Black Nubble Wind Farm Project

Basis of Design for
Primary Access Roads and Summit Roads

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1.0 Introduction

DeLuca-Hoffman Associates, Inc. was retained to prepare designs and portions of the permit applications for a series of wind turbines proposed to be sited on Black Nubble. DeLuca-Hoffman Associates, Inc. designed the primary access roads and summit roads, which will be used to access the wind turbines from existing roadway systems; and also prepared the Stormwater Management Report, Erosion and Sedimentation Control Plans, Road Maintenance Plan, Solid Waste Narrative, and Blasting Narrative associated with the primary access roads and summit roads. Note that the term "summit road" is synonymous with "ridgeline road" within this application. The work of DeLuca-Hoffman Associates, Inc. is summarized in a series of reports as follows:

- Basis of Design for Primary Access Roads and Summit Roads;
- Erosion and Sedimentation Control Plan for Roadway Construction;
- Stormwater Management for Primary Access Roads and Summit Roads;
- Road Maintenance;
- Blasting Narrative;
- Erosion and Sedimentation Control Plan for Transmission Line Corridor Construction; and
- Solid Waste Narrative.

The narratives prepared by DeLuca-Hoffman Associates, Inc. are supported by the project Civil Engineering Design Drawings included with this submission. Please refer to Cover Sheet C-1 for a complete list of the project drawings.

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

Civil Engineering Design Specifications for the project are provided in Appendix 2.11.

The baseline data prepared by other consultants include the following:

- The identification and location of wetlands and other natural resources by Woodlot Alternatives.
- Surficial Soils Surveys, identification of water courses and seep areas, and narratives prepared by Albert Frick.
- Base topographic mapping prepared by Aerial Survey with ground truthing survey integrated by Westwood Professional Services.
- Geotechnical evaluations and recommendations for Roadway Construction prepared by S. W. Cole.
- Information for the basis of Roadway Design "Narrow Road" specification established by Endless Energy Corporation, revision E, dated December 13, 2005, included with this report in Appendix 2.6.

Note: The only change made to the "Narrow Road" specification provided in the attachment from what was submitted in the preliminary LURC submission last year, is that a platform trailer will be used to transport blades with a 62-foot rear overhang and 20-foot front overhang, and wide-outs will be provided every ¼ mile instead of every ½ mile for vehicle passing. Dimensions of the blade transport trailer are provided following the "Narrow Road" specification in Appendix 2.6.

Transportation guidelines for Vestas V90 are included in Appendix 8.3. These V90 transportation guidelines have been reviewed and partially considered for the road design, however, the "Narrow Road" specification sets the parameters for road travel width and curve criteria.

Additional Civil Design Criteria are provided in Appendix 2.10.

LURC Chapter 10, Rules and Standards, defines three roadway classifications with minimum roadway widths ranging from 8 to 18 feet. In an effort to design the roadway to meet the specific requirements of this project, a minimum gravel travelway width of 12 feet is proposed for access roads and 32 feet for mountaintop summit roads. A wider travel width up to 20 feet is required at the tightest curves of the proposed access roadways and at wide-outs for passing of equipment.

The roadways have been designed to minimize the use of ditching and to fit the natural topography of the land such that cuts and fills are minimized while preserving the scenic qualities of the surrounding land to the extent possible.

A potential connector access road through steep terrain between Lower and Upper Black Nubble is shown on the project Base Map. The potential connector will be reviewed further in the final design and could potentially eliminate the need for the proposed Upper Black Nubble access road.

There are other physical elements of the project such as the electrical power transmission lines, staging area, and small buildings with attendant construction areas, which are being designed by other consultants and discussed in separate portions of the application. Site grading and erosion control for turbine sites will be included with the final roadway design drawings.

A portion of the access to the proposed wind turbines and substation will use existing roads. These roads are shown as red lines on the Base Map C-3, and have the following lengths:

Table 1 - Access to Wind Turbines		
Existing Road Segment	**Distance (ft)**	**Distance (miles)**
I.P. Road from Route 16 to tee intersection just beyond the Batch Plant Site.	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 proposed road to access the Substation	8,000	1.5
TOTALS	**51,824**	**9.8**

2.0 Seasonal Restrictions

Once the project is complete, seasonal restrictions will be applied to roadways associated with the project.

In general during snow months the access roads to the turbine sites will not be plowed. Access to the turbine sites will be via tracked snow vehicles or ATVs, as site conditions allow. Only small ATVs will be allowed to use these roads during the spring thaw to prevent damage to the roadway.

3.0 Basis of Roadway Design

The basis for the design of new roads, as well as upgrades to existing roads, is discussed in this narrative. This report and the accompanying plans provide horizontal alignment and vertical alignment for the proposed roads. The baseline data available for design is limited to 2-foot contours developed with aerial topographic surveys and ground truthing survey along roadway alignments and at turbine sites by variable section spacing as deemed necessary.

The roadway construction will need to proceed in an uphill direction. Completed roadway sections will be used to access the next roadway construction area (the Erosion and Sedimentation Control Plan for Roadway Construction presented in Section 14 of this application, requires construction of the roadway by segments which are completed prior to moving to the next segment). This requirement is stipulated to minimize the size of denuded areas exposed to erosion during adverse weather conditions.

This basis of design for the roadways integrates the technical load bearing and geometric criteria with site-specific observations including additional challenges of construction of roadways in the higher elevations (above elevation 2,700). The design intent for roadway construction is to use naturally occurring materials supplemented by manufactured products that will enhance the performance and design. Use of manufactured material will be consistent with recommendations made in the project's Geotechnical Engineering Report. A list of the manufactured materials that will be used includes:

- **Filter Cloth:** Native materials that can be layered to meet geotechnical filter criteria are difficult to obtain in this area and require relatively large section thicknesses. This is because there are several layers of materials required and each layer needs to be at least 6" in thickness to be practical to install. A synthetic material which can provide this filtering and material separation in a very thin, single layer is geotextile filter cloth.
- **Geotextile Fabrics:** Bridging soft subgrades and maintaining the separation between soils can be achieved with geotextile fabrics. These fabrics have some tensile strength not found in native materials and can be very effective when placed over weak subgrade areas. Native cover is placed over the geotextile cloth to help disperse the load over the weak subgrade area. Fabric placement with overlaps and avoidance of excessive creasing is necessary.
- **Reinforced Turf and Erosion Control Meshes (ECM):** There are numerous grades of materials for reinforced turf and ECMs. Some are intended merely to resist wind from dislodging the cover material (netting), while others permit the slope to be increased or the erosion control resistance to be increased.
- **Geogrids:** Geogrids provide lateral reinforcement to the soil, thereby increasing the natural angle of repose.

These synthetic materials are proposed as tools to supplement the constructed roadway section, to permit an increase in the angle of cut and fill slopes, and to stabilize the surface of disturbed areas. These same materials are integrated with the erosion control plan for the roadways.

The roadway is designed for construction and long-term access to the wind turbines. The design is illustrated on the typical details, profiles, and plan views of the drawings which accompany this application.

The following are the design parameters for the roadway and a description of how the proposed roadway alignment shown on the plan conforms to these design criteria.

3.1 Longitudinal Grades

The basis of the vertical alignment for the access roads is as follows:

The maximum longitudinal grade at the centerline of the access roads is 14%, based upon limitations of the equipment which will transport the project equipment to the summits of the mountains for fabrication and erection at the wind turbine sites. Grade along the inside corners of horizontal curves may exceed this 14% grade in some places.

A K-value of 15 is desirable for vertical curves, with a minimum K of 10.5 acceptable when deemed necessary. The K-value of a vertical curve is equal to the length of the curve divided by the algebraic difference between the grade into the curve and the grade out of the curve. This parameter is based upon the need to provide for a maximum vertical crown or sag of 30 inches in a 50-foot distance for existing and proposed access roads and to provide for a maximum vertical crown or sag of 6 inches in a 50-foot distance for proposed mountaintop roads. K-values for the Black Nubble Wind Farm project are shown on Cut/Fill Road Analysis Detail located in Appendix 2.4.
The application submission includes profiles of the roadway, which illustrate the existing vertical alignment along the centerline. Cuts and fills will be required principally due to the existing transverse grades. The slope maps, which accompany this report in Appendix 2.5, illustrate the side hill slopes that the roadways will traverse. The transverse grade varies from being gentle on the mountain ridge tops to being extremely steep on portions of the access roads.

Flexibility to adjust the vertical profile grade based on field conditions has been provided in some areas by selecting a route where the existing grade is less than the maximum permissible grade. The most likely field condition which would require an upward adjustment be considered will occur in areas where wet conditions or springs are encountered. An upward adjustment will permit the road contractor to reduce the depth of cut for roadway back slopes into wet seeps and increase the cover thickness over weak subgrade areas. In rock areas, the contractor may want to lower the profile to gain additional material and to reduce the size of the fill slope.

3.1.1 Upper Black Nubble Access Road

The Upper Black Nubble Access Road has been realigned from the preliminary LURC submission submitted last year to avoid a large wetland discovered near Station 2025+00. See drawing C-BN7.

3.1.2 Upper Black Nubble Summit Roadway

There are only minor changes to the alignments included in last year's preliminary application. These minor changes were made as a result of the ground-truth topography work performed after the submission of the preliminary application and the public hearing. These minor changes were needed to further integrate the road alignments with the crane pads for erecting the turbines. See drawing C-BN7.

3.1.3 Lower Black Nubble Access Road

The Lower Black Nubble Access Road horizontal alignment was not altered from what was submitted in last year's preliminary LURC submission.

3.1.4 Lower Black Nubble Summit Roadway

The Lower Black Nubble Summit Road horizontal alignment was altered to reduce the length of the proposed turnaround from what was submitted in last year's preliminary LURC submission. The alternate route was selected as the preferred route for the spur to access turbines 10 and 11 and minor adjustments were made between turbines 9 and 10 to best fit the mountain topography. See drawing C-BN6.

3.2 Horizontal Alignment

The horizontal alignment for proposed access roads and summit roads utilizes a variable centerline radius to best fit the mountain topography. Because of the slow travel speed anticipated, there is no specific tangent distance between compound or reverse curves. The minimum design standards in Appendix 2.6 indicate that a minimum outside radius of 115 feet can be used. This tighter radius has been used in areas where wetlands are present, along existing roads requiring widening as shown in inset area drawings included with this submission and at switchback curve locations.

The horizontal alignment was selected to permit the route to stay within permissible vertical limits with a preference for areas of mild transverse grades and to avoid the natural resource constraints identified by Woodlot Alternatives to the extent practicable. Because meeting the vertical limitations requires an alignment skewing across the contours, it is necessary to periodically introduce a switchback curve. These locations were selected to occur in areas of mild topography to the extent possible and require an increase in roadway travel width up to 20 feet. Wherever possible, the switchback curves have been located on the area of the mountainside with a less steep grade to minimize the depth of the cut into the mountain topography.

The location of the roadway relative to topographic constraints and the attempt to site it within the milder topographic areas of the route corridor will permit the road to achieve its function while being constructed to set harmoniously within the existing conditions found along the corridors.

It is possible that during construction, elevations could be adjusted in the field. For example, if the actual elevations were three feet higher and the existing transverse slope was 15%, a 20-foot down slope adjustment would result in a relative vertical alignment mirroring that anticipated. Caution will be needed with any horizontal adjustment to check and make sure that any resultant shortening of the route length can be accommodated with the final vertical alignment. The design tools also provide the ability to increase cut or fill volumes. On site ground truthing of aerial survey data has significantly improved the accuracy of the baseline data from what was previously available.

The horizontal alignment results from the skewing across steep contours to maintain a profile up to or below the 14% maximum grade. Periodically, it is necessary to introduce a switchback in the alignment. The locations for the switchbacks are areas where the topography flattens out somewhat. Otherwise, the vertical alignment goal is exceeded and deep cuts result.

Intersections and turnaround areas are also shown with the horizontal alignment. There are certain areas where siting a turnaround is not practicable, which will necessitate that large haul vehicles either back up to the last roadway segment, or be picked up and turned around by the crane. The most notable area where turnarounds are not practicable is at the northern turbine sites on Upper Black Nubble.

The horizontal alignment of the Upper Black Nubble Access Road is a series of small curves which lengthen the roadway, thereby allowing the ascent up the hill to be made generally paralleling the existing grades. The horizontal alignment of the Upper Black Nubble Summit Road has an immediate switchback to sweep around the ridgetop and head northerly to other turbine sites. There are several spurs at the end of the summit road to gain access to individual turbines. The Lower Black Nubble Road is fairly smooth in alignment reflecting gentler topography.

3.3 Roadway Width

The access roadway width for road segments leading up to the mountaintops in tangent sections is approximately 12 feet in width. Shoulders should be 2 feet on the uphill side to aid in some snow storage. A four-foot shoulder is used for the downhill side except where the fill height is less than 4 feet and a 3:1 or flatter slope can be constructed. In these areas the shoulder can be reduced to 2 feet. Wide-outs approximately 20 feet in width and 200 feet in length for passing will be constructed along existing and proposed incoming access roads every ¼ miles for vehicle passing. Locations of wide-outs along existing roads will be selected to avoid wetland areas. Field notes, which identify potential locations for wide-outs along existing access roads, from a site visit the week of October 4, 2004 by Dwight Anderson, P.E., of DeLuca-Hoffman Associates, Inc. and Michael Johnson of Woodlot Alternatives are included in Appendix 2.7.

The roadway width increases in curve sections, especially the switchback areas. The plans include details for increasing the road width in non-tangent areas.

The summit and mountaintop spur roadways width is 32 feet. Shoulder requirements will be the same as that for other access roadways noted above.

3.4 Transverse Grades

A roadway with a shoulder and travel lane section width of 18 feet and a one-foot wide by two-foot-deep ditch on the uphill side with 3:1 side slopes will have a grade differential across the 31 foot wide transverse section of the following:

Table 2 - Transverse Slope

Transverse Slope (%)	Differential from Uphill Side of Ditch to Edge of Outside Shoulder
1	0.31’
3	0.93’
10	3.10’
20	6.20’
25	7.75’
33	10.23’
50	15.50’

Actual construction widths will be wider depending upon the respective cut or fill height relative to existing grade, fill slopes, and back slopes.

The design tools (i.e. Tool Box of Design Details) allow the selection of materials to steepen either the back slopes or the fill slopes. These tools are illustrated in the roadway section options that accompany the submission. As shown, it is possible for fill and back slopes to be constructed nearly vertically. However, the near-vertical construction requires special construction techniques, is very labor intensive, and requires special equipment. Therefore, while tools are available for slope construction of up to 1H:6V slopes as shown for select areas of this project; the majority of the roadway will be constructed with back and fill slopes of 1-1/2H to 1V, or with even a less steep grade. This is possible since the alignment allows the profile to nearly mirror the existing conditions, thereby reducing the width of the disturbed area when compared to an alignment with substantial cuts and fills.

Drawing Sheet C-BN18 has been provided as an example of a detail showing back and fill slopes, as well as soil hydrology preservation detail and proposed erosion control measures. The flatter back and fill slopes are possible since the alignment allows the profile to nearly mirror the existing conditions, thereby reducing the width of the disturbed area when compared to an alignment with substantial cuts and fills.

Field selection for implementation of the most appropriate details from the Tool Box of Civil Design Details is intended to allow construction to progress efficiently with environmentally sensitive field alignment adjustments and placement of stable slope treatments.[1]

[1] D. Anderson prefiled testimony Page 14

3.5 Cuts and Fills

The roadway alignment was selected with the idea that material would be cut from the high side and used for subgrade fill on the low side.

Where necessary, the cut amount can be increased to obtain fill material; however, the overall proposed clearing area is to be maintained to the extent possible.

3.6 Roadway Surface Treatment

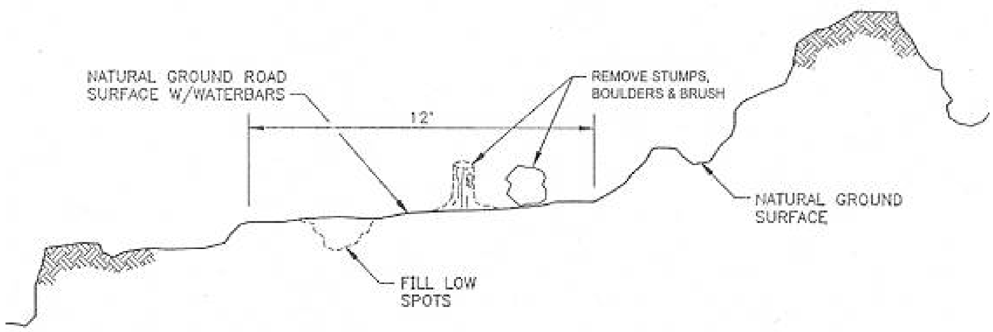
The proposed access roads have steep grades. Runoff across the roadway has a propensity to erode the surface. Without erosion control treatment the roadway will unravel and become rutted over time.

Surfacing treatment methods are provided with the civil design drawings.

3.7 Temporary Construction Roads

Temporary upland construction roads may be cleared to a minimum width to allow passage of construction equipment and will require no other improvements than removal of large rocks, stumps, and brush and limited earth cutting and filling to facilitate vehicular passage, as shown on the figure below. Previously used logging roads will follow the natural ground contours when practical and standard erosion control measures described in the Erosion and Sediment Control Plan will be utilized along these areas. Corduroy road and geotextiles may be used in areas where poor soil conditions exist.

When temporary upland construction roads are constructed along the proposed roadway alignment, the alignment will be cleared to a maximum 40-foot width and constructed as described above. This will allow for advancement of construction activities along the route and slight horizontal shifts or vertical adjustments to the final roadway alignment can be evaluated and marked out prior to completing clearing activities.



TEMPORARY UPLAND CONSTRUCTION ROAD

3.8 Natural Resource Areas

The alignment of the roadway has been selected to minimize impacts to the natural resource areas which have been identified by Woodlot Alternatives, principally by avoidance. The bridge crossings of the major streams are detailed separately in another section of this application and show how impacts have been minimized.

4.0 Anticipated Improvements to Existing Roads

Access to the wind turbines will use approximately 43,724 feet (8.3 miles) of existing gravel roadways identified as the IP (International Paper) Road, and RE2 and as shown in red on the base map. An additional 8,000 feet (1.5 miles) of existing gravel roadway will be used to access the proposed substation. This section is also shown in red on the base map.

Improvements to existing roads would include strengthening any bridge crossings to accept the wheel loads required for the project, or use of temporary bridges as discussed in Appendix 2.0 to Section 1 (Bridge Design Narrative) of this Revised Application, widening of the roadway surface where necessary, and geometric improvements. Two types of improvements will require realignment of the existing roadway in a new location:

- Realignment to reduce vertical grade; and
- Realignment of the roadway to eliminate corners with insufficient radii.

4.1 Areas with Insufficient Turn Radii

The existing roadways are depicted on the Base Map. The known areas of deficient horizontal geometry are identified on the base drawing as C1 through C10. The anticipated remedial measures are discussed below.

C1 is located at the intersection of IP Road and Route 16. This is a relatively flat area where minimal widening of corner radii will be necessary. The existing travel width of the road is 23 feet at this location.

C2 is located just after the second bridge crossing on IP Road about 2.7 miles from Route 16. This is a tight corner with inadequate radii located on terrain with moderate slope. The outside edge will need to be widened to a 115-foot radius. The existing road travel width is 16 feet at this location. No wetlands were observed in this area during an October 2004 site visit by Woodlot Alternatives and DeLuca-Hoffman Associates, Inc. Field notes from the site visit are included in Appendix 2.7.

C3 is located just after the third bridge crossing on IP Road about 3.1 miles from Route 16. This will require similar improvements to C2, but is located on flatter terrain. The existing road travel width is 13 feet at this location. Again, no wetlands were observed in this area during the October 2004 site visit.

C4 is located just before the proposed Batch Plant Site about 4.0 miles from Route 16. Grade in this area is approximately 10 percent and a limited amount of outside curve widening is expected to be required. The existing road travel width is 15 feet at this location. No wetlands were observed in this area during the October 2004 site visit.

C5 is located just after the proposed Batch Plant Site and is also the intersection which splits the route to the substation or Black Nubble Mountain. The turn toward the substation will require widening of the roadway as detailed on drawing C-40. Wetlands exist in the area of C5; therefore, Inset Area 3 has been prepared to show the limits of the roadway improvements in this area.

C6 and C8 are located approximately 2,000 feet each side of C5 and both are expected to require limited roadway widening to improve their alignments. The existing roadway travel width at C6 is 15 feet and C8 is 12 feet. No wetlands at C6 or C8 were observed during the October 2004 site visit.

C7 is located just after Bridge Crossing #1 leading up to Lower Black Nubble (the southwestern portion). Existing grades are moderate in this area and improvements are required. Wetlands exist in the area of C7; therefore, Inset Area 5, Drawing C-42 has been prepared to show the limits of roadway improvements in this area.

Corners C1 through C8 were reviewed for wetlands by Woodlot again in 2006.

Other minor improvements will be necessary along existing access roads to address larger radii curves. These areas have been reviewed by M. A. Mortenson Company and clearing areas for improvements associated with these curves are included in the key facts.

4.2 Vertical Realignment

The vertical grade along the existing roadways has not been formally measured by ground survey. However, the areas where the existing vertical alignments are steep are identified on the base drawing as V1 through V6, and the approximate grades in these areas were visually estimated in the field with the use of an inclinometer.

V1 is located just after the turn to go to Black Nubble after the Batch Plant Site. Grades in this area have been estimated at 13% and the road is stable in its current location; therefore, realignment should not be required to lengthen the roadway.

V2 is located along RE2 after the shale pit. Many dips exist in this area due to culvert crossings which have been removed. Installation of culverts and filling of dips is anticipated in this area. Many of these missing culverts have recently been installed to accommodate logging operations.

V3 is located along the existing route leading up to Lower Black Nubble after Bridge Crossing #1. Grades in this area have been estimated at 14% and short sections of existing road grade up to 18% are allowed by the "Narrow Road" specification; therefore, realignment of this road section is not required.

V4 is located along the existing route leading to the substation just before Bridge Crossing #2. This is a steep section with an estimated grade of 17%. Inset area 6A on drawing C-41, shows proposed improvements at this location. A photo looking downgradient toward Bridge Crossing #2 is shown below.

V4

V5 with an estimated grade of 17% is located after Bridge Crossing #3 off of the selected route.

V6 is beyond the route proposed to be used for this project.

The improvements to the existing roads will be required to meet the same erosion control provisions and basis of design as the new roads, except that short sections of existing roads will be allowed to have grades of up to 18%. Where wetlands are present and existing road improvements are required, inset areas 3, 4, 5, 6A, and 6B are shown on drawings C-40, C-41, C-42 and C-43 to depict improvements in these areas. In areas where access road widening and corner widening is required and no wetlands are present, standard project details including erosion control details, ditching, and slope treatments will be employed. A Wetland Specialist will be present during construction to assist with location of access road wideouts to determine that no wetland impacts will occur.

5.0 Materials of Construction

The materials for construction of the roadway section are discussed in the geotechnical narrative that accompanies the application and are illustrated on the detail drawings.

6.0 Other Tools for Construction of the Roadway

Other tools are available to the contractor, including the use of under drain and trap-rock in the roadway subgrade to address subgrade drainage, the use of synthetic materials, and other opportunities which will result in a roadway section which is appropriate for the actual conditions encountered.

If conditions were found which were not reflected on the baseline data, it would also be possible to make minor changes to the location of the centerline for the roadway, provided the basis of design criteria is not violated and the roadway remains within the permissible roadway corridor.

7.0 Implementation

The erosion and sedimentation control plan requires the roadway be constructed in segments. It is recommended that the area of construction be staked and a corridor 40 feet wide be cleared ahead of the construction crews.

Subsequently, this area should be staked out at 50-foot centers and walked by the design team, the geotechnical engineer, and the contractor to agree on the following:

- Confirmation or recommended adjustment of horizontal and vertical alignment;
- Selection of cross section to be used in the area;
- Locations for cross culverts; and
- Other tools to be employed.

It will be necessary for this effort to precede construction by a sufficient period of time in order that adjustments can be made and the contractor can have final clearing, blasting, and proper materials on hand.

8.0 Closure

The basis of roadway design allows third parties to understand the requirements for the roadway, define the basis of how the alignment was selected, and provide a description of the flexibility for construction, which has been reserved for implementation.

As required by LURC Chapter 10, Rules and Standards, the roadways have been designed to minimize the use of ditching and to fit the natural topography of the land such that cuts and fills are minimized while preserving the scenic quality of the surrounding land to the extent possible

APPENDIX 2.1

Mountain Road Maps (C-1 to C-BN7 and C-BN18)

APPENDIX 2.2

Toolbox of road section designs (C-46 – C-55)

APPENDIX 2.4

Cut/Fill Road Analysis Detail (C-BN24 – C-BN30)

APPENDIX 2.5

Slope Maps

APPENDIX 2.6

RMW Narrow Road Specification

APPENDIX 2.7

DeLuca-Hoffman Site Visit Notes

APPENDIX 2.8

Inset Area Detail (C-40 – C-43)

APPENDIX 2.9

Substation Interconnect Layout, Grading and Erosion Control (C-44)

APPENDIX 2.10

Additional Civil Design Criteria

APPENDIX 2.11

Civil Engineering Design Specifications

APPENDIX 8.3

Vestas V90 Transport Guidelines