DISHMILL BROOK WATERSHED – STORMWATER MASTER PLAN

EAST BURKE, VERMONT

FINAL REPORT
March 25, 2015

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I. Disclaimer

The intent of this report is to present the data collected, evaluations, analysis, designs, and cost estimates for the Dishmill Brook watershed under a contract between the Caledonia County Natural Resources Conservation District and Watershed Consulting Associates, LLC. Funding for the project was provided from the Vermont Ecosystem Restoration Program (ERP). The plan presented is intended to provide the watershed's stakeholders a means by which to identify and prioritize future stormwater management efforts. This planning study presents a recommended potential collection of Best Management Practices (BMPs) that would address specific concerns that have been raised for the Dishmill Brook watershed, specifically the issue of sediment entering the Brook and its tributaries. There are certainly other BMP strategies that could be implemented in the watershed – these are the sites and practices that project stakeholders felt would have the greatest impact and the greatest probability of implementation. **These practices do not represent a regulatory obligation of any type, nor is any property owner within the watershed obligated to implement them.**

1 Project Overview

In May 2013, the State of Vermont Department of Environmental Conservation (VTDEC) issued a document titled Vermont Stormwater Master Planning Guidelines. This document is designed to provide communities in Vermont with a standardized guideline and series of templates to assist them in planning for future stormwater management practices and programs. Vermont has had stormwater regulations in place since 1978, with updates concerning unified sizing criteria in 2002. Currently, the State is re-writing the stormwater manual to reflect new priorities. The State recognizes that managing stormwater can be a costly endeavor – the guidelines are written to help identify the appropriate practices for each watershed, community, and site in order to maximize the use of funds.

The guidelines encourage each stormwater master plan (SWMP) to follow the same procedures. They are:

- Problem Definition
- Collection of Existing Data
- Development of New Data
- Existing and Proposed Program, Procedure, or Practice Evaluation
- Summary and Recommendations

In keeping with these guidelines, we have prepared the following report which will detail the methods regarding problem definition, the collection of existing data, the development of new data, the development of proposed practices and procedures, and the final summary and recommendations for the stakeholders concerned.

2 Background

2.1 Problem Definition

Dishmill Brook is a 6.7 square mile watershed located in Caledonia County near the town of East Burke, VT. The watershed is largely rural, with a small amount of development near the village center of East Burke. The other notable amount of development in the watershed is the area comprising QBurke Mountain Resort, a four-season resort focused on skiing in the winter and a variety of activities in the summer. QBurke maintains numerous ski trails that extend into the uppermost reaches of the watershed, as well as several base lodge facilities and parking areas. Most roads in the watershed are unpaved and, as this is a mountainous watershed, many are steep.

Development in the watershed, in addition to the natural characteristic of many of the soils to erode easily, has led to Dishmill Brook being listed since 2008 on Vermont's 'Part C' list of 'surface waters in need of further assessment.' This can be a precursor to stream or other water body being listed on the 303(d) list as 'surface waters in need of a Total Maximum Daily Load (TMDL) listing,' otherwise known as impairment.

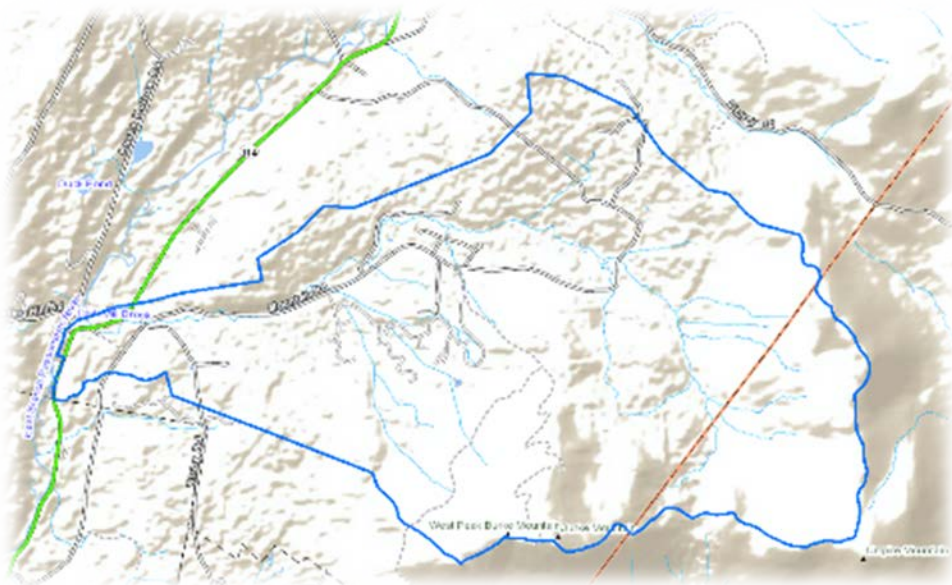
To attempt to keep Dishmill Brook off the 303(d) list, this study has found potential projects that rely on a mixture of Green Stormwater Infrastructural development whenever possible, and more traditional end-of-pipe stormwater Best Management Practices where applicable in order to use the most effective tools. These practices are designed to eliminate sediment in stormwater runoff to the greatest degree and to help mitigate the effects of channel-changing storms.

2.2 Dishmill Brook Watershed – Existing Conditions

The Dishmill Brook watershed is approximately 6.7 square miles or 4,300 acres which empties into the East Branch of the Passumpsic River. Average slopes are quite steep on the generally west-facing watershed.

Soils analyses indicate that of the 4,300 total acres in the watershed, 3,600 acres are classified as either potentially high erodible or highly erodible by the latest NRCS soils mapping data. Additionally, the majority of the soils in the watershed belong to either Hydrologic Soil Group C (2,515 acres) or D (800 acres), while only 100 acres are in group A and 260 acres in group B. This combination of steep slopes with limited infiltration capacity and a highly erodible surface make the watershed particularly susceptible to erosion, as seen from the recurring high turbidity levels in tributaries to Dishmill Brook.

Development in the watershed is fairly limited – overall impervious cover (as digitized in 2015 from the most recent aerial imagery) is ~65 acres or around 1.5% of the watershed total. Note – this acreage does not include all impervious cover within the watershed – only areas around the village and QBurke Ski Resort. The remaining impervious cover in the watershed is very distributed and comprises only a relatively small fraction of the overall whole. However this development does have an impact on tributaries as many of the roads and developed areas are in close proximity to streams. Analysis indicates that there are 7.75 acres of impervious cover within 50' of stream centerlines (not necessarily top of bank). As this acreage is 11% of the approximate total acreage, this stands to have a large impact on stream health. Maps depicting these aspects of the soils and stream buffers can be seen in Appendix A-1 – Dishmill Brook Atlas.



The Dishmill Brook watershed – the majority of the watershed is undeveloped, or lightly developed with ski resort trails and associated infrastructure. Most of the soils in the basin are erodible.

2.2.1 Stressors on the Watershed:

The primary stressors on the watershed are the development of roads in proximity to tributaries to Dishmill Brook, development of residential and commercial buildings and associated parking in proximity to tributaries, as well as the clearing of trees in the upper reaches of the watershed for ski trail development. It should be noted that while there has not been a lot of development in the watershed related to ski trails in recent years, QBurke is currently in the midst of expansion and may be developing additional ski trails, as well as additional base facilities (lodging as well as entertainment amenities). These developments, even if under State-required permit requirements for stormwater, should approach stormwater management with sensitivity as the soils within the watershed are highly susceptible to development-induced erosion.

All of these stressors should be viewed in light of the Brook's listing as 'surface waters in need of further assessment.' If the Brook were to be listed on the next step, the 303(d) list of impaired waters, there would be more stringent requirements for development within the basin.

These conclusions on the general stressors within the watershed are further reinforced by data collected during the summer of 2015 by the Burke Conservation Commission and the VT DEC. A study of eight sites was conducted in the Dishmill Watershed for turbidity, phosphorus (total) and nitrogen (total). Samples were collected every three weeks from June 24th to September 30th, as well as two rain events on September 30th and November 20th.

The study concluded, albeit from only one year of data, that the most significant sources of sediment and phosphorus in the Dishmill watershed appear to be between the Pinkham Road and the Dishmill Pull-off sites – an area that comprises the majority of the ski resort development in the basin. The two smaller subwatersheds evaluated, one above Pinkham Road and one above Dishmill Tributary 1a – High Meadows Road – don't seem to contribute as much phosphorus or sediment as they are generally less developed and disturbed.

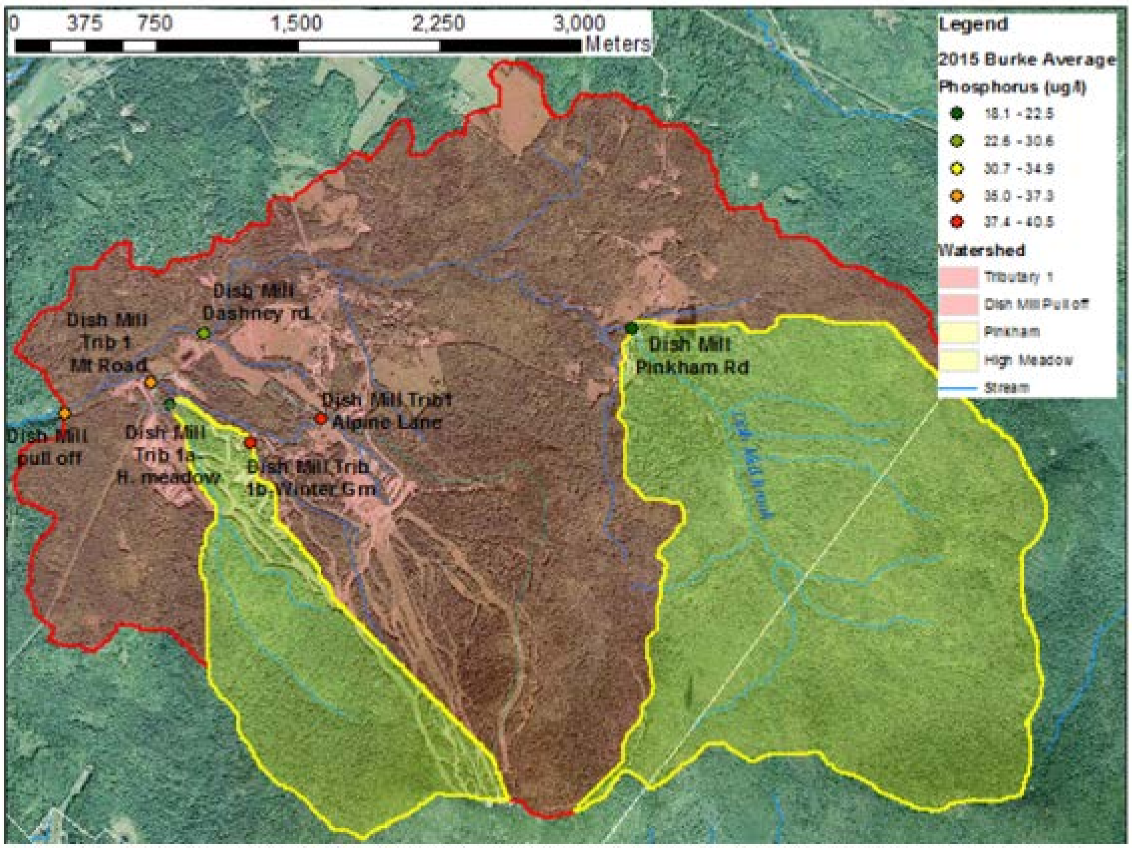


Figure 8. Subwatersheds in the Dish Mill Brook watershed which were identified as generating higher levels of phosphorus (highlighted in red) vs subwatersheds identified as generating lower levels of phosphorus (highlighted in yellow).

Figure 1 High-priority phosphorus and sediment sources to Dishmill Brook (from 2015 VT DEC and Burke Conservation Commission water quality report)

3 Proposed Best Management Practices

3.1 Road Erosion Ranking and Proposed Solutions

The first phase of the project involved identifying sections of road using the newly-created VT DEC Road Erosion Risk Analysis (RERA).

We conducted our assessment and prioritization over three days of field work throughout the spring and early summer of 2015. To guide our assessment we used both our own observations of sections of unpaved roads that had the potential for road erosion impacting water quality as well as the Vermont Agency of Natural Resource's Road Erosion Risk Analysis (RERA) layer, developed for the ANR in the fall of 2014. This assessment, available through the VT ANR's Natural Resources Atlas, displays the results of a GIS model that analyzes road slope, soil erodiblity, and proximity to mapped waters of the State (streams, wetlands, ponds, etc.). These factors contribute to a constraint value and are then classified as either Low, Moderate, or High risk. We extracted the RERA segments for Dishmill Brook's watershed and conducted in-field assessments of each of them.

Road erosion assessment site DMB1 near Burke Mountain Academy on Alpine Lane.

For our field assessment we used a set of criteria that we developed and submitted for Vermont's Better Backroads Program as the Road Erosion Risk Inventory. The criteria are based on a model that WCA has used previously in the Mad River Valley, as well as with the Lamoille County Regional Planning Commission, but that has been significantly revised and updated to reflect the comments and concerns of various reviewers at the State level, as well as local planning commission, watershed groups, and municipal officials. It is a method and system of scoring that we feel is well-suited to Vermont's unpaved roads and gives a good picture of overall priorities. These criteria will be adopted by the Better Backroads program for use in the Category A grant process.

The criteria are broken into two major categories – Buffer and Road Characteristics. Under the Buffer Characteristics we look at Connection to Water Body (a measure of how much road or ditch material could reach the water body), Runoff Volume (the approximate size of the drainage area), and the Slope and Ground Cover of the Slope to the Water Body. Under Road Characteristics we assess the Road Slope, Shape, and Surface Material, as well as the Bank Stability (the bank above the road, also called the cut slope), Ditch Shape and Stability. The Buffer Characteristics account for approximately 75% of the score, while Road Characteristics total 25%. The logic behind this is that the ability of the buffer to filter out road or ditch material is more important than if the road will erode generally.

Some of the sites that we evaluated individually are actually adjacent to each other and solutions for one may affect another. This is noted in the Summary Table under the 'Proximity' column and can also be seen on the Overall Site Locator map. While we score and rank them individually, it is potentially feasible to consider them as one site and to repair them as such. With that said, this also means that the ranking, as presented, isn't meant to be completely predictive of the schedule in which potential repairs will take place – rather it is a starting point to begin discussing potential options and repair scenarios. These options and scenarios may depend on a variety of factors, such as feasibility of repair, willingness of town or other designated road crew to implement them, and the willingness of adjacent landowners to participate on some level.

We have included some basic field notes that we made regarding potential solutions. These notes should not be interpreted as conceptual solutions in and of themselves. Rather they provide general guidance for the selection and development of final conceptual solutions.

In consultation with our project partner the Caledonia County NRCD, and officials from QBurke Mountain Resort which has maintenance responsibility for certain roads in the Dishmill Watershed, two sites, comprising five overall road segments, were chosen for complete solution development. These sites, along High Meadows Road and upper Alpine Lane (lower Mountain Brook Road), are located near two high-priority sites as identified by the summer 2015 monitoring report published by the Burke Conservation Commission and the VT DEC.

It is recommended that these sites receive the designed repairs during the summer of 2016. Layouts for these repairs, along with the necessary design details, can be seen in Appendix A-2 – Road Erosion Inventory and Solutions. In addition to the two sites with full designs, all sites that were inventoried are ranked according to relative impact on the neighboring tributary and have general notes describing possible solutions. Details for these possible solutions can be found in the Details section of A-2, or can also be pulled from the VT Better Backroads Manual.

3.2 Design/Build BMP Evaluation and Design

As part of the project related to siting and designing Best Management Practices (BMPs) for non-road specific drainage areas, a series of potential small 'design/build' retrofit practices were evaluated. The 'design/build' nature of these practices is related to their relatively small size and simplicity of construction. These practices were intended to be constructed by Northwoods Stewardship Center over the course of the summers of 2015 and 2016. These practice locations and designs can be seen in Appendix A-3 – Design-Build Stormwater Retrofit Projects. It should be noted that one project at Site #2 has already been constructed and is operational.

3.3 Potential BMP Priority Site Evaluation

Potential BMP sites were evaluated both in the field over the course of three field days during the summer of 2015, as well as using desktop GIS mapping and analysis to look for likely open spaces that collect runoff (or have runoff conveyed to them via stormwater infrastructure). The VT DEC's Stormwater Infrastructure Mapping layer was used for this effort – all infrastructure was field verified where necessary to ensure drainage area accuracy. Once a site was selected, the drainage area was then delineated using the best-available contours. For most of the Dishmill watershed the contours were provided by QBurke in the form of a site-specific flyover for LiDAR contours dating from 2006.

Once drainage areas were delineated, landuse/landcover was digitized using the best-available aerial imagery from ESRI. This allowed us to create an initial simple site ranking for each potential drainage area based on two factors – drainage area size in acres and the percent of the drainage area that is impervious. Approximate natural breaks for these factors were found and each factor was assigned a score according to the table below.

Table 1 Scoring matrix for Dishmill BMP Drainage Areas

% IC Score	Score	DA Size (acres)	Score
0 - 38.57%	1	0 - 1.22	1
>38.57 - 61.83%	2	>1.22 - 2.61	2
>61.83%	3	>2.61 - 4.5	3

Scoring matrix for the initial BMP drainage areas.

Scores are as follows:

Table 2 Preliminary scores for all Dishmill BMP Drainage Areas

Site Code	Acres DA	% Impervious	DA Size Rank	% IC Rank	Total:	Rank:
PLT_002	2.52	73.54	2	3	5	High
VLL_002	3.54	58.75	3	2	5	High
VLL_003	0.66	87.65	1	3	4	Medium/High
BMA_002	0.72	76.12	1	3	4	Medium/High
BPL_001	0.39	75.31	1	3	4	Medium/High
BSD_001	0.82	69.06	1	3	4	Medium/High
PLT_001	1.82	61.52	2	2	4	Medium/High
BAR_001	1.92	54.00	2	2	4	Medium/High
PLT_003	1.48	51.60	2	2	4	Medium/High
BPL_002	1.77	44.13	2	2	4	Medium/High
SWC_001	1.71	43.19	2	2	4	Medium/High
VLL_001	4.50	17.48	3	1	4	Medium/High
BAR_003	2.61	11.70	3	1	4	Medium/High
HMR_001	0.75	61.83	1	2	3	Medium
MBC_002	0.48	61.23	1	2	3	Medium
AOF_001	1.22	59.62	1	2	3	Medium
WGR_001	0.60	58.47	1	2	3	Medium
MBC_001	0.99	57.43	1	2	3	Medium
BSD_002	0.32	54.04	1	2	3	Medium
BPL_005	0.70	52.37	1	2	3	Medium
BAR_002	0.71	52.07	1	2	3	Medium
BMA_004	1.11	41.09	1	2	3	Medium
BPL_006	0.93	38.57	1	1	2	Low
SWC_002	0.81	37.34	1	1	2	Low
BPL_004	0.78	26.07	1	1	2	Low
BMA_003	0.49	24.67	1	1	2	Low
BPL_003	0.77	18.50	1	1	2	Low

Locations for all these drainage areas can be seen Map M-1 – Dishmill Brook Preliminary Retrofit Sites Drainage Areas. Descriptions of the practice initially envisioned for each drainage area, along with locaton and site-specific maps, as well as photos, can be found in Appendix A-4 – Preliminary BMP Prioritization. This material was initially presented to QBurke staff, along with project partners from CCNRCD and the VT DEC in October 2015. The outcome of that meeting was used to create the final project site prioritization and guide development of the 'Sketch' Concept and 30% Concept Designs.

4 Proposed Best Management Practices (BMPs)

Using the outcome of our meeting with project partners and stakeholders in October 2015, a final three sites were selected to proceed to 30% Concept Design, pending development of satisfactory existing conditions and soil infiltration rate surveys. The existing conditions topographic and infrastructure survey results can be seen in Appendix A-5 – Existing Conditions. The results of the soils testing can be found in Appendix A-6 – Soil Conditions.

If implemented, these three BMP sites would treat approximately 36.5 acres, 8.5 acres or 23% of which is impervious. Two of these concept BMPs (at QBurke's Sherburne Base Lodge and Burke Mountain Academy) are designed to fully treat both the water quality (WQv) and channel protection (CPv) storms to VT Stormwater Manual specifications, while one retrofit (below Bear Path Lane) is designed to slow down highly-erosive flows which are cutting into natural soils and transporting sediment to the nearest tributary. Annual sediment reduction associated with these practices would be approximately 12,500 pounds, with an additional retention of 43-72 tons of eroding material from the swale below Bear Path Lane. Total phosphorus would be reduced by 42.2 pounds, in addition to the fraction of total phosphorus removal associated with retaining between 43-72 tons of eroding sediment from the swale below Bear Path Lane.

4.1 Sketch Concept Development:

Using the information gained from the surveys, preliminary 'sketch concept' designs were created using hydrologic and hydraulic modeling software (HydroCAD v.10.00). These sketch concepts were presented to officials from QBurke in a meeting with the CCNRCD and the VT DEC in February, 2016. The purpose of this meeting was to ensure that the designs were compatible with usage on-site and would be something that the resort could maintain.

Resort officials did express their desire that these retrofits, and the stormwater they capture, potentially be integrated with the resort's snowmaking system. WCA did look into the feasibility of this on a preliminary level, however the challenges of coming up with a 30% design for a system that would both manage stormwater runoff and integrate with the snowmaking water storage system were found to be multiple. While this idea certainly has merit and should be explored, especially with respect to the existing stormwater detention pond associated with the resort's new hotel development, it was not able to be integrated into this particular study.

4.1.1 Sherburne Base Lodge – Infiltration Basin:

For the QBurke Sherburne Base Lodge area a large infiltration basin for capturing and infiltrating runoff is envisioned along the lower-most tier of the parking lots there. This basin would capture runoff from drainage areas PLT_003, PLT_002, PLT_003, PLT_004, AOF_001, and BAR_001 – essentially all the base lodge parking areas, roofs, and access road as well as some runoff from the adjacent condominiums.

This infiltration practice was initially conceived of as requiring an approximately 90'x90'x4' deep footprint. QBurke officials expressed their acceptance of this general concept. Additionally this practice would require the installation of some additional infrastructure such as supplementary catchbasins and pipes to ensure runoff conveyance to the basin. Officials similarly expressed their acceptance of these retrofits.

4.1.2 Bear Path Lane (below High Meadows Ski Trail) – Infiltration Galleries or Basins:

Below Bear Path Lane (a planned-unit development not owned or controlled by QBurke), there is a culvert outfall with a highly eroded swale below it. QBurke staff noted previously that, below the swale, there was often large volumes of sediment and runoff that threatened lower Bear Path Lane, which QBurke does maintain. While there have been smaller, localized efforts to control this runoff and sediment, no efforts have been made to stabilize the swale above.

WCA initially proposed to create a series of terraced infiltration basins perpendicular to the flow path of the swale. QBurke officials expressed their acceptance of these practices, pending final design.

4.1.3 Burke Mountain Academy – Bioretention:

The Burke Mountain Academy site actually consists of two separate drainage areas. One, BMA_003, comprises the main BMA paved parking lot adjacent to the classroom building. The second, BMA_002, is across Alpine Lane and comprises the main dirt parking lot associated with the Fitness Center.

The initial sketch concepts for each of these sites are small, shallow Bioretention practices designed to treat either the WQv or CPv runoff volumes. For BMA_002 the practice was envisioned to be approximately 25’x25’for the CPv, while the practice for BMA_003 was envisioned at 40’x3’ (a long, linear Bioretention swale) for the CPv.

WCA was not able to present these initial sketch concepts to BMA officials, however CCNRCD staff were able to speak to officials at BMA and obtain consent to continue designing to the 30% Concept level.

A simple display for these ‘sketch concepts,’ as well as the drainage areas associated with each of them can be seen in Appendix A-7 – Dishmill Sketch Concepts and Drainage Areas

4.2 30% Concept Development:

4.2.1 Sherburne Base Lodge – Infiltration Basin:

The Sherburne Base Lodge parking area and associated buildings represent one of the largest contiguous areas of impervious cover in the Dishmill watershed with a mix of paved and unpaved surfaces. The proposed retrofit for this area is a large infiltration basin with a sand-filter berm with integrated curtain drain on the back edge of the basin to provide additional filtration of runoff water and stored snow as it melts. This basin would be located on the northeastern edge of the parking lot (along the margin of the lower-most terrace).

At 4’ deep with a footprint of 28,800 square feet, the basin will fully treat the water quality (1” rain in 24 hours) and channel protection (1.98” rain in 24 hours) storms via infiltration into groundwater. The 10-year overbank flood protection storm (3.24” rain in 24 hours) peak discharge rate will be reduced from 23.2 CFS to 3.9 CFS. Preliminary modeling of assumed pre-development condition for this drainage area (modeled as forested land cover with predominantly Hydrologic Soil Group ‘C’ soils) indicate that the pre-development peak discharge rate likely ranged from 5-10 CFS, indicating the retrofit practice as modeled would reduce 10-year peak discharge below pre Q-Burke rates. Additionally, the 100-yr storm (5.31” rain in 24 hours) peak discharge rate will be reduced from 44.1 CFS to 29.9 CFS. Similar pre-development modeling as for the 100-year storm indicates that peak discharge rate was between 12 – 20 CFS. The practice does not likely reduce the 100-year storm event to the pre Q-Burke development rate, but does represent a best-fit practice.

Pollutant Load Reductions Possible:
Pollutant load reduction modeling indicates that the infiltration basin as designed will remove approximately 8,157 pounds of sediment annually via settling and infiltration in the basin. This amount may be even higher given that the area proposed for the basin is a primary snow storage area for the resort. Plowing typical tends to mobilize more sediment than rain runoff alone. The basin will remove part or all of that plow-mobilized sediment. Approximately 20 pounds of total phosphorus (particulate and dissolved) will be removed, along with 78.8 pounds of total nitrogen. Pollution associated with heavy metals (lead, zinc, and copper) will be reduced by 85%. This last factor is important as those metals are typically associated with parking lots where the source is cars. As the drainage area for this basin is primarily parking lots, reducing this pollutant is a definite benefit.
Finally, this basin will provide groundwater recharge for the watershed. Modeling indicates that around 440,000 cubic feet of water will infiltrate annually, which is a base flow increase of around 77%.

Cost Estimate:
Using typical VTrans costs for materials and pipes (all placed costs with machine time embedded in the unit-cost), materials for the basin are as follows:

Material	**Cost**
Type I Stone	$1,111
Bedding Sand	$1,778
4” Pipe	$19,635
24” Pipe	$22,870
30” Pipe	$2,912
Manhole/Outlet Structures	$12,000
TOTAL	$60,306

Excavation Costs (using VTrans averages times the total cubic foot storage volume of 66,000 cu. Ft.) will total $31,069 at $12.71/cu. Yd.

The total cost with a 50% contingency for material cost variation, labor cost overruns, etc., is $137,000.

4.2.2 Bear Path Lane (below High Meadows Ski Trail) – Swale Armoring:

The proposed retrofit for the eroded swale below Bear Path Lane is primarily an armoring practice. Erosion of the swale and pollutant washoff from the watershed are the primary pollutant vectors. Armoring the swale with multiple layers of different sizes of stone will prevent this erosion from continuing, as well as slow runoff discharge rates and promote infiltration.

The swale will need to be re-shaped in certain sections so that side slopes are not hollow. A layer of gravel and stone (1.5" minus) will be placed on the soil in an evenly distributed layer on the bottom and up the side slopes of the swale. This layer will be followed by a relatively fine stone (2-3") layer. These two layers will serve to increase friction between the larger stone to be placed above and the native soil, preventing material creep down the swale's gradient. These layers will also prevent the formation of solution channels between the larger stone material and the native soil – these solution channels would quickly undermine the armoring and lead to slumping and pollutant transport.

Above this fine gravel/stone layer, a layer of larger Type I stone (1" – 12" with at least 50% 4" or greater) will be placed to provide larger anchoring material and pore space for runoff water storage. This layer will be overlain by Type II stone (2" – 36" with at least 12" or greater). These larger boulders will anchor the surface and provide the greatest resistance to runoff water. Layering from larger material on the surface to smaller material on the bottom will also promote rapid infiltration of runoff into the stone's pore space and increase roughness which will reduce velocity. Modeling in HydroCAD indicates that runoff velocity from the 1-year (Channel Protection or CPv) storm will be reduced from 4.40 feet per second to 2.18 feet per second. This value is consistent with published allowable velocities for this soil type.

Table 5-1. Example of Simple Allowable Velocity Objectives (From COE undated, EM 1110-2-1601)

Channel Material	Mean Channel Velocity (ft/sec)
Fine Sand	2.0
Coarse Sand	4.0
Fine Gravel	6.0
Earth	
���� Sandy Silt	2.0
���� Silt clay	3.5
���� Clay	6.0
Grass-lined Earth (Slopes less than 5%)	
���� Bermuda Grass	
��������� Sandy Silt	6.0
��������� Silt Clay	8.0
���� Kentucky Blue Grass	
��������� Sandy Silt	5.0
��������� Silt Clay	7.0
Poor Rock (usually sedimentary)	10.0
���� Soft Sandstone	8.0
���� Soft Shale	3.5
Good Rock (usually igneous or hard metamorphic)	20.0

Table 5-2. Maximum Permissible Velocities and Corresponding Unit Tractive Force (Shear Stress) (U.S. Bureau of Reclamation research, Fortier and Scobey 1926)

Material	n	Clear Water (diversion structures) V (ft/sec)	Clear Water τ_o (lb/ft^2)	Water Transporting Colloidal Silts (on site and down slope) V (ft/sec)	Water Transporting Colloidal Silts τ_o (lb/ft^2)
Fine sand, colloidal	0.020	1.50	0.027	2.50	0.075
Sandy loam, noncolloidal	0.020	1.75	0.037	2.50	0.075
Silt loam, noncolloidal	0.020	2.00	0.048	3.00	0.11
Alluvial silts, noncolloidal	0.020	2.00	0.048	3.50	0.15
Ordinary firm loam	0.020	2.50	0.075	3.50	0.15
Volcanic ash	0.020	2.50	0.075	3.50	0.15
Stiff clay, very colloidal	0.025	3.75	0.26	5.00	0.46
Alluvial silts, colloidal	0.025	3.75	0.26	5.00	0.46
Shales and hardpans	0.025	6.00	0.67	6.00	0.67
Fine gravel	0.020	2.50	0.075	5.00	0.32
Graded loam to cobbles when noncolloidal	0.030	3.75	0.38	5.00	0.66
Graded silts to cobbles when noncolloidal	0.030	4.00	0.43	5.50	0.80
Coarse gravel, noncolloidal	0.025	4.00	0.30	6.00	0.67
Cobbles and shingles	0.035	5.00	0.91	5.50	1.10

Note:
� an increase in velocity of 0.5 ft/sec can be added to these values when the depth of water is greater than 3 ft.
� a decrease in velocity of 0.5 ft/sec should subtracted then the water contains very coarse suspended sediments.
� for high and infrequent discharges of short duration, up to 30% increase in velocity can be added

From Pitt., R., University of Alabama, Erosion Control – Module 5 (course materials), accessed March, 2016 - http://rpitt.eng.ua.edu/Class/Erosioncontrol/Module5/Module5.htm#_Toc75167492

Table 3 Table of allowable velocities for channels and soil types

Pollutant Load Reductions Possible:

Using the U.S. EPA's Spreadsheet Tool for Estimating Pollutant Loads (STEPL) Gully Erosion reduction calculator we were able to create an approximate pollutant mass load reduction for our concept plan based solely on the amount of erosion the armoring of this swale will prevent. Assuming that the swale was formed over the course of approximately 15-25 years to reach its current dimensions, and assuming an approximately 90% erosion reduction efficiency for the armoring practice proposed, the retrofit for this swale should remove between 43 and 72 tons annually of eroding fine silt loams. Please note that this calculated amount only uses the current dimensions of the gully, soil type, and time of formation to establish an erosion amount estimate – while we accurately know dimensions and soil type, we do not know how long it took for the gully to form. Therefore the range given reflects an estimate of between 15 and 30 years formation time – if less, then the annual erosion amount could be more; if more, then the annual erosion amount would decrease. It is important to note these limitations of the STEPL modeling process.

We are not able to calculate a specific phosphorus removal amount as we lack a site-specific soil phosphorus analysis, but it can be assumed that if these numbers are within reason, the amount of total phosphorus prevented from entering local waterways is significant.

We also conducted WinSLAMM analysis of the proposed retrofit to model the amount of phosphorus and sediment being transported from the drainage area's various land use surfaces that will potentially be removed by this practice. WinSLAMM indicates that 3,551 lbs. of particulate solids will be removed, along with 20 lbs. of total phosphorus. Around 275,000 cubic feet of water will be infiltrated into groundwater to be added to local streams as baseflow.

Cost Estimate:
This project primarily involved the excavation and shaping of the existing eroded swale, followed by the placement of the stone lining. Using typical VTrans cost numbers for 'Common Excavation' at $12.71/cu. Yd. and assuming a rough swale dimension of 250'Lx10'Wx7'D, the cost for excavation will be around $8,000. Materials costs were also estimated using VTrans costs for placed materials (machine time is included in the cost). Assuming an overall similar dimensions for length and width for all stone layers with varying depth as per the concept plan, materials costs should be around $7,000. Accounting for a margin of error with transportation cost variation and labor costs, a safe budget estimate should be between $20-25K.

4.2.3 Burke Mountain Academy – Bioretention:

The practices proposed at Burke Mountain Academy are two separate Bioretention basins to treat separate drainage areas. One, labeled by drainage area BMA_002, will take runoff from the Shelly Glover Fitness Center parking lot, an unpaved area of approximately 0.71 acres. The second, labeled by drainage area BMA_003, will take runoff from the school's main paved parking lot outside the Fraser House building, representing a paved area of 1/10 of an acre with an addition 3/10 of an acre grass drainage.

Proposed Practice – Shelly Glover Fitness Center:
The Bioretention practice will be 3.0' deep covering an area of approximately 1,500 sq. ft. located behind the Fitness Center building in an area currently occupied by mowed lawn. Runoff will be directed to the Bioretention practice by re-grading the entrance to the Fitness Center parking lot to ensure that runoff enters a shallow grass swale from the parking lot. This can be accomplished by adding several inches of stone and re-surfacing the entrance to create a shallow berm. To ensure that the re-grading of the entrance continues to direct runoff over a longer time-span, it is recommended that the entire parking surface be stabilized through the addition of a crushed ledge aggregate product like Stay-Mat (available locally through the Calkins gravel pit in Lyndonville). This would ensure that the re-grading would hold its shape over time.

It is also recommended that the eastern edge of the parking lot be restored to an approximately 10' – 15' wide grass buffer strip. There is a perennial stream running along this edge of the parking lot that currently receives a substantial amount of sediment-laden runoff from the parking lot surface. A grass buffer strip would help mitigate this. Creating a grass buffer here would be very low-cost and would not overly impact the parking lot – given current parking patterns, vehicles would only need to move back 4' – 6' feet from where patterns indicate that they park now. This would still leave a 70' wide parking lot, edge to edge, which is adequate for two rows of parked cars at either edge.

This proposed Bioretention practice would completely infiltrate the water quality and channel protection storms with no overflow out the outlet pipe or weir. The 10-year storm peak discharge rate would be reduced from 1.4 CFS to 0.9 CFS. Preliminary modeling of the pre-development condition (forested with predominantly Hydrologic Soil Group 'D' soils) indicates that the peak discharge rate for the 10-year storm was between 0.5 and 0.9 CFS, meaning that the Bioretention practice should closely match the pre-existing 10-year peak discharge rate.

Pollutant Load Reductions Possible:
The Bioretention basin will remove approximately 367 pounds of sediment that is currently reaching Dishmill Brook via the town road ditch and a small tributary. It will also remove 0.7 pounds of total phosphorus and 2.8 pounds of total nitrogen. Additionally it will remove up to 94% of pollution associated with heavy metals (zinc, lead, and copper). It will accomplish these removals by bio-remediation via the plants in the Bioretention, as well as by infiltration. The Bioretention will also infiltrate approximately 34,000 cu. Ft. of runoff annually.

The practice will also have the added benefit of removing a significant amount of runoff from directly impacting the town road ditch along Alpine Lane. This ditch is currently incised and eroding into the small tributary of Dishmill Brook. The runoff from the parking lot is contributing to this issue and will be eliminated by installing this Bioretention.

Proposed Practice – Fraser House Main Parking Lot:
The proposed practice is a long, linear Bioretention practice that will be 1.5' deep and cover a surface area of 825 sq. ft. located along the downhill edge of the parking lot where there is currently mowed lawn space. There is some drainage infrastructure that will have to be removed to make space for the Bioretention. Overflow will be directed to the grassy roadside swale via a 12" HDPE pipe or a stone weir.

Modeling indicates this practice will fully infiltrate the water quality and channel protection volume storms. Modeling also indicates that the 10-year overbank flood protection storm, which had a peak discharge rate between 0.4 and 0.8 CFS in the pre-development condition, will be discharged by the practice at a rate of 0.6 CFS, indicating that the practice would likely closely match the pre-existing 10-year peak discharge rate.

Pollutant Load Reduction Possible:
The Bioretention basin will remove approximately 397 pounds of sediment that is currently reaching Dishmill Brook via the town road ditch and a small tributary. It will also remove 1.51 pounds of total phosphorus and 6 pounds of total nitrogen. Additionally it will remove up to 84% of pollution associated with heavy metals (zinc, lead, and copper). It will accomplish these

removals by bio-remediation via the plants in the Bioretention, as well as by infiltration. The Bioretention will also infiltrate approximately 24,500 cu. Ft. of runoff annually.

Cost Estimate:

For the Burke Mountain Academy projects, a rough cost estimate was developed that takes into account the following:

- Base cost (based on a cost estimate for each cubic foot of BMP, where applicable)
- Labor cost (which is calculated but not added to the final project cost)
- Planting cost
- Final Design and Permitting cost
- Implementation cost

- Base Cost Estimation:

This amount is derived from the following calculation:

BMP volume (ft^3) X \$5.30/ft^3 (2006 EPA Estimate) X 3% annual inflation (2006-2016)

- Labor Cost Estimation:

This amount is split out from the Base Cost and represents roughly 75% of the Base Cost total. This is presented to show estimated cost of labor, a source of potential savings for some projects where labor will be performed by municipal crews as 'in-kind' labor donation.

Base Cost X 1.75

- Planting Cost Estimation:

This amount is based on plant costs for perennial flower and grass plugs typically used in stormwater retrofit applications. Some costs could be saved using seeds instead of the more mature plugs – however plugs are hardier and will likely have a higher survival rate.

BMP ft^2 X \$1.39/ft^2

- Final Design and Permitting Cost Estimation:

This cost is based largely on the Base and Planting Costs, as these are the aspect of a project most likely to change as the project moves toward implementation.

(Base Cost + Planting Cost) X 30%

- Implementation Cost Estimation:

This represents the basic, no-contingency cost to put the BMP in the ground. It's simply the sum of Base, Planting, and Design and Permitting Costs.

Given these factors the costs are as follows:

Shelly Glover Fitness Center Bioretention –

Assuming approximately 3,550 cu. Ft. of excavation, Implementation Cost would be ~$35,000.

Fraser House Main Parking Lot Bioretention -

Assuming approximately 1,215 cu. Ft. of excavation, Implementation Cost would be ~$12,000.

Table 4 U.S. EPA Cost Estimator Breakdown **(**some costs modified to reflect local conditions and inflation).

BMP ID	BMP Volume (cu. Ft)	Base cost (EPA 2006 - $5.30/cu. Ft)	Inflation (3%/yr 2006-2016)	2016 Base Construction Cost	Estimated Labor (75% Base Cost)	Plantings (No. Creek Nurseries plugs - $1.39/sq. ft.)	Final Design and Permitting	Implementation Cost	Total Implementation Cost Estimate
BMA_002	3550	$ 18,815.00	$ 5,644.50	$ 24,459.50	$ 13,976.86	$ 2,071.10	$ 7,959.18	$ 34,489.78	**$ 34,489.78**
BMA_003	1215	$ 6,439.50	$ 1,931.85	$ 8,371.35	$ 4,783.63	$ 1,146.75	$ 2,855.43	$ 12,373.53	**$ 12,373.53**

5 Summary and Recommendations:

The results of this Stormwater Master Plan have identified a number of potential sites that could have an impact on water quality in Dishmill Brook. We have divided these into two major categories for consideration – Projects to Implement and Projects Requiring Additional Study and/or Design.

5.1 Projects to Implement:

Under Projects to Implement there are two sub-categories – Road Erosion projects and Non-Road BMPs.

5.1.1 Road Erosion –

- Implement the road erosion solutions specified for sites DMB2/3/4 (Corner of Meadow Brook Road and Upper Alpine Lane / Lower Mountain Brook Road)
- Implement the road erosion solutions specified for sites DMB6/7 on High Meadow Road
- Choose an additional five (5) sites on which to being implementation of selected solutions. Sites initially recommended are
  - DMB21/DMB27 (Pinkham Road)
  - DMB1 (near Burke Mountain Academy)
  - DM8 (High Meadow Road – near Wintergreen Condos)
  - DMP9 (High Meadow Road – near corner of Access Road)
  - DMB23 (Pinkham Road – separate from DMB21/DMB27)

These sites can be seen in greater detail in Appendix A-2 – Road Erosion Inventory and Solutions.

It is also our general recommendation for roads within the Dishmill Brook watershed that road standard associated with the Better Backroads Manual be universally adopted. This includes ensuring that roadside 'grader berms' are removed each spring and fall to reduce erosion occurring on the road surface, as well as ensuring that ditches are armored (stone or vegetation), are properly shaped (preferably U-shaped) and turn out into wooded or otherwise vegetated areas prior to entering tributaries.

5.1.2 Non-Road BMPs –

- Design/Build Project Implementation – work with the Northwoods Stewardship Center during the summer of 2016 to finalize installation of the remaining three projects for which there are designs. These include
  - Retrofit Site 1 (QBurke Administrative Office Building Rain Garden)
  - Retrofit Site 3 (Burkeside Condominiums Rain Garden)
  - Retrofit Site 6 (Burke Mountain Academy Stormwater Planter)

These sites and designs can be seen in Appendix A-3 – Design-Build Stormwater Retrofit Projects.

- 30% Concept Design Implementation – finalize designs to 100% construction design level, including bid estimates and final permitting needs. Work with each of the selected property holders (QBurke Mountain Resort and Burke Mountain Academy) to construct the projects within the next two years.

These designs can be seen in Appendix A-8 – 30% Concept Designs.

5.2 Projects Requiring Additional Study and/or Design:

There are a number of other sites and potential practices within the watershed that deserve additional attention.

Firstly, an effort should be made to return stream buffers to a minimum of 50' from top of bank. There are a number of locations throughout the watershed where this is possible and would potentially have a high impact on sediment entering the stream. These locations can be seen in Appendix A-1.

Secondly, only a select few sites from the original list of potential sites made the cut for concept design. Most of the original sites investigated for QBurke will be managed by the proposed infiltration basin, however there are many other sites distributed throughout the watershed that can be investigated. It is our recommendation that five sites be more thoroughly investigated and designs pursued for each of them, pending landowner approval and cooperation. These sites are

- VLL_002 (East Burke Village) – potential for a hydrodynamic separator to treat runoff from a section of VT Rte. 114 draining to Dishmill Brook.
- VLL_003 / VLL_001 (East Burke Village) – potential for a small Bioretention to treat runoff from a portion of Belden Hill and the parking lot associated with the East Burke General Store.
- BSD_001 (Burkeside Condos) – restore the riparian buffer along the eastern edge of the dirt parking lot, add in a stone diaphragm to trap sediment, and potentially stabilize the lot with Stay-Mat.
- SWC_001 / SWC_002 (Sprucewoods Condos) – improve existing grass swales to increase treatment before runoff enters the adjacent tributary.

- MBC_001 / MBC_002 (Mountain Brook Condos) – the dirt parking lots for each of these condo complexes are within the 50' stream buffer. Restore the riparian buffer, or create a Bioretention practice that would intercept this runoff prior to it entering the stream.

These sites can be seen in Appendix A-4 – Preliminary BMP Prioritization.

Lastly, there is a series of parking unpaved parking lots and storage zones currently associated with the Mid-Burke Lodge and new hotel development that are not covered under a stormwater permit and are unmanaged with respect to stormwater runoff. These parking lots and access roads are contributing a large amount of sediment to tributaries of the Dishmill Brook. This study did not investigate or analyze these sites in depth because of the ongoing construction activities at these sites made them difficult to study as far as drainage patterns and management features go. This area should be a high priority for any future stormwater management activities in Dishmill Brook and for QBurke Mountain Resort.

The momentum developed during this study, as well as the partnerships created between the Caledonia County NRCD, QBurke Mountain Resort, and Burke Mountain Academy, should be strengthened and promoted in the next phase of work for the Dishmill Watershed.