (Appendix 7). For all other projects, a modified spreadsheet method was used as detailed in section 7.1.2.

7.1.1 Itemized Cost Estimates:

The itemized cost estimates were estimated using a combination of the VTRANS estimator program, RS Means, and local values, based on the 30% engineering plans. The full itemized cost estimates are included in Appendix 7. The cost estimates are based on the following criteria:

- **Construction Cost**: The construction costs were developed based on using both VTRANS 5 year average costs, VTRANS Estimator Program, and RS Means (where applicable) and vendor estimates as necessary for each of the itemized units.

- **Construction Contingency**: The construction contingency is calculated as 15% of the construction cost.
- **Final Design Engineering**: The final design engineering cost is estimated based on the State Fee Curve Allowance as developed by VT DEC. The equations used are as follows:
  - For construction costs less than $780,000
    - Construction cost = $1,950+(Construction cost *0.069)
  - For construction costs greater than $780,000,
    - Construction cost = (Construction cost^0.9206)*0.6788*0.30.
- **Construction Engineering**: The construction engineering cost is based on the State Fee Curve Allowance as developed by VT DEC. The equations used are as follows:
  - For construction costs less than $780,000
    - Construction cost = $3,575+(Construction cost *0.1265)
  - For construction costs greater than $780,000
    - Construction cost = (Construction cost^0.9206)*0.6788*0.55.
- **Other costs:** These costs are established based on simple percentages of the construction cost for the project as follows:
  - Administrative = 0.5%
  - Easement Assistance = 1.5%
  - Land Acquisition =$120,000 per acre for projects on private land (*Value estimated by local Town Assessor)
  - Legal = 5%
  - Bond Vote Assistance = 0.5%
  - Short Term Interest = 2.5%.

7.1.2 Cost Estimates Using Spreadsheet Method:

A spreadsheet cost estimation tool was developed based on guidance from the US EPA and Center for Watershed Protection (CWP) for stormwater retrofit projects. All estimates were calculated as a base construction cost plus a 30% contingency factor for final design and permitting, site specific factors, and land cost, if applicable. The base cost was estimated on a unit cost basis, using a specified design volume (cu. ft) multiplied by a unit cost ($/cu.ft). Due to the variability in retrofit projects and application of general unit cost values, adjustment factors were applied, based on cost research by the CWP and professional engineering judgment. **The cost estimates presented are based on typical values, and may vary due to site specific challenges and unforeseen land acquisition costs.**

Unit Costs: Base construction costs were estimated using unit costs, summarized in Table 11 below. Unit costs for existing **pond retrofits, new storage retrofits, and Green Stormwater Infrastructure practices (planters, bioretention, etc.)** were acquired from cost research completed by the Center for Watershed Protection, derived from a synthesis of real retrofit practice construction costs [2] (Table 11). For **underground storage chambers**, a unit cost for

[2] Schueler, T., Hirschman, D., Novotney, M., Zielinski, J. 2007. Urban Stormwater Retrofit Practices Appendices: Urban Subwatershed Restoration Manual Series. Center for Watershed Protection, Ellicott City, MD. Appendix E. Table E-4.

StormTech MC-3500 chambers was used, accounting for the cost of the chambers and additional site work.

Table 11: Unit Costs for Different BMP Types

BMP Type	Unit Costs ($/cft)
Pond Retrofits	$3
New Storage Retrofits	$5
Underground Chamber Systems	$11
Green Stormwater Practices (i.e. Bioretention)	$8

Adjustment factors were applied depending on the type of retrofit. An adjustment factor of 0.5 was used for a pond retrofit involving an upgrade to the outlet structure and basic site work[1]. The CWP found retrofits in developed areas to be 1.5 to 2 times more expensive than a new storage practice, and sometimes as great as 6 times more, due to the higher chance of utility conflicts, space restrictions, additional permitting costs, and/or sensitive site conditions. Engineering judgment and past project experience was used to assign the appropriate adjustment factors.

Storage Volume: The unit costs were multiplied by a design volume (cft), based on a storage volume required. The storage volume was used to approximate the required excavation and related costs. The 100-year storm storage volume was used for above-ground detention and infiltration basins, while the 1-year storm (CPv) storage used for underground chamber systems, designed as offline practices. Storage volumes were estimated using the HydroCAD® model.

Design and Permitting Contingency: A 30% design and permitting contingency factor was applied, based on cost research provided by the EPA[3] , which found that a typical cost for design and permitting was approximately 30% of the base construction costs.

Land Acquisition Costs: For sites on private land, in which the Town or City would need to acquire ownership of the land, and an estimate was included based on a general cost of $120,000 per acre. This is based on past local project experience.

7.1.3 BMP Cost Estimates Table

[3] U.S. Environmental Protection Agency (EPA). 2006. Preliminary Data Summary of Urban Stormwater Best Management Practices, Maryland, MD. Chapter 6. Costs and Benefits of Stormwater BMPs. EPA-821-R-99-012

The total cost for implementation of the FRP projects was determined, with assumed cost-sharing for the joint-MS4 projects based generally on contributing drainage areas (Table 12). This is an approximate estimate and is subject to change, based on more refined design and cost-sharing agreements. The cost breakdown is relatively consistent with the impervious cover breakdown in the watershed.

Table 12: Total Project Cost Estimate for FRP Projects by MS4, assuming cost sharing for joint-MS4 projects

MS4	Total Project Cost
Town of St. Albans	$1,739,922.30
City of St. Albans	$419,849.01
VTRANS	$1,256,769.23
Total:	**$3,416,540.55**

Table 13, below, includes a summary of the project cost estimates.

Table 13: Proposed BMPs Cost Estimates

BMP ID	New or Existing Site	Control	Impervious acres	Storage Volume		Unit Cost*	Retrofit Adjustment Factor	Construction Cost	Land Cost	Final Design and Permitting Cost (30% Contingency)	Total Project Estimate	Cost Per Impervious Acre
				acft	cft							
Industrial Park Pond	New	100-year	18.49	1.36	59134	$3	1.00	$177,402.00		$53,220.60	$230,622.60	$12,470.81
Tanglewoods	Existing	100-year	7.70	1.59	69043	$3	0.50	$103,563.90		$11,900.00	$115,463.90	$14,988.23
S. Main St. Infiltration	New	1-year	3.14	0.28	12066	$11	1.50	$199,090.98	$12,000.00	$59,727.29	$270,818.27	$86,330.34
SASH/Nason St Connector	New	1-year	4.26	0.37	16117	$5	1.50	$120,879.00		$36,263.70	$157,142.70	$36,905.28
Twin Court	New	100-year	4.20	0.45	19776	$3	1.50	$88,993.08	$12,000.00	$26,697.92	$127,691.00	$30,395.38
Barry Callebaut Inc	Existing[2]	100-year	7.01	0.48	20865	$3	0.50	$31,297.86		$9,389.36	$15,000.00	$2,139.71
Nason St./ Green Mountain Dr.	New	100-year	1.47	0.23	10106	$3	1.50	$45,476.64		$13,642.99	$59,119.63	$40,217.44
Clyde Allen Dr.	New	1-year	2.43	0.32	13765	Itemized Cost Estimate*					$250,000.00	$92,266.81
St Albans Milk and Maple (P3)	Existing[2]	100-year	1.30	1.16	50355	$3	0.50	$75,533.04		$22,659.91	$15,000.00	$11,530.48
South Main St.-2	New	1-year	1.08	0.03	1481	$19	1.50	$62,073.00		$18,621.90	$80,694.90	$75,065.02

BMP ID	New or Existing Site	Control	Impervious acres	Storage Volume		Unit Cost[1]	Retrofit Adjustment Factor	Construction Cost	Land Cost	Final Design/ Permitting Cost (30% Contingency)	Total Project Estimate	Cost Per Impervious Acre
				acft	cft							
St Albans Milk and Maple (P2)	Existing[2]	100-year	1.41	0.18	7667	$3	0.50	$11,499.84		$3,449.95	$15,000.00	$10,630.76
Freeborn St.	New	1-year	1.08	0.03	1263	Itemized Cost Estimate*					$120,000.00	$111,627.91
South Main St.-3	New	1-year	0.41	0.02	1002	$19	1.50	$28,553.58		$8,566.07	$37,119.65	$90,096.25
Church of the Rock	Existing	100-year	1.42	0.14	6098	$3	1.00	$18,295.20		$5,488.56	$23,783.76	$16,702.08
Pineview Estates (P2)	Existing[2]	100-year	1.69	0.43	18600	$3	0.50	$27,900.18		$8,370.05	$15,000.00	$8,875.74
Pineview Estates (P3)	Existing[2]	100-year	0.54	0.45	19384	$3	0.50	$29,076.30		$8,722.89	$15,000.00	$27,726.43
Sunset Terrace Phase 3	Existing[2]	100-year	0.26	0.04	1786	$3	0.50	$2,678.94		$803.68	$15,000.00	$58,139.53
Pineview Estates (P1)	Existing[2]	100-year	0.23	0.11	4661	$3	0.50	$6,991.38		$2,097.41	$15,000.00	$64,377.68
South Main St.-1	New	1-year	0.22	0.01	479	$19	1.50	$13,656.06		$4,096.82	$17,752.88	$81,435.22
Exit 19 South	New	100-year	6.93	6.56	285797	Itemized Cost Estimate*					$360,000.00	$51,948.05
Access Rd. East	New	100-year	10.16	1.82	79279	Itemized Cost Estimate* (Significant Land Cost included)					$820,000.00	$80,708.66

BMP ID	New or Existing Site	Control	Impervious acres	Storage Volume		Unit Cost*	Retrofit Adjustment Factor	Construction Cost	Land Cost	Final Design/ Permitting Cost (30% Contingency)	Total Project Estimate	Cost Per Impervious Acre
				acft	cft							
Access Rd. West	New	100-year	0.57	0.94	40838	Itemized Cost Estimate*					$250,000.00	$438,596.49
SDC87	New	1-year	1.90	0.13	5579	$5	1.00	$27,895.00		$8,368.50	$36,263.50	$19,106.16
SDC83b	New	1-year	0.58	0.08	3339	$5	1.00	$16,695.00		$5,008.50	$21,703.50	$37,484.46
SDC27	New	1-year	0.64	0.06	2762	$5	1.00	$13,810.00		$4,143.00	$17,953.00	$28,139.50
SDC280	New	1-year	0.40	0.06	2741	$5	1.00	$13,705.00		$4,111.50	$17,816.50	$44,541.25
SDC347	New	1-year	0.43	0.06	2608	$5	1.00	$13,040.00		$3,912.00	$16,952.00	$39,793.43
SDC83a	New	1-year	0.52	0.06	2534	$5	1.00	$12,670.00		$3,801.00	$16,471.00	$31,614.20
SDC342	New	1-year	0.45	0.05	2358	$5	1.00	$11,790.00		$3,537.00	$15,327.00	$34,442.70
SDC29	New	1-year	0.67	0.05	2358	$5	1.00	$11,790.00		$3,537.00	$15,327.00	$22,876.12
I-89/Holyoke Farm	New	1-year	2.68	0.05	15246	$11	1.00	$167,706.00	$41,322.31	$50,311.80	$259,340.11	$96,696.54
			84.26							**Project Total:**	**$3,416,540.55**	

1- Unit Costs were derived from cost research completed by the CWP on stormwater retrofit projects. Pond Retrofits = $3/cft, New Storage Retrofits = $5/cft, Underground Storage systems = $11/cft, Green Stormwater Infrastructure(GSI) = $8/ cft (Schueler, T., Hirschman, D., Novotney, M., Zielinski, J. 2007. Urban Stormwater Retrofit Practices Appendices: Urban Subwatershed Restoration Manual Series. Center for Watershed Protection, Ellicott City, MD. Appendix E.Table E-4)

2- Lump sum set Cost for Pond Outlet Structure retrofit, based on past project experience for projects of similar scope. No Land Cost included.

*See Itemized Cost Estimate Attached in Appendix 7

8 Regulatory Analysis

The Town and City are currently developing a policy regarding the handling of expired State stormwater permits. This final policy will be included in the final FRP. The Town and City are considering consolidating aspects of their stormwater activities and budgets, which may influence their permit compliance ordinance mandating how to deal with expired permits in the context of the MS4 permit. As part of this plan, retrofits are being proposed on sites tied to an expired State operational stormwater permit. The policy could provide private permittees to either have their permit adopted under the MS4 permit, or to request coverage under a Residual Designation Authority (RDA) permit from the State, which they can do now. If retrofit projects are to be covered under the MS4 permit, the MS4 may elect to take over operation and maintenance (O&M) of the stormwater system and will report on any pertinent O&M activities as part of the MS4 requirements. If the retrofit project is to be covered under an RDA permit, the private landowners holding the RDA permit may retain the responsibility of O&M on the retrofit stormwater system. The decision as to how these retrofit projects are covered in the future will be subject to discussion and agreement with the private landowners, the MS4, and the State. A full list of the expired permits with discharges to Rugg Brook indicating the retrofits proposed under this FRP is included in Appendix 2 (Table A-2-1).

9 Glossary of Terms

A glossary of relevant terms is provided below.

Best Management Practice (BMP)- Generally, BMPs are defined as "Schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the State and waters of the United States. BMPs also include treatment requirements, operating procedures, and practices to control runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage" (MS4 Permit, 2012). In the context of the FRP, BMPs include prescribed stormwater flow control practices as defined in the computer-based BMPDSS model, in which various BMPs scenarios can be assessed.

BMPDSS- Best Management Practice Decision Support System- A computer-based hydrologic model used to assess the impact of various stormwater Best Management Practice (BMP) scenarios. This tool was developed by a private consultant for VT DEC to use as the assessment tool for the compliance of the Stormwater TMDLs.

Channel Protection Volume (CPv)- The stormwater volume generated from the one-year, 24-hour rainfall event (1.9"). The Vermont Stormwater CPv Design Standard requires 12 hours of extended detention storage (ED) of the CPv in warmwater fish habitat (24 hour for coldfish), as a means to reduce channel erosion.

Detention BMP- A BMP (eg. Pond, biofilter) which stores stormwater for a defined length of time before it eventually drains to the receiving water body. Stormwater is not retained in the practice. The objective with e detention BMP is to reduce the peak discharge (Qp) from the Basin, in the effort to reduce channel erosion and settle out pollutants from the stormwater.

Flow Duration Curve (FDC)- An FDC is a curve displaying the percentage of time during a period that flow exceeds a certain value, with the "low" flow represented by the 95th percentile ($Q_{95\%}$) of the curve and the "high" flow represented by the 5th percentile ($Q_{0.3\%}$).

Flow Restoration Plan (FRP)- The FRP is a required element of the MS4 General Permit #3-9014, under section IV. C. 1., for stormwater discharges to impaired waters. The FRP is a 20-year implementation plan of stormwater flow control Best Management Practices (BMPs) to meet the TMDL high-flow target and return the impaired water to its attainment condition. The FRP is required to include a list of stormwater BMP controls, as well as modeling results from the States VTBMPDSS model demonstrating compliance of the approved TMDL flow-target with the proposed BMP list.

Infiltration BMP- A BMP **(**eg. Storm-tech Chamber, bioretention) which allows for the infiltration of stormwater into the subsurface soil as groundwater, which returns to the stream as baseflow. Mapped soils of Hydrologic group A or B (sandy well drained soils) are an indicator of infiltration potential. Infiltration reduces the amount of surface storage required. Typical BMP practices include infiltration basins, underground chamber systems, bioretention practices, etc.

Non-Jurisdictional Impervious- Non-jurisdictional growth is by definition impervious area that does not require a stormwater permit and it not managed by a stormwater BMP (impervious growth < 1 acre).

Residual Designation Authority (RDA)- State's authority to issue an RDA permit to discharges not covered by the MS4 Permit. The RDA permit is separate from the MS4 permit, held by the private landowner.

Stormwater Management Plan (SWMP)- A comprehensive program to manage stormwater discharges from the Municipal Separated Storm Sewer System as mandated by the MS4 General Permit #3-9014.

Stormwater TMDL (TMDL)- Vermont developed stormwater TMDL's for impaired watersheds using stormwater flow as a surrogate for pollutants. The basis for the flow-based TMDL is the understanding that stormwater is the source of pollutant loading, therefore minimizing stormwater flows will reduce pollutant loading to the streams and Lake Champlain. The approved TMDL is defined by a reduction in high-flows, defined as greater than the 1-year storm event (~1.94" in St. Albans). The TMDL also includes a non-actionable (not enforced) lo-flow target which is an increase in baseflow (groundwater flow to streams).

Total Maximum Daily Load (TMDL)- A TMDL is a calculation of the maximum pollutant loading that a water body can accommodate and still meet Vermont Water Quality Standards. The term TMDL also refers to the regulated management plan, which defines who the water body will be regulated and returned to its acceptable condition, including the maximum loading, sources of pollution, and criteria for determining if the TMDL is met.

TMDL High-Flow Target - The TMDL target defined as the percent change between the baseline condition (pre 2002) and the existing or proposed condition (Post 2002) high flow. The high-flow is the flow rate in the stream that is exceeded only 0.3% of the time (Q0.3%), over a 10 year simulation period. The Q0.3% has been equated to the 1-year design storm runoff.

TMDL Low-Flow Target - The non-actionable TMDL target defined as the percent change between the baseline condition (pre 2002) and the existing or proposed condition (Post 2002) low flow. The low flow is the flow rate in the stream that is exceeded 95% of the time (Q95%), over a 10 year simulation period. The Q95% is considered "baseflow" which is the flow in a stream fed by groundwater.

10 Appendices