INDIAN BROOK
FLOW RESTORATION PLAN

MS4 General Permit Requirement (IV.C.1)

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In Partnership with:

Town of Essex, VT City of Essex Junction, VT , Town of Colchester, VT, Vermont Department of Transportation

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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 Indian Brook Flow Restoration Plan (FRP) Project, completed under a contract between the Town of Essex and the hired consultant team, Watershed Consulting Associates, LLC and Aldrich & Elliott, PC. The Indian Brook FRP was prepared to meet the compliance requirement for the Indian Brook impervious surface owners, including the Town of Essex, City of Essex Junction, 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.

It is noted that on July 1, 2022 the City of Essex Junction became an independent city and is now recognized as the City of Essex Junction.

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 Indian Brook watershed under contract with the Town of Essex, in partnership with the City of Essex Junction, 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 Indian 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) from the pre 2002 condition, as required by the Indian 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 **42%** 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 the actionable flow target.

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 14 projects—four (4) retrofits of existing ponds, three (3) retrofits of existing natural detention areas to detention systems, three (3) new underground infiltration systems, two (2) new sand filters in the I-289 median, one (1) repaving project to increase capture to the Essex High School Rain Garden, and removal of 0.11 acres of existing impervious in the Briar Lane cul-de-sac. The proposed BMPs were assessed with the BMPDSS model, and determined to provide a –1.85% reduction in the high-flow which addresses 212% 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 0.6%, which addresses 58% of the low-flow target. The total planning level cost for the 14 projects is $2,899,000. Based on a calculation of the percent target mitigated by each project and cumulative percent addressed, only the top 2 of the 14 proposed projects are required to meet 100% of the TMDL high-flow target. The top two projects, in terms of high-flow reduction are the LDS North Pond Option 4 and the Fairview Dr. retrofit. The planning level cost for the top two projects (with LDS Option 5) is $1,230,000.

The projects were ranked using a comprehensive matrix. From the top projects, four (4) were selected for to be constructed.

1. **LDS North Pond:** Retrofit of the Church of Latter-Day Saints (LDS) detention pond into an underground storage system. Estimated construction 2024.
2. **Fairview Dr.:** Retrofit of an existing detention area into a terraced detention basin at the corner of Fairview Dr. and Main St. Constructed in 2019.
3. **Brickyard Dr./Mansfield Ave.:** Retrofit of a natural detention area into a detention basin at the corner of Mansfield Dr. and Brickyard Dr. Constructed in 2020.
4. **Woodlands/Sydney Dr:** Retrofit of a non-functioning detention pond into an underground infiltration basin with 48" perforated pipe for additional storage. Constructed in 2020.

HydroCAD files and As-builts, if available were submitted to the State in March 2024 on the constructed projects. As-builts and final plans for each project are also included in the Appendices. Sketch plans were developed for all other proposed BMPs.

2 Background

Indian 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 Indian Brook and lift its impaired designation, a flow-based Total Maximum Daily Load (TMDL) was developed for Indian 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 Indian 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 Indian Brook, including the Town Essex, City of Essex Junction, 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.

Future Growth

The VT DEC added a future growth factor to the TMDL flow targets to account for future non-jurisdictional impervious growth. Non-jurisdictional growth was defined as impervious area that is not subject to a state stormwater permit and is therefore not managed by a state permitted stormwater BMP. This type of growth is typical of a small project, which involves the addition of new impervious below the state threshold of 1 acre. This future growth factor was developed under the assumption that no local zoning or land use rules would be in place to require stormwater management for smaller projects. VT DEC used a future non-jurisdictional growth estimate of 18 acres, provided to VT DEC based on local development and projected growth. Documentation for this estimate was not provided to VT DEC.

To develop the TMDL target with future growth, the estimated future impervious growth (18 acres) was added to the watershed’s existing impervious cover, to simulate the watershed conditions at the end of the FRP implementation timeframe (20 years), which at the time was projected to be 2025. With the projected non-jurisdictional future growth, the high-flow target reduction changed by -0.4% and the low-flow target increase changed by +0.6% (Table 1).

The approved TMDL flow targets 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)	-0.9%	0.4%
TMDL Targets with **18 acres** of Non-Jurisdictional Future Growth	-1.3%	1.1%
*The low flow target is not actionable under the TMDL, but is included because improving base flow in the watershed is still a water quality goal.		

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

2.2 MS4 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 40.4% of the impervious cover in the Indian Brook watershed is within the Town of Essex, 51.3% within the City of Essex Junction, and about 8.4% in the VTRANS Right-of-Way (Table 2).

Table 2: Indian Brook MS4 Impervious Breakdown

MS4 Impervious Owner	Total Area w/in Watershed (acres)	Impervious Cover (acres)	% of Watershed Impervious Cover
Town of Essex	3,492.39	171.85	40.4%
City of Essex Junction	952.60	218.08	51.3%
VTrans	141.91	35.56	8.4%
Watershed Total	**4,586.90**	425.49	

The TMDL flow targets, including a -1.3% ***reduction*** (-) in high flow across the watershed, and a 1.1% ***increase (+)*** in low flow, were then split between the three MS4's based on their percent share of the total impervious ownership in the watershed (Table 3).

Table 3: Indian Brook TMDL Flow Target Allocation by MS4

MS4 Impervious Owner	Target High Flow[1] **Reduction** (%)	Target Low Flow[2] **Increase** (%)
Town of Essex	-0.53%	0.44%
City of Essex Junction	-0.67%	0.56%
VTrans	-0.11%	0.09%
Watershed Total[3]	**-1.3%**	**1.1%**
[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 assessment because improving base flow in the watershed is still a water quality goal.		
[3] Watershed delineation from file: "Indian_watershed121614"		

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 (i.e. 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 table of the expired stormwater permits within the Indian Brook impaired watershed is included in Appendix A-2-1.

Table 4: "Group 1" Expired Permit Stormwater BMPs

Permit #	Project/BMP Name	MS4	BMP Type in BMPDSS	Permit Renewal	Ownership
1-0775a	Lang Farm Parcel A- Phase 2- Essex Outlets	Town	Detention Pond	6262-9020 upgrades	Private
1-0775b	Lang Farm Parcel A- Phase 2, Essex Outlets	Town	Detention Pond	6262-9020 upgrades	Private
1-0775c	Lang Farm Parcel A- Phase 2, Essex Outlets	Town	Detention Pond	6262-9020 upgrades	Private
1-1307	Homestead Design, Inc.	Town	Detention Pond discharges 1-0775 pond b	4002-INDS.A upgrades	Private
1-1382	Essex Community Educational Ctr.	City	Infiltration Basin	4119-INDS	Private
1-1074	Countryside II Fairview Farms: Locust lane, Chestnut Lane, Spruce Land, Walnut Lane	City	Detention Pond (S/N 001) and natural detention area (S/N 002)	Upgrades completed	Public/ Private
1-1186	Woodlands II- Lang Farm Parcel	Town	Detention Pond		Public
1-1319_p1	Church of Jesus Christ of Latter Day Saints	Town	Detention Pond		Private
1-1319_p2	Church of Jesus Christ of Latter Day Saints	Town	Detention Pond		Private
1-1381_p1	The Commons at Essex Way Condominium Association	Town	Detention Pond		Private
1-1381_p2	The Commons at Essex Way Condominium Association	Town	Detention Pond		Private
2-0631	Essex Resort & Spa	Town	Detention Pond		Private
1081	Old Stage Rd/Rt-15 (Essex STP 030-1(17))	Town	Detention Pond		Essex
1-1409	Champlain Valley Exposition, Inc	City	Detention Pond		Private
2-0289	East Creek Condominiums	City	Detention Pond		Private
2-0835 p1	City Glen Condos- CGPM, Inc.	City	Dry well		Private
2-0835 p2	City Glen Condos- CGPM, Inc.	City	Dry well		Private
2-0952	North Creek, South Creek and East Creek Condominiums	City	Natural Detention Area		Private

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

3.1.2 VTDEC BMPDSS Existing Model Review

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 BMPs 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).

- Permit #1-1409 Champlain Valley Exposition Historical Drainage:

  It was confirmed as a part of the model review process that the historical drainage changes implemented at the Sunderland Brook headwaters on the Champlain Valley Exposition (CVE) Property were accounted for in the baseline model. The permit 1-1409 was issued in August of 2000 followed by implementation later that fall. The drainage changes included routing an area from Sunderland *to* Indian Brook in an effort to mitigate localized flooding issues around the Essex Automotive Area and the Kinney Drug store.

3.1.2.1 Base model (Pre 2002 condition) Revisions

- Adjustments to subwatershed boundaries at Chestnut Lane to account for mapped storm infrastructure.
- Adjustments to the drainage area for the detention pond covered under #1-1409, at the Champlain Valley Exposition.
- Adjustments to subwatershed boundaries around Lincoln St/Grove St.
- Subwatershed adjustments at Brickyard and Mansfield Ave.
- Subwatershed adjustments along Essex Way.

Revisions were made to BMP design parameters (storage, outlet dimensions, etc.) for several existing ponds to reflect field measurements, including:

- #1-1307 Homestead Design Pond, located in the Essex Shopping Center
- #1-1319 Church of LDS Ponds 1 and 2, along Essex Way
- #1-1381 The Commons at Essex Way Condominium Association Ponds 1 and 2, located off Essex Way.
- #1-1382 Pond located behind the Essex Community Educational Center.

- #2-0631 Pond located on the Essex Resort & Spa property
- #2-0289 East Creek Condominiums Pond, located off Brickyard Rd.

Existing detention storage not previously accounted for in the model was added for two locations:

- **Fairview Dr./Main St.**- A natural detention area was identified by the City DPW, and added to the model. The outlet of the existing detention area is a permitted discharge under expired permit #1-1074 (S/N 002).
- **Brickyard Rd./ Mansfield Ave**- A man-made berm from past construction with an 18" culvert provides natural detention for runoff from the East, North, and South Creek Condominiums, covered under expired permit #2-0952.

3.1.2.2 Existing Condition (Post 2002) Model Revisions

The Existing condition model was revised as follows:

- Impervious cover mapping to reflect build out of several new projects including Handy Suites, and expected development at Thasha Lane (permit #7125-INDS).

Several new projects previously omitted from the model were added including:

- **#6262-9020** Essex Outlet Pond Upgrades
- **#4002-INDS.A** Essex Town Center Pond Upgrades to Pond B and Pond C
- **#3626-INDS.1** (upgrade to #1-1409) including new outlet structure, dry pond and grading plan
- **#5864-INDS** Lang Farm new parking and Wet Swale
- **#6713-INDS** Route 2A mini Storage Unit with detention pond.

Figure 1: WCA Staff, with Town of Essex Staff and Interns inspecting Essex Outlet Ponds (6/26/14).

- **#7125-INDS** new development at Thasha Lane with three detention ponds.
- Essex Union High School Rain Garden

- Handy Suites Apartments with Porous Asphalt parking lot

Additional revisions included removal of the upgrade to #1-1186 previously included as an existing upgrade. The design was based on the proposed design by Lamoureux & Dickinson. A new retrofit design was developed for this site and added to the Credit model scenario.

3.1.2.3 *Existing Conditions Model Results*

The existing condition (Post 2002) model was revised with two iterations resulting in an overall ***decrease*** in progress toward the targets 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-2-2). The existing condition scenario includes 37 individual BMPs, each managing the 1-year design storm, and 8 of which also provide recharge to groundwater. The most up to date existing condition model scenario (as of 1/12/2015) was estimated to provide a -0.54% reduction in high flow, calculated as a percent change between the unadjusted flow in the baseline condition (pre 2002) and Post 2002 scenario, addressing **41.5%** of the TMDL high-flow(Q0.3%) target. The low-flow was estimated to increase by 0.6% over the baseline scenario, addressing **58.3%** of the non-actionable low-flow 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 Indian 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** (%)	BMPDSS Model Run Date
TMDL Targets *Stormwater Allocation only		-1.3%	1.1%	----
DEC Existing Condition Model	DEC's existing model, includes all Post2002 BMPs	-1.14%	0.0%	1/31/2014
WCA Existing Condition Model (7/31/2014)	WCA revised subwatersheds and existing BMP design entries.	-1.49%	0.0%	7/31/2014
WCA Existing Condition Model (10/20/2014)	Additional revisions to BMP designs based on field assessment.	-1.40%	0.0%	10/20/2014
WCA Existing Condition Model (1/12/2015)	Changes to Base condition reduced high-flow % change	-0.54%	0.6%	1/12/2015
Percent of Target Managed (with Existing Condition Model 1/12/15)		**41.5%**	58.28%	----
* 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 June 26th and 27th 2014, of existing CPv BMPs covered by an expired permit to assess the opportunity for upgrade potential to VT 2002 Stormwater design standards. During the initial field assessment with the Town and City Staff, the team also visited several sites identified by the Town and City as potential future retrofits. The team then conducted a desktop assessment of the watershed to identify additional open spaces ideal for BMP implementation with priority on municipally owned land. In addition, 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 top 4 projects as needed. An in-depth engineering assessment will still be required at each site to confirm the presence/absence of utilities, natural resource constraints, and potential transportation impacts, as part of the final design process.

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 5-4. Four (4) projects were selected from the top ranked projects with a preference to include plans for Town and City projects. The team prepared 30% preliminary engineering conceptual designs for the four projects and orthophoto-based sketch plans for all other projects, provided in Appendix 1. The top four projects include:

- **LDS North Pond:** Retrofit of the Church of Latter Day Saints (LDS) detention pond into an underground storage system
- **Fairview Dr.:** Retrofit of an existing detention area into a terraced detention basin at the corner of Fairview Dr. and Main St.
- **Brickyard Dr./Mansfield Ave.:** Retrofit of a natural detention area into a detention basin at the corner of Mansfield Dr. and Brickyard Dr.
- **Woodlands/Sydney Dr:** Retrofit of a non-functioning detention pond into an underground infiltration basin with 48" perforated pipe for additional storage.

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 five (5) retrofits to existing detention ponds, two (2) sand filters in the I-289 Median, and one (1) proposed pavement regrade project to increase capture of the Rain Garden at the Essex High School. The 1st proposed scenario estimated a decrease in high flow of -1.85%, addressing **142%** of the target (Table 6). The low flow did not increase. Additional field work was completed at several sites and revisions were made to the Credit1 BMPs. In addition, three (3) infiltration BMPs were added (Densmore Dr, Grove St, and Countryside Dr.), as well as two (2) retrofits to existing BMPs (LDS P2, Commons P1 along Essex Way). Removal of 0.11 acres of impervious in the Briar Lane cul-de-sac was also included in the model. These revisions and additions constitute the Credit 2 model. The "Credit 2" scenario estimated a -2.75% decrease in the high-flow from the base condition, addressing **212%** of the high-flow and a 0.6% increase in baseflow, addressing 58% of the non-actionable low-flow target. A full modeling summary including all the model run results completed for Indian Brook, 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** (%)	Low Flow* **Increase** (%)	BMPDSS Model Run Date
TMDL Targets *Stormwater Allocation only		-1.3%	1.1%	----
Existing Condition Model (1/12/2015)	WCA revised additional subwatersheds and existing BMP design entries.	-0.54%	0.6%	1/12/2015
Percent of Target Managed (with Existing Condition Model 1/12/15)		**41.5%**	58.28%	----
Credit1 Model	Add 8 proposed retrofits.	-1.85%	0.0%	10/21/2014
Percent of Target Managed (with Credit1 run on 10/21/14)		**142%**	0%	----
Credit2 Model	Add 3 infiltration BMPs, two pond retrofits, and impervious removal.	-2.75%	0.6%	1/14/2015
Percent of Target Managed (with Credit2 run on 1/14/15)		**212%**	58%	----
Note: 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.				
* 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.				

4.2 Proposed FRP Model Scenario

The final recommended BMP list is represented in the “Credit2” model run, which includes 14 proposed BMPs (Table 7). The proposed FRP scenario addresses ***212%*** of the modified high-flow target providing a significant factor of safety (FOS). The additional FOS is included in the recommended BMP list to provide the MS4’s additional options, in the event the list has to be modified or as conditions in the watershed change from what is present today.

The individual and cumulative percent of the high-flow target mitigated is also included in Table 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 Indian Brook FRP

Site Name (*Note)	MS4 Imp. Owner	Owner of BMP Land	BMP Type (*Key)	Permit #	Runoff Area (acres)	Impervious Acres Managed (ac)	Channel Protection Volume (CPv) Managed above Base Condition*		Percent of High-flow Target Managed, %	***Cumulative* Percent of High-Flow Target Managed %**	Retrofit Description
							CF	Ac-ft			
Existing Post2002 BMPs[1]	Varies	Varies	Varies	Varies	Varies	Varies	---	----	42%[1]	**42%**	Varies
LDS Church North Pond Retrofit (Outfall 204)- Option 5: Underground Storage with Perforated Pipe	Town	Private	USC	1-1319, 2-0631, 2-0613	29.59	12.00	44431	1.02	42%	**84%**	Route outfalls North and South of LDS pond to retrofit. Option 5: Convert pond to expanded underground stone gallery with 48" Perforated Pipe.
Fairview Dr./Main St.	City/Town VTRANS	Public	GW	1-1074 SN002	22.53	3.94	19384	0.45	18.4%	**102%**	Regrade existing detention area, add terraced WQ bays, and replace existing culvert. Stabilize eroded outfall on North side of Main St.
Fairview Dr. Add-on	City/Town VTRANS	Public	GW	1-1074 SN002	6.87	1.30	9583	0.22	9.1%	**111%[2]**	Install new culvert to direct North side of Main St. to basin.

1. See Table 6. The existing BMPDSS model run estimated 42% of the flow target is addressed with existing BMPs.
2. 100% of the High-flow Target is met with the top two projects ranked by CPv storage. The table is set up so projects can be rearranged to determine which set of projects meet the target

Site Name (*Note)	MS4 Imp. Owner	Owner of BMP Land	BMP Type (*Key)	Permit #	Runoff Area (acres)	Impervious Acres Managed (ac)	Channel Protection Volume (CPv) Managed above Base Condition*		Percent of High-flow Target Managed, %	**Cumulative Percent of High-Flow Target Managed %**	Retrofit Description
							CF	Ac-ft			
Brickyard/North, South, East Creek Condos	City	Private	GW	2-0952	8.7	4.68	24960	0.57	23.7%	**135%**	Convert existing detention area at the corner of Mansfield/Brickyard to gravel wetland with CPv storage.
Woodlands (Detention Pond 139)	Town	Public	UIB	1-1186	35.42	9.59	15682	0.36	14.9%	**150%**	Retrofit existing detention pond to an underground stone gallery with 48" perforated pipe.
Densmore Dr.	City	Private	UIB	2-1103	38.28	11.73	14985	0.34	14.2%	**164%**	Install StormTech Chamber System on Densmore Dr. Verify high groundwater elevation.
East Creek Condominiums	City	Private	DB	2-0289/ 2-0317	48.2	14.40	13721	0.32	13.0%	**177%**	Retrofit outlet structure for CPv control. Armour spillway.
The Commons P1 (Outfall 131)	Town	Private	USC	1-1381	7.91	2.07	8668	0.20	8.2%	**185%**	Convert existing detention pond to StormTech chamber system. Improve aesthetics and landscaping.
Grove St.	City	ROW	UIB	2-0187	23.39	8.71	5576	0.13	5.3%	**191%**	Install two underground storage basins in series for detention and infiltration of the CPv storm.
I-289/Route 15 North	VTrans	ROW	MF	NP	2.78	0.90	5271	0.12	5.0%	**196%**	Retrofit existing median swale with CPv volume control sand filter.
Countryside Dr Intersection	City	ROW	USC	2-0155	5.25	1.95	4704	0.11	4.5%	**200%**	Stabilize outfall and bank. Install underground detention chamber at intersection of Countryside Dr./Brickyard. Add Stormwater planters in ROW on Countryside Dr.

Site Name (*Note)	MS4 Imp. Owner	Owner of BMP Land	BMP Type (*Key)	Permit #	Runoff Area (acres)	Impervious Acres Managed (ac)	Channel Protection Volume (CPv) Managed above Base Condition*		Percent of High-flow Target Managed, %	**Cumulative Percent of High-Flow Target Managed %**	Retrofit Description
							CF	Ac-ft			
LDS Church South P1 (Outfall 209)	Town	Private	DB	1-1319	1.34	1.01	4400	0.101	4.2%	**204%**	Retrofit existing detention pond to an underground stone gallery with 48" perforated pipe.
I-289/Route 15 South	VTrans	ROW	MF	NP	2.15	0.96	4443	0.10	4.2%	**209%**	Retrofit existing median swale with CPv volume control sand filter.
Essex Union High School-Rain Garden-Regrade Parking Lot	City	School District	GSI	NP	1.61	1.07	2222	0.05	2.1%	**211%**	Regrade parking lot to increase capture. Garden has capacity for more runoff without expansion.
Briar Lane Cul-de-sac Impervious Removal	City	No Practice	No Practice	2-0855 (City Knoll)	NA	0.11	900	0.02	0.9%	**212%**	Eliminate cul-de-sac to reduce plowing needs. Small impact.
Total:						**74.41**		**4.11**			

***Key :** BMP Type: DB: Detention Basin, USC = Underground Storage Chamber, UIB= Underground Infiltration Basin, GW = Gravel Wetland, GSI = Smaller-scale GSI practice DW= Dry Wells

***Note**: See Table A-3-2 for a list of the projects sorted by the BMPDSS Model run to which they were added. Summary: **Credit 1**- LDS Church North (Only Existing Drainage), Fairview Dr., Brickyard, Woodlands, East Creek Condos, I-289 N and S, EHS Rain Garden. **Credit 2**: Fairview Add-on, LDS Church Option 4, LDS Church South P1, The Commons P1, Countryside Dr., Grove St, Densmore Dr, Briar Lane

* Channel Protection Volume Managed above Base condition = New Storage Volume - Existing Volume pre2002

5.1 Town of Essex Proposed BMPs

Church of Latter Day Saints (LDS) North Pond Retrofit

The Church of Latter Day Saints (LDS), located along Essex Way, is currently covered under an expired permit #1-1319. The permit covers two wetland ponds, one in the back of the property to the South (Pond 1), and one to the North in the front of the Church (Pond 2). Essex Way, a Town owned road, drains to a swale behind the Church property and is covered under an expired permit #2-0613. Options to route the roadway to an expanded retrofit of the North LDS pond was assessed. The North Pond (P2) was identified as a good site for retrofit primarily because of the availability of open space for expansion, visibility, and ease of access. Preliminary studies of the LDS ponds and Essex Way drainage completed by the UVM Civil Engineering Department in 2010 were reviewed and considered as a part of the FRP assessment.

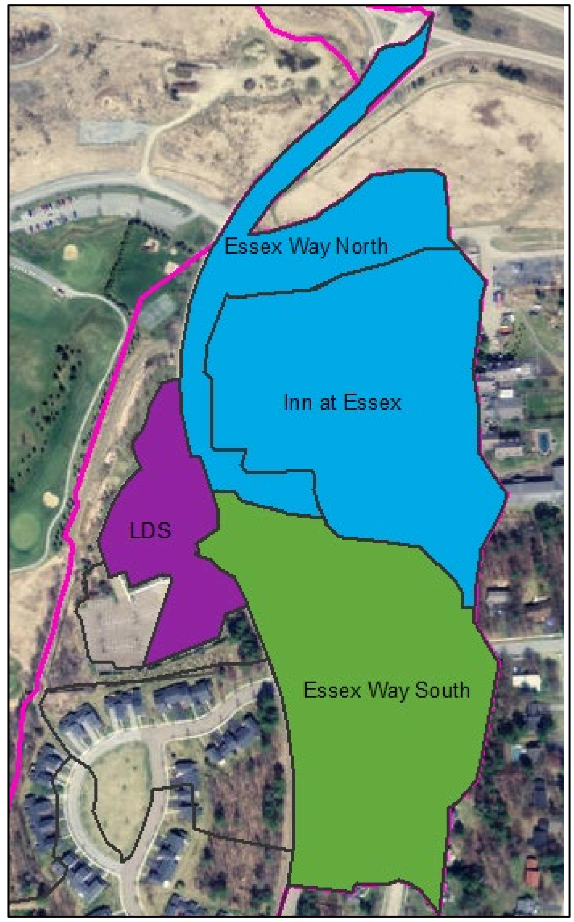

Figure 2: Drainage area map for LDS North Pond retrofit options. Each color represents the drainage to a separate inlet (3) to the proposed LDS retrofit.

Five options were explored for a retrofit of the North Pond, to assess the cost benefit of design alternatives. A summary of the five options and preliminary cost estimates is provided in Table 8 below. High flow (> 1 year storm) reduction would be provided and also potentially water quality benefit. Inflow areas would include the existing LDS North Lot, plus the CPv runoff via two new flow splitters from Essex Way North and Essex Way South, and the Essex Resort & Spa drainages (Figure 2).

Option #1 would involve expanding the present basin to a larger wet basin, while not encroaching on the existing swale along the bike path. The pond would provide the largest storage volume, of the four options. The preliminary cost estimate was the cheapest option (Table 8).

Option #2 would involve expanding and filling the existing pond area with stone to create a subsurface storage system. This option does not meet the target volume storage, but does reduce maintenance previously required for the open pond and improves aesthetics.

Option #3 is the same design alternative as Option #2 but with an expanded footprint that includes the existing swale adjacent to the bike path, providing CPv control for all the add-on areas (Figure 2). Based on our initial review, eliminating the upper reaches of this swale might be acceptable from a natural resources standpoint, given that the wetland area is poor for habitat, is manmade, and that conditions downstream will be improved as a result of the project. The land required is approximately twice that of the other options, which increases the total project cost.

Option #4 involves StormTech MC-3500 Chambers which would fit in the expanded pond area footprint, eliminating the need to encroach on the existing swale. The chambers could potentially sit on a bed of sand, which would allow for extended filtration through a sand bed as well as detention. This would benefit both high flow and also future water quality goals. Option #4 is considerably more expensive, due to the cost of the chambers and added manifold structures, as compared to the stone gallery for Option #3 (Table 8). A 30% design plan was developed for this option (Appendix 1).

Option #5 was the final selected design alternative, involving a system of 48" perforated HDPE pipe arranged in a stone bed. This system avoids the use of prefabricated chambers, while providing more storage volume within the same footprint as Option #4 using StormTech chambers. The system would include 20' sections of pipe in 19 rows, each with a 30" manway and 18" vent at the end of each row. An 18" equalization outlet pipe with an 18" tee into each HPDE pipe will allow for an even discharge from the pipe system. Hydrodynamic separators, called Downstream Defenders, would be placed at each inlet for pretreatment. Option #5, while less expensive than option #4, is still more expensive than an open pond. However, the underground system would create a more usable space for passive use and will require less maintenance than a pond option. A 30% design plan was also developed for this option (Appendix 1).

Table 8: Preliminary Cost comparison for LDS North Pond 2 Retrofit Options

BMP ID	Storage Volume		Construction Cost	Land Cost	Design and Permitting Cost (30%)	Total Project Cost	Cost per Impervious Acre
	cft	acft					
Option 1: Expanded Open Pond	57,630	1.32	$172,890.00	$43,200.00	$51,867.00	$267,957.00	$22,329.75
Option 2: Expanded Gravel Wetland with Stone Gallery (CPv not met)	27,800	0.64	$288,150.00	$43,200.00	$86,445.00	$417,795.00	$34,816.25
Option 3: Additional Expansion of Gravel Wetland with Stone Gallery (CPv met)	49,875	1.14	30% Cost Estimate (Includes land cost)			$510,000.00	$42,500.00
Option 4: Expanded StormTech Chamber system with MC-3500 chambers	54,886	1.26	30% Cost Estimate (Includes land cost)			$1,100,000.00	$91,666.67
Option 5 (selected): Stone Gallery with 48" Perforated Pipe	54,886	1.26	30% Cost Estimate (Includes land cost)			$940,000.00	$78,333.33

Church of Latter Day Saints (LDS) South Pond Retrofit


Figure 3: LDS South Pond (P1), exhibiting significant overgrowth.

The other pond on the LDS property, located behind the Church, is heavily overgrown and hard to access from the Church parking lot. Currently, a 1.0 acre portion of the back parking lot is routed to the pond. The proposed retrofit, would convert the existing pond to an underground storage similar to that proposed for the North Pond. The system would consist of a series of 48” HPDE perforated pipes placed in a bed of stone. A horizontal 18” equalization outlet pipe will connect the rows of perforated pipes via an 18” tee at each pipe outlet. The proposed system was sized to mitigate the CPv volume, and will provide water quality benefits from additional filtration through a sand subbase. An alternative option for the retrofit is to place the proposed chamber system under the parking lot, in the event access is an issue for the existing pond location.

The Commons at Essex Condominium Association North Pond Retrofit

The Commons at Essex Condominiums, located just South of the LDS Church, has two stormwater ponds covered under permit #1-1381. The North pond (Figure 4), is in the backyard of one of the condominium units, limiting use of the backyard and is not aesthetically pleasing to the residents.

Figure 4: The Commons North Pond Outlet Structure

The proposed retrofit for this pond involves conversion of the pond to an underground storage chamber system, and leveling to ground level to provide additional backyard space. A less costly alternative option, is to convert the wet pond to an expanded gravel wetland with aesthetic improvements including a new outlet structure and landscaping features, sized to mitigate the CPv storm volume.

A design was first explored to combine the LDS South Pond drainage with The Commons North pond, into an expanded underground detention system located where The Commons North pond is currently. However, it was determined that the required footprint for a combined system, sized to treat the CPv volume would not fit within the available space behind the Condominiums, while still providing adequate passage of higher flows through the existing culvert downstream. A second combined system was assessed for a system located in the LDS Church back parking lot. However, it was determined the grade was not adequate to route The Common North Pond drainage to the parking lot system. Therefore, two separate retrofits were proposed for The Commons North Pond and the LDS Church South Pond. An alternative system with a decreased treatment volume and higher bypass flows is still an option if it is determined that a separate retrofit is not an acceptable alternative.

Woodlands/Sydney Drive Pond Retrofit

Figure 5: View of proposed retrofit site from roadway.

Detention pond 139, located in the wooded area, just off Syndey Drive is currently covered under permit #1-1186 for the Woodlands development. The detention pond was designed with a flow splitter from Sydney Drive, intended to route a majority of the flow to the detention pond, and overflow to an outfall behind The Commons Condos. The flow splitter has been observed to not function as designed, and most of the flow is diverted to the outfall, with direct discharge to the stream. A proposed retrofit study was completed by Lamoureux and Dickinson in 2007, resulting in a design to upgrade the existing pond, but maintain the system as an open basin. The Town would like to limit the amount of new detention ponds, due to the cost of maintenance and lack of aesthetic appeal and use in the landscape.

A retrofit was developed for the pond, which would convert the pond to an underground stone gallery with limited infiltration. The existing depression would be filled with stone and converted to an open space/passive recreation on grassed land (Figure 5). Existing piping would be utilized to bring flow into/out of the storage area from the road. Pretreatment of inflow would be provided by a hydrodynamic swirl Downstream Defender or similar structure. Additional water quality benefit could be provided by adding a sand filter layer below the storage. The project would meet high flow goals and potentially benefit water quality goals as well.

Figure 6: Sydney Drive Pond Retrofit during construction in August 2020.

5.2 City of Essex Junction Proposed BMPs

Fairview Dr./Main St. Retrofit (1-1074 S/N 001)-Project Completed 2019

At the corner of Fairview Dr. and Route 15 (Main St), there is an existing natural detention area, controlled by a 12" culvert (Figure 6). The culvert captures runoff from the development above, covered under permit #1-1074, as well as Town land and Route 15, partially owned by VTRANS and the City. The existing outfall on the North side of Route 15 is severely eroded due to high flows and runoff bypassing the catch basins and flowing over the bank, therefore capture of this runoff was assessed (Figure 7).

Figure 7: Fairview Dr. natural detention area (6/27/14)

The proposed retrofit is to convert the natural depression to a gravel wetland with water quality treatment bays. This retrofit will benefit the high flow target, as well as water quality treatment which will benefit future phosphorus TMDL goals. Runoff from the northwest side of Route 15 (Main St.) would be intercepted and directed into the system via a new culvert, represented as the "Fairview Add-on" drainage" in Figure 7. This would eliminate most runoff to the highly-eroded outfall. Runoff would exit the system back under Route 15 via an upgraded pipe (12" to 30").

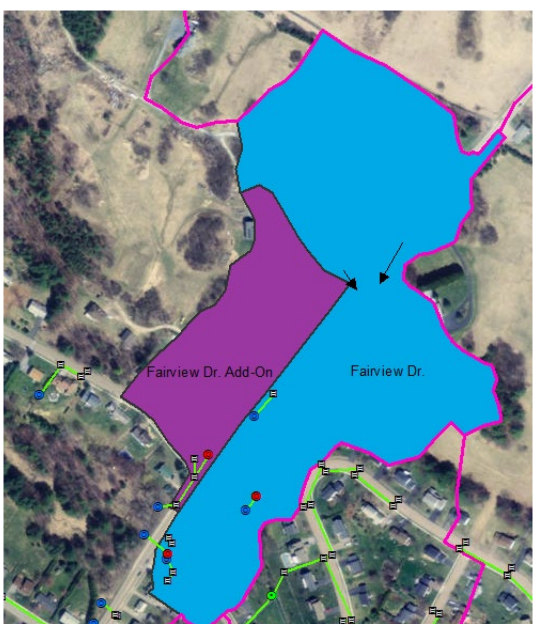

Figure 8: Drainage area map for Fairview Dr. Retrofit Options.

Figure 9: Fairview Dr. Gravel Wetland one year after install -Summer 2021

Brickyard Rd/North, East, South Creek Condos (# 2-0952) -Completed 2020

The North, East, and South Creek Condominiums, located on Brickyard Road, drain to a natural detention area that was formed by a man-made berm before draining to a Class II Wetland. The existing detention area was identified as an ideal opportunity for retrofit, to provide CPv volume control for runoff from the North, East, and South Creek Condominiums, as well as a portion of the City-owned road.

The proposed retrofit will convert the existing depression into a gravel wetland. There would be no permanent pool of water. The wetland will provide detention, benefitting the high flow target. Depending on confirmed groundwater elevation and duration of filtration time there could also be some low-flow benefit. Water quality treatment will be provided in a subsurface gravel layer potentially benefitting future phosphorus TMDL goals. A forebay could be installed at the inflow to the basin. As an alternative, a forebay could be created on the north side of Brickyard Road adjacent to the condominium complex entrance. Filling the depression with stone or chambers to create a level at-grade surface was contemplated for this site however it did not seem to be worth the cost for this particular location as it would not be expected to be a draw for local residents. The retrofit would not change the character of the area significantly. If anything, new plantings in the wetland could improve aesthetics.


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Figure 10: Mansfield Brickyard Gravel Wetland after install Sept. 2020

Densmore Dr. Underground Infiltration Chamber System

A 38-acre residential area in the southeast corner of the Indian Brook impaired watershed was identified as a good opportunity for retrofit because of the potential for infiltration and to mitigate runoff from a significant area. An underground infiltration system using SC-740 StormTech® chambers was proposed at the corner of Densmore Dr. and Sherwood Square, just up the pipe from the exiting outfall. The system would mitigate the CPv volume and 1-year design storm peak discharge, while providing water quality benefit through infiltration. Groundwater elevations will need to be verified, if the project is moved to implementation.

East Creek Condominiums Pond Retrofit (#2-0289)

The East Creek Condominiums, covered under permit #2-0289 drains to a dry pond controlled by a culvert and weir structure. The existing system provides minimal low-flow control. The proposed retrofit would involve retrofitting the dry pond to a wet pond with extended detention through addition of a low-flow orifice and overflow grate, as well as re-armoring of the spillway. No additional storage or regrading would be needed.

Grove St. Underground Infiltration Chamber System

A 23.4 acre subwatershed draining to an outfall just north of the North St./Grove St. intersection in downtown Essex Junction was identified as an opportunity for retrofit. The proposed retrofit would involve installation of a StormTech Chamber system in the Grove St. ROW. The footprint of the proposed practice would be within the City-Owned ROW. A groundwater monitoring well installed for the Essex High School Pump System Retrofit project measured a high groundwater table of ~323' on the opposite side of the brook from the proposed retrofit. Upon initial design, there would be adequate head to allow infiltration. Confirmation of the high groundwater table will need to be verified.

Countryside Dr./Brickyard Rd. Underground Detention Chamber System

The lower portion of Countryside Dr., south of Beech Dr. was identified by the City as a potential retrofit area for consideration primarily because the current roadway is wider than required and the outfall is significantly eroded. There is opportunity to install stormwater planters along the wide portion of Countryside Dr. with surface inlets to capture runoff from the roadway, providing water quality benefits and reducing impervious cover. A below-grade storage chamber system in the ROW is also proposed at the intersection of Countryside Dr and Brickyard Rd., sized to provide storage for the 1-year storm (CPv storage) from the existing catchment system.

Essex High School Parking Lot Improvements

A 1.28-acre area of the existing Essex High School parking lot drains to a rain garden, providing water quality and flow control benefits. Based on the 1-ft contours and field assessment, runoff from an additional 0.33 acres of impervious could be mitigated if the parking lot were regraded to provide positive flow to the east side of the parking lot. The proposed project would involve repaving approximately 0.5 acres of pavement. The existing rain garden has capacity for the additional runoff, and therefore would not require any retrofit to the garden itself, nor would the project increase maintenance demands.

Figure 11: Essex High School Rain Garden

Briar Lane Cul-de-sac Pavement Removal

An existing Cul-de-sac along Briar Lane was identified as an opportunity to reduce stormwater runoff, through the removal of the cul-de-sac. The removal of 0.11 acres of pavement was estimated to mitigate approximately 900 cft of stormwater runoff. An additional benefit of the project would be the reduction in plowing time, which currently takes the City Plowing Staff an extra 30 min- 1 hour just to plow the cul-de-sac.

5.3 VTRANS Proposed BMPs

I-289/Route 15 North and South Exit Ramp Sand Filter Retrofits

The I-289/Route 15 Exit Ramp was identified as a potential opportunity to manage runoff from primarily VTRANS owned impervious. Two sand filter systems were proposed in the median on the North and South side of the Route 15 overpass (Figure 9). The proposed practice is an approximately 4' deep sand filter, with a 4" underdrain, and 1.5' surface ponding depth before passing over a weir. The system is designed to provide storage for the CPv volume. The low-flow orifice and sand filter provide extended filtration, which provides water quality benefit.

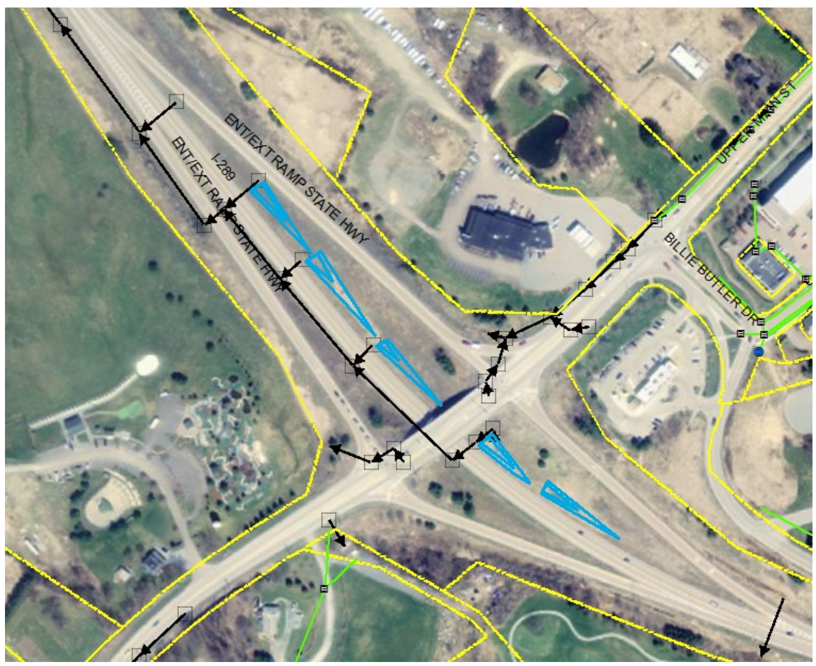

Figure 12: I-289 Exit Ramp with proposed retrofit.

5.4 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, 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

ID #	Site ID	BMP Type	Retrofit Description	Total Score
4	Woodlands (Detention Pond 139)	UIB	Retrofit existing detention pond to an underground infiltration practice with 48" perforated pipe.	39.0
3	Fairview Dr./Main St. with Add-On	GW	Regrade existing detention area and add riser. Route outfall on North side of Fairfield Dr. to retrofit.	38.0
1	Church LDS North P2 (Option 5)	USC	Retrofit existing Detention Pond in front of LDS Church. Convert pond to underground storage system with 48" perforated pipe. Route Essex Way and Inn at Essex runoff to retrofit.	34.0
2	Fairview Dr./Main St.	GW	Regrade existing detention area and add riser. Stabilize eroded outfall on North side of Fairfield Dr.	32.0
10	Densmore Dr.	UIB	StormTech Chamber System on Densmore Dr. Verify high groundwater elevation.	32.0
11	Grove St.	UIB	StormTech Chamber System in Grove St ROW. High groundwater table 323'.	31.0
6	Brickyard/North, South, East Creek Condos	DB	Retrofit existing detention area.	27.0
7	I-289/Route 15 North	MF	Retrofit existing median swale with CPv volume control sand filter.	27.0
8	I-289/Route 15 South	MF	Retrofit existing median swale with CPv volume control sand filter.	27.0
15	The Commons North Pond (P1)	USC	Convert existing detention pond to a Storm-Tech chamber system.	26.0
12	Countryside Dr Intersection	USC/GSI	Underground detention chamber at bottom of Countryside Dr is an option. Stabilize outfall and bank.	26.0

ID #	Site ID	BMP Type	Retrofit Description	Total Score
5	East Creek Condominiums	DB	Expand Existing Detention Pond and retrofit outlet structure for CPv control.	25.0
14	Church LDS South P1	USC	Convert to underground storage system with 48" perforated pipe.	23.0
9	Essex Union High School-Rain Garden- Regrade Parking Lot	GSI	Regrade parking lot to increase capture. Garden has capacity for more runoff without expansion.	19.0
13	Briar Lane Cul-de-sac Impervious Removal	No Practice	Eliminate Round-about to reduce Plowing needs. Small impact.	19.0

6 Design and Construction Schedule

A Design and Construction (D&C) schedule is a required element of the final approved FRP, providing an outline for the implementation of the proposed FRP over a 20-year timeframe. A D&C was prepared for the proposed projects. The projects were spaced out over the timeframe. The timeline considered effort for design, acquisition of necessary permits and/or regulatory approvals, and actual construction of the project. The project ranking (Appendix A-5-3) was used to prioritize projects for construction. The six projects included in the D&C are expected to achieve 117.3% (or 108.2%) of the Indian Brook TMDL target. The implementation schedule can be found in Appendix 8.

Modeling shows that 212% of the high flow target will be met if full project implementation is achieved (Table 6). If targets are met in Indian Brook as supported by biological monitoring data and/or other information concerning flow reduction progress, it is likely that not all projects will need to be constructed and will be implemented only if deemed necessary. The D&C is a working document and will be revised based on new information about the projects and/or as stream conditions change.

The Town and City fully expect to meet the target with the six identified projects. However, all parties understand that if implementation of all the Town and City "potential projects" was done, a higher percentage approaching 212% could be met. Pending DEC phosphorous removal requirements will also improve water quality to the benefit the FRP and TMDL. We count on the DEC on evaluating the stream in a timely manner. ~~It is prudent to proceed with the first six projects~~

~~and concurrently evaluate the stream conditions before implementing other flow reduction projects that may not have phosphorous reduction benefits associated with them.~~

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 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. WCA considered MS4 permittee ownership, and strived to identify BMPs with a sole MS4 owner, however optimal BMP locations did not always follow property boundaries. Most of the proposed retrofits have a sole MS4 owner, however there are few projects, like Fairview Dr., which have contributing runoff from impervious owned by all three MS4's. For joint ownership projects, the funding responsibility will be negotiated between the involved MS4's.

Town and City of Essex Junction Stormwater Program Consolidation:

The Town of Essex and City of Essex Junction Department of Public Works (DPW) decided to consolidate their Town and City stormwater budgets, as a result of watershed-wide improvement efforts required under the MS4 permit and FRP implementation plans for Indian and Sunderland Brook. The City and Town storm water activities budgets will be combined into the Town stormwater budget in the Town General Fund. The Town General Fund tax will be used to pay for the service to combine the programs. This merge will avoid duplication of effort and achieve cost savings. Furthermore, the Town and City previously formed a Joint Storm Water Coordinating Committee (SWCC), in the effort to more easily work collectively to develop the watershed-wide FRPs for Indian and Sunderland Brook. The consolidation of the City and Town budgets provides the SWCC with a financial framework to directly fund FRP projects with joint MS4 responsibility and address current and future permit compliance requirements. Costs will be less under the consolidated program, versus a separated program.

The SWCC will determine additional costs for FRP projects on an annual basis to be funded by the combined stormwater activities fund. In the future, the SWCC can also recommend to the City Board of Trustees and the Town Selectboard that a separate charge or fee be developed to cover the costs for stormwater permit compliance and program management, in addition to the Town General Fund.

Funding Sources: The main funding source for Town and City stormwater projects will be the Town General Fund Tax, paid by taxpayers within the Town and City. VTRANS will utilize their budget funds for stormwater-related 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 top 4 priority projects based on 30% preliminary engineering plans, detailed below. 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 for the top 4 projects were estimated using a combination of the VTRANS estimator program, RS Means, and local values, based on 30% engineering plans. The full itemized cost estimates are included in Appendix 6. 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:

For projects not designed to the 30% level, 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 10 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 [1] (Table 10). For **underground storage chambers**, a unit cost for StormTech MC-3500 chambers was used, accounting for the cost of the chambers and additional site work. The cost estimates are summarized in Table 10 below.

Table 10: Unit Costs for Different BMP Types

BMP Type	Unit Costs ($/cft)
Pond Retrofits	$3
New Storage Retrofits	$5
Underground Chamber Systems (StormTech MC-3500)	$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.

For the East Creek Condominiums Pond retrofit, an average cost per impervious acre managed was used instead of the unit cost approach, because the amount of work for the retrofit was not appropriately estimated based on the design volume[2]. For the Briar Lane imperious removal

[1] 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] 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-1.

project, a unit cost from the literature of $40,000 per acre removed was used[3]. For the Essex High School project, a unit cost of $30 per square yard to repave a portion of the parking lot was used, based on local construction experience.

Storage Volume: The unit costs were multiplied by a design volume (cu. ft), based on a storage volume required. The 100-year storm storage volume was used for above-ground detention and infiltration basins. The 1-year or 10-year storm (CPv) storage volume used for underground chamber systems. Underground chamber systems were designed as offline practices, which means only the 1-year or 10-year storm was routed to the practice. Higher flows were diverted from the system using a flow splitter. 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[4] , 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.

Table 11, below, includes a summary of the project cost estimates.

[3] 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. Impervious Cover Conversion.

[4] 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

Table 11: Proposed BMPs Cost Estimates

BMP ID	Design Storm	Impervious acres	Storage Volume		Unit Cost*	Retrofit Adjustment	Construction Cost	Land Owner	Land Cost	Design and Permitting Cost (30%)	Total Project Cost	Cost per Impervious Acre
			cft	acft								
LDS Church Option 5-Add On Essex Resort & Spa, Essex Way North, and Essex Way South	10 year	12.00	54886	1.26	30% Cost Estimate						$940,000.00	$78,330.00
Fairview Dr./Main St.	100 year	3.94	75185	1.73	$5	0.50	$187,961.40	City	$0.00	$56,388.42	$244,350.00	$62,010.00
Fairview Dr. with Add-on	1 year	5.24	78887	1.81	30% Cost Estimate						$290,000.00	$55,340.00
Brickyard/North, South, East Creek Condos	100 year	4.68	65253	1.50	30% Cost Estimate						$130,000.00	$27,770.00
Woodlands (Detention Pond 139)	10 year	9.59	52838	1.21	30% Cost Estimate						$200,000.00	$20,855.00
East Creek Condominiums	100 year	14.40	161433	3.71	NA[1]	0.50	NA[1]	HOA	NA[1]	NA[1]	$79,920.00	$5,550.00
I-289/Route 15 North	1 year	0.90	5271	0.12	$5	1.00	$26,353.80	VTRANS	$0.00	$7,906.14	$34,260.00	$38,190.00
I-289/Route 15 South	1 year	0.96	4443	0.10	$5	1.00	$22,215.60	VTRANS	$0.00	$6,664.68	$28,880.00	$30,050.00
Densmore Dr.	1 year	11.73	14985	0.34	$11	1.00	$164,831.04	Private Owner	$27,600.00	$49,449.31	$241,880.00	$20,620.00

BMP ID	Design Storm	Impervious acres	Storage Volume		Unit Cost*	Retrofit Adjustment	Construction Cost	Land Owner	Land Cost	Design and Permitting Cost (30%)	Total Project Cost	Cost per Impervious Acre
			cft	acft								
Grove St.	1 year	8.71	5576	0.13	$11	1.50	$91,998.72	City ROW	$0.00	$27,599.62	$119,600.00	$13,730.00
Countryside Dr.	1 year	1.95	7492	0.17	$19	1.50	$213,531.12	City ROW	$0.00	$64,059.34	$277,590.00	$142,560.00
LDS Church South P1 (Outfall 209)	100 year	1.01	10500	0.24	$5	1.50	$78,750.00	Private Owner	$16,200.00	$23,625.00	$118,575.00	$117,400.00
The Commons P1 (Outfall 131)	100 year	2.07	23087	0.53	$11	1.00	$253,954.80	Private Owner	$18,360.00	$76,186.44	$348,500.00	$168,360.00
Essex Union High School-Rain Garden-Regrade Parking Lot	1 year	1.07	741	0.02	NA[2]	NA[2]	$72,600.00	School	NA[2]	NA[2]	$72,600.00	$145,200.00
Briar Lane Cul-de-sac Impervious Removal	Remove Impervio us	0.11	---	---	NA[3]	NA[3]	$13,200.00	City Road	NA[3]	$3,960.00	$17,160.00	$85,800.00
										Project Total:	**$3,143,315**	

* 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)

NA[1] Not Applicable. Estimate based on Cost per impervious acre managed of $11,100 times a 0.5 retrofit adjustment factor. Unit cost came from CWP cost research on pond retrofit projects (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-1)

NA[2] Not Applicable. Estimate based on Unit cost for repaving of $30/ SYD, based on local construction costs.

NA[3] Not Applicable. Estimate based on cost research from Impervious removal including $40,000/ impervious acre removed plus $26,000/ac for site restoration. (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. Impervious Cover Conversion)

8 Regulatory Analysis

Under the joint Storm Water Compliance Committee (SWCC), the Town and City have developed an expired permit compliance ordinance. The latest update to the Town of Essex Title 10.20 Stormwater Ordinance is included in Appendix 7. The ordinance outlines the types of stormwater permits within Indian Brook based on varying ownership. For each permit type the corresponding procedure for how the Town and City has dealt with that permit type in terms of permit responsibility and maintenance of the permitted stormwater infrastructure is included.

As part of this plan, retrofits are being proposed on sites tied to an expired State operational stormwater permit. The ordinance outlines the options for 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. The decision as to how the responsibility for the proposed retrofit projects on private land are covered in the future will be subject to discussion and agreement with the private landowners and the MS4 according to the approved Stormwater Ordinance. A list of expired permits within the Indian Brook impaired watershed is included in Appendix A-2-1, including whether the existing BMP is proposed for a retrofit under the FRP.

9 Revisions Log

October 6th, 2015:

A discrepancy was realized between the drainage area and impervious area reported in the FRP tables versus the GIS mapping data for the Woodlands/Sydney Drive proposed retrofit site. It was determined that the areas in the HydroCAD model, which were the source for the values in the tables, were incorrect. The revised drainage area is 35.42 acres, with 9.59 acres of impervious surfaces, including 4.27 acres of streets, 2.16 acres of roofs, and 3.16 acres of driveways and sidewalks. The following Tables and Appendix items were revised:

Table 13 Final Proposed BMPs for the Indian Brook FRP

Table 9 Ranked Proposed FRP BMPs based on comprehensive ranking matrix: Revised total score for Woodlands/Sydney Dr. from 38 to 39, bringing the project to the top of the ranking list.

Table 11 Proposed BMP Cost Estimates: Revised Woodlands site impervious acreage and Cost per impervious acre.

Appendix A-3-2 Indian BMP by Model List

Appendix A-5-3 Indian_RankingMatrix_7_23_15: Revised impervious area for Woodlands/Sydney Dr. and changed Impervious Acres Managed score from 5 to 6 points. As a result, the total ranking score for the Woodlands Dr. project increased from 38 to 39.

Appendix A-5-4 Total Phosphorus and TSS Reduction Benefits from Proposed BMPs

February 8th, 2017:

Section 6, the Design and Construction Schedule, was amended to include a reference to Appendix 8.

10 Appendices