

Redington Wind Farm Project

Basis of Stormwater Management for Access Roadways

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South Portland, Maine

Basis of Stormwater Management for Access Roadways

Table of Contents

1.0	Introduction.....	1
2.0	Existing Site Conditions	3
3.0	Existing and Proposed Drainage Features	8
4.0	References.....	10
5.0	Overview of Stormwater Runoff Modeling.....	11
6.0	Method of Analysis – Stormwater Quantity	12
7.0	Site Specific Predevelopment Conditions Considered in the Analysis	17
7.1	Groundwater Seeps And Subterranean Water Flow	18
7.2	The High Elevations and Steep Topography	18
7.3	The Lack of Alternate Access.....	19
7.4	Existing Flow Regimes	19
8.0	Watershed Characteristics.....	19
9.0	Postdevelopment Conditions	19
10.0	Roadway Drainage System.....	20
11.0	Requirement for Stormwater Management.....	24
12.0	Water Quality Provisions.....	27
13.0	Water Quality Standards and Proposed Management Methods	28
14.0	Thermal Provisions	29
15.0	Maintenance of Stormwater System.....	30
15.1	Overview.....	30
15.2	Standard Inspection/Maintenance Descriptions.....	31
15.2.1	Sediment in Forebay	31
15.2.2	Stormwater Inlets and Culverts.....	33
15.2.3	Tributary Drainage System	35
15.2.4	Sorbent Booms.....	37
16.0	Conclusions.....	37

Basis of Stormwater Management for Access Roadways

List of Attachments

Attachment A – Reference Figures and Tables

Attachment B – Stormwater Flow and Culvert Sizing Computations

Attachment C – Ditch Sizing Calculations

Attachment D – Time of Concentration Flow Paths and Inset Area Discharge Figures

Attachment E – Water Quality Calculations and Meeting Minutes

Attachment F – Water Quality Buffer Drawings

List of Appendices

Appendix 2.3 – Mountain Drainage Analysis Maps

List of References

Refer to Section 4.0

List of Tables

Table 1 - Topographic Ranges on Redington Range Parcel

Table 2 - Topographic Ranges on Black Nubble Parcel

Table 3 - Access to Wind Turbines

Table 4 - Slope Distribution on Redington Summit

Table 5 - Slope Distribution on Black Nubble Summits

Table 6 - Storm Rainfall Amounts

Table 7 - Flow Through Culverts with Inlet Control

Table 8 - Ditch Capacity and Velocity

Table 9 - Predevelopment Condition on Redington Range Parcel

Table 10 - Postdevelopment Condition on Redington Range Parcel

Table 11 - Predevelopment Condition on Black Nubble Range

Table 12 - Postdevelopment Condition on Black Nubble Range

Basis of Stormwater Management for Access Roadways

1.0 Introduction

DeLuca-Hoffman Associates, Inc. has prepared the following Basis of Stormwater Management for Access Roadways report. Redington Mountain Windpower, LLC has retained DeLuca-Hoffman Associates, Inc. to prepare a number of reports for the Redington Wind Farm Project. The work of DeLuca-Hoffman Associates, Inc. is summarized in seven reports, which accompany the Maine Department of Environmental Protection (MeDEP) and LURC applications and are titled:

- Erosion and Sedimentation Control Plan for Roadway Construction;
- Basis of Design for the Roadways to Access Wind Turbines;
- Basis of Stormwater Management for Access Roadways;
- Access Road Maintenance;
- Blasting;
- Erosion and Sedimentation Control Plan for Transmission Line Corridor Construction; and
- Solid Waste

The reports are supported by a series of drawings prepared by DeLuca-Hoffman Associates, Inc. and include the following:

Basis of Stormwater Management for Access Roadways

Index of Drawings	
Drawing	Description
Base Map	Redington Wind Farm Project Base Map
C-1	Cover Sheet, Index And Legend
C-2	Lower Black Nubble Summit Road
C-3	Lower Black Nubble Access Road, Spur To Turbines 20, 21 & 22, and Portions of Summit Roads
C-4	Upper Black Nubble Access Road And Summit Road
C-5	Redington Access Road
C-6	Redington Summit Road And Spurs To Turbines 1, 2, 3 & 4
C-7	Redington Summit Road And Spur to Turbines 8, 9, 10 & 11
C-8	Lower Black Nubble Summit Road Profile
C-9	Lower Black Nubble Summit Road, Access Road, And Spurs To Turbines 13, 14, & 15 Profiles
C-10	Lower Black Nubble Spur to Turbines 20, 21 & 22 Profiles
C-11	Upper Black Nubble Access Road Profile
C-12	Upper Black Nubble Access Road And Alternate Route to Turbines 20 & 21 Profiles
C-13	Upper Black Nubble Summit Road and Spurs to Turbines 16 & 19 Profiles
C-14	Redington Summit Road Profile
C-15	Redington Summit Road Profile
C-16	Redington Spur to Turbines 2-4 and Spur to Turbines 8-11 Profiles
C-17	Redington Access Road Profile
C-18	Redington Access Road Profile
C-19	Redington Access Road Profile
C-20	Roadway Details
C-21	Backslope Details
C-22	Ditch Details
C-23	Erosion Control Details
C-24	Fill Slope Details
W-1	Lower Black Nubble Drainage Areas
W-2	Lower Black Nubble Drainage Areas
W-3	Upper Black Nubble Drainage Areas
W-4	Redington Access Road Drainage Areas
W-5	Redington Summit Road Drainage Areas
W-6	Redington Summit Road Drainage Areas
I-1	Existing Road Improvements Inset Areas 4 and 5
I-2	Access Route Extensions and Existing Road Improvements Inset Areas 1, 2, 3, and 6
I-3	Substation Interconnect and Access Road Inset Area 7
B-1	Redington Parcel Water Quality Buffer Area
B-2	Black Nubble Parcel Water Quality Buffer Areas

The designs and reports prepared by DeLuca-Hoffman Associates, Inc. rely upon baseline information provided for this project by other consultants of Redington

Basis of Stormwater Management for Access Roadways

Mountain Windpower, LLC. The baseline data prepared by other consultants to Redington Mountain Windpower, LLC include the following:

- ❑ The identification and location of wetlands and other natural resources by Woodlot Alternatives.
- ❑ Surficial Soils Surveys and narratives prepared by Al Frick.
- ❑ Base topographic mapping prepared by Aerial Survey.
- ❑ Geotechnical evaluations and recommendations for Roadway Construction prepared by S. W. Cole.

There are other physical elements of the project such as the electrical power transmission lines, staging areas, small buildings, and the wind turbines, with attendant construction areas, which are being designed by other consultants and are discussed in separate portions of the application.

This narrative contains the Basis of Design for Stormwater Management Systems required for the new access roadways to be constructed to the wind turbines on the Redington and Black Nubble mountaintop ridges, the new access roadway to the proposed substation and the access roadways to the transmission line at Inset areas 1 and 2.

The project is not in a lake, river, stream or brook most at risk from development.

2.0 Existing Site Conditions

The proposed wind turbines will be erected on two mountaintop ranges. The first is the Redington range located in Redington Township. The centroid of the parcel is approximately latitude 45 degrees 1 minute and longitude 70 degrees 23.5 minutes. The land for the wind turbines is about 517 acres bounded by U. S. Department of the Navy land to the south, Carrabassett Valley to the east and other portions of Redington Township to the north and west. The parcel is an inverted “C” shape. Elevations ranging

Basis of Stormwater Management for Access Roadways

from 3,050 to 3,990 occur on this parcel. The topography is quite steep with flatter sections near the summit. The topographic ranges are characterized in Table 1:

Table 1 - Topographic Ranges on Redington Range Parcel		
Slope Ranges	Percent	Area
0-8	6.6	34
8-15	17.0	88
15-20	16.8	87
20-25	18.0	93
25-30	16.2	84
30-33	8.5	44
33-100	16.9	87
TOTALS	100.0	517

The USDA medium intensity soils map shows the following soil types:

- ❑ Sisk-Surplus
- ❑ Surplus-Sisk
- ❑ Saddleback-Mahoosuc-Sisk
- ❑ Ricker-Rock Outcrop
- ❑ Hermon Monadnock

These soils are described in the detailed soil narrative prepared by Al Frick.

The parcel is within a region of commercial forestry, although forest harvesting activities at the higher elevations are uncommon. Therefore, roads to the summits of Redington and Black Nubble do not exist and will need to be constructed as part of the overall project.

Natural resources on the parcel have been identified by Woodlot Alternatives and are depicted on project maps.

The second area where wind turbines are proposed is in the Black Nubble mountain range area. The centroid of the parcel is approximately latitude 45 degrees 1.25 minutes and

Basis of Stormwater Management for Access Roadways

longitude 70 degrees 27 minutes. The land for the wind turbines is about 487 acres, bounded by Department of the Navy lands to the south and other portions of Redington Township on the other sides.

The parcel is generally “L” shaped but could also be described as two connected inverted “T” shapes. Elevations range from approximately 2,700 to 3,705. The topography is also steep with some flatter areas on the summits. The topographic ranges on the Black Nubble parcel are characterized in Table 2:

Table 2 - Topographic Ranges on Black Nubble Parcel		
Slope Ranges	Percent	Area
0-8	6.6	31
8-15	14.5	68
15-20	14.0	66
20-25	14.8	70
25-30	12.0	56
30-33	6.0	28
33-100	32.1	151
Area Without Topo		17
TOTALS	100.0	487

The USDA medium intensity soils map shows the following soil types:

- ❑ Sisk-Surplus
- ❑ Surplus-Sisk
- ❑ Saddleback-Mahoosuc-Sisk
- ❑ Hermon Monadnock
- ❑ Surplus-Saddleback-Ricker

As noted, detailed information on these surficial soils is provided in other reports which accompany this application.

Basis of Stormwater Management for Access Roadways

Natural resources on the Black Nubble parcel have been identified by Woodlot Alternatives and are depicted on project maps.



The project also affects areas attendant with the required access to the parcels and on proposed transmission lines. The sites will be accessed from Route 16/27 using a series of existing paper company roads to get as close to the mountain ranges as possible before starting new road construction.

The existing roads from Route 16 are gravel paper company roads. The lengths of the existing roads, which are proposed to be used for access to the Redington and Black Nubble parcels, are as follows:

Table 3 - Access to Wind Turbines		
Existing Road Segment	Distance (ft)	Distance (miles)
I.P. Road from Route 16 to tee intersection just beyond the Maintenance Building Lot.	26,928	5.1
Road segment from tee intersection to Lower Black Nubble (includes portion of RE2).	16,896	3.2
Road segment from tee intersection to log yard at base of Redington Mountain (includes portion of RE6b).	16,896	3.2
TOTALS	60,720	11.5

Basis of Stormwater Management for Access Roadways

The IP road is an excellent quality paper company road with widths which vary from 10 to 18 feet and a generally smooth horizontal alignment and flat to moderate vertical grades. The IP road has three existing bridges and three sharp corners.



IP Road

Paper company road RE6b will be used as a portion of the access to the Redington Range parcel. This road is of lesser grade construction than the IP road, has a typical width of about 12 feet.

Paper company road RE2 will be used as a portion of the access to the Black Nubble Mountain parcel. The road is similar in character to RE6b with travel widths from 9 to 16 feet and has one bridge.



RE6b (to right)

The new access road to the Redington parcel will start at the current terminus of RE6b, and traverse steep topography to ascend from elevation 2,555 to 3,695 to the parcel.

Basis of Stormwater Management for Access Roadways

Black Nubble will be accessed from two roads. Both roads are in Redington Township. The lower Black Nubble Road will ascend from elevation 2,640 to 2,875, and the upper Black Nubble Road will ascend from elevation 2,660 to 3,310. The land where the access roads will be constructed is currently commercial forest land.

***RE2******RE2***

Natural resources along the existing and proposed access roads have been identified by Woodlot Alternatives under contract to Redington Mountain Windpower, LLC and are described in other portions of the applications.

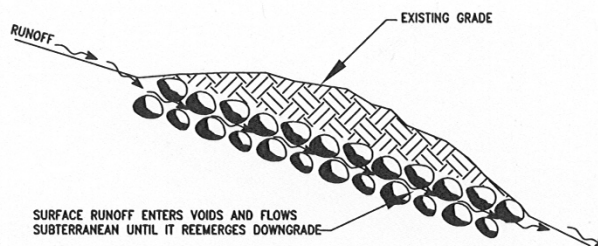
Resource maps are appended to this narrative. Base and project maps are printed separately.

3.0 Existing and Proposed Drainage Features

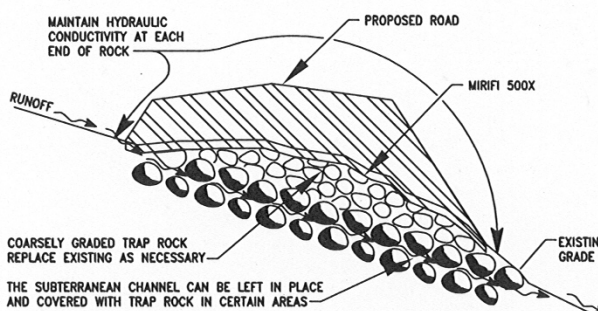
The new roadways will traverse timberland with no formal drainage systems. The basis of design for the drainage system for the new roadways is detailed further in this Stormwater Management Report for Access Roadways. The basic principles include:

Basis of Stormwater Management for Access Roadways

- Existing seeps and subsurface drainage channels will be retained to the extent possible. (In certain areas, surface seeps and runoff enter the subterranean features and can be heard moving, but there is no evidence of surface flow). The tools to accommodate these are the fabric and crushed stone sandwich to be placed in locations where wet conditions are observed or the use of trap rock protected by fabric under the prepared subgrade. These are illustrated in the figures shown on this page.



EXISTING SUBTERRANEAN FLOW AREA



CONSTRUCTION OVER SUBTERRANEAN FLOW AREAS

- Especially in the higher elevations, the runoff is principally a mix of sheet flow, shallow concentrated flow, and subterranean flow. Culverts will be placed at frequent intervals to avoid flow concentration. When no downstream swale or runoff conveyance channel is observed, the flow will be re-dispersed at the outlet.
- Several larger culverts are proposed along the mountain access roads.
- Intercepting groundwater where seeps or erosion of the cut slope is likely to occur.

The stormwater management report provides the basis for the size and placement of most culverts. However, placement will rely on field judgment and reconnaissance because the baseline data has been the five-foot aerial photogrammetry. Minor drainage channels where runoff is likely to be channeled are not evident on the photogrammetric maps due to obscured ground conditions.

Basis of Stormwater Management for Access Roadways

Monitoring of the culvert outlets after construction will be necessary to confirm the culvert discharges are not causing erosion in downstream areas. If erosion is observed, the following corrective alternatives are available:

- Placement of non-erodible material or geotextiles to re-disperse the flow.

- Adding Culverts – For example, if a problem area was observed, and it appeared to be fed by 200 feet of runoff intercepted in the uphill ditch, a second culvert placed midway back of the ditch line would reduce the flow by 50%. Therefore, follow-up monitoring of the outlets will occur to verify discharge stability.

The existing roadways have existing culverts and bridges, which will be retained. If lengthening of culverts is required along existing roadways, the size will be matched. If culvert replacement were required, the replacement for small culverts would be increased by one size. (For example, a 15-inch culvert would be replaced with an 18-inch culvert.) Larger culverts would be checked for size before replacement using the procedures described in the stormwater management report for roadways.

4.0 References

- HydroCAD Version 6.10 – Used for SCS-TR-20 Comparison Analysis to Rational Method.
- IDF Curve – Town of Rangeley – MDOT Highway Design Manual, Figure 12-14.
- Culvert Design Form – MDOT Highway Design Manual, Figure 12-20.
- Chart 1 – Headwater Depth for Concrete Pipe Culverts with Inlet Control – MDOT Highway Design Manual, Figure 12-21.
- Appendix D-1 – (SCS) One Day Precipitation Values – MeDEP Stormwater BMPs.
- Rainfall Factor “RF” (BPR 1021 Series Method), MDOT Highway Design Manual, Figure 12-5.
- Peak Runoff Rates (BPR 1021 Series Method), MDOT Highway Design Manual, Figure 12-6 (a), (b), and (c).

Basis of Stormwater Management for Access Roadways

- Appendix D-12: Runoff Coefficients for the Rational Formula by Hydrologic Soil Group and Slope, MeDEP Stormwater Management BMPs.
- Appendix D-13: Runoff Curve Numbers for Use in TR-55, MeDEP Stormwater Management BMPs.
- Buffer Removal Efficiencies; Addendum to Stormwater Management for Maine: Best Management Practices, December 12, 1996.
- Stone Size for Rip Rap (USDA Soil Conservation Service), MeDEP BMPs for Construction, Figure 70.1, March 1991.

These reference figures and tables are appended to this report as Attachment A.

5.0 Overview of Stormwater Runoff Modeling

The project will be constructed in land within unorganized territories with four access roads to the proposed transmission line to be constructed in Carrabassett Valley. The proposed wind turbines will be sited on the Redington and Black Nubble Mountain Ridges with 12 turbines to be constructed on Redington and 18 turbines to be constructed on Black Nubble Mountains. The topography of the mountains is steep except for relatively mild topography on the very crests. The portions of Redington and Black Nubble Mountains, which will be owned by Redington Mountain Windpower, LLC, are characterized by the following topography.

Slope Ranges	Percent	Area
0-8	6.6	34
8-15	17.0	88
15-20	16.8	87
20-25	18.0	93
25-30	16.2	84
30-33	8.5	44
33-100	16.9	87
TOTALS	100.0	517

Elevations range from 3,050 to about 3,990 feet, based upon USGS datum. Drainage is divided on the ridge and flows down the hillsides as a mix of sheet flow, shallow

Basis of Stormwater Management for Access Roadways

concentrated flow, and a portion of runoff entering subterranean watercourses and reemerging further down the slope. As can be seen on the base mapping, the majority of the land is upland with only limited natural resources such as streams or wetlands, based upon the work prepared by Woodlot Alternatives.

Slope Ranges	Percent	Area
0-8	6.6	31
8-15	14.5	68
15-20	14.0	66
20-25	14.8	70
25-30	12.0	56
30-33	6.0	28
33-100	32.1	151
Area Without Topo		17
TOTALS	100.0	487

Elevations range from about 2,700 to about 3,705 feet based upon USGS datum. Drainage is divided on the ridge and flows down the hillsides as a mix of sheet flow, shallow concentrated flow, and a portion of runoff entering subterranean watercourses and reemerging further down the slope. As can be seen on the base mapping, the majority of the land is upland with only limited natural resources such as streams or wetlands, based upon the work prepared by Woodlot Alternatives.

Soils on the site are variable but either shallow to bedrock soils or dense glacial tills. More detailed soils examinations are presented in Section 11 of the application.

The Redington and Black Nubble Mountains areas are not located in a mapped 100-year floodplain.

6.0 Method of Analysis – Stormwater Quantity

The hydrologic analyses for the evaluation of roadway culverts have been conducted based upon simple methods that are easy to employ in the field to check culvert capacity and placement. The methods include the rational method, BPR series method, and the

Basis of Stormwater Management for Access Roadways

USDA Soil Conservation Services's Method used by MDOT. These methods generate a peak flow needed for culvert and ditch design. Four catchments have been analyzed using the methodology contained in the USDA Soil Conservation Service's Technical Releases No. 20 and 55 (SCS TR-20 and TR-55) as modified for special site conditions. For Franklin County, Maine, a 24-hour SCS Type III storm distribution was used for the analysis using the following storm frequencies and rainfall amounts:

Storm Event	24-Hour Rainfall (inches)
2-Year Storm	2.9
10-Year Storm	4.2
25-Year Storm	4.9
100-Year Storm	5.9

The rational method requires a time of concentration to be determined from which a peak rainfall intensity is selected, a land cover coefficient, and the watershed area. The intensity and land cover coefficient for the analysis are based upon references outlined in Section 4.

The four catchments mentioned above were also analyzed using the BPR 1021 series method. The BPR 1021 series method requires the following input: a rainfall factor, land cover factor, frequency factor, runoff index, and watershed area. The rainfall, land cover and frequency factors for the analysis are based upon figures 12-5, 12-6(a), 12-6(b) and 12-6(c) from the MDOT.

The HydroCAD computer program was used for the watersheds analysis with the SCS methodology. Input parameters for this were based upon the watersheds delineated from the base mapping. This program determines the critical points of the project watershed and uses SCS TR-20 methodology for evaluation of the anticipated conditions at these points. Drainage areas are defined with runoff curve numbers, times of concentration, and travel time data based on methods outlined in the USDA TR-55 manual. To assess

Basis of Stormwater Management for Access Roadways

storage and kinematic effects of runoff, the model uses reservoirs and pipes to imitate actual conditions. Specific hydrologic characteristics, including travel times, storage capacity, and the effects of hydraulic head, are considered for analysis with this program.

To model any watershed, the drainage system is represented by a system network consisting of four basic components:

- Subcatchment: A relatively homogenous area of land that drains into a single reach or pond. Each subcatchment generates a runoff hydrograph.
- Reach: A uniform stream, channel, or pipe which conveys water from one point to another reach or pond. The outflow of each reach is determined by a hydrograph routing calculation.
- Pond: A pond, swamp, dam, or other impoundment which fills with water from one or more sources and empties in a manner determined by a weir, culvert or other device(s) at its outlet. A pond may empty into a reach or into another pond. The outflow of each pond is also determined by a hydrograph routing calculation.
- Link: A multi-purpose mechanism for introducing a hydrograph from outside the diagram, by either manual entry, file import, or linkage to another diagram. A link also allows the diversion and/or scaling of hydrographs.

After identifying each of the components, the system may be represented by a routing diagram such as shown in the schematics and computations contained in Attachment A.

To calculate the outflow for each structure, HydroCAD automatically performs these steps:

1. If there is more than one inflow, the inflows are summed together to produce a single hydrograph. If a pipe is being re-sized, its diameter will be calculated to handle the peak inflow.

Basis of Stormwater Management for Access Roadways

2. The inflow is routed through the structure using the description and method previously specified. For a subcatchment, the specified storm type and rainfall are used.
3. For a reach, the peak depth, peak velocity, contact time, etc. are calculated.
4. For a pond, the peak elevation, peak storage, etc. are calculated.
5. Any warning messages are displayed.
6. For the inflow and outflow, the peak flow and time of peak are calculated by interpolating between the three highest points.
7. The total volume of inflow and outflow are calculated.
8. The results are stored in a database for subsequent calculations or to be examined at any time.

The process is automatically repeated for each structure until the design point is reached. HydroCAD is a hydrograph routing model. It is specifically designed to handle time varying flows, as required for pond design and other volume-sensitive calculations. As such, HydroCAD routes completely through one structure at a time. Only after determining the outflow hydrograph from a given structure does it consider the next structure downstream.

Ditch scour protection was based upon methods outlined in the Maine Erosion Control BMP Handbook. A nomograph was used which provides a d50 stone size for a given ditch flow and velocity.

Land use, cover, delineation of watershed subcatchments, hydraulic flow paths and hydrologic soil types were obtained using the following data:

Basis of Stormwater Management for Access Roadways

1. 7.5 minute Quadrangles Maps.
2. Franklin County, USDA Medium Intensity Soils Survey.
3. Onsite Topographic Survey with 5' contour intervals prepared by Aerial Survey, Inc. (Note: Many areas are annotated with the note "ground obscured" indicating the accuracy of the contours is limited.)
4. The Class D Medium Intensity Soil Survey for the site prepared by Al Frick closely mirrors the Medium Intensity Soil Survey available from the Soil Conservation Service.

The traditional SCS methodology and BPR 1021 series methodology were used to check the simple method computations for the larger watersheds. This includes the proposed bridge crossings. They were also used to compare one of the smaller watersheds. The results are as follows:

Sample	Storm Event	Access Roadway	Culvert Station	Drainage Area (Acres)
1	100-Year	Redington Access	1440+23	22.66
2	100-Year	Redington Access	1444+63	16.94
3	100-Year	Redington Summit	1212+70	12.20
4	25-Year	Redington Summit	1221+28	4.17

Basis of Stormwater Management for Access Roadways

Methodology	Storm Event	Culvert Station	Peak Flow (cfs)	Culvert Size Selected based upon Rational Method (Inches)
SCS Rational BPR	100-Year	1440+23	38.49 35.35 24.05	36"
SCS Rational BPR	100-Year	1444+63	30.17 26.43 19.77	36"
SCS Rational BPR	100-Year	1212+70	22.95 19.03 15.48	30"
SCS Rational BPR	25-Year	1221+28	5.74 5.33 5.45	18"

This check verifies that although the simple methods employed to compute the watershed flows do not yield a hydrograph, good values are provided for peak flow values. Stormwater flow and culvert sizing computations are appended to this report in Attachment B. Time of concentration flow paths for the four watershed areas listed above are provided as Figures 1 through 4 appended to this section as Attachment D.

7.0 Site Specific Predevelopment Conditions Considered in the Analysis

The specific site conditions considered in establishing the basis of design include:

- ❑ The presence of seeps and subterranean water flows;
- ❑ The high elevations, topography, and the respective short growing seasons;
- ❑ The lack of alternate access; and
- ❑ The flow regimes observed during limited site reconnaissance.

These specific conditions have been addressed as follows:

Basis of Stormwater Management for Access Roadways

7.1 Groundwater Seeps And Subterranean Water Flow

The basis of design is to minimize disruption of current drainage flow regimes. When the initial corridor is cleared, evidence of seeps and subterranean flow will be recorded and a decision made to address these in one of the following ways:

- ❑ Raising the roadway profile slightly to reduce the depth of cut on the uphill side of the road.
- ❑ Installing a drainage blanket on the cut slope: Options include a Miraweb drainage fabric behind soil nail walls, the use of a drainage aggregate below the surface cover, a stone and fabric behind gabion walls, and the use of a stone backslope. The details in the plans illustrate these options.
- ❑ In the event that the existing surface is wet, the area will be identified and a sandwich of stone between filter fabric will be provided.
- ❑ If subterranean flow is heard and identified, the disruption will be minimized and trap rock sandwiched between geotextiles will be employed. The geotechnical engineer should monitor excavations in this area.
- ❑ The use of an underdrain on the uphill side to protect the base and subgrade of the road.

7.2 The High Elevations and Steep Topography

Will require winter measures to be employed earlier in the season, vegetation to reestablish these areas has been selected for harsher climates, and the period between disturbance and restoration of the roadway has been reduced for these areas. The steep topography has been considered by including methods which can be employed to steepen fill and backslopes, thereby reducing the changes in land cover.

Basis of Stormwater Management for Access Roadways

7.3 The Lack of Alternate Access

To protect the road from damage from timber blowdowns, the edges of the roadway will be selectively cleared a minimum of 30 feet on either side of the edge of clearing for the roadway. Culverts 24 inches diameter and larger will have armor stone over the fill to help protect the roadway from washout in the event of a culvert failure.

7.4 Existing Flow Regimes

The drainage patterns, particularly in the higher elevations near the summits, are poorly defined and principally sheet and shallow concentrated flow. For this reason, the basis of design employs closely spaced small diameter culverts spaced 200 to 300 feet apart with flow dispersion berms on the outlet side of the culvert except where an established drainage swale is identified when the roadway corridor is cleared. The culvert location would then be field adjusted.

8.0 Watershed Characteristics

The current cover for the predevelopment watersheds tributary to the roadway culvert is not materially different than will exist after the project is constructed. Culverts are intended to be placed in existing drainage swales and low areas to the extent these can be identified after initial clearing. In general, the watershed shapes will not be significantly altered, except at the lower edge where runoff will be collected in a ditch and directed through a culvert. Therefore, the shape of the pre and postdevelopment watersheds is essentially the same. The watersheds are provided on the plans which accompany this narrative and are contained in Appendix 2.3.

9.0 Postdevelopment Conditions

The postdevelopment conditions consider the proposed culvert locations and the attendant tributary watersheds. These watersheds are shown on the drainage maps and are summarized in the appended computations.

10.0 Roadway Drainage System

The drainage system for the roadways includes design and consideration of the following:

- ❑ Culvert Placement
- ❑ Culvert Sizing
- ❑ Ditch Capacity
- ❑ Ditch Lining
- ❑ Culvert Inlet and Outlet Aprons
- ❑ Flow Dispersion

This section of the narrative describes the basis design for these elements of the roadway system.

Culvert Placement

The drawings which accompany the application are based upon aerial photogrammetry with five-foot form lines. Much of the mapping has the annotation “ground obscured”. Consequently, the location and existence of drainage swales and low areas where surface runoff is currently conveyed cannot be discerned from the current mapping. These drainage swales and low areas are the natural and preferred locations for the culverts, but the locations are not available from the project database. Because this information is not available from the mapping, the culverts will be different than the stations currently called for on the plans. However, the basis of design for culverts is provided in this narrative and should be used when locations of culverts are finally determined.

The field procedure to adjust the culvert locations should be as follows:

- ❑ Field locate the proposed culvert based upon the preliminary plan after the narrow corridor for reconnaissance of the roadway has been cleared;
- ❑ Review the conditions to determine if the culvert location should be adjusted;

Basis of Stormwater Management for Access Roadways

- ❑ If an adjustment is needed, identify the location by the station shown on the drawings;
- ❑ Recheck the tributary drainage area and confirm the culvert size is acceptable;
- ❑ Confirm the basis of design as annotated on the profiles is appropriate;
- ❑ Determine the culvert length based upon the final field elevations and anticipated profile grade; and
- ❑ Notify the contractor of the adjusted culvert station, length, and size.

LURC Standards indicate that for roads constructed at 11 to 15 percent grades, ditch relieve culverts are to be placed at a minimum spacing of 127 to 136 feet. The culvert spacing proposed for this project exceeds this minimum spacing; however, is supported by calculations and provides a margin of safety of 2 or more and a number of design tools to help convey stormwater and subterranean flow.

Culvert Sizing

The culvert sizes have been based upon a ratio of one for the headwater to culvert diameter. Because the culverts are depressed below the shoulder, additional culvert capacity is provided. This added capacity is intended to provide for a margin of safety to help offset the database accuracy issue of obscured ground which may result in some error in the watershed size. A comparison between the culvert capacity at an HW/D of one and the available HW/D is provided in the following table:

Basis of Stormwater Management for Access Roadways

Culvert Size	Flow at HW/D Ratio of 1	HW/D to Roadway	Shoulder Elevation
12	2.4 cfs	4.00	8.00 cfs
15	4.2 cfs	3.20	12.00 cfs
18	6.8 cfs	2.67	17.25 cfs
24	13.6 cfs	2.00	28.00 cfs
30	24.0 cfs	1.80	45.00 cfs
36	37.0 cfs	1.67	72.00 cfs

It is also noted that while the culverts have been sized not to exceed an HW/D ratio of 1; actual HW/D ratios are frequently less as shown in the appended computations. This provides an additional margin of safety in the design.

The culvert sizing also considered the distance of the roadway from the ridge of the mountain ranges. In the ridge areas the drainage regime is poorly defined with sheet and shallow concentrated flow being predominant. In these areas the design uses small, frequently placed 12-inch and 15-inch culverts to reduce the discharge volumes at the culvert locations.

As the roadway descends, the tributary areas will be larger, and it is more likely that drainage patterns will be discernable and larger culverts are proposed.

The locations and sizes of the culverts are shown on the profile sheets and in the appended computations.

Ditch Sizing

All ditches have been sized to be a minimum of 12 inches wide with 3:1 sideslopes on the road side and variable sideslopes on the cut side. The depth of flow in the ditches will vary with the longitudinal grade and ditch treatment. The capacity of the ditch flowing 12-inches deep with stone surface material and different grades are as follows:

Basis of Stormwater Management for Access Roadways

Table 8 - Ditch Capacity and Velocity		
Stone Lined Ditches Longitudinal Grade (%)	Velocity (fps)	Flow (cfs)
14	8.57	21.43
12	7.94	19.84
10	7.24	18.11
8	6.48	16.20
6	5.61	14.03

The ditch lining material is to prevent erosion by the flow conveyed by the ditch. The ditch lining stone size is based upon the maximum flow in the ditch based upon the flow to the cross culvert. Ditch riprap stone sizing is provided with the project details and supported by appended calculations included in Attachment C.

Culvert Inlet and Outlet Aprons

The culvert inlet and outlet aprons have been provided to:

- ❑ Lower the Ditch to the Culvert Inlet Elevation
- ❑ Block Water from Bypassing the Culvert
- ❑ Disperse the Culvert Discharge

The apron sizes are based upon culvert flow velocities and volumes. The details are shown on drawings C-22 and C-23 and supported by the appended computations.

Flow Dispersion

The flow dispersion beyond the outlet aprons of the culvert is intended to re-disperse the flow if no apparent receiving channel or swale is evident. The length of the dispersion berm should be at least six times the rated culvert capacity such that flows in a 25-year storm would not exceed a depth of six inches when crossing the flow dispersion berm.

Basis of Stormwater Management for Access Roadways

This flow dispersion berm is a variation of the level lip spreader, but designed to hold the level of the berm somewhat better than some commonly used lip spreaders.

11.0 Requirement for Stormwater Management

Stormwater management is intended to provide either:

- Control of Peak Discharge Rates; or
- Measures to address Non-Point Runoff and Stormwater Quality

The need for Stormwater Management to control discharge rates can be determined by comparing the predevelopment (or current) flows with postdevelopment flows. The proposed roadway system is linear in nature, resulting in only minor land cover changes within a given watershed. The following is a comparison between the current conditions and proposed land cover conditions on the 517-acre and 487-acre portions of the Redington and Black Nubble mountain ranges which will be owned by the applicant.

- Predevelopment Condition on Redington Range:

- 517 acres of forested land

Postdevelopment Condition on Redington Range:

- 517 acres of forested land less that following proposed development less the following:
 - 18,999 linear feet of gravel roadway at an assumed average shoulder-to-shoulder width of 38 feet or 16.57 acres, of which only 12 feet or 5.23 acres will remain gravel after completion of the project, and the remaining 26 feet or 11.34 acres will be re-vegetated.
 - 18,999 linear feet of slopes for ditches, back slopes, and fill slopes.

Basis of Stormwater Management for Access Roadways

- An assumed average cut slope including the ditch of 30 feet = 13.08 acres, 50% of which is to be revegetated or mulched with forest products, with 50% rip rapped.
- An assumed average fill slope of 22 feet = 9.60 acres; 50% percent of which is to be revegetated or mulched with forest products with 50% rip rapped.
- An assumed gravel assembly area and a tower foundation of .41 acres x 12 turbines for an area of 4.92 acres of which 3.60 acres is to be covered with bark mulch and revegetated.

Although a limited portion of the site contains soils types with hydrologic soil groups A and B, as identified in the soils section of this application, the majority of the soils are hydrologic soil group C; therefore, hydrologic soil group C has been used for calculations which will be conservative in some areas.

Table 9 - Predevelopment Condition on Redington Range Parcel

Land Cover	RCN	Area (ac.)	RCN*A
Forest (Good HSG C)	70	517	36,190
Meadow (HSG C)	71	--	--
Gravel (HSG C)	89	--	--
Riprap (HSG C)	89	--	--
Total	--	517	36,190
Average RCN Value			70.0

Table 10 - Postdevelopment Condition on Redington Range Parcel

Land Cover	RCN	Area (ac.)	RCN*A
Forest	70	472.83	33,098
Meadow	71	26.28	1,866
Gravel	89	5.23	466
Riprap	89	12.66	1,127
Total	--	517	36,556
Average RCN Value			70.71

Basis of Stormwater Management for Access Roadways

□ Predevelopment Condition on Black Nubble Range:

- 487 acres of forested land

Postdevelopment Condition on Black Nubble Range:

- 487 acres of forested land less that following proposed development less the following:
 - 25,628 linear feet of roadway at an assumed average shoulder-to-shoulder width of 38 feet or 22.36 acres, of which only 7.06 will remain gravel at the end of the project.
 - 25,628 linear feet of slopes for ditches, back slopes, and fill slopes.

- An assumed average cut slope including the ditch of 30 feet = 17.65 acres, 50% of which is to be revegetated or mulched with forest products with 50% rip rapped.

- An assumed average fill slope of 22 feet = 12.94 acres, 50% percent of which is to be revegetated or mulched with forest products with 50% rip rapped.

- An assumed gravel assembly area and a tower foundation of 0.41 acres x 18 turbines for an area of 7.38 acres, of which 5.40 acres is to be revegetated.

Table 11 - Predevelopment Condition on Black Nubble Range

Land Cover	RCN	Area (ac.)	RCN*A
Forest (Good HSG C)	70	487	34,090
Meadow (HSG C)	70	--	--
Gravel (HSG C)	89	--	--
Riprap (HSG C)	89	--	--
Total	--	487	34,090
Average RCN Value			70.0

Basis of Stormwater Management for Access Roadways

Table 12 - Postdevelopment Condition on Black Nubble Range			
Land Cover	RCN	Area (ac.)	RCN*A
Forest	70	426.67	29,867
Meadow	70	35.99	2,556
Gravel	89	7.06	628
Riprap	89	17.28	1,538
Total	--	487	34,588
Average RCN Value			71.02

As demonstrated, the runoff curve number is only increased a minimal amount. In addition, a portion of the potential increase in runoff due to change in land cover will be offset by the additional hydrologic flow path of the roadway ditch. Consequently, detention is not warranted.

12.0 Water Quality Provisions

The Redington Wind Farm Project area is tributary to Flagstaff Lake, Caribou Pond, Redington Pond and a number of streams and rivers. The northerly portion of the project area discharges to Nash Stream, flows to the South Branch of the Dead River, and continues to Flagstaff Lake. The outlet is the Dead River, which flows to the Kennebec River at the West Forks. The southerly portion of the project area discharges to Redington Pond, flows to Orbeton Stream, and continues to the Sandy River, which also enters the Kennebec River at Starks. The easterly portion of the project area discharges to Caribou Pond, flows to the South Branch of the Carrabassett River, to the confluence with the Carrabassett River, which flows to the Kennebec River at Anson. Ultimately, all of the site is tributary to the Kennebec River north of Norridgewock. None of these water bodies are in the watershed of a lake most at risk from development, of rivers, streams, or brooks most at risk from development, and are not coastal wetlands most at risk from development, as listed in Chapter 502 of the Maine Department of Environmental Protection regulations effective December 31, 1997.

Because the project will create a disturbed area of more than one acre in the direct watershed of a body of standing water 10 acres or greater in size, phosphorous control standards must be met in accordance with LURC Chapter 10 Rules and Standards.

Basis of Stormwater Management for Access Roadways

Provisions are required to limit the export of phosphorus from the site following completion of the development so that the project will not exceed the allowable per-acre phosphorus allocation for the water body, determined by the Commission according to “Phosphorus Control in Lake Watersheds: A Technical Guide for Evaluating New Development” (Maine Department of Environmental Protection, 1992).

DeLuca-Hoffman Associates, Inc. has met with Jeff Dennis of the Maine Department of Environmental Protection Watershed Planning and Management Department to review water quality requirements for the proposed Redington Wind Farm Project. Mr. Dennis verified that the project would be required to meet the phosphorus control standard noted above for portions of the project tributary to Flagstaff Lake, as well as portions of the project tributary to Redington Pond. Minutes from this meeting with Jeff Dennis are included in Attachment E.

13.0 Water Quality Standards and Proposed Management Methods

Representatives from DeLuca-Hoffman Associates, Inc., Endless Energy, the Maine Department of Environmental Protection (MeDEP), and LURC met on December 1, 2005 to discuss water quality requirements relating to the Redington Wind Farm Project. The results of this meeting are summarized in Meeting Minutes contained in Attachment E. MeDEP’s 1992 Phosphorus Control Technical Guide will apply to this project and phosphorus standards will need to be met for Flagstaff Lake and Redington Pond.

Based upon a phosphorus export of 1.75 lbs/acre for gravel road surfaces and 0.50 lbs/acre for riprap ditches, the phosphorus export to Flagstaff Lake without treatment has been calculated at 29.28 lbs. The allowable phosphorus export based upon the developable area of the Redington and Black Nubble parcels tributary to Flagstaff Lake is 29.18 lbs, therefore a limited amount of buffering is required to reduce the phosphorus export by 0.10 lbs. 22 buffer areas are depicted on drawings B-1 and B-2, provided in Attachment F, which have been calculated to reduce the phosphorus export to Flagstaff Lake by 1.85 lbs, based upon buffer treatment factors provided in Table 5-3 of MeDEP’s Phosphorus Control Technical Guide for hydrologic group C soils (category 2). Some

Basis of Stormwater Management for Access Roadways

hydrologic group A soils exist within the parcels; however, the C soils buffer factor was selected as a conservative value. With this treatment, 0.10 lbs of phosphorus can be applied to match the allowable phosphorus export for the project and an additional 1.75 lbs will be available for development at such locations as the maintenance center.

Based upon a phosphorus export of 1.75 lbs/acre for gravel road surfaces and 0.50 lbs/acre for riprap ditches, the phosphorus export to Redington Pond without treatment has been calculated at 4.51 lbs. The allowable phosphorus export based upon the developable area of the Redington and Black Nubble parcels tributary to Redington Pond is 7.32 lbs. Therefore, the phosphorus export to Redington Pond is 2.81 lbs less than the allowable and additional treatment is not required. However, some natural buffering to Redington Pond will occur.

Detailed calculations associated with access roadways, turbine sites, and the project's substation providing a breakdown of phosphorus export to Flagstaff Lake and Redington Pond are included in Attachment E. These calculations will need to be updated to reflect any changes during final design.

No additional water quality measures are proposed for the proposed roadway system.

14.0 Thermal Provisions

The proposed roadways have a narrow width; by selecting an alignment which closely follows the natural profile, the need for large clearings for major cuts and fills is minimized. The adjacent forest will provide shade in many areas and the roadway surfaces will be gravel with less tendency to act as a heat sink than bituminous concrete pavement. No special provisions have been made for thermal impacts since the impact is not anticipated to be significant.

15.0 Maintenance of Stormwater System

15.1 Overview

The proposed storm drainage system is the portion of the project which intercepts the stormwater and runoff from the uphill side of the roadway and delivers it to the downgradient side. The proposed surface restoration, ditch linings, and culvert sizing are designed under the assumption that the stormwater management system will be maintained such that the runoff reaches the areas intended by the basis of design. In addition, there are provisions to adjust this system to reflect field conditions not identifiable on the base maps from which the plan has been prepared, since the plan accuracy is limited to five-foot form lines and existing vegetative cover which obscured the ground and the related accuracy of the base maps.

This portion of the narrative addresses the maintenance of the drainage system.

Key permits issued (or applied for) on the project include:

- MeDEP Site Location of Development and Natural Resources Protection Permits
- Land Use Regulation Zoning Approvals

The application for this permit contains the basis of design information for the roadways and stormwater management system within separate sections of this application.

A copy of these permits and applicable sections of the application should be appended to this manual. The permittee/operator of the stormwater management system should review these permits for a general description and background of the project, as well as any specific permit conditions or requirements of the project.

Basis of Stormwater Management for Access Roadways

DeLuca-Hoffman Associates, Inc. has been the consultant who was engaged to prepare the basis of design for the stormwater management facilities and may be contacted at:

DeLuca-Hoffman Associates, Inc.
778 Main Street, Suite 8
South Portland, Maine 04106
(207) 775-1121

It is recommended the preparer of the plan be contacted with any particular questions on the design intent or similar issues.

The maintenance provisions contained herein are intended for general guidance. However, any substituted deviations from the manual should be reviewed by the applicant.

The following narratives have been prepared to describe the recommended maintenance of the stormwater systems for the roadway portion of this project.

15.2 Standard Inspection/Maintenance Descriptions*15.2.1 Sediment in Forebay*

Preface: The culvert inlets and outlets will be constructed with a small sump constructed with riprap. The purpose of this sump is to collect and detain sediment void of the riprap which may exit the area.

Inspection: During periods of quiescent water surface it should be possible to inspect the forebay sump and to observe the sediment accumulation. Heavy sediment is likely to be a sign of upgradient erosion and needs to be identified and repaired.

Maintenance: If a significant accumulation of sediment is recorded in the sump above stone level or to obstruct flow from the inlet pipe it should be

Basis of Stormwater Management for Access Roadways

removed. Depending on the size of the sump, the amount of sediment collected, and its location, the sediment may be removed manually, by a vacuum truck or other methods. The material removed from the sump should be disposed of in accordance with local practice.

Frequency: The forebay sump should be inspected annually if possible, preferably in the early spring after spring runoff. During the first two to three years of operation, a more frequent (3-4 times per year) inspection is recommended. The frequency of sump cleaning will depend on the rate of sediment buildup. Cleaning on a 1-to-2-year basis is likely. It is noted that cleaning of the forebay sump will lengthen the time between culvert cleanings.

The rate of sediment buildup will depend on the tributary drainage facilities, road gradient, and road treatment (i.e., faster buildup with long open ditch transport systems, runoff from steeply graded roads, especially if the optional asphaltic penetration is not used).

Basis of Stormwater Management for Access Roadways

Comments: None.



This sediment sump also functions as an outlet plunge pool to provide protection and reduce velocities prior to discharge to forested areas.

15.2.2 Stormwater Inlets and Culverts

Preface: The success of any stormwater facility relies on the ability to intercept stormwater runoff at the design locations. Stormwater inlets for the roadways of this project are principally open culverts. Inlets exist along the entire roadway, except bridge crossings, typically at a 200-to-300-foot spacing. It is recommended the culvert locations be marked with a highway delineator for ease of location. This section is directed at maintenance of the actual inlet point. A later section addresses more substantive maintenance of the conveyance facilities.

Inspection: The inspection of inlet points will need to be coordinated with other maintenance items described in this section.

Basis of Stormwater Management for Access Roadways

The key elements of the inspection are to assure the inlet entry point is clear of debris and will allow the intended water entry and to inspect the inside of the culvert for debris accumulation.

Maintenance: The key maintenance is the removal of any blockage or accumulated sediment in the culvert which restricts the entry of stormwater to the inlet. The material should be taken out of the area of the inlet and tributary ditches and placed where it will not reenter the runoff collection system.

Frequency: All inlets and culverts should be inspected on a quarterly basis, and after/during significant storm events.

Maintenance/Inspection Responsibility:

Maintenance Personnel: The maintenance personnel will perform the normal maintenance/inspections of the inlets and culvert crossings.

Comments: Maintenance of inlets is critical on this project.



Poorly stabilized inlet allows entrance of debris and reduced capacity.

Basis of Stormwater Management for Access Roadways



Stabilized inlets reduce debris accumulation and maintain design capacity.

15.2.3 Tributary Drainage System

Frequency: It is recommended vegetated swales be inspected quarterly until vegetation is established and a year after installation. Thereafter, if no problems have been noticed, the frequency can be increased to one year.

Design Guidelines: The vegetated swale should consider channel cover at the time of construction as well as several years after construction.

Design computations state the assumed channel dimension and provide the basis for the Manning's or other roughness coefficient used for design.

Applicability: The vegetated swales are limited due to the gradients of the ditches. Most are stone lined.

Basis of Stormwater Management for Access Roadways



Vegetated swale with hay bale check dam to reduce velocities under construction.



A well-stabilized vegetated swale shows little sign of erosive velocities or flows.

Basis of Stormwater Management for Access Roadways

15.2.4 Sorbent Booms

Preface: During construction, sorbent booms should be installed ahead of the culvert inlet in any roadway area which receives the asphaltic treatment. The intent of these is to absorb oil and runoff from new pavement surfaces. These will be removed when construction of the project is complete.

Recommendation: It is recommended the applicant have three of these sorbent booms or pillows onsite in the event of an unexpected spill or if oil sheen is observed frequently on any inlet.

16.0 Conclusions

The proposed roadways are linear in nature resulting in only small changes in overall land use cover within the various project watersheds. The use of frequently placed culverts and efforts to maintain any subterranean flow is intended to avoid any significant alteration of flow regimes in the proposed roadway area. Since the land area affected by the roadway is small in comparison to the attendant project area, there is little difference anticipated between pre and postdevelopment flows. Formal detention is therefore not proposed and is unwarranted in the opinion of DeLuca-Hoffman Associates, Inc. This report and the accompanying plans provide the basis of design, culvert sizing, and describe the procedure to field adjust the locations of the culverts. This procedure is necessary since the accuracy of the baseline data is limited to aerial photogrammetry with five-foot form lines and obscure ground conditions in many areas. Therefore, swales may exist and, if found, should be used for culvert discharge locations.

The discharge from the roadway culverts provides for dispersion of flow to the forest buffers beyond the fill slopes of the roadway. These downhill areas will act as buffers. The most important water quality element of the roadways is the need to phase the construction and minimize the amount of area denuded at any time. This requirement is discussed in detail in the accompanying erosion and sedimentation control report for the roadways.

Basis of Stormwater Management for Access Roadways

The stormwater management system for the roadways will consist of ditches, culverts, and measures to disperse the flows. The culvert locations will be marked for ease of location during maintenance. A roadway maintenance check list including ditches and culverts is included in a separate section of this application.