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Memorandum

To: Stowe Mountain Resort
Stowe, VT
Project File

Date: May 18, 2012

Project No.: 57272.06

From: Krista Reinhart, CPESC, CPSWQ
Scott E. Manley

Re: Water Quality Remediation Plan for the Mansfield Base Area

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1.0 INTRODUCTION

As required by the Order issued by the Vermont Department of Environmental Conservation (VT DEC) pursuant to 10 VSA § 1272 (Order), dated May 3, 2012, this memorandum and supporting technical data prepared by Vanasse Hangen Brustlin, Inc. (VHB), comprise a water quality remediation plan for the Mansfield Base Area at Stowe Mountain Resort in Stowe, Vermont. This plan provides an overview of on-site assessments, watershed mapping, and hydrologic modeling that have been conducted to date, in conformance with items A.1 through A.3 of the Order. In addition, this memorandum addresses priority areas that have been identified through these aforementioned efforts, with specific regard to proposed improvements within these priority areas in order to improve site conditions and, in turn, reduce sediment loading to and peak stormwater runoff rates and velocities within the West Branch of the Little River and its tributaries within the resort vicinity. These efforts have resulted in identification of the following three opportunities:

1. Upgrades to existing and retrofit of new stormwater management systems
2. Protection and/or maintenance of riparian buffers
3. Modifications to snowplowing, snow piling, and sanding operations

Discharges of treated and controlled stormwater runoff from portions of the Mansfield Base Area are currently authorized under existing General Permit (GP) No. 3929-9010, which was issued by the Vermont Department of Environmental Conservation (VT DEC) on February 18, 2009, with an expiration date of March 6, 2018.[1] As referenced in GP No. 3929-9010, this authorization includes 14.5 acres of existing impervious surface that encompasses discharges from a portion of the water quality remediation plan study area, including "roadways, parking, and roofs associated with the Mount Mansfield Base Lodge and Parking lots, the Barnes Camp Parking lots, and the Spruce Hamlet Complex, Stowe, Vermont to the West Branch of the Little River, unnamed tributaries of the West Branch of the Little River and groundwater" (see Existing Conditions Site Map in the map pocket). With the exception of the Spruce Hamlet Complex, the Existing Conditions Site Map

[1] General Permit Authorization No. 3929-9010 supersedes a previous individual discharge permit (No. 1-0559) that had been issued by VT DEC, with an expiration date of March 31, 2005.

provides orientation of these areas (although some with updated names), as well as additional areas that are of particular interest to the studies that are currently underway. At this time, the unnamed tributaries to the West Branch of the Little River are referred to as (from north to south): Long Trail Brook, Gondola Brook, Sepps Brook, Quad Brook, Demo Center Brook, and Lookout Brook; as shown on the Existing Conditions Site Map.

2.0 EXISTING CONDITIONS

During late winter/early spring snowmelt in 2012, VHB conducted site visits on March 19th, April 3rd, April 17th, and April 24th to meet with relevant staff of Stowe Mountain Resort, examine existing conditions, assess possible problem/priority areas, and determine potential opportunities for improvements. The site investigations involved comparing as-built infrastructure (e.g., buildings, parking lots, roadways, stormwater management systems) with available site plans (see References in Section 7.0); assessing drainage area delineations; inspecting the existing stormwater management systems (e.g., basins, roadside swales, catch basins); and identifying possible opportunities for upgrading existing and/or retrofitting new stormwater management systems.

2.1 Planned vs. Existing Infrastructure

During our investigation, VHB performed a comparison of existing as-built infrastructure with available site plans. The following is a summary of observations that were made during the site investigations. *Please note that as-built surveying was not conducted as a component of these site assessments so there may be finer discrepancies between planned and actual designs that were not apparent or observable during the site visits.*

- Existing development (e.g., buildings, parking lots, access drives, etc.) as depicted on Civil Engineer Associates, Inc.'s (CEA's) Site Plan Sheet C1.0, dated September 2010, and Sheet C-4.2, dated October 2002, have been constructed generally in accordance with prior plans.
- Stormwater management systems (e.g., basins, roadside swales) as depicted on CEA's Site Plan Sheets C-1.0 and C-4.2 differ slightly from existing conditions although appear to be operating as intended.

2.2 Drainage Areas and Stormwater Management

As observed, the Mansfield Base Area is generally separated into five major drainage areas, as defined by existing topography, conveyance channels, culverts, and/or stormwater management systems that drain to a particular discharge point on the West Branch of the Little River, Gondola Brook, and Long Trail Brook; see the Existing Conditions Site Map in the map pocket. These five major drainage areas include the following manners of discharge (from north to south), with labels that correspond to the Existing Conditions Site Map in the map pocket:

DA-1. Stormwater runoff from a portion of the Vehicle Maintenance Yard and the Upper Barnes Lot is conveyed via overland flow and swales to the Upper Barnes Lot Basin with overflow piped to a roadside swale then through a culvert under the access road to a swale to the West Branch of the Little River.

DA-2. Stormwater runoff from the Lower Barnes Lot is conveyed via overland flow and swales to the Lower Barnes Lot Basin with overflow to a swale then to Long Trail Brook.

DA-3. Stormwater runoff from a portion of the Midway Lodge and the upper Midway Lot is conveyed via overland flow and a grass-lined swale then to a stone-lined swale where it converges with runoff from the middle Midway Lot, which is conveyed via overland flow and a grass-lined swale to the stone-lined swale, where runoff is then conveyed to a catch basin and culvert then to a roadside swale where it converges with a grass-lined swale from the lower Midway Lot to a culvert then to Gondola Brook.

DA-4. Stormwater runoff from a portion of the Mansfield Base Lot, a portion of the Mansfield Operations Center, and a portion of the access drive is conveyed to the Mansfield Lot Basin with discharge to the West Branch of the Little River.

DA-5. Stormwater runoff from a portion of the Mansfield Base Lot, the Mansfield Base Lodge, and the Permit Lot are conveyed via overland flow to catch basins then to the Mansfield Exit Basin with overflow to the West Branch of the Little River. Stormwater runoff from the Bus Lot is conveyed via overland flow and a stone-lined swale to a settling basin then via a culvert under the access drive to Mansfield Exit Basin with overflow to the West Branch of the Little River. In addition, stream flow from the Demo Center Brook and Lookout Brook are conveyed via culverts to the Mansfield Exit Basin with discharge to the West Branch of the Little River.

In addition to these five major drainage areas, there are several smaller drainage areas although only one that appeared to be contributing to potential impacts to water quality in receiving waters. This small drainage area (DA-6) includes a portion of the Snow Plant and the adjacent work road, with stormwater runoff conveyed via overland flow to Long Trail Brook (see Existing Conditions Site Map in the map pocket).

Lastly, Sepps Brook, Quad Brook, and partial runoff from slopeside areas are directed via swales, catch basins, and culverts to an underground piping system that conveys runoff to one of the resort's snowmaking ponds, with a flow splitter that directs excess flow to the West Branch of the Little River. As observed, stream flow and slopeside runoff do not typically commingle with stormwater runoff from the adjacent impervious surfaces (e.g., Mansfield Base Parking Lot) and are not posing any apparent water quality issues, and are therefore not included in our assessment of priority areas.

Table 1 provides a summary of the information provided above, with regard to existing major drainage areas (DA-1 through DA-5) and one minor drainage area (DA-6), and their respective existing impervious areas, stormwater management systems (if any), and receiving waters; this information also corresponds to the Existing Conditions Site Map.

Table 1: Summary of Mansfield Base Area Existing Conditions: Drainage Areas, Impervious Areas, Stormwater Management Systems, and Receiving Waters

Drainage Area ID	Drainage Area Name	Impervious Area (acres)	Stormwater Management System(s)	Receiving Water
DA-1	Upper Barnes Lot	1.81	Grass channel and stormwater basin with forebay (Upper Barnes Lot Basin)	West Branch of the Little River
DA-2	Lower Barnes Lot	1.02	Stormwater basin with forebay (Lower Barnes Lot Basin)	Long Trail Brook
DA-3	Midway Lots	2.84	Grass channels	Gondola Brook
DA-4	Mansfield Base Lot	5.33	Stormwater basin with forebay (Mansfield Base Lot Basin)	West Branch of the Little River
DA-5	Mansfield Exit and Bus Lot	3.85	Settling basin and stormwater basin with forebay (Mansfield Exit Basin)	West Branch of the Little River
DA-6	Snow Plant	0.61	None	Long Trail Brook

Although there are several existing stormwater management systems within the Mansfield Base Area (as summarized in Table 1), it was observed during the site visits that several of these systems are in need of maintenance and/or upgrades in order to improve the level of treatment and control that is being provided. For example, the Mansfield Base Lot Basin was constructed with a forebay and main pond; however over time, the stone berm between the forebay and main pond has fallen and is in need of repair in order for sediment to be captured within the forebay prior to overflow of runoff into the main pond. Under existing conditions, runoff enters the forebay and flows directly into the main pond, without providing opportunity for sediment to settle in the forebay. Additional examples of this type are further summarized in Sections 4.0 through 6.0, as part of observations and recommendations.

3.0 PRELIMINARY HYDROLOGIC MODELING AND ENGINEERING FEASIBILITY ANALYSIS RESULTS

As outlined in previous sections of this memorandum, hydrologic modeling was a component of the preliminary studies that were conducted to determine priority areas and associated opportunities for improved treatment and control of stormwater runoff to the West Branch of the Little River and its tributaries. The hydrologic models (existing and proposed) that were prepared for the Mansfield Base Area were built upon previous modeling that had been conducted for this area. The revised models (using HydroCAD®) focused on the five major drainage areas (DA-1 through DA-5) and the smaller drainage area (DA-6; see Section 2.2), the performance of their existing stormwater

management systems, and the potential for upgrades to these systems and/or retrofit of new systems to these drainage areas.

As a component of these efforts, compliance with three criteria of the Vermont Stormwater Management Manual (VSMM) was assessed as a means of understanding the amount of treatment and control that the existing stormwater management systems are currently providing, as well as the potential amount of improvement in treatment and control with future upgrades and/or retrofits. The assessment was conducted using VT DEC's Engineering Feasibility Analysis (EFA)[2] procedure as guidance, which involves assessing performance as it pertains to the following three VSMM criteria:

- Groundwater Recharge (Re)
- Channel Protection Volume (CP_v)
- Water Quality Volume (WQ_v)

Results of the existing conditions assessment are provided in Table 2 on page 1 of the Attachment. The following is a list of notes and assumptions that were used in conducting these analyses:

- Associated with stormwater basin design, CEA's plan details reference: 1'' *Diameter Holes* (see Sheet C-5.8 of Stowe Mountain Resort, Spruce Hamlet, Detention Basin Details, Sheet C-5.8, prepared by CEA, dated October 2002). Based on this information and for the purpose of modeling the four stormwater basins, it was assumed that two 1-inch orifices are present.
- The one-year, 24 hour storm event for Lamoille County (2.1 inches) was used for CP_v determinations.
- Manning's N value of 0.025 was used for ditches throughout Mansfield Base Area; this is typical for an open earth ditch that is clean and winding (per HydroCAD® technical guidance).
- An outlet pipe diameter of 24-inches was modeled for the Bus Lot Basin.
- Basin dimensions did not include any volume displacement that may currently exist due to excess sediment accumulation in the forebay and/or main pond.

By way of comparison, an assessment of full compliance with the three criteria (Re, CPv, and WQv) of the VSMM was also conducted in order to determine the percent treatment and control that existing stormwater management systems are providing. A summary of this comparison is presented in Table 2 on page 1 of the Attachment. *Please note that as a component of the EFA process, a "best fit" scenario with partial compliance is typically determined to be feasible, as opposed to full compliance, recognizing that full compliance is difficult on sites that have existing infrastructure and other limitations. Thus, the full compliance thresholds provided in Table 2 are presented for comparison purposes only.*

Table 3 provides an overview of hydrologic modeling and EFA results, as they pertain to the level of treatment and control that is being provided by existing stormwater management systems within each of the five major drainage areas (DA-1 through DA-5) and the additional smaller drainage area of interest (DA-6). The amount of treatment and control that is currently being provided is

[2] The EFA procedure is outlined in the Vermont Environmental Protection Rules, Chapter 22, Stormwater Management Rule for Stormwater-Impaired Waters, Appendix B – VTDEC Procedure for Evaluation of Stormwater Discharges and Offsets in Stormwater Impaired Watersheds.

presented as "poor", "fair", "good", or "very good", as dictated by the percent of full compliance being provided under existing conditions. The threshold used in determining the ranking of "poor" was 25 percent or less, "fair" was greater than 25 percent to 50 percent, "good" was greater than 50 percent to 75 percent, and "very good" was greater than 75 percent. Those stormwater management systems that ranked as "poor" and "fair" represent potential priority areas for improvement (see grey highlighted in Table 3). This resulting information was then used in conjunction with observations that were made during the site investigations to prepare the list of priority areas, recommended action items, and proposed next steps that are presented in Sections 4.0 through 6.0.

Table 3: Summary of Mansfield Base Area Existing Conditions: Level of Treatment and Control Provided by Existing Stormwater Management Systems per Outcome of the Engineering Feasibility Analysis (EFA)

Drainage Area I.D.	Drainage Area Name	Stormwater Management System(s)	Groundwater Recharge (Re) Provided	Channel Protection Volume (CP_v) Provided	Water Quality Volume (WQ_v) Provided
DA-1	Upper Barnes Lot	Grass channel and Upper Barnes Lot Basin	Very Good	Fair	Very Good
DA-2	Lower Barnes Lot	Grass channel Lower Barnes Lot Basin	Poor	Fair	Good
DA-3	Midway Lots	Grass channels	Very Good	Poor	Fair
DA-4	Mansfield Base Lot	Mansfield Base Lot Basin	Poor	Very Good	Very Good
DA-5	Mansfield Exit and Bus Lot	Mansfield Exit Basin	Poor	Fair	Poor
DA-6	Snow Plant	Small Settling Basin	Poor	Poor	Poor

With regard to the outcome of the comparison for Groundwater Recharge (Re), as summarized by the ranking in Table 3, it should be noted that although certain drainage areas (DA-2, DA-4, DA-5, and DA-6) have resulted in a ranking of "poor" for groundwater recharge, implementation of additional groundwater recharge opportunities within those drainage areas is not feasible and therefore will be applied elsewhere within the larger West Branch of the Little River watershed (within the Mansfield Base Area), including within the Midway Lots drainage area (DA-3). Restrictions on implementing additional stormwater treatment practices that facilitate groundwater recharge in those drainage areas are primarily associated with lack of open space, as is typical in built environments, in which to install measures.

Similarly, with regard to the outcome of the comparison for Channel Protection Volume (CP_v), it should be noted that although the existing stormwater basins in DA-1 (Upper Barnes Lot Basin) and DA-2 (Lower Barnes Lot Basin) each resulted in a ranking of "fair", it was determined based on observations that control of stormwater runoff volume within these basins is sufficient with no signs of significant erosion at the outfalls of these basins. Therefore, retrofits to these existing basins other

than regular maintenance were not considered as part of this study. Alternatively, opportunities for providing additional CP_v storage in other stormwater treatment practices within the Mansfield Base Area watersheds were considered as part of the overall plan for improving water quality within the West Brach of the Little River.

With regard to DA-4/Mansfield Base Lot, hydrologic modeling results found that the existing basin is providing approximately 80% of CP_v storage and 100% of WQ_v storage, as compared to full compliance with the VSMM (see Table 2 on page 1 of the Attachment). Therefore, the assessment of potential opportunities within this drainage area focused on maintenance activities in terms of a potential reduction in sediment loading to the basin, as well as performance of the existing basin in terms of a potential reduction of sediment transport from the basin.

4.0 PRIORITY AREAS AND RECOMMENDED ACTION ITEMS

Based on observations that were made during the site investigations, subsequent drainage area mapping, known site limitations, and revised hydrologic modeling, the following are lists of priority areas, possible opportunities, and recommended next steps. These are presented as upgrades to existing stormwater management systems and retrofits of new stormwater management systems within each drainage area (DA-3 through DA-6; see Section 4.1). These recommendations and their numbered labels correspond to labels on the Proposed Upgrades and Retrofits Map in the map pocket. In addition, general operations and maintenance recommendations for site-wide improvements is provided in Section 4.2. A timeline for implementing these improvements is presented in Section 5.0.

4.1 Stormwater Management System Improvements

1

<u>DA-3/Midway Lots</u>

- Upgrade the existing grass swale that is located between the Middle Midway and Lower Midway parking lots to include a dry swale with check dams and a dry pond in order to increase ground water recharge, volume storage capacity, and detention time of stormwater runoff; see VSMM Dry Swale (O-1) sheet, Check Dam detail, and VSMM Dry Detention Pond (LA-1) on pages 2 through 5, respectively, of the Attachment for examples.
- Re-route stormwater runoff from the Upper Midway Lot via a new culvert[3] to the upgraded dry swale and dry pond located between the Middle Midway and Lower Midway Lots to further increased potential for groundwater recharge, volume storage capacity, and detention time of stormwater runoff.
- Maintain the existing grass channel between the Upper Midway and Middle Midway parking lots as a grass channel.
- Maintain the existing grass channel between the Lower Midway Lot and the access road as a grass channel.

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- Replace and/or repair remaining existing ditches with stone lining; see Lined Waterway detail on pages 6 through 10 and Table 4 on page 11 of the Attachment.

[3] Sizing of new and replacement culverts is to be determined as part of the engineering and permitting phase of future action items.

Implementing these measures will result in full compliance with the VSMM for all three criteria (Re, CP_v, and WQ_v) (see Table 2 on page 1 of the Attachment).

2

DA-4/Mansfield Base Lot

- Re-install the catch basin and sump at the inlet of the Mansfield Base Lot Basin to effectively capture and convey runoff from the parking lot to the basin.
- Remove accumulated sediment from the forebay and main pond of the basin, and deposit in an upland location with seed and mulch, as needed.
- Repair the forebay berm by re-installing stone along the berm in order to capture road wash-off prior to overflow into the main pond and ultimately to the West Branch of the Little River; see VSMM Wet Pond (P-2) sheet on page 12 of the Attachment for an example of a stormwater basin berm.
- Assess opportunities to modify current snowplowing and piling operations as part of a "Snowplowing/piling Operations and Maintenance Plan" to be prepared (see Section 4.2), and to possibly include:
    - Designating the parking area just upslope and adjacent to the basin for snow storage;
    - Avoiding snow storage within the basin.
    - Extending the block retaining wall further upslope along the perimeter of the parking lot to reduce potential for snow piling within the adjacent stream buffer.
    - Re-planting of vegetation along the stream buffer to re-establish vegetative growth and improve bank stabilization.
    - Increasing the frequency of sand removal from the Mansfield Base Lot in order to reduce the amount of washoff of sand to the basin.

It is anticipated that implementing these measures will result in a reduction in sediment transport to the Mansfield Base Lot Basin, as well as a reduction in potential transport of sediment from the basin. These measures will also allow an adequate volume storage capacity to be maintained over time.

3

DA-5/Mansfield Exit and Bus Lot

- Evaluate feasibility of re-route Demo Center Brook and Lookout Brook away from Mansfield Exit Basin in order to increase volume storage capacity and detention times for stormwater runoff within the basin and, in turn, increase opportunity within the basin for sediment to settle prior to overflow from the basin to the West Branch of the Little River.
- Remove accumulated sediment from the settling basin, forebay, and main pond of the basin, and deposit in an upland location with seed and mulch, as needed.
- Repair the forebay berm by re-installing stone along the berm in order to capture sediment prior to flow into the main pond and ultimately to the West Branch of the Little River; see VSMM Wet Pond (P-2) sheet on page 12 of the Attachment for an example of a stormwater basin berm.
- Re-install the catch basin, install a sump, and re-install a properly sized culvert to effectively capture and convey runoff from a portion of the Mansfield Base Lot located just upslope of the Bus Lot to the basin.
- Increase maintenance frequency of the settling basin associated with the Bus Lot.

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- Replace and/or repair existing ditches with stone lining; see Lined Waterway detail on pages 7 through 11 and Table 4 on page 12 of the Attachment.

Implementing these measures will improve the performance of the Mansfield Exit Basin particularly with regard to CP_v, as well as WQ_v, which is anticipated to double in terms of storage provided (see Table 2 on page 1 of the Attachment).

4

DA-6/Snow Plant

- Install a second small settling basin at the base of the work road; see VSMM Dry Detention Pond (LA-1) on page 6 of the Attachment for an example.
- Regrade the work road to provide a larger turning radius for snow cats and to direct runoff from the road surface to the new settling basin.
- Install stone-lined swales to convey runoff from the road to the settling basin; see Lined Waterway detail on pages 7 through 11 of the Attachment.
- Maintain an existing small settling basin by removing accumulated sediment and depositing in an upland location with seed and mulch, as needed.

Implementing these measures will result in a greater capacity for sediment laden runoff from the temporarily exposed work road to be captured prior to discharge to Long Trail Brook, thereby reducing potential for water quality impairment downstream of this area (see Table 2 on page 1 of the Attachment).

4.2 Site-wide Improvements

Parking Lot Maintenance and Snowplowing/piling Operations (site-wide)

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- Replace and/or repair existing ditches with stone lining, where needed (see Proposed Upgrades and Retrofits Map in the map pocket; see Lined Waterway detail on pages 7 through 11 and Table 4 on page 12 of the Attachment).
- Prepare a "Snowplowing/piling Operations and Maintenance Plan" that identifies opportunities for low impact snow storage and snowmelt.

On-mountain Tributary

- Culvert a short reach of unnamed on-mountain tributary to minimize sand wash-off from the Upper Midway Lot to Long Trail Brook; or include this open channel as a "no snow piling zone" in the Snowplowing/piling Operations and Maintenance Plan (to be prepared).

DA-1/Upper Barnes Lot

- Continue annual maintenance including possible installation of a trash rack on the riser pipe.

DA-2/Lower Barnes Lot

- Continue annual maintenance including stabilization of inner slope of main pond, possible installation of a trash rack on the riser pipe, and monitoring of minor iron seep on downslope side of the basin berm.

- Monitor rilling and gullying that occurs in lower portion of lot (directly upslope of basin forebay) and assess potential need for diverting runoff through a stabilized channel.

5.0 IMPLEMENTATION TIMELINE

As a result of on-going coordination with Stowe Mountain Resort, and as required by the Order, the following timeline has been established for implementing the stormwater management system improvements (Section 4.1 above) and site-wide improvements (Section 4.2 above) pending further results of engineering and design. This timeline has been created with many considerations in mind, including but not limited to: (1) anticipated design and permitting needs, (2) limited window of opportunity for construction during non-winter months, and (3) financing and capital availability. In addition to action items listed below, Stowe Mountain Resort will:

- Apply for necessary permits (e.g., General Permit 3-9020) or permit amendments that may be required by June 15, 2012 (per Condition B of the Order).
- Complete all approved remediation measures for 2012 by September 30, 2012 (per Condition C of the Order).
- Submit a monitoring plan designed to assess effectiveness of installed remediation measures and overall compliance of the affected reach of the West Branch of the Little River to VT DEC by September 30, 2012 (per Condition C of the Order).
- Implement the monitoring plan once approved by VT DEC (per Condition C of the Order).
- By October 15, 2012 (per Condition D of the Order), conduct a post-implementation meeting with VT DEC staff to review the condition and adequacy of implementation measures and discuss potential next steps.
- Complete all approved remediation measures for 2013 by September 30, 2013.

Phase 1: Spring - Fall 2012

- Upgrade stormwater management systems associated with DA-3/Midway Lots to re-route a portion of runoff from the Upper Midway Lot via a new culvert, and to include a dry swale with check dams and a dry pond between the Middle Midway and Lower Midway parking lots
- Upgrade stormwater management systems associated with DA-4/Mansfield Base Lot to re-install a catch basin and sump, and repair the forebay berm.
- Upgrade the stormwater management system associated with DA-5/Bus Lot to re-install the catch basin, install a sump, and re-install a properly sized culvert to the settling basin.
- Upgrade the stormwater management system associated with DA-6/Snow Plant to install a small settling basin and regrade the work road.
- Install the culvert within the unnamed on-mountain tributary to Long Trail Brook that is located adjacent to the Snow Plant.
- Remove accumulated sediment from all settling basins and stormwater basin forebays and main ponds (site-wide).
- Replace and/or repair existing ditches with stone lining (site-wide).
- Prepare the "Snowplowing/piling Operations and Maintenance Plan" to be implemented during the 2012/2013 winter and spring snowmelt seasons (site-wide).

- Conduct civil engineering and design associated with re-routing of Demo Center Brook and Lookout Brook away from Mansfield Exit Basin.

Phase 2: Spring - Fall 2013

- Upgrade the stormwater management systems associated with DA-5/Mansfield Exit and Bus Lot to re-route Demo Center Brook and Lookout Brook away from Mansfield Basin, and repair the forebay berm.
- Remove accumulated sediment from all settling basins and stormwater basin forebays and main ponds (site-wide).
- Assess effectiveness of the "Snowplowing/piling Operations and Maintenance Plan" during the 2012/2013 season; update and revise, as needed.
- Conduct any remaining action items associated with the "Snowplowing/piling Operations and Maintenance Plan" that are needed, such as preparing and implementing a planting plan.

Phase 3: Ongoing Maintenance and Operations

- Remove accumulated sediment from settling basins and stormwater basin forebays and main ponds following snowmelt and prior to snowfall each year.
- Remove accumulated sediment from ditches, repair ditches, and repair check dams, as needed, each year, particularly as soon as practicable following spring snowmelt.
- Revisit the "Snowplowing/piling Operations and Maintenance Plan" and revise, as needed, each year.
- Conduct any additional maintenance items that are identified during annual inspections associated with the existing operational phase stormwater discharge permit(s).

6.0 CONCLUSIONS AND NEXT STEPS

Based on observations made during the site investigations, as well as the results of the EFA (as presented above), VHB determined that there are several opportunities for upgrades and/or retrofits to the Mansfield Base Area that could significantly improve water quality conditions within the receiving waters, consistent with the requirements of the Order. Although this is a built site with existing infrastructure, there are a variety of opportunities for improving water quality within the West Branch of the Little River and its tributaries. The following is an overall summary of our findings and recommendations for next steps:

- Based on observations, as well as results of revised drainage area mapping and hydrologic modeling, it was determined that within the Mansfield Base Area, there are opportunities to upgrade existing stormwater management systems, as well as retrofit the site with new stormwater management systems in order to achieve improved treatment and control of stormwater runoff. Recommended next steps include: model refinements, design of feasible upgrades and retrofits, permitting, and construction

- With implementation of an alternative means of snowplowing and piling that includes designated areas, as well as "no plow" and "no piling" zones, protection of sensitive riparian buffers can be achieved. Recommended next steps include: preparation of the

Snowplowing/piling Operations and Maintenance Plan, as well as a follow-up assessment of existing riparian buffers during the growing season to determine whether or not a supplemental planting plan is needed (followed by preparation of the planting plan).

7.0 REFERENCES

In conducting the EFA and preparing the enclosed recommendations for stormwater management system upgrades and retrofits, VHB relied primarily on the following resources and site plans:

Stowe Mountain Resort, Spruce Hamlet, Detention Basin Details, Sheet C-5.8, prepared by CEA, dated October 2002. From Act 250 Application: Phase I Construction.

Mansfield Parking Lot Proposed Stormwater Pond Modification, Sheet, ST1, prepared by CEA, dated January 26, 2007.

Stowe Mountain Resort, 2010 Mansfield Drainage Improvements, Site Plan, Sheet C4.1, prepared by Civil Engineering Associated, Inc. (CEA), dated September 2010.

Stowe Mountain Resort, 2010 Mansfield Parking Lot Drainage Improvements, Site Plan, Sheet C1.0, prepared by Civil Engineering Associated, Inc. (CEA), dated September 2010.

Stowe Mountain Resort, Spruce Hamlet, Site Plan of Mansfield Base, Sheet C-4.2, prepared by CEA, dated October 2002.

Stowe Mountain Resort, SMR 2000 Community Plan, Water Quality Management Plan, prepared by Pioneer Environmental Associates, LLC (now VHB), dated October 28, 1999.

Stowe Mountain Resort, SMR 2000 Community Plan, Water Quality Management Plan, Addendum, prepared by Pioneer Environmental Associates, LLC, dated March 1, 2000.

Vermont Environmental Protection Rules, Chapter 22, Stormwater Management Rule for Stormwater-Impaired Waters, Appendix B.

The Vermont Standards and Specifications for Erosion Prevention and Sediment Control, 2006 (Amended 2008).

The Vermont Stormwater Management Manual, Volume I – Stormwater Treatment Standards, Vermont Agency of Natural Resources, April 2002 (revised).

HydroCAD® Stormwater Modeling System, Owner's Manual, Version 8, HydroCAD Software Solutions, LLC.

ATTACHMENT

Stowe Mountain Resort
Mansfield Base Area
Summary of Stormwater Compliances and Observations
Prepared by VHB
May 11, 2012

Table 2: Results of Engineering Feasibility Analysis (EFA) for Mansfield Base Area

Subwatershed ID	Basin ID	Existing						Following Proposed Retrofits and Upgrades[a]					
		ReV (cubic feet)	CPv	WQv	Percent of Full Compliance Provided			ReV (cubic feet)	CPv	WQv	Percent of Full Compliance Provided		
					ReV (cubic feet)	CPv	WQv (cubic feet)				ReV (cubic feet)	CPv	WQv (cubic feet)
DA-1	Upper Barnes Lot Basin	2,407	1,072	5,720	92%	29%	100%	-	-	-	-	-	-
DA-2	Lower Barnes Lot Basin	0	1,018	792	0%	44%	25%	-	-	-	-	-	-
DA-3	Upper Midway Lot	1,550	0	1,550	354%	0%	40%	-	-	-	-	-	-
	Middle Midway Lot[c]	1,397	0	1,397	419%	0%	48%	1,685	4434	3651	404%	100%	100%
	Lower Midway Lot	967	0	967	373%	0%	43%	-	-	-	-	-	-
DA-4	Mansfield Base Lot Basin	0	17,549	16,547	0%	80%	100%	-	-	-	-	-	-
DA-5[b]	Mansfield Exit Basin w/ 2 forebays	0	9,344	8,688	0%	26%	21%	0	3,725	4,834	0%	36%	40%
DA-6	Snow Plant Basin	0	0	0	0%	0%	0%	0	883	479	0%	59%	25%

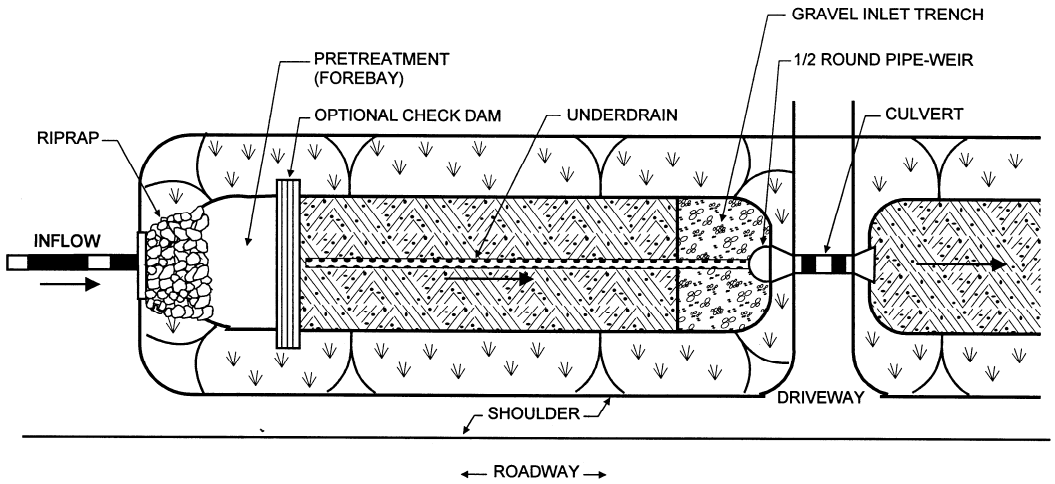
Subwatershed ID	Basin ID		Full Compliance with VSMM (2002)			
			ReV (cubic feet)	ReA (square feet)	CPv	WQv (cubic feet)
DA-1	Upper Barnes Lot Basin		2,621	31,448	3,693	5,720
DA-2	Lower Barnes Lot Basin		1,481	17,772	2,297	3,200
DA-3	Upper Midway Lot		438	5,254	4,791	3,860
	Middle Midway Lot[c]	Existing Drainage Area	334	4,002	3,372	2,935
		Following Retrofits	417	5,009	4,434	3,651
	Lower Midway Lot		259	3,106	2,908	2,244
DA-4	Mansfield Base Lot Basin		4,427	53,130	21,808	16,547
DA-5[b]	Mansfield Exit Basin w/ 2 forebays	Existing Drainage Area	2,703	32,540	36,539	41,421
		Following Retrofits	2,679	32,159	10,309	12,127
DA-6	Snow Plant Basin		483	5,797	1,498	1,925

[a] Retrofit and Upgrades includes the removal of flow from Lookout Brook and Demo Center Brook to Mansfield Exit Lot Basin, installation of a dry swale with check dams and a dry pond between Middle Midway and Lower Midway Lots with additional drainage from the Upper Midway Lot, and the installation of a new basin for DA-6 (Snow Plant).

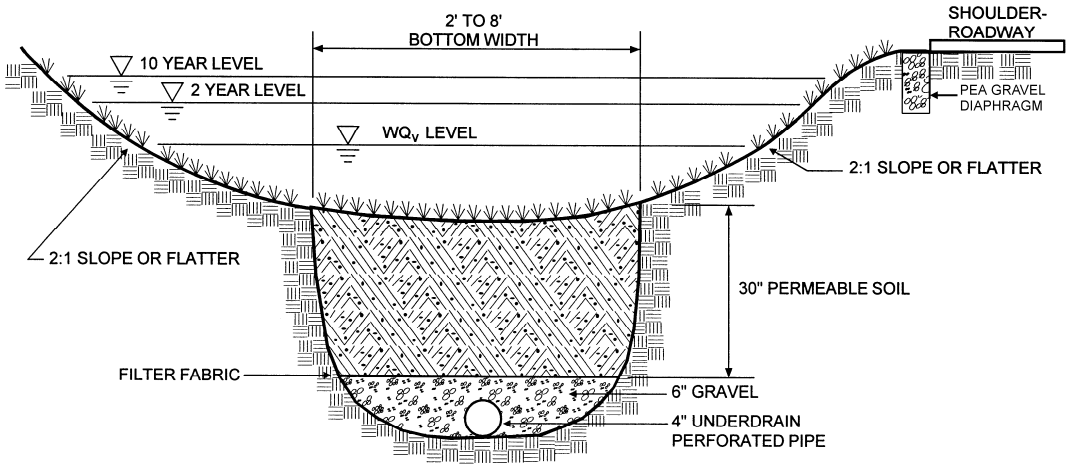
[b] DA-5 for "Existing Cconditions" is compared to the Full Complinace with VSMM of the ~45 acre drainage area. Following retrofits, the proposed ReV, CPv, and WQv are compared to the Full Compliance of the ~5 acre drainage area.

[c] DA-3 Middle Midway Lot for "Existing Condtions" is compared to the Full Complinace with VSMM of the ~1.40 acre drainage area. Following retrofits, the proposed ReV, CPv, and WQv are compared to the Full Compliance of the ~1.65 acre drainage area.

Note: dry swales and grass channels, while both considered open channel system variants, are fundamentally different in terms of their design approach. Specifically, dry swales are essentially a linear filter system that is a function of a volume-based designs. Grass channels are conveyance systems that can provide water quality treatment based on rate-based design criteria.



PLAN VIEW



SECTION

Figure 2.19 Example of Dry Swale (O-1)

STANDARD AND SPECIFICATIONS FOR CHECK DAM

Definition

Small barriers or dams constructed of stone, bagged sand or gravel, or other durable material across a drainage way.

Purpose

To reduce erosion in a drainage channel by restricting the velocity of flow in the channel.

Condition Where Practice Applies

This practice is used as a temporary or emergency measure to limit erosion by reducing velocities in small open channels that are degrading or subject to erosion and where permanent stabilization is impractical due to short period of usefulness and time constraints of construction.

Design Criteria

Drainage Area: Maximum drainage area above the check dam shall not exceed two (2) acres.

Height: Not greater than 2 feet. Center shall be maintained 9 inches lower than abutments at natural ground elevation.

Side Slopes: Shall be 2:1 or flatter.

Spacing: The check dams shall be spaced as necessary in the channel so that the crest of the downstream dam is at the elevation of the toe of the upstream dam. This spacing is equal to the height of the check dam divided by the channel slope.

Therefore:

$$S = h/s$$

Where:

S = spacing interval (ft.)
h = height of check dam (ft.)
s = channel slope (ft./ft.)

Example:

For a channel with a 4% slope and 2 ft. high stone check dams, they are spaced as follows:

$$S = \frac{2 \text{ ft.}}{.04 \text{ ft/ft.}} = 50 \text{ ft.}$$

Stone size: Use a well graded stone matrix 2 to 9 inches in size.

The overflow of the check dams will be stabilized to resist erosion that might be caused by the check dam.

Check dams shall be anchored in the channel by a cutoff trench 18 inches wide and 6 inches deep and lined with filter fabric to prevent soil migration.

Maintenance

The check dams should be inspected after each runoff event. Correct all damage immediately. If significant erosion has occurred between structures, a liner of stone or other suitable material should be installed in that portion of the channel.

Remove sediment accumulated behind the dam as needed to allow channel to drain through the stone check dam and prevent large flows from carrying sediment over the dam. Replace stones as needed to maintain the design cross section of the structures.

Considerations

For added stability, the base of the check dam should be keyed into the soil to a depth of 6 inches.
Filter fabric may be used under the rock to provide a stable foundation and to facilitate removal of the rock.
Check dams are effective in reducing flow velocity and thereby the potential for channel erosion. It is usually better to establish a protective vegetative lining before flow is confined or to install a structural channel lining than to install rock check dams. Field experience has shown rock check dams to perform much more effectively than silt fences or straw bales in the effort to stabilize "wet-weather" ditches.

STANDARD AND SPECIFICATIONS FOR CHECK DAM

Accordingly, silt fences dams and hay bale check dams are not accepted practices in Vermont.

Rock check dams installed in grass-lined channels may kill the vegetative lining if submergence after rains is too long and/or siltation is excessive.

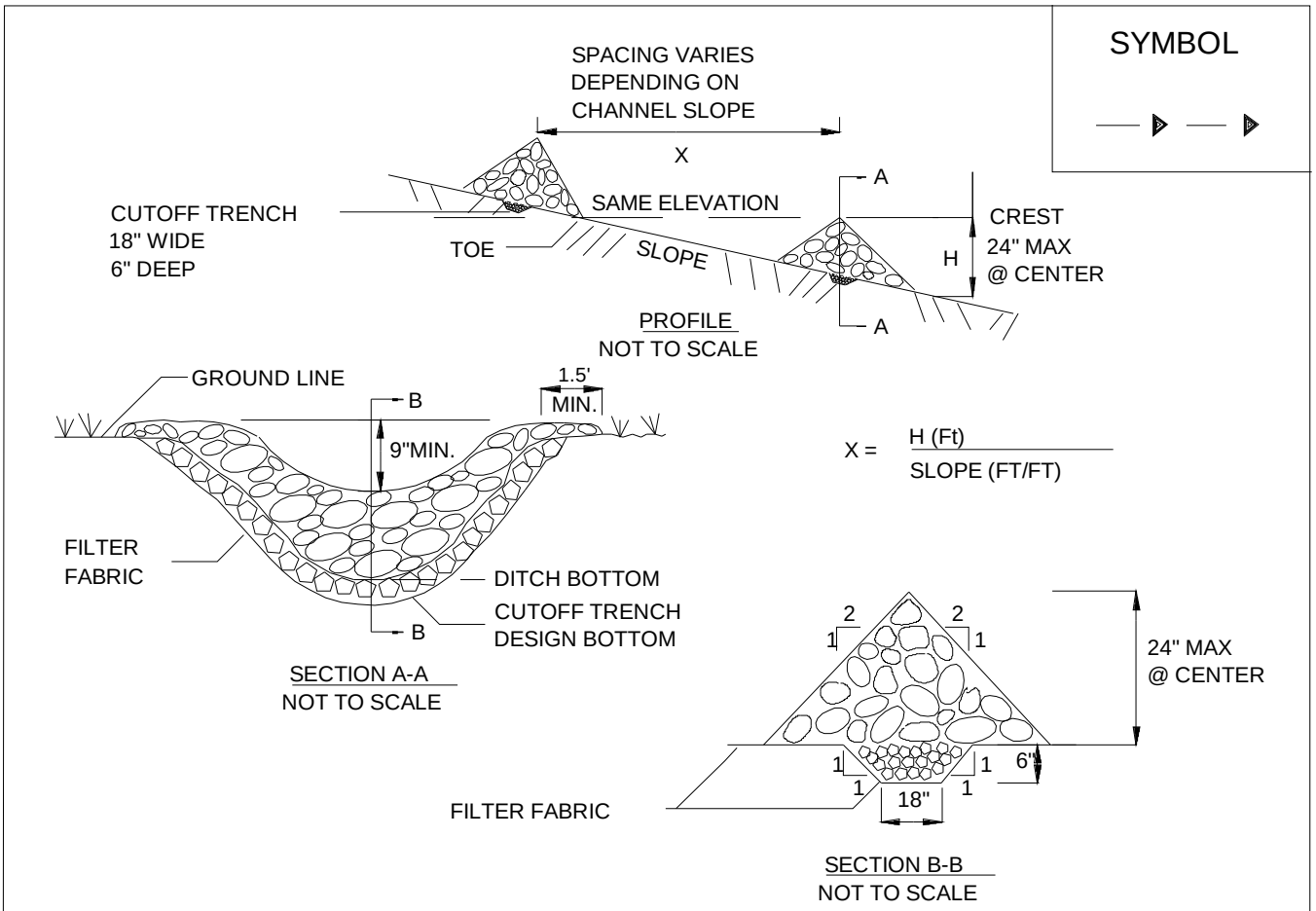
If temporary rock check dams are used in grass-lined channels that will be mowed, care should be taken to remove all the rock when the rock check dam is removed. This should include any rocks that have washed downstream.

Field experience has shown that many rock check dams are not constructed with the center lower than the sides forming a weir. Stormwater flows are then forced to the rock-soil interface, thereby promoting scour at that point and subsequent failure of the structure to perform its intended function.

Plans and Specifications

Plans and specifications for installing check dams shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following:

1.Location where the practice will be installed.
2. Dimensions, elevations, and spacing between the dams.
3. Rock gradation and quality.
4. Fabric specification if used.
5. Construction detail.



CONSTRUCTION SPECIFICATIONS

1. STONE WILL BE PLACED ON A FILTER FABRIC FOUNDATION TO THE LINES, GRADES AND LOCATIONS SHOWN IN THE PLAN.
2. SET SPACING OF CHECK DAMS TO ASSUME THAT THE ELEVATIONS OF THE CREST OF THE DOWNSTREAM DAM IS AT THE SAME ELEVATION OF THE TOE OF THE UPSTREAM DAM.
3. EXTEND THE STONE A MINIMUM OF 1.5 FEET BEYOND THE DITCH BANKS TO PREVENT CUTTING AROUND THE DAM.
4. PROTECT THE CHANNEL DOWNSTREAM OF THE LOWEST CHECK DAM FROM SCOUR AND EROSION WITH STONE OR LINER AS APPROPRIATE.
5. ENSURE THAT CHANNEL APPURTENANCES SUCH AS CULVERT ENTRANCES BELOW CHECK DAMS ARE NOT SUBJECT TO DAMAGE OR BLOCKAGE FROM DISPLACED STONE.

MAXIMUM DRAINAGE AREA 2 ACRES.

ADAPTED FROM DETAILS PROVIDED BY: NEW YORK STATE DEC ORIGINALLY DEVELOPED BY USDA-NRCS VERMONT DEPARTMENT OF ENVIRONMENTAL CONSERVATION	CHECK DAM

Figure 4.13 Check Dam

STANDARD AND SPECIFICATIONS FOR LINED WATERWAY OR OUTLET

Definition

A waterway or outlet with a lining of concrete, stone, or other permanent material. The lined section extends up the side slopes to the designed depth. The earth above the permanent lining may be vegetated or otherwise protected.

Purpose

To provide for the disposal of concentrated runoff without damage from erosion or flooding, where grassed waterways would be inadequate due to high velocities.

Scope

This standard applies to waterways or outlets with linings of cast-in-place concrete, flagstone mortared in place, rock riprap, gabions, or similar permanent linings. It does not apply to irrigation ditch or canal linings, grassed waterways with stone centers or small lined sections that carry prolonged low flows, or to reinforced concrete channels. The maximum capacity of the waterway flowing at design depth shall not exceed 100 cubic feet per second.

Conditions Where Practice Applies

This practice applies where the following or similar conditions exist:

1. Concentrated runoff is such that a lining is required to control erosion.

2. Steep grades, wetness, prolonged base flow, seepage, or piping that would cause erosion.

3. The location is such that damage from use by people or animals precludes use of vegetated waterways or outlets.

4. Soils are highly erosive or other soil and climate conditions preclude using vegetation.

5. High value property or adjacent facilities warrant the extra cost to contain design runoff in a limited space.

Design Criteria

Capacity

1. The minimum capacity shall be adequate to carry the peak rate of runoff from a 10-year, 24-hour storm. Velocity shall be computed using Manning's equation with a coefficient of roughness "n" as follows:

Lined Material	"n"
Concrete (Type):	
Trowel Finish	0.015
Float Finish	0.019
Gunite	0.019
Flagstone	0.022
Riprap	Determine from Figure 4.23
Gabion	0.030

2. Riprap gradation and filter (bedding) are generally designed in accordance with criteria set forth in the National Cooperative Highway Research Program Report 108, available from the University Microfilm International, 300 N. Ree Road, Ann Arbor, Michigan 48016, Publication No. PB-00839; or the Hydraulic Engineering Circular No. 11, prepared by the U.S. Bureau of Public Roads, available from Federal Highway Administration, 400 7th Street, S.W., Washington, D.C. 20590, HNG-31, or the procedure in the USDA-NRCS's Engineering Field Manual, Chapter 16.

Velocity

1. Maximum design velocity shall be as shown below. Except for short transition sections, flow with a channel gradient within the range of 0.7 to 1.3 of this flow's critical slope must be avoided unless the channel is straight. Velocities exceeding critical will be restricted to straight reaches.

STANDARD AND SPECIFICATIONS FOR LINED WATERWAY OR OUTLET

Design Flow Depth (ft.)	Maximum Velocity (ft./sec.)
0.0 – 0.5	25
0.5 – 1.0	15
Greater than 1.0	10

2. Waterways or outlets with velocities exceeding critical shall discharge into an energy dissipater to reduce velocity to less than critical, or to a velocity the downstream soil and vegetative conditions will allow.

Cross Section

The cross section shall be triangular, parabolic, or trapezoidal. Monolithic concrete or gabions may be rectangular.

Freeboard

The minimum freeboard for lined waterways or outlets shall be 0.25 feet above design high water in areas where erosion resistant vegetation cannot be grown adjacent to the paved side slopes. No freeboard is required where good vegetation can be grown and is maintained.

Side Slope

Steepest permissible side slopes, horizontal to vertical will be as follows:

1. Non-Reinforced Concrete
Hand-placed, formed concrete:
Height of lining, 18 inches or less……. Vertical
Hand placed screened concrete or mortared in-place flagstone:
Height of lining, less than 2 ft……..… 1:1
Height of lining, more than 2 ft…….. 2:1
2. Slip form concrete:
Height of lining, less than 3 ft……... 1:1
3. Rock Riprap…… ……. 2:1
4. Gabions…… …….. Vertical
5. Pre-cast Concrete Sections…… …. Vertical

Lining Thickness

Minimum lining thickness shall be as follows:

1. Concrete……..4 in.
(In most problem areas, shall be 5 in. with welded wire fabric reinforcing.)
2. Rock Riprap……1.5 x maximum stone size plus thickness of filter or bedding.
3. Flagstone……..4 in. including mortar bed.

Related Structures

Side inlets, drop structures, and energy dissipaters shall meet the hydraulic and structural requirements of the site.

Filters or Bedding

Filters or bedding to prevent piping, reduce uplift pressure, and collect water will be used as required and will be designed in accordance with sound engineering principles. Weep holes and drains should be provided as needed.

Concrete

Concrete used for lining shall be so proportioned that it is plastic enough for thorough consolidation and stiff enough to stay in place on side slopes. A dense product will be required. A mix that can be certified as suitable to produce a minimum strength of at least 3,000 pounds per square inch will be required. Cement used shall be Portland Cement, Type I, II, IV, or V. Aggregate used shall have a maximum diameter of 1 ½ inches.

Weep holes should be provided in concrete footings and retaining walls to allow free drainage of water. Pipe used for weep holes shall be non-corrosive.

Mortar

Mortar used for mortared in-place flagstone shall consist of a mix of cement, sand, and water. Follow directions on the bag of mortar for proper mixing of mortar and water.

STANDARD AND SPECIFICATIONS FOR LINED WATERWAY OR OUTLET

Contraction Joints

Contraction joints in concrete linings, where required, shall be formed transversely to a depth of about one third the thickness of the lining at a uniform spacing in the range of 10 to 15 feet.

Rock Riprap or Flagstone

Stone used for riprap or gabions shall be dense and hard enough to withstand exposure to air, water, freezing, and thawing. Flagstone shall be flat for ease of placement and have the strength to resist exposure and breaking. Rock riprap maximum size shall be as follows:

Velocity, f.p.s.	dmax, inches
5.0	6
8.5	12
10	18
12	24
15	36

Cutoff Walls

Cutoff walls shall be used at the beginning and ending of concrete lining. For rock riprap lining, cutoff walls shall be keyed into the channel bottom and at both ends of the lining.

Construction Specifications

1. The foundation area shall be cleared of trees, stumps, roots, sod, loose rock, or other objectionable material.

2. The cross-section shall be excavated to the neat lines and grades as shown on the plans. Over-excavated areas shall be backfilled with moist soil compacted to the density of the surrounding material.

3. No abrupt deviations from design grade or horizontal alignment shall be permitted.

4. Concrete linings shall be placed to the thickness shown on the plans and finished in a workmanlike manner. Adequate precautions shall be taken to protect freshly placed concrete from extreme (hot or cold) temperatures, to ensure proper curing.

5. Filter bedding and rock riprap shall be placed to line and grade in the manner specified.

6. Construction operation shall be done in such a manner that erosion, air pollution, and water pollution will be minimized and held within legal limits. The completed job shall present a workmanlike appearance. All disturbed areas shall be vegetated or otherwise protected against soil erosion.

Maintenance

Pavement or lining should be maintained as built to prevent undermining and deterioration. Existing trees next to pavements should be removed, as roots can cause uplift damage.

Vegetation next to pavement should be maintained in good condition to prevent scouring if the pavement is overtopped. See Standard and Specifications for Permanent Critical Area Seeding.

Considerations

The outlets of channels, conduits and other structures are points of high erosion potential, because they frequently carry flows at velocities that exceed the allowable limit for the area downstream. To prevent scour and undermining, an outlet stabilization structure is needed to absorb the impact of the flow and reduce the velocity to non-erosive levels. A riprap-lined apron is the most commonly used practice for this purpose because of its relatively low cost and ease of installation. The riprap apron should be extended downstream until stable conditions are reached even though this may exceed the length calculated for design velocity control.

Riprap-stilling basins or plunge pools reduce flow velocity rapidly. They should be considered in lieu of

STANDARD AND SPECIFICATIONS FOR LINED WATERWAY OR OUTLET

aprons where overfalls exit at the ends of pipes or where high flows would require excessive apron length. Consider other energy dissipaters such as concrete impact basins or paved outlet structures when conduits are flowing more than 10 fps.

Plans and Specifications

Plans and specification for installing a lined waterway or outlet shall be in keeping with this standard and will describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following:

1. Location where the practice will be installed.
2. Dimensions of the practice.
3. Construction detail.
4. Design calculations.

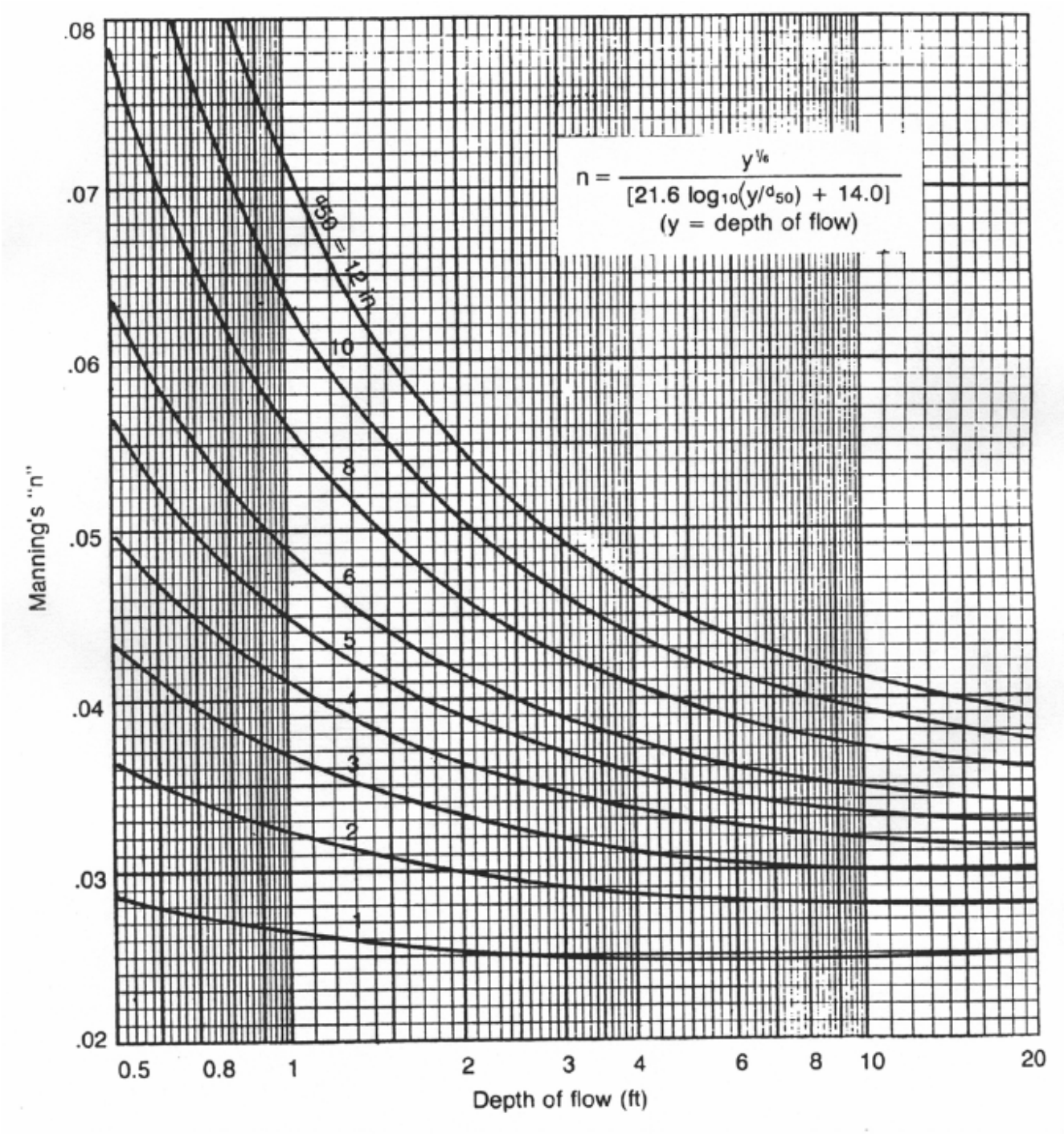


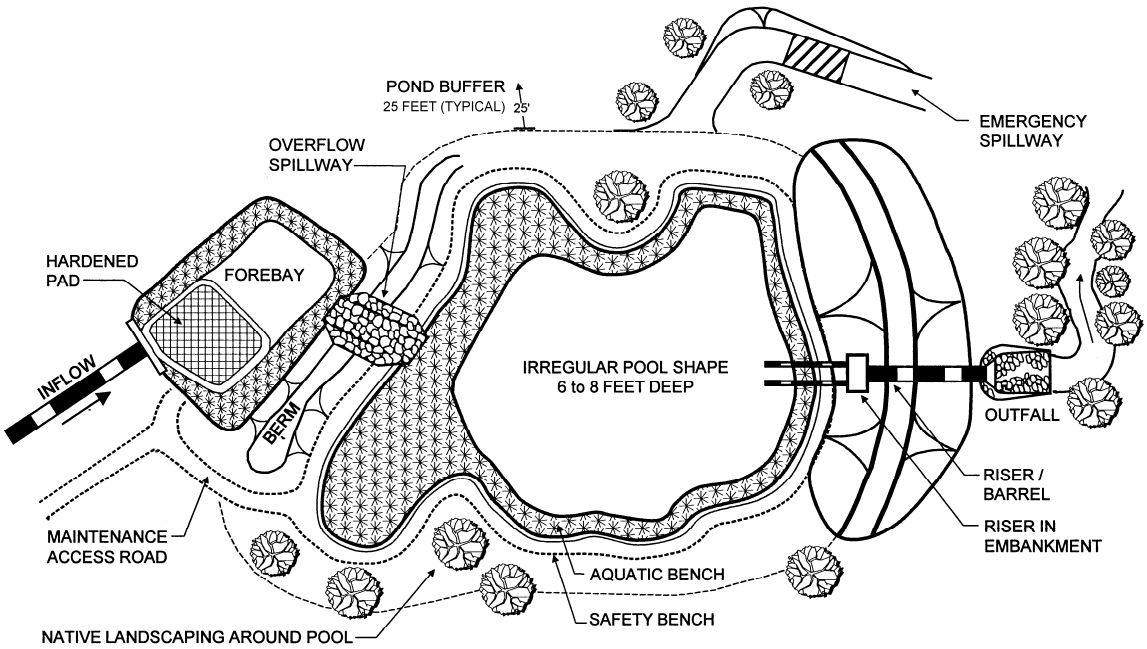
Figure 4.23 Determining "n" for Riprap Lined Channel using Depth of Flow (USDA–NRCS)

Stowe Mountain Resort
Mansfield Base Area
Summary of Stone-lined Channels
Prepared by VHB
May 11, 2012

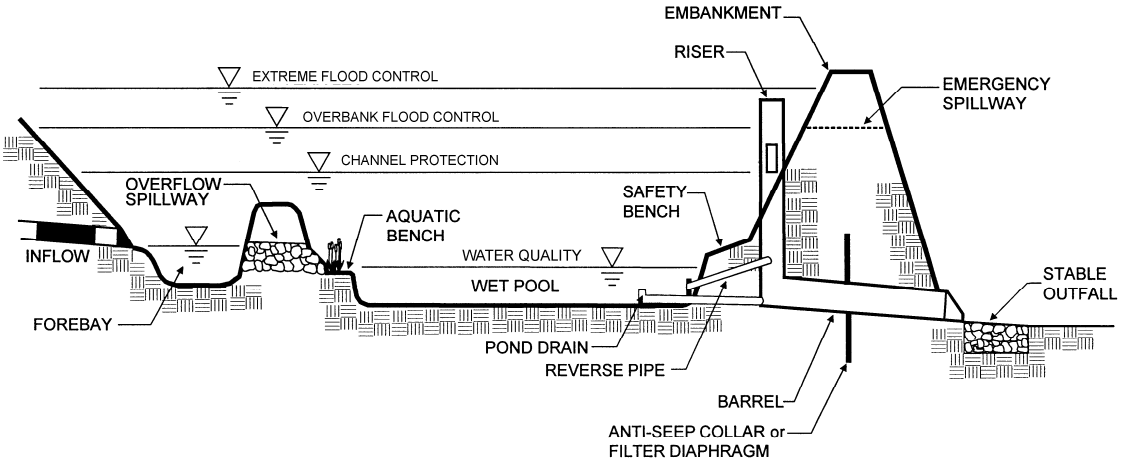
Table 4: Summary for Stone-lined Channels

Channel Characteristics							Q10			Recommended Stone Size (inches)
Stone-lined Channel		Drainage Area (acres)	IA Acres	CN	Channel Length (feet)	% Slope	Depth (feet)	Max Velocity (Feet per Second)	Manning's N	
A	Onsite impervious from DA-5 Mansfield Base Lodge and parking	4.31	3.21	91	630	7%	0.81	5.83	0.044	4''
B	Offsite area directing flow to Quad Brook and Snow Making routing	4.86	0.04	72	355	3%	0.51	2.55	0.049	4''
C	Trout Pond culvert outlet to Gondola Brook	9.67[a]	3.27	82	100	4%	1.10	4.73	0.048	6''
D	Lower Midway Grass Channel Inlet	0.39	0.32	94	100	9%	0.28	2.55	0.065	6''
E	Middle Midway Grass Channel Inlet	0.62	0.55	94	110	11%	0.35	3.1	0.065	6''
F	Upper Midway Grass Channel Outlet	2.16	1.21	87	240	11%	0.55	4.36	0.059	6''

[a]Stone-lined Channel C consides of off-site area and the drainage areas of the three Midway Lots. This includes three Stone-lined Channels (D, E, and F), the three associated Grass Channels, and the Dry Swale/Dry Basin between the Middle Midway and Lower Midway Lots.

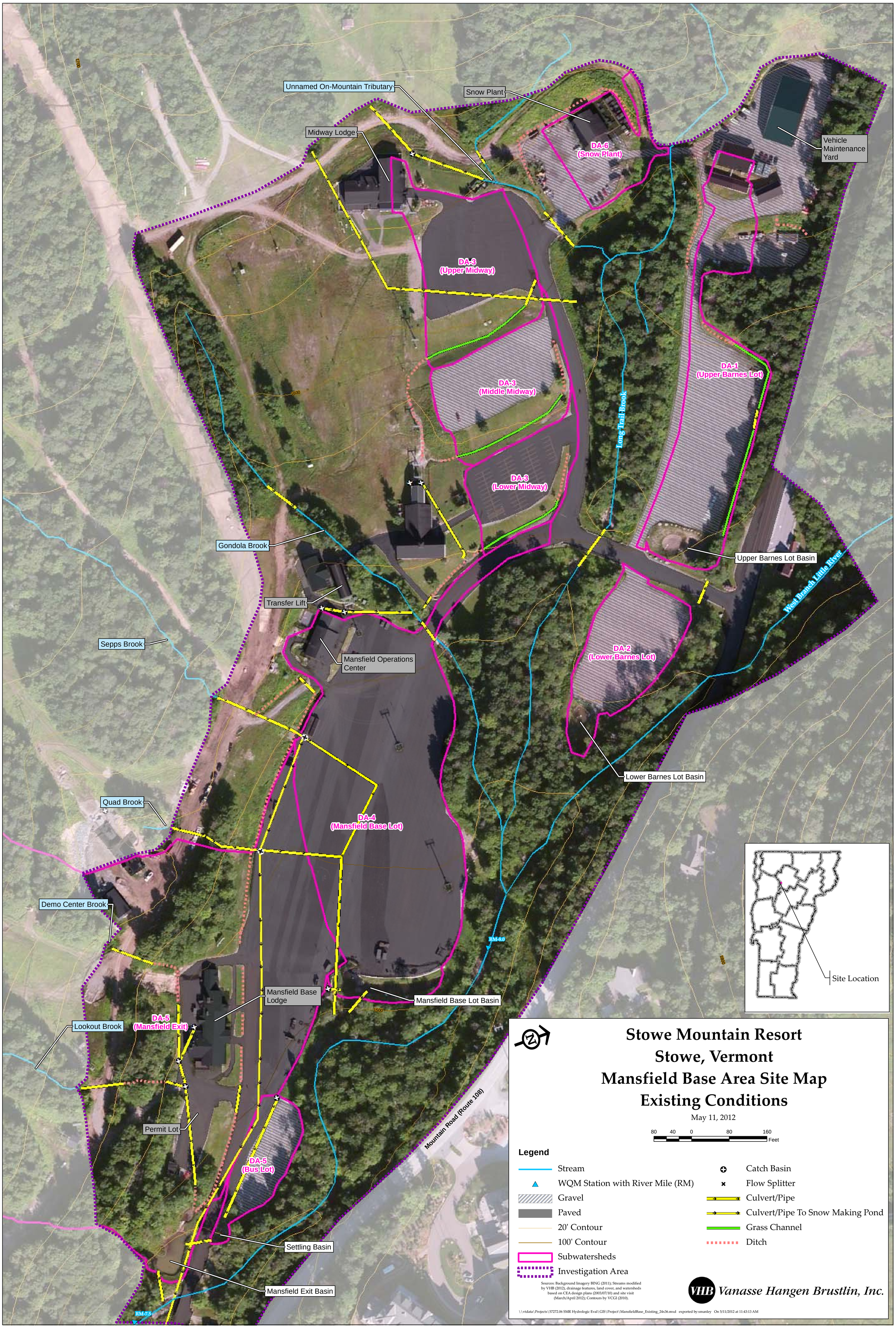


PLAN VIEW



PROFILE

Figure 2.2 Example of Wet Pond (P-2)


Unnamed On-Mountain Tributary
Snow Plant
Midway Lodge
Vehicle Maintenance Yard
DA-6 (Snow Plant)
DA-3 (Upper Midway)
DA-3 (Middle Midway)
DA-3 (Lower Midway)
DA-1 (Upper Barnes Lot)
Long Trail Brook
Gondola Brook
Upper Barnes Lot Basin
West Branch Little River
Transfer Lift
Sepps Brook
Mansfield Operations Center
DA-2 (Lower Barnes Lot)
Lower Barnes Lot Basin
Quad Brook
DA-4 (Mansfield Base Lot)
Demo Center Brook
RM-8.0
Site Location
Mansfield Base Lodge
Mansfield Base Lot Basin
Lookout Brook
DA-5 (Mansfield Exit)
Permit Lot
Mountain Road (Route 108)
DA-5 (Bus Lot)
Settling Basin
Mansfield Exit Basin
RM-7.5
Stowe Mountain Resort
Stowe, Vermont
Mansfield Base Area Site Map
Existing Conditions
May 11, 2012
80 40 0 80 160
Feet
Legend
Stream
WQM Station with River Mile (RM)
Gravel
Paved
20' Contour
100' Contour
Subwatersheds
Investigation Area
Catch Basin
Flow Splitter
Culvert/Pipe
Culvert/Pipe To Snow Making Pond
Grass Channel
Ditch
Sources: Background Imagery BING (2011); Streams modified by VHB (2012), drainage features, land cover, and watersheds based on CEA design plans (2003/07/10) and site visit (March/April 2012); Contours by VCGI (2010).
VHB Vanasse Hangen Brustlin, Inc.
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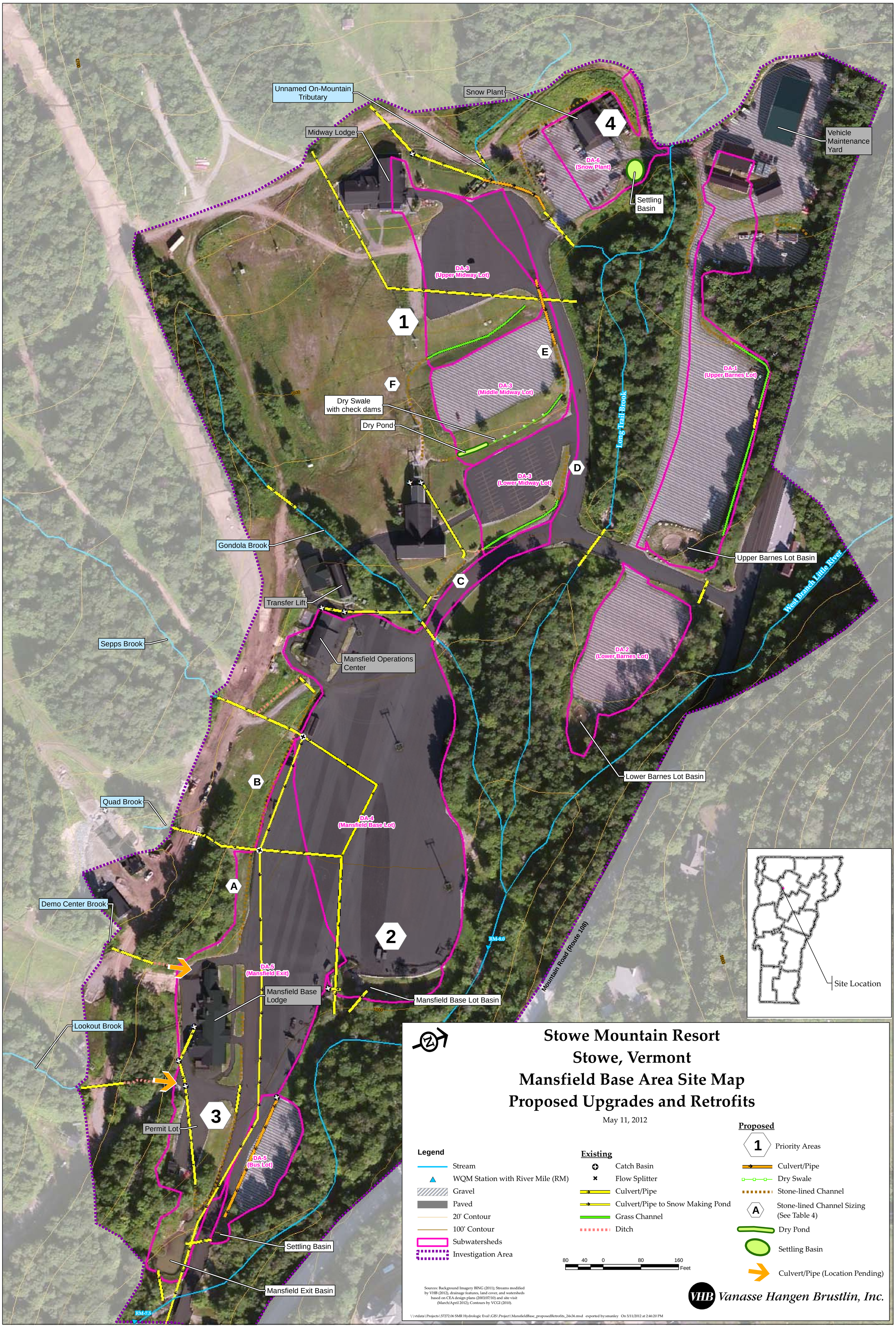

Stowe Mountain Resort
Stowe, Vermont
Mansfield Base Area Site Map
Proposed Upgrades and Retrofits

May 11, 2012

Legend

- Stream
- WQM Station with River Mile (RM)
- Gravel
- Paved
- 20' Contour
- 100' Contour
- Subwatersheds
- Investigation Area

Existing

- Catch Basin
- Flow Splitter
- Culvert/Pipe
- Culvert/Pipe to Snow Making Pond
- Grass Channel
- Ditch

Proposed

- Priority Areas
- Culvert/Pipe
- Dry Swale
- Stone-lined Channel
- Stone-lined Channel Sizing (See Table 4)
- Dry Pond
- Settling Basin
- Culvert/Pipe (Location Pending)

80 40 0 80 160 Feet

Sources: Background Imagery BING (2011); Streams modified by VHB (2012), drainage features, land cover, and watersheds based on CEA design plans (2003/07/10) and site visit (March/April 2012); Contours by VCGI (2010).

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