Moon Brook
Flow Restoration Plan (FRP)

Town of Rutland, VT

September 29, 2016

Prepared for:
Town of Rutland

Prepared by:
Watershed Consulting Associates, LLC
P.O. Box 4413
Burlington, VT 05406
P: 802.497.2367

WATERSHED
CONSULTING ASSOCIATES, LLC

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

Appendix A- Watershed Map Including Proposed and Existing Stormwater BMPs

Appendix B- Summary Sheets for All Proposed BMPs

Appendix C- Cost Estimate Worksheet for Proposed BMPs

Appendix D- Table Describing Pre-2002 and Post-2002 BMPs

Appendix E- Map of Pre-2002 and Post-2002 BMPs

Appendix F- BMPDSS Model Runs Summary Table

Appendix G- Randbury Rd. Basin Concept Plan

Appendix H- Horsley-Witten Memo Detailing Basis for Cost Estimate Methodology

I. Disclaimer

The intent of this plan is to present the data collected, evaluations, analysis, designs, and cost estimates for the Moon Brook Flow Restoration Plan (FRP) Project, completed under a contract between the Town of Rutland and the hired consultant team, Watershed Consulting Associates, LLC. The Moon Brook FRP was prepared to meet the compliance requirements for the National Pollutant Discharge Elimination System General Permit 3-9014 (Vermont Department of Environmental Conservation, 2012) for stormwater discharges to impaired waters for Moon Brook impervious surface owners. This plan is intended as a regulatory document for the Town of Rutland only, and is not meant to serve as a watershed-wide plan.

II. Executive Summary

This Flow Restoration Plan (FRP) for the section of the Moon Brook Watershed (MBW) that falls within the Town of Rutland was developed in accordance with requirements for Municipal Separate Storm Sewer System (MS4) entities. Once approved by the Vermont Department of Environmental Conservation (VT DEC) this FRP will become part of the Moon Brook Stormwater Management Plan (SWMP) prepared by the Town of Rutland. The MS4 permitees in this watershed are the Town of Rutland, the City of Rutland, and the Vermont Department of Transportation (VTrans). This FRP will serve as a long term planning tool for the Town of Rutland to implement stormwater best management practices (BMPs) throughout their section of the watershed in the effort to return Moon Brook to its attainment condition. Although three MS4 entities own impervious cover within the MBW, the Town of Rutland has elected to prepare its own FRP document.

The Vermont Best Management Practice Decision Support System (BMPDSS) model, a Geographic Information Systems (GIS)-based hydrologic model maintained by the VT DEC, was used to assess the impact of various stormwater BMP scenarios proposed as part of this FRP process. The VT DEC provided a Pre-2002 model run for the watershed, which included any BMPs that existed prior to 2002 in the watershed and provided an estimated stream flow during the 1-year storm event. The goal of the FRP is to reduce stream flow by 11.9% during this target storm event as outlined in the Total Maximum Daily Load (TMDL) document described below.

A second BMPDSS model was run by the VT DEC for the Post-2002 condition, including all BMPs that were constructed in the watershed after 2002 and thus designed to meet the Vermont 2002 Stormwater Management Manual (VT SWMM) design standards. This model reflected the existing conditions in the watershed and it was used to determine to what extent current stormwater controls have reduced high flows (flows occurring less than 0.3% of the time).

Revisions were made to both the Pre-2002 and Post-2002 models based on field investigations of BMPs with expired stormwater permits, discussions with the MS4s, and information from the VT DEC. These revisions were made watershed-wide, not just within the Town of Rutland, as the BMPDSS is an aggregate model and thus takes into account the condition of the entire watershed. Both of these models (Pre-2002 and Post-2002) were rerun following revisions, and these revised model runs were used for all subsequent modeling. Following revisions, the Post-2002 BMPDSS model run showed a 0.71% reduction in high flows from the revised Pre-2002 condition, which accounts for 6% of the required flow reduction of 11.9%. Once allocated by impervious area for each MS4, this reduction accounted for 6.6% of the Town of Rutland’s high flow allocation. As such, additional BMPs were required to meet 100% of the required high flow reduction target for the Town.

An initial list of potential BMP sites was identified remotely using GIS with a focus on managing impervious area within the Town of Rutland. A preliminary field assessment was completed at each site to document potential BMP practices, constructability issues, and review drainage areas. These new BMPs were then incorporated into the BMPDSS Credit model, which simulates the high flow reduction from the future construction of the identified BMPs. This was an iterative process where new BMPs were added and the model rerun as new BMPs were identified. The final run of the model was aimed at achieving target high flow reduction for the Town of Rutland. Watershed-wide, a high flow reduction of 2.72% was achieved with the proposed scenario, which, allocated by impervious cover managed, resulted in a 1.9% high flow reduction for the Town of Rutland. This equates to 67% of the Town's allocated target. While the target was not achieved by the Town, the proposed BMP scenario does manage 35% of the Town's impervious surfaces. The majority of the remaining impervious cover is low density and widely distributed throughout the watershed. This makes large stormwater BMPs infeasible for this area. Additional reductions could be achieved through distributed green stormwater infrastructure (GSI).

The final BMPDSS Credit model run included a total of eight retrofits, all of which are located in the Town of Rutland. One project, a gravel wetland site known as Randbury Road, is a joint project with VTrans. Of the eight projects, three are gravel wetlands, three are detention swales, and two are outlet retrofits of existing detention ponds. The total cost for implementation of these BMPs for the Town of Rutland is estimated at approximately $1,027,000. This total is reduced to $948,000 when a cost-share for the Randbury Road project was estimated. All cost estimates utilize 2014 construction cost estimates.

While not an actionable target, increasing the stream's low flow (baseflow) is still a water quality goal. However, due to limited soil infiltration potential within the Town of Rutland, the proposed BMPs do not improve modeled watershed-wide stream low flow (reduction of -0.45%).

III. Background

Moon Brook, located in central Vermont in Rutland County, extends into the Town of Rutland, the City of Rutland, and the Town of Mendon. This watershed covers approximately 7.8 mi^2 (5032 acres) and contains approximately 10% impervious cover (0.8 mi^2). The watershed is currently on the State of Vermont's impaired waters list, determined by the Environmental Protection Agency's (EPA) 303(d) list, as a result of stormwater runoff. Biological monitoring data has shown that Moon Brook fails to meet Vermont Water Quality Standards.

The final MS4 general permit, dated December 2012, requires that the Town of Rutland develop and submit a comprehensive FRP for their section of the MBW. The purpose of this Moon Brook FRP is to identify the necessary stormwater BMPs that will be used to achieve the flow restoration targets prescribed in the Moon Brook TMDL document.

III.1 TMDL Flow Targets

In the effort to restore Moon Brook to its attainment condition and lift its impaired designation, a flow-based TMDL was developed for Moon Brook using flow as a surrogate for pollutant loading. This document outlines required reductions in stream high flows and increase in stream low or base flows.

The basis for the TMDL required high flow reductions was the comparison of modeled Flow Duration Curves (FDCs) between the impaired Moon Brook and comparable attainment watersheds. An FDC graphs the percentage of time during a period that flow exceeds a certain value, with the low flow represented by the 95^{th} percentile ($Q_{95\%}$) and the high flow represented by the 5^{th} percentile ($Q_{0.3\%}$). 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 to develop FDCs from which an area of normalized high flow and low flow were extracted by drainage area. The percent change between impaired and attainment FDCs was used as a basis for the TMDL requirements. The high flow ($Q_{0.3\%}$) was determined to be relatively equivalent to the 1-year design storm flow. Therefore, all proposed BMPs are designed to the Channel Protection volume (CP_v) storage standard to address the high flow reduction target.

Included in the 2012 MS4 permit issuance were requirements for municipalities to develop FRPs to comply with the stormwater TMDLs. The FRPs must be developed for each impaired watershed by October 1, 2016, and must include the following elements:

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

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

III.1.1 Future Growth

A future growth factor was included in the TMDL to account for future non-jurisdictional impervious growth within the watershed. Non-jurisdictional growth is, by definition, impervious area that does not require a stormwater permit and is not managed by a stormwater BMP. Therefore, the long term stormwater management plan must account for this type of growth and future unmanaged impervious area. The VT DEC estimated a future growth of 25 acres in the watershed based on local development and projected growth for Moon Brook. The approved TMDL flow targets for Moon Brook are shown in Table 1.

Table 1. Moon Brook TMDL flow restoration targets

Target High Flow $Q_{0.3}$ (± %) Reduction	Target Low Flow Q_{95} (± %) Increase
-11.9%	**23.9%**

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 BMP identification for this study.

III.2 MS4 Allocation of Flow Targets

Allocation of the flow targets by MS4 was approximated for Moon Brook based on relative impervious cover. However, there are limitations to this method as the BMPDSS model is an aggregate model in which upstream BMPs affect downstream flow and runoff does not necessarily follow political boundaries.

Approximately 76% of the impervious cover within the Moon Brook Watershed is within the City of Rutland, 24% within the Town of Rutland, and 0.5% is owned by VTrans (Table 2). Although a section of Moon Brook is located in the Town of Mendon, this town is not considered a small MS4 community and therefore was not included in the allocation. Based on impervious surface ownership, the Town of Rutland is responsible for a high flow reduction of 2.82% and a low flow increase of 5.66% of the overall TMDL targets.

Table 2. Moon Brook flow targets allocated by MS4

Owner	Total Watershed Area (acres)	Impervious Cover (acres)	% of Watershed Impervious Cover	Target High Flow $Q_{0.3}$ (± %) Reduction [1]	Target Low Flow Q_{95} (± %) Increase
Mendon	2041.8	42.1	----	----	----
Rutland City	1415.3	353.8	75.8%	-9.02%	18.12%
Rutland Town	1556.4	110.6	23.7%	-2.82%	5.66%
VTrans	18.7	2.3	0.5%	-0.06%	0.12%
Watershed Total [2]	**2990.4**	**466.7**		**-11.90%**	**23.90%**
[1] The high flow target is negative (-), indicating a reduction in high flow from the baseline condition is required. The low flow target is positive (+), indicating a need for an increase in low flow from the baseline condition.					
[2] Watershed totals do not include watershed area or impervious area within the Town of Mendon as this community is not designated as a small MS4 community.					

IV. Best Management Practice Decision Support System Model Assessment

The VT DEC worked with an external consultant (TetraTech) to develop a Vermont specific hydrologic model, the VT BMPDSS, to predict progress toward the TMDL flow targets based on proposed BMP implementation scenarios. This modeling was adapted for use in Vermont with funding from the Vermont Agency of Natural Resources. The BMPDSS model is used to predict peak flows at the watershed outlet for a Pre-2002 (baseline), Post-2002 (existing condition), and a Credit (BMP implementation) scenario. All models are compared to the Pre-2002 model on a percent change basis.

IV.1.1 Permit Review

In order to confirm the information included in the Pre-2002 and Post-2002 BMPDSS models, all expired stormwater permits in the Town of Rutland, in the Moon Brook Watershed were acquired and reviewed. Two expired permits were identified. The first was Permit #4375-INDS - Wynnmere Senior Housing, and the second was Permit #1-1031 - La Victoire Subdivision (Table 3). The permitted detention pond under #4375-INDS was assessed for compliance with Vermont 2002 Stormwater Standards and for a retrofit opportunity. Based upon this review, a change to the outlet structure would bring the pond into compliance with these standards and increase detention. The stormwater system permitted under #1-1031 consists of a system of vegetated swales and culverts. A portion of the permitted runoff area drains to another proposed BMP, the Hitzel Terrace detention pond (further details regarding this proposed BMP can be found in Appendix B). Only a portion of the site permitted under #1-1031 drains to the proposed Hitzel Terrace detention pond because it was determined to be most feasible. A portion of the permitted site will remain uncollected. The entire permitted site however is planned to be incorporated into the Town of Rutland MS4.

Table 3. Expired stormwater permits in Moon Brook

Site Name	Permit #	Permit Expiration Date	Stormwater System
Wynnmere Senior Housing Project	4375-INDS	1/22/2012	Swales and catchbasin collection to detention pond
LaVictoire residential subdivision	1-1031	6/30/1996	Vegetated swales to culverts
Table prepared by Emily Schelley (VT DEC, Jan. 2014). Revised by WCA (2015).			

IV.1.2 Review of Existing Models

Both the Pre-2002 and Post-2002 models were assessed and revised as needed. New BMPs, either developed since the models were last updated or BMPs that were unknown at the time of the last model updates, were added. Additionally, other revisions such as watershed boundary changes, subwatershed boundary changes, and combined sewershed boundary changes were incorporated. Updated input files for the Pre-2002 and Post-2002 models were submitted to VT DEC so that updated model scenarios could be run. Input files included revised HydroCAD® models of each BMP as necessary, and GIS data for BMP drainage areas, subwatersheds, and BMP locations. A full list of the existing BMPs in the Pre-2002 and Post-2002 models is included in Appendix D and a map is included in Appendix E.

IV.1.2.1 Pre-2002 Condition Revisions

Several revisions were made to the Pre-2002 BMPDSS model based on information provided by the MS4 entities and the VT DEC, as well as field investigations. The model was revised as follows:

- Replaced previous combined sewershed delineation with revised version provided by Rutland City (currency: February 2013).
- Revised subwatershed delineations to reflect updated sewershed boundaries. These revisions reduced the watershed area from 5070 acres to 5032 acres.
- Revised subwatershed boundaries to account for updated utility infrastructure mapping and field verification of drainage paths in areas where there was either an existing BMP installed or a permitted discharge.
- Based on field observations and discussion with the City of Rutland staff, a section of the mapped MBW near the VTrans-owned rail yard was determined to be out of the watershed as it was concluded that the property drains to the combined sewer rather than to Moon Brook.
- Added four existing but previous unmodeled BMPs to the Pre-2002 model:
    1. Allen Pond Development - detention pond,
    2. Family Dental Associates - detention pond,
    3. Natural Detention area near Rutland Plywood, and
    4. Northeast School (Thrall Avenue) – detention pond (without new outlet structure, which was added after 2002 and included in the Post-2002 model revisions).

IV.1.2.2 Post-2002 Model Revisions

Upon field and remote review, and in light of information provided by the MS4 entities, several revisions were necessary for the Post-2002 BMPDSS model. The model was revised as follows:

- Mapped impervious cover was adjusted in areas where an existing BMP was located.
- Revised Pre-2002 model subwatershed boundaries to account for additional BMPs.
- Added five rain gardens (Rutland Natural Resources Conservation District projects).
- Added five existing BMPs implemented after 2002 to the model including:
    1. Vermont Eye Care Center - detention pond,
    2. Rutland Eye Physicians building - detention swale,
    3. Rutland Heart Center, Common Street – detention pond,

4. Gravel Wetland - Rutland Natural Resources Conservation District project, and
5. Northeast School (Thrall Avenue) - detention pond with new outlet structure added after 2002.

IV.1.2.3 Post-2002 Model Results

Following the revisions to the Pre-2002 and Post-2002 BMPDSS models described above, the model scenarios were rerun by the VT DEC. A watershed-wide high flow reduction of 0.71% was observed as a result of Post-2002 BMPs in place in the watershed. This accounts for 6% of the total required, watershed-wide, high flow reduction of 11.9%. The Post-2002 model results show that the Town of Rutland has addressed approximately 6.6% of their high flow target reduction. Model results are summarized in Table 4.

Based on the model results, additional CPv stormwater controls will be required to meet the Town of Rutland's allocated portion of the high flow reduction target. Biomonitoring of Moon Brook will ultimately determine when the stream has reached attainment conditions, but the minimal modeled high flow reduction with existing BMPs suggests that additional stormwater controls will be needed.

Table 4. Post-2002 BMPDSS model assessment results

Owner	Target High Flow $Q_{0.3}$ (± %) Reduction	High Flow $Q_{0.3}$ (± %) Reduction Achieved with Post-2002 Model	High Flow $Q_{0.3}$ (± %) Reduction Remaining with Post-2002 Model	High Flow ($Q_{0.3}$) Target addressed (%)
Rutland City	-9.02%	-0.52%	-8.5%	5.8%
Rutland Town	-2.82%	-0.19%	-2.63%	6.6%
VTrans	-0.06%	0.00%	-0.06%	0.0%
Watershed Total	**-11.90%**	**-0.71%**	**-11.19%**	**6.0%**

V. Required Controls Identification

Initial analyses utilizing GIS and remotely sensed data provided a basis for targeted field investigation. This process identified large, contiguous, unmanaged areas of impervious cover, existing stormwater infrastructure, town-owned parcels, and existing stormwater management features. Soils data provided by the Natural Resource Conservation Service and topographic data were also reviewed. A list of potential BMP locations was identified, and sites were investigated in the field to determine BMP feasibility.

Field investigations also involved documenting potential constructability issues, assessing site conditions, assessing natural resource concerns, determining utility conflicts, assessing ease of operation and maintenance, and reviewing drainage areas. An in-depth engineering assessment will still be required at each site to confirm the presence or absence of utilities, natural resource constraints, and potential transportation impacts as part of the final design process. The BMPs were designed using the HydroCAD® model to meet the CPv storage criteria for cold waters (12-hour detention standard).

Ultimately, it was determined that eight of the assessed locations were appropriate for BMP implementation (Table 6). These BMPs included three gravel wetlands, three detention swales, and two outlet retrofits of existing detention systems. Though all projects are located in the Town of Rutland, the Randbury Road gravel wetland project is a joint project with VTrans. Project details, photos, and maps for all BMPs are included in Appendix A and Appendix B, and a brief summary of each BMP is located in Table 6. Concept level designs of the Randbury Road project can be found in Appendix G.

V.1 BMPDSS Model Assessment Results

Selection of the final proposed BMP list was an iterative process and a total of three BMPDSS Credit model runs were completed. The initial BMPDSS Credit model run (Credit 1) included one BMP, the Randbury Road project. The Credit 1 scenario did not achieve the Town of Rutland's allocated flow reductions required by the TMDL, only addressing 20.5% of the Town of Rutland's allocated high flow reduction target. As such, three additional BMPs were identified and added in a subsequent iteration of the model. These projects included the 4375-INDS Wynnmere pond retrofit, the VELCO / Carmel Place project, and the Hitzel Terrace project. Following this Credit 2 model run, a high flow reduction of 1.59% of the Town of Rutland's allocation target reduction of 2.82%, was modeled. This equates to 56% of the Town's target high flow reduction. As high flow reduction targets were still not met, a Credit 3 model run was completed. This model run included the remaining four projects: Cannon Drive, Industrial Park, North End Drive, and Nancy Lane. Following this model run, a high flow reduction of 2.72% was modeled, 1.89% of which was allocated to the Town of Rutland (Table 5). This reduction equates to 67% of the Town's high flow reduction target. All model runs are summarized in Appendix F.

As these BMPs were targeted within the Town of Rutland and excluded BMP placement in the City of Rutland, the total watershed-wide high flow reduction was only 2.72%, which is 22.9% of the watershed-wide high flow target.

Table 5. BMPDSS final BMPDSS Credit model summary for the proposed FRP scenario

Owner	Target High Flow $Q_{0.3}$ (± %) Reduction	High Flow $Q_{0.3}$ (± %) Reduction Achieved with Credit Model	High Flow $Q_{0.3}$ (± %) Reduction Remaining with Credit Model	High Flow ($Q_{0.3}$) Target addressed (%)
Rutland City	-9.02%	-0.72%	-8.3%	8.0%
Rutland Town	-2.82%	-1.89%	-0.93%	66.9%
VTrans	-0.06%	-0.11%	0.05%	189.5%
Watershed Total	**11.9%**	**-2.72%**	**-9.18%**	**22.9%**

V.2 Proposed FRP Model Scenario

The final recommended BMP list includes eight proposed BMPs (Table 6), and the proposed FRP scenario addresses 22.9**%** of the watershed-wide high flow target. As BMPs were not proposed for the City of Rutland at this time, it was not expected that this Credit scenario would achieve 100% of the Moon Brook TMDL high flow reduction targets. However, the BMPs proposed for the Town of Rutland managed 35% of the Town’s impervious cover and address 67% of their allocated high flow reduction target. The remaining unmanaged impervious area in the Town of Rutland is low density and widely distributed. Any additional stormwater management would likely need to be addressed through distributed GSI. As such, the Credit 3 scenario described above was considered the most feasible for implementation by the Town. It is expected that 100% of the watershed-wide high flow target would be met if the City of Rutland chose to implement BMPs throughout their section of the watershed. The ultimate determination of when Moon Brook returns to its attainment condition will be made by the State, based on monitoring data or other relevant information (MS4 General Permit Sec. IV.J.3).

VI. Proposed Implementation Plan

The final list of proposed BMPs for the Town of Rutland are summarized in Table 6, including the impervious cover managed, drainage area, and CPv storage estimated by the HydroCAD® model. A map of the proposed BMP locations is included in Appendix A. Further details about each project can be found in Appendix B. The high flow target managed by BMP (%) based on managed impervious cover is also included in Table 6.

Table 6. Final proposed BMPs for the Moon Brook FRP

Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	% Impervious	% of Total Managed Impervious Cover in the Town of Rutland MS4	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	Town of Rutland High Flow Target Managed by BMP (%)
4375-INDS - Wynnmere Pond Retrofit	Town of Rutland	Private	Outlet Retrofit	4375-INDS	17.3	3.7	21.1%	100%	0.55	9.8%
Cannon Dr	Town of Rutland	Town of Rutland	Gravel Wetland	No Permit	3.7	0.7	18.1%	100%	0.15	1.8%
Hitzel Terrace	Town of Rutland	Private	Outlet Retrofit	No Permit	67.2	9.4	14.0%	100%	1.03	25.2%
Industrial Park	Town of Rutland	Private	Gravel Wetland	No Permit	8.5	4.1	48.3%	100%	0.79	11.0%
N End Dr	Town of Rutland	VELCO	Detention Swale	No Permit	16.4	2.5	15.0%	100%	0.50	6.6%
Nancy Ln	Town of Rutland	VELCO	Detention Swale	No Permit	34.1	5.9	17.4%	100%	1.27	15.9%
Randbury Rd	VTrans/ Town of Rutland	VTrans/ Town of Rutland/ Private	Gravel Wetland	New Road Project (Construction Permit)	23.1	11.0	47.6%	80%	0.86	23.7%
VELCO / Carmel Place	Town of Rutland	VELCO	Detention Swale	No Permit	21.3	2.3	10.6%	100%	0.62	6.1%

VII. Design and Construction Schedule

A design and construction (D&C) schedule was developed to provide a long term plan for the implementation of the FRP. The eight projects were spaced out over the timeframe in eight separate, 2-year phases. The timeline provides for design, acquisition of necessary permits, regulatory approvals, acquisition of necessary land, and actual construction. The flow restoration targets are subject to adjustment by the Secretary, based on biological monitoring data or other confounding information concerning high flow reduction progress. Adjustments to the flow targets may impact the schedule and full implementation of the proposed projects. The D&C is a working document and will be revised based on new information regarding the projects and stream conditions.

The projects were scheduled based on the ease of construction as well as the benefit of the individual BMP based on the relative impervious cover managed by that BMP. The two retrofits of existing BMPs were scheduled first as it was assumed that these projects would provide a significant benefit to the watershed while costs and construction complexity remain low. This allows time for the Town of Rutland to plan for the construction of the remaining five BMPs where the Town is the sole impervious cover owner. These projects, which are more expensive to construct and will require more extensive engineering and design, were ranked based on relative impervious cover managed. The final project, Randbury Road, is not scheduled until 2032 as this is the timeframe that VTrans has agreed to for this project and cooperation from VTrans is required for the construction of this BMP. The proposed implementation schedule and cost per implementation phase can be found in Table 7.

Table 7. Implementation schedule for proposed BMPs

Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Impervious Cover Managed (acres)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	Town of Rutland High Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)	Estimated Cost for Town of Rutland with Cost Share	Implementation Year
Hitzel Terrace	Town of Rutland	Town of Rutland	Outlet Retrofit	No Permit	9.4	1.03	25.2%	$14,000	$14,000	2018
4375-INDS - Wynnmere Pond Retrofit	Town of Rutland	Private	Outlet Retrofit	4375-INDS	3.7	0.55	9.8%	$10,000	$10,000	2020
Nancy Ln	Town of Rutland	VELCO	Detention Swale	No Permit	5.9	1.27	15.9%	$133,000	$133,000	2022
Industrial Park	Town of Rutland	Private	Gravel Wetland	No Permit	4.1	0.79	11.0%	$307,000	$307,000	2024
N End Dr	Town of Rutland	VELCO	Detention Swale	No Permit	2.5	0.50	6.6%	$52,000	$52,000	2026
VELCO / Carmel Place	Town of Rutland	VELCO	Detention Swale	No Permit	2.3	0.62	6.1%	$65,000	$65,000	2028
Cannon Dr	Town of Rutland	Town of Rutland	Gravel Wetland	No Permit	0.7	0.15	1.8%	$130,000	$130,000	2030
Randbury Rd	VTrans/ Town of Rutland	Private	Gravel Wetland	New Road Project (Construction Permit)	11.0	0.86	23.7%	$316,000	$237,000	2032
Watershed Total					**39.5**			**$1,027,000**	**$948,000**	

VIII. Financial Plan

Planning level costs were estimated for each project using a consistent spreadsheet-based method. A cost-share allocation was calculated for the Randbury Road project due to joint MS4 contributions. As of now, the Town of Rutland 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 Town's Public Works Department. The Town is in the process of developing their stormwater program and regulations in the upcoming year, which will determine how they will fund 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 program and municipal bond bank funds.

VIII.1BMP Cost Estimates:

A spreadsheet-based method, originally developed by the Horsley-Witten (HW) Group, was used to develop planning level costs for all proposed BMPs. The methodology was used in the development of the Centennial Brook FRP and provides consistent cost estimates for each BMP within the watershed (see HW Memo in Appendix H). It is expected that these costs will change as further designs are completed and site conditions and constraints are better understood. Cost estimates are based on limited site investigation, but are useful for planning purposes. All estimates presented are based on 2014 dollars.

VIII.1.1 Cost-Share Allocation

A cost-share was calculated for the Randbury Road project, which manages impervious cover owned by both the Town of Rutland and VTrans. A concept plan was developed for this project (Appendix G). This cost-share was determined using a combination of the percent runoff contribution and percent impervious surface ownership managed within the BMP drainage area. The runoff managed was determined by site-specific HydroCAD models. The percent impervious was determined through GIS using 2011 impervious cover mapping published by the Lake Champlain Basin Program. An average of the percent runoff volume generated and the impervious cover managed by MS4 was taken. The average was rounded to the nearest quarter, and the cost was allocated based on this percent. The cost-share allocation applied provides one example for how these two MS4s can share the financial responsibility for this project. The cost breakdown is summarized in Table 8.

Table 8. A potential cost-share for the Randbury Rd project by MS4

Total Cost: $356,000		
	VTrans	**Town of Rutland**
Runoff Volume 1-Year (ac-ft)	0.4	0.5
Percent Runoff Volume	45%	55%
Impervious Acres	2.2	8.8
Percent Impervious	20%	80%
Percent Cost Allocation	32%	68%
Cost Allocation Rounded to Nearest 25%	**25%**	**75%**
Cost Share	**$ 89,000**	**$ 267,000**

VIII.1.2 Cost Estimate Calculations

The BMP cost estimation is based on the design control volume as determined by HydroCAD models developed for each site, unit costs that take into account the type of BMP, a site adjustment factor that takes into account the difficulty of construction based on present development at a location, a factor for the design and permitting of the BMP, and a land acquisition cost.

Base unit costs were dependent on the type of BMP proposed, as well as the area of the BMP. For example, a detention basin's base cost would be \$2 per ft^3 (Table 9 upper). Depending on the type of site where the BMP will be constructed, a cost multiplier was used with more constricted and developed sites assumed to increase construction complexity and cost (Table 9 lower).

Table 9. Unit costs and adjustment factors for each BMP type

BMP Type	Base Cost (\$/ft^3)
Detention Basin	\$2
Infiltration Basin	\$4
Underground Chamber (infiltration or detention)	\$12
Bioretention	\$10
Green Infrastructure/ Underground Chamber Combo	\$22
Site Type	Cost Multiplier
Existing BMP retrofit	0.25
New BMP in undeveloped area	1
New BMP in partially developed area	1.5
New BMP in developed area	2
Adjustment factor for large aboveground basin projects	0.5

Final costs were also influenced by a number of other factors. These include:

- Base Construction Cost: Calculated as the product of the design control volume, the unit cost, and the site adjustment factor.
- Permits and Engineering Costs: A cost multiplier of either 20% for large storage volume projects, or 35% for small or complex projects was applied.
- Land Acquisition Costs (modified from the HW method): For projects that require the acquisition of private land, a variation from the HW method was applied. An approximate land acquisition cost of $120,000 was applied per acre required for the BMP. It should be noted that this value is based on a limited estimate and not necessarily an expected cost per acre.
- Total Project Cost: Calculated as the sum of the base construction cost, permitting and engineering costs, and land acquisition costs. This cost was then rounded to the nearest $1,000.
- Cost per Impervious Acre: Calculated as the construction costs, plus the permitting and engineering costs, divided by the impervious acres managed by the BMP.
- Operation and Maintenance (O&M): The annual O&M was calculated as 3% of the base construction costs. A maximum of $10,000 was used.
- Minimum Cost Adjustment: This methodology tends to underestimate the cost of small retrofits, so a minimum project cost of $10,000 was applied for a simple, small project such as an outlet retrofit, and a minimum cost of $25,000 was applied for more complex projects.

VIII.1.3 BMP Cost Estimates

The total cost for implementation of the FRP projects for the Town of Rutland was determined to be $948,000. This total assumes a cost-share for the joint-MS4 project (Randbury Road, Table 8). This is an approximate estimate and is subject to change based on more refined design and cost-sharing agreements. Table 10, below, includes a summary of the project cost estimates. The worksheet used to develop cost estimates for each proposed BMP is included in Appendix C.

Table 10. Cost estimates for proposed BMPs

Project Name	Retrofit Type	Impervious Area (acres)	Design Control Volume (ac-ft)	Base Unit Cost ($/cft)	Site Adjustment Factor	Minimum Project Cost ($10k for simple retrofits; $25k otherwise)	Final Project Cost Rounded to Nearest $1,000	% of Impervious within the Town of Rutland MS4	Town of Rutland Cost Share	Cost/ Impervious Acre	O&M
4375-INDS - Wynnmere Pond Retrofit	Outlet Retrofit	17.3	0.11	$2	0.25	$10,000	$10,000	100%	$10,000	$166	$72
Hitzel Terrace	Outlet Retrofit	67.2	0.55	$2	0.25	$10,000	$14,000	100%	$14,000	$212	$356
VELCO / Carmel Place	Detention Swale	21.34	0.62	$2	1	$25,000	$65,000	100%	$65,000	$3,047	$1,626
N End Dr	Detention Swale	16.4	0.50	$2	1	$25,000	$52,000	100%	$52,000	$3,185	$1,309
Nancy Ln	Detention Swale	34.1	1.27	$2	1	$25,000	$133,000	100%	$133,000	$3,888	$3,314
Randbury Rd	Gravel Wetland	23.1	0.86	$10	0.5	$25,000	$316,000	75%	$237,000	$9,671	$5,587
Industrial Park	Gravel Wetland	8.5	0.79	$10	0.5	$25,000	$307,000	100%	$307,000	$27,389	$5,162
Cannon Dr	Gravel Wetland	3.7	0.15	$10	1.5	$25,000	$130,000	100%	$130,000	$34,931	$2,881
Total:							**$1,027,000**		**$948,000**		

IX. Regulatory Analysis

The Town of Rutland intends to incorporate the two expired permits in the MBW into the Town’s MS4 permit. The Town has not yet worked out details of this transfer with homeowners covered under these two permits, so the possibility does exist that the Town may ask the State to issue a Residual Designation Authority permit in the future if this incorporation process fails. A description of both expired permits in the Town of Rutland with discharges to Moon Brook is included in Table 3.

X. 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.

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

Channel Protection Volume (CPv)- The stormwater volume generated from the 1-year, 24-hour rainfall event. The Vermont Stormwater CPv Design Standard requires 24 hours of extended detention storage of the CPv in warm water fish habitat and 12 hours for cold water fish habitat as a means to reduce channel erosion.

Detention BMP- A BMP (e.g. detention pond) 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 long term. The objective with a detention BMP is to reduce the peak discharge (Q_p) 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 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 VT BMPDSS model demonstrating compliance of the approved TMDL flow target with the proposed BMP list.

Infiltration BMP- A BMP that 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, and others.

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

Residual Designation Authority (RDA)- 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- Vermont developed stormwater Total Maximum Daily Loads (TMDLs) 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 requires a reduction in high flows, defined as greater than the 1-year storm event. The TMDL also includes a non-actionable (not enforced) low flow target, which is measured by an increase in stream 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 how 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 Pre-2002 (baseline) condition and the Post-2002 (existing) high flow. The high flow is the flow rate in the stream that is exceeded 0.3% of the time ($Q_{0.3\%}$) over a 10-year simulation period. The $Q_{0.3\%}$ 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 Pre-2002 (baseline) condition and the Post-2002 (existing) low flow. The low flow is the flow rate in the stream that is exceeded 95% of the time ($Q_{95\%}$), over a 10-year simulation period. The $Q_{95\%}$ is considered baseflow, which is the flow in a stream fed by groundwater.

XI. Appendices