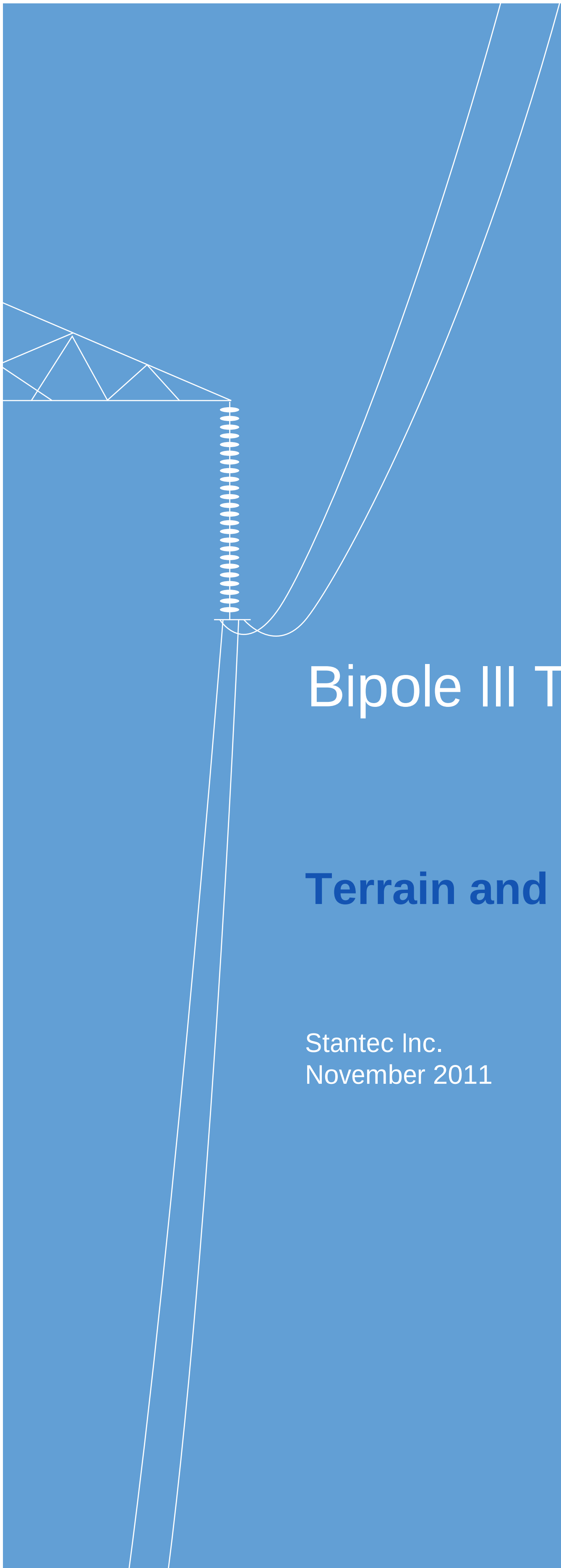

Bipole III Transmission Project

Terrain and Soils Technical Report

Stantec Inc.
November 2011

Manitoba Hydro

Stantec

Technical Report on Terrain and Soils – Bipole III Transmission Project

November 2011

Executive Summary

Manitoba Hydro is proposing to construct the Bipole III Transmission Project. Stantec Consulting Ltd. has been retained to conduct the environmental assessment of and develop an environmental impact statement for the terrain and soils environmental components. This Technical Report was developed to contribute to and inform the terrain and soil components of the Environmental Impact Statement being developed for the Bipole III Transmission Project.

The Project consists of a 1,384 km 500 kV HVdc transmission line; a new northern converter station, the Keewatinoow converter station including a construction camp and construction power; a new southern converter station including construction power; new 230 kV transmission lines linking the Keewatinoow converter station to the northern collector system; and new ground electrode sites for each converter station, connected to the station by a low voltage feeder line. Associated components of the Project include access trail construction; marshalling yards establishment and the use of existing and new sources of borrow, as required.

Project activities likely to affect the terrain and soil environment include the use of heavy equipment, removal of vegetation, grading, installing anchors and foundations and handling and storage of hazardous materials.

The northern portion of the Local Study Area, characterized primarily by wetland and forested land-uses, predominantly consists of low productivity soils including Cryosolic and Organic orders in the low-lying and wetland areas, and the Brunisolic order in the upland, mineral soil areas. The Cryosolic soils are currently, or have been historically, influenced by permafrost. Agro-Manitoba predominantly consists of Chernozemic and Vertisolic orders, which are generally considered productive soils for agricultural production. The Regosolic, Gleysolic and Luvisolic soil orders, and Non-Soil are generally considered azonal in nature throughout the Local Study Area.

Soil drainage is predominantly very poorly, imperfect or well in the Local Study Area, with a combination of very poorly and well drained soils in the northern portion and predominantly imperfectly drained soils in the southern portion of the Local Study Area (Table 5.1, Map 200 - 1:17 – Soil).

Surface soil textures are an important consideration, as surficial soil horizons are relatively productive and maintenance of these typically thin and fragile horizons is a key consideration in the maintenance of soil productivity. Organic surface textures were found to be mesic and fibric in nature. A considerable portion of the Local Study Area was found to have medium and very fine textured mineral surfaces. Very fine and fine textured soils are important to consider, as they tend to be prone to compaction effects under trafficking. Another important consideration is coarse textured (very coarse, coarse and moderately coarse) surface materials, particularly

when they occur on poorly developed soils, as they have little resistance to wind erosion. These surface textures occupy a minor portion of the Local Study Area, and are distributed throughout the Local Study Area.

Valued environmental components and environmentally sensitive sites/areas were identified as part of the environmental effects assessment. Soil productivity, unique terrain/soil features, and stable terrain were identified as valued environmental components. Environmentally sensitive sites/areas included wind erosion-prone soils, water erosion-prone soils, compaction-prone soils, unique terrain/soil features, unstable/steep slopes and permafrost areas.

Potential environmental effects of the Project were identified using a combination of methods, including an environmental interaction matrix, feature mapping, professional opinion and review of Aboriginal Traditional Knowledge, key perspectives and comments from the Environmental Assessment Consultation Process and literature.

Anticipated adverse environmental effects to the soil environment include: loss of soil structure due to compaction and rutting, loss of topsoil from accelerated wind and water erosion, loss of soil capability from admixing topsoil with less suitable or saline subsoils, increase in annual mean soil temperature in areas cleared of vegetation, reduced soil productivity due to herbicide residuals from right-of-way vegetation management; and impairment of soil quality in the event of accidental hazardous material spills or leaks. A potential positive effect on soil productivity may be realized as a result of early spring thaw due to increased mean soil temperatures, in non-drought-prone areas.

Potential adverse environmental effects to the terrain environment include a loss of terrain stability due to the initiation or acceleration of mass wasting or permafrost thaw and impairment of landscape integrity of enduring features located within Areas of Special Interest or other unique terrain/soil features. Loss of surficial and bedrock geological materials as a result of utilizing borrow sources is also anticipated.

Residual environmental effects, anticipated to remain after mitigation in some areas, include some loss of soil structure, increased soil temperatures, impairment of landscape integrity of three single occurrence and one rare occurrence enduring feature located within Areas of Special Interest, loss of terrain stability, loss of surficial and bedrock geology and some impairment of soil quality in the event of a major spill. It is anticipated that landscape integrity, soil productivity and terrain stability may be subject to cumulative effects in consideration with other developments and activities, particularly in the northern region.

Residual environmental effects are typically long-term in duration, occurring within the project footprint on an infrequent basis. With the exception of a nominal loss of landscape integrity, residual effects to the terrain and soil environmental are primarily of moderate ecological and societal importance. The final determination regarding the significance of residual environmental effects was made in consideration of uncertainty and likelihood of occurrence and will be reported in the EIS summary volume.

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1.0 Introduction

Manitoba Hydro is proposing to construct the Bipole III Transmission Project (the Project). This Technical Report consists of a description of the existing terrain and soil environment of the proposed Project areas, an assessment of potential effects of development on this environment, and identification of proposed mitigation measures to address these potential effects.

1.1 BACKGROUND

Stantec Consulting Ltd. (Stantec) has been retained to conduct the environmental assessment and develop an environmental impact statement for the terrain and soils environmental components. This work has included conducting a constraints analysis as part of the alternative routes evaluation (Stantec 2010) and a detailed environmental assessment of the final preferred transmission line route and associated project components.

1.2 SCOPE

The scope of this technical report is the Land Component of the environment of the final preferred transmission alignment, and associated project components, including northern electrode sites, the Keewatinoow convertor station site, the northern construction power site, the southern converter station site and southern electrode sites. The Land Component, as defined by the *“Bipole III Transmission Project: A Major Reliability Improvement Initiative Draft Environmental Assessment Scoping Document”* (Manitoba Hydro, 2009) is comprised of the terrain, geology and soils.

Specifically, this Report will provide available information in sufficient detail in order to predict, avoid and/or minimize any potential adverse effects on the following components:

- Terrain, including physiography/landforms, elevations, relief, unique features, etc.
- Surficial geology, including types and depths.
- Bedrock geology including types, location and depths.
- Soil types and characteristics.
- Soil capabilities and limitations.
- **Permafrost**[1] conditions.

[1] Terms in **bold** are defined in glossary.

Special consideration was provided towards identified Valued Environmental Components (VECs; Section 5.2) and environmentally sensitive sites and areas (ESSs; Section 6.1) of the terrain and soil environment derived from study results.

1.3 PURPOSE

This Technical Report was developed to contribute to and inform the Land Component of the physical environment for the Environmental Impact Statement being developed for the Bipole III Transmission Project. The Land Component, as defined by the *"Bipole III Transmission Project: A Major Reliability Improvement Initiative Draft Environmental Assessment Scoping Document"* (Manitoba Hydro, 2009) is comprised of the terrain, geology and soils, as discussed in Section 1.2, above.

1.4 REPORT OUTLINE

The following report outlines the subject assessment areas, methods for fieldwork and data analysis undertaken, description of the proposed project, existing environment description and environmental effects assessment, including proposed mitigation measures and residual and cumulative effects.

2.0 Study Areas

The following sections outline the spatial boundaries associated with the project and local study areas of the terrain and soil environment considered in this report.

2.1 PROJECT STUDY AREA

The Project Study Area consisted of a total land area of approximately 13.6 million hectares and encompassed the alternate routing options. The Project Study Area was not used explicitly in the assessment of the terrain and soil environment, however was considered generally in the assessment (e.g., cumulative effects).

2.2 LOCAL STUDY AREA

The Local Study Area for the assessment of the terrain and soil environment consists of the established 3 mile wide corridor (4.8 km) associated with the final preferred route, as well as the project footprints associated with other project components (i.e., electrode sites, converter stations, construction power site, northern temporary construction camp, northern AC collector lines).

2.2.1 Project Footprint

The area covered by a project component is considered the project footprint. The project footprint for the transmission line and northern and southern infrastructure components is described below.

2.2.1.1 Transmission Line

The project footprint for the final preferred transmission line consists of the 66 metre transmission line right-of-way (the “HVdc right-of-way”).

2.2.1.2 Northern Infrastructure Components

The project footprint of the northern infrastructure components consist of the following:

- Northern collector lines corridor (310 m) and ground electrode line corridor (15 m).
- Construction power site.
- Northern temporary construction camp.
- Northern converter station.
- Preferred northern ground electrode site and.

- Northern electrode connection line.

2.2.1.3 Southern Infrastructure Components

The project footprint of the southern infrastructure components consist of the following:

- Southern converter station.
- Preferred southern ground electrode site.
- Southern electrode connection line.

3.0 Methodology

The methodology for conducting the environmental assessment, including an overview of desktop and field investigation activities for data collection, the route/site selection process, and the environmental assessment process, is discussed below.

3.1 DATA COLLECTION AND REVIEW

Data on terrain and soil was collected and compiled from numerous existing data sources. However, these data tend to be regional in nature, particularly in the northern portions of the Local Study Area. Existing data sources were complemented and supplemented by conducting aerial photo interpretation and field assessments.

3.1.1 Ecosystem-Based Approach

The description of the existing environment and the evaluation of soils, terrain and geology data was conducted on an ecosystem basis. Ecoregion summary information was sourced from Smith et al. (1998) "Terrestrial Ecozones, Ecoregions, and Ecodistricts of Manitoba, An Ecological Stratification of Manitoba's Natural Landscapes".

3.1.2 Existing Data/Desktop Review

A desktop review of existing data for the assessment of the soil, terrain and geology environment was conducted for the Local Study Area. In describing the existing geological, terrain and soil environment, major sources of information included: ecoregion physical environment summaries, geology, physiography, existing soil resource information (i.e., provincial soil resource information [detailed and reconnaissance level soil surveys] and soil landscapes of Canada), wind erosion risk index, enduring features data, Manitoba wetlands, stereo-photography acquired for Bipole III, and field investigation activities. These data sources are described in greater detail below.

3.1.3 Bedrock and Surficial Geology

The distribution, thickness and extent of bedrock geology in Manitoba was based on Betcher et al. (1995). This provides a regional overview of geological formations (era, period, formation, member), description of basic lithology and thickness.

Surficial geology data is based on the Surficial Geology Compilation Map Series (SGCMS) for Manitoba compiled by Matile and Keller (2007). The data provides a regional overview of surficial geology deposits.

3.1.3.1 Existing Soil Resource Information

Existing soil resource information (SRI) was collected and compiled for the Local Study Area, including:

- Soil Landscapes of Canada (Versions 2.2b and 3.1).
- Detailed and Reconnaissance Soil Resource and Agricultural Interpretation Information - Manitoba Land Initiative.
- Reconnaissance Soil Surveys and Biophysical Surveys - Agriculture Canada.

Existing SRI was generally in digital format; however, some existing data sources were available in hard copy format only, and had to be digitized. The most detailed (i.e., largest scale) SRI available for the Local Study Area was incorporated into a seamless soil database to support the assessment.

3.1.3.1.1 Provincial Soil Resource Information

Detailed and Reconnaissance soil resource information exists for the southern portion of the Local Study Area, primarily agro-Manitoba, and was obtained from the Manitoba Land Initiative Core Maps – Data Warehouse (https://mil2.gov.mb.ca). Soil resource information (SRI) by Rural Municipality was compiled for the Local Study Area. Soil information ranged in scale from 1:20,000 to 1:50,000 and from 1:100,000 to 1:126,720. Reconnaissance Soil Surveys and Biophysical Surveys provided supplementary information for a portion of the northern section of the Local Study Area and were obtained from Agriculture and Agri-Food Canada's Canadian Soil Information (http://sis.agr.gc.ca/cansis/publications/). Soil and biophysical maps were georeferenced for use within the ArcGIS environment.

3.1.3.1.2 Soil Landscapes of Canada

Soil Landscapes of Canada (Version 2.2b) was originally published in 1994 and includes comprehensive soil and landscape information at a broad reconnaissance scale of 1:1,000,000 for the entire Local Study Area. All previous and subsequent versions of this dataset have coverage limited to the agricultural regions of Canada, and are therefore of limited use for the project. This data was downloaded from Agriculture and Agri-Food Canada's Canadian Soil Information Service (http://sis.agr.gc.ca/cansis/nsdb/slc/intro.html).

An existing soil resource inventory index map is presented in Map 1 - Existing Soil Resource Inventory (SRI) in Manitoba,, and provides an overview of the level of detail of existing soil resource information sources.

3.1.3.2 Wind Erosion Risk - Manitoba

A wind erosion risk map was developed for southern Manitoba by the Land Resource Research Centre of Agriculture Canada's Research Branch (Coote et al. 1989) in order to assess the inherent risk of wind erosion occurring as a consequence of the natural characteristics of a soil landscape unit, combined with the associated climatic conditions. The wind erosion risk map is based on the Soil Landscapes of Canada soil resource information and was reported at a scale of 1:1,000,000, so is limited in use to regional planning activities. The wind erosion risk polygon attribute data was manually inputted from Coote et al. (1989) by Stantec into the digital Soil Landscapes of Canada polygon shapefile (referenced in 5.1.1.1, above) for data interpretation and map production. The coverage of the wind erosion risk data is limited to the Local Study Area south of Wabowden.

For each soil polygon a dimensionless risk class for wind erosion occurring on bare, unprotected mineral soils is provided in the map symbol for the dominant soil, and subdominant soil, if present. There are five wind erosion risk classes:

- Negligible (N)
- Low (L)
- Moderate (M)
- High (H)
- Severe (S)

Determination of wind erosion risk class by Coote et al. (1989) was based on a calculation of the maximum instantaneous soil movement by wind using a wind erosion risk equation based on several factors, including surface roughness and aggregation factor, soil resistance to movement by wind, drag velocity of wind at the soil surface, soil moisture shear resistance, and available moisture of the soil surface.

3.1.3.3 Enduring Features and Other Unique Terrain/Soil Features Data

Enduring features data was received from the Protected Areas Initiative (PAI). For the purposes of this assessment and as determined by PAI, single and rare occurrence enduring features located within Areas of Special Interest (ASI) intersected by the Project Footprint were of interest for the assessment. Enduring features datasets were reviewed in relation to existing soil resource information. Due to limitations related to the scale of data on which enduring features are identified, these features can be further measured by larger-scale mapping based on aerial photo interpretation, aerial reconnaissance and groundtruthing for detailed site and soil conditions. The spatial boundary of the enduring feature is a measurable parameter, with the precision of the boundary being related to the scale at which the feature was mapped. Re-mapping of single and rare occurrence enduring features was conducted in the HD-MAPP environment, based on the combination of soil and surficial geology intended to be captured. Data on the spatial distribution and nature of enduring features, including single and rare occurrence features (i.e., unique combinations of geology and soils) and associated priority areas were provided by PAI, Manitoba Conservation, through MMM Group Limited

Other unique terrain/soil features were identified through stereo-paired aerial photo interpretation and review of existing soil resource information conducted for project footprints. These features are measurable as having unique terrain and/or soil properties relative to the dominant properties of the surrounding soil-landscape, and have discrete boundaries identified with a level of precision based on the scale at which they were mapped.

3.1.3.4 Manitoba Wetlands

Wetlands in Manitoba were mapped by Halsey and Vitt (1997) at a scale of 1:50,000. Mapping included the identification of areas with a permafrost landform modifier. The Manitoba Wetlands data were used as part of this study to assess the extent and distribution of permafrost within the Local Study Area based on the extent of mapped areas identified as having a permafrost landform modifier. Manitoba Wetlands polygons were digitized from hard copy map sheets by Stantec for use in this assessment.

3.1.3.5 Aboriginal Traditional Knowledge

Manitoba Hydro and MMM Group Limited provided Aboriginal Traditional Knowledge information gathered from workshops, meetings and interviews undertaken throughout the Project Study Area. ATK was reviewed and utilized in identifying valued environmental components, describing existing environmental conditions and scoping regional issues associated with the soil and terrain environment.

3.1.3.6 Aerial Photo Interpretation

Aerial photo interpretation was conducted digitally in stereo within Stantec's High Definition Mapping and Applications (HD-MAPP) system, based on the PurVIEW and ArcGIS platforms. Stereo aerial photos, acquired for the preferred route, were examined for the Local Study Area to determine the presence of site-specific issues of concern (e.g., sensitive soil areas/sites, steep/unstable slopes, enduring features within ASIs).

Stereo photos were acquired for the Local Study Area corridor in black and white at a scale of 1:40,000. Digital aerial photos were used to develop a stereo-paired aerial photograph model for photo interpretation within the PurVIEW platform in the ArcMAP environment. Within the HD-MAPP environment, stereo-photo interpretation was conducted to a useful scale of 1:3,000.

3.1.3.7 Field Investigations

Field investigations were conducted to supplement existing soil resource information, as required to support the assessment. Field activities included aerial reconnaissance and groundtruthing of select portions of the Local Study Area. Field assessments targeted areas where site-specific assessments where required to address limitations posed by existing soil resource information and included select project infrastructure (electrode sites, Keewatinoow converter station, construction power site, northern work camp) and select sensitive soil and terrain features (e.g., unique soil/terrain features within Stephens Lake ASI and highly erodible soils in agro-Manitoba). Field investigations were not undertaken at the Riel Converter Station site due to the developed nature of the site.

Aerial reconnaissance was conducted for select portions of the Local Study Area. During aerial reconnaissance, visual confirmation of terrain and soil features was conducted. Aerial reconnaissance of the potential northern ground electrode sites, northern converter station, northern construction power site and preferred route Local Study Area from the proposed Conawapa site to the intersection of HWY580 and the preferred route, was completed from October 4th to October 8th, 2010. Aerial reconnaissance of the potential ground electrode sites, construction power site and northern converter station included photographing the sites from the air, identifying soil map units within the proposed component footprints and positioning potential ground inspection locations within the map units for groundtruthing. Aerial reconnaissance of the preferred route corridor was completed by flying directly over the proposed center of the transmission right-of-way at an elevation that allowed for viewing of the entire Local Study Area. Inspection locations for groundtruthing of the preferred route were pre-selected using the HD-MAPP system; however, additional inspection locations for were identified from the aerial reconnaissance based on landform, topography and extent of these features within the Local Study Area. In addition, key elements, including the majority of groundtruthing sites, were photographed from the air to provide complimentary images for the site inspections.

Groundtruthing consisted of conducting detailed site and soil classifications. Detailed soil classifications were conducted in a manner consistent with the approach outlined by the Expert Committee on Soil Survey (1982) and, where necessary, soils were classified to the sub-group level based on the guidelines established by the Soil Classification Working Group (1998). Soil inspections were conducted using a hand shovel and dutch auger. At each site, a field form was completed and, as deemed necessary, photographs of the soil profile, site vegetation and landscape (aerial photograph from the helicopter) were taken. Site inspections were completed from October 4th to October 8th, 2010 and from October 25th to October 30th, 2010 for the northern project components, and on September 30th and November 30th, 2010 for the southern ground electrode sites. A total of 128 inspections were completed during the field shifts, however only 90 inspections remain within final project component footprints and are distributed as follows: final preferred route Local Study Area, 69 inspections; northern construction power, 4 inspections; Keewatinoow converter station, 8 inspections; preferred northern electrode, 3 inspections; alternate northern electrode, 3 inspections; alternate southern electrode, 3 inspections. A summary of pertinent site and soil information, including GPS coordinates, surficial materials, topsoil depth, soil classification, drainage and landform information, from soil inspection data sheets is presented in Appendix D. Locations of site inspections are also found on various site maps referred to throughout this report.

3.1.4 Data/Information Gaps

Existing soil resource information was available for all areas of the project footprint; however, at varying scales with associated limitations in utility for the assessment process, environmental protection plans, and follow-up and monitoring. Soil resource inventories are designed based on typical soil survey objectives, and information is collected at a survey intensity level (SIL) to support these objectives. Established SIL range from SIL1 (reported at 1:5,000) to SIL5 (reported at 1:100,000 to 1:1,000,000) for soil resource information in Canada (Coen 1987). Typical objectives by SIL and reporting scale (based on Coen 1987) for soil resource information in the Local Study Area are as follows:

- SIL2 or Detailed Soil Resource information – usual reporting scale of 1:20,000 and used for many purposes down to the level of supporting local planning such as groups of farms and stream catchments, however is limited in use for specific site selection.
- SIL3 or Reconnaissance Soil Resource Information – usual reporting scale of 1:50,000 and used to support decisions at the level of farming area, district and county (rural municipality).
- SIL4 or Broad Reconnaissance Soil Resource Information – usual reporting scale of 1:100,000 and used to support decisions at the level of large agricultural areas or regional planning.
- SIL5 or Exploratory Soil Resource Information – usual reporting scale of 1:250,000 to 1:1,000,000 and used to support broad regional planning or provincial planning.

In the northern portion of the Local Study Area, SRI ranged from reconnaissance and biophysical surveys (presented at scales of approximately 1:125,000) to broad reconnaissance (presented at a scale of 1:1,000,000). In the southern portion of the Local Study Area, SRI ranged from reconnaissance 1:126,750 to detailed (presented at scales of 1:20,000 to 1:50,000). This SRI is limited to supporting regional level evaluation and planning, and precludes meaningful site-specific assessments.

3.1.4.1 Implications of Gaps

While the scale of existing SRI is generally considered suitable for supporting the assessment process, it is limited in its utility to support site-specific soil quality baseline condition assessment and development of environmental protection plans. This is of particular importance for specific project components, such as ground electrode sites, converter stations, temporary work camps and marshaling yards, and borrow locations, as well as for some localized, sensitive terrain/soil areas/sites. This resulted in the need for additional information to be collected through other existing data sources, aerial photo interpretation and field investigations, as discussed above.

Field investigations were conducted to address these limitations in SRI for select project infrastructure (i.e., preferred and alternate Northern Ground Electrode sites, alternate Southern Ground Electrode site, Keewatinoow Converter Station, Construction Power Site) and select sensitive soil and terrain features (e.g., unique soil/terrain features within Stephens Lake ASI and highly erodible soils in agro-Manitoba). However; due to the timing of the field investigation assessment window in relation to the identification some projects components (i.e., Southern Ground Electrode, Keewatinoow Construction Camp, Borrow Areas, Access Routes and Northern Infrastructure Lines). Additional soils baseline information was not collected at the Riel Converter Station due to its current development stage (i.e., gravel pad).

The following specific activities should be undertaken to address remaining soil resource information limitations/gaps to ensure sufficient baseline information exists for effective development of site-specific environmental protection measures and to support follow-up and monitoring activities, as required, for project component sites:

- Groundtruthing of project components to determine surface and subsurface soil properties, as follows:
  - Southern Ground Electrode site – soil inspections should be conducted to support topsoil stripping and subsoil handling recommendations and construction-level environmental protection plans.
  - Keewatinoow Construction Camp – soil inspections should be conducted to support topsoil stripping recommendations and construction-level environmental protection plans.
- Desktop review of existing soil and terrain resource information, including aerial photo analysis and/or LiDAR data review, if available, at Borrow Areas, as they are identified.
- Desktop review of existing soil and terrain resource information, supplemented by aerial reconnaissance and groundtruthing, as deemed necessary following desktop data review, for Access Routes.
- Review of LiDAR-derived digital elevation model and associated products to supplement review of terrain features (e.g., steep/unstable slopes) identified through aerial photo interpretation along the transmission Local Study Area.

Existing SRI will also be of limited use for follow-up and monitoring requirements, which may be required at some future date. For example, should the need arise to assess a potential residual effect of a project activity, based on a site-specific concern, additional site-specific SRI may need to be collected to support a meaningful assessment. However, the need for additional baseline SRI to support the follow-up and monitoring program is not anticipated at this time, and detailed soil information can be collected from a site at a future date, as required.

3.2 ROUTE/SITE SELECTION

Manitoba Hydro transmission projects utilize a Site Selection and Environmental Assessment (SSEA) process to better understand the potential issues and concerns associated with the routing and siting of the transmission line and components, to assess the potential for adverse effects and identify appropriate mitigation measures to manage the overall effect of the proposed project on the environment. This process was undertaken for the Bipole III transmission line project.

Terrain and soil constraints were reviewed for the proposed alternative routes throughout the alternative routes evaluation. As part of this desktop study and evaluation, major terrain constraints to the proposed development were assessed and potential VECs were identified. The assessment was based on review and evaluation of existing terrain and soil resource information, as well as a review of stereo-paired aerial photographs for the northern portion of the Local Study Area. Constraints included terrain and soil hazards (i.e., steep/unstable slopes, consolidation settlement, flooding, seepage), permafrost, sensitive soils, and PAI-identified priority areas, major water features and surficial geology. Identified VECs included agricultural capability and enduring features within Areas of Special Interest (ASI). Terrain and soil constraints and VECs were rated according to their relative degree of constraint (i.e., Low, Moderate, High) to the Project, and used to assign an overall degree rating based on a proportional assessment for each segment of the alternate routes. Weighted constraint scoring was then conducted for each segment based on the relative degree of all constraints and the area (hectares) of the constraint, which allowed for meaningful comparison between all segments regardless of length and the three identified alternate routes (i.e., A, B and C). Final terrain and soil ratings were included as part of the overall biophysical team evaluation of the alternate routes.

It was concluded that alternate route B, which generally corresponds to the selected route, was the overall preferred route from a terrain and soil constraint perspective.

Of the three alternate routes, route A had the highest area and proportional area transecting Enduring Features (approximately 31,720 ha or 4.5% of the route), while routes B and C had much lower potential for impacts to these features (approximately 3,014 ha or 0.5% of routes B and C). Route A had the highest area and proportional area of steep/unstable slopes, while routes B and C had lower and comparable areas constrained by slopes. When constraints for agricultural capability were evaluated, route B had the lowest area constrained (219,603 ha or 35.2% of route), while routes A and C had 260,836 ha (36.6%) and 248,981 ha (38.1%) affected, respectively. Sensitive soil areas and organic deposit areas were generally comparable amongst the routes.

The reader is referred to “Bipole III Transmission Line Project: Summary Report for the Evaluation of the Alternative Routes – Soils, Terrain and Groundwater” (Stantec 2010), for more detail on the alternative route evaluation for terrain and soils.

3.3 ENVIRONMENTAL ASSESSMENT

The environmental assessment, presented in Section 6.0, considers all physical works and activities associated with the pre-construction, construction, operation, maintenance and decommissioning of Project components. In addition, this Technical Report considers residual and cumulative effects. An assessment of greenhouse gas effects relative to the terrain and soil environment was not included in the scope of the work plan.

The environmental assessment has been focused on valued environmental components (VECs) selected for the terrain, soil and geology environment. Valued environmental components are elements of the environment that are considered to have scientific or cultural importance and therefore should be afforded special consideration. VECs were selected based on literature reviews, previous project experience, professional judgment, as well as consultations with stakeholders, and Aboriginal Traditional Knowledge. Regions and sites of environmental sensitivity, or environmentally sensitive sites (ESSs), generally associated with the selected VECs have been determined, mapped and described in Section 6.1, to aid in the development of region/site-specific environmental protection measures.

Potential interactions between Project activities and environmental components were identified using an environmental interaction matrix (Section 6.0, Table 6.1). Potential environmental effects were determined based on the interaction matrix, feature mapping, a review of published and available literature, including previous Environmental Impact Statements (EISs) completed for hydroelectric projects in Manitoba (e.g., *Wuskwatim Transmission Project EIS*) and peer-reviewed articles regarding development-related terrain, soil and geology effects. Additional information sources included outcomes of the Aboriginal Traditional Knowledge (ATK) workshops and Environmental Assessment Consultation Process in relation to the terrain, soil and geology environment.

In addition to avoidance during the routing process (Section 3.2), proposed general and site-specific mitigation, environmental protection measures, and monitoring and follow-up activities to address the potential environmental effects to the terrain and soil environment were developed based on available and collected baseline data, interpreted risk indices and review of literature and other linear developments. Best management practices (BMPs), policy and guideline documents and standard and precedent Manitoba Hydro protection measures were also used as a resource.

The significance of residual environmental effects, or environmental effects anticipated to remain after the implementation of mitigation measures, were assessed based on eight assessment factors identified and defined below. The assessment criterion for each of the eight factors is presented in Table 3.1.

1. **Direction**: the difference or trend compared with existing or pre-project conditions, assessed as positive, negligible or negative.

2. **Ecological Importance**: the rarity, uniqueness and fragility within the ecosystem and importance to scientific studies, assessed as high, moderate or low.

3. **Societal Importance**: the value that individuals and/or communities place on components of the affected socio-economic and biophysical environments that are necessary for economic, social and cultural well-being, assessed as high, moderate or low.

4. **Magnitude**: the predicted degree of disturbance the effect has on a component of the biophysical or socio-economic environment, assessed as large, medium or small.

5. **Geographic Extent**: the spatial boundary where the residual environmental effect is expected to occur, assessed as affecting the regional assessment area (Project Study Area), local assessment area (Local Study Area) or project footprint.

6. **Duration**: how long the predicted residual environmental effect would last, assessed as long-term, medium-term or short-term.

7. **Frequency**: how often the predicted residual environmental effect would occur, assessed as regular or continuous; sporadic or intermittent; or infrequent.

8. **Reversibility**: how long it would take for the site to be restored to an acceptable condition, assessed as irreversible or reversible.

MMM Group Limited and Manitoba Hydro Licensing and Environmental Assessment staff in conjunction with Stantec will make the actual determination of significance based on the information provided in this assessment and consideration of uncertainty and likelihood of occurrence. The outcome will be reported in the EIS summary volume.

A cumulative effects assessment, presented in Section 6.8, was conducted to identify any potential environmental effects likely to result from the Project in combination with the effects of other past, existing or future actions. The cumulative effects assessment process was based on guidance from CEAA (1994) and Hegmann et al. (1999) and included scoping, analysis of effects, identification of mitigation, evaluation of significance, and follow-up. Other actions were identified after the scoping stage using various sources including review of federal (Canadian Environmental Assessment Registry) and provincial (Manitoba Environmental Assessment and Licensing Registry) project registries, provincial transportation planning studies (http://www.gov.mb.ca/mit/tspd/current.html), resource exploration databases, forest fire records and professional opinion. Potential future actions were then overlaid on Project and single and rare occurrence PAI enduring feature footprints located within ASIs in natural regions common to the Project to identify overlap.

4.0 Project Description

The following is a brief summary of project components and activities to be undertaken. The reader is referred to Chapter 3 of the Environmental Impact Statement for the Bipole III Transmission Project for the complete project description which informed this report.

4.1 PROJECT COMPONENTS

The major components of the Bipole III Project are:

- A 500 kV HVdc transmission line.
- A new northern converter station, the Keewatinoow converter station, to be located near the proposed site of the Conawapa Generating Station including a construction camp and construction power.
- A new southern converter station located at the Riel site in the Rural Municipality of Springfield including construction power.
- New 230 kV transmission lines linking the Keewatinoow converter station to the northern collector system at the existing 230 kV switchyards at Henday Converter Station and Long Spruce Generating Stations.
- New ground electrode sites for each converter station, connected to the station by a low voltage feeder line.

Associated components of the Project include access trail construction; establishing marshaling yards and the use of existing and new sources of borrow, as required. The location of these components is yet to be determined.

4.1.1 500 kV HVdc Transmission Line

The Bipole III 500 kV HVdc transmission line will originate at the Keewatinoow converter station and terminate at the new southern converter station on the Riel site. The overall length of the line is about 1,376 km located on a 66 m wide right-of-way.

Two basic tower types will be used for the straight line sections of the transmission line. In northern Manitoba and forested/pasture areas in the south, the line conductors will be suspended from guyed lattice steel towers. In the more densely developed areas of southern Manitoba, self-supporting lattice steel towers will be used to minimize potential effects on farming practice (i.e., to reduce the tower footprint) and to reduce the land acquisition requirement. Typical tower dimensions will be 45 m in height with a 7.8 m square base footprint for self-supporting towers. Towers will be spaced approximately 480 m apart in most areas.

Prior to construction, the right-of-way and required easements will first be surveyed and flagged to establish the line alignment. Clearing and disposal of trees on the proposed right-of-way will be undertaken in advance to facilitate construction activities. Clearing requirements for the new transmission line right-of-ways will also require selective clearing of “danger trees” beyond the right-of-way. Such trees could potentially affect the function of the transmission line or result in safety concerns, and are normally identified during initial right-of-way clearing activities and removed.

A variety of methods are available for right-of-way clearing. Typically, these include conventional clearing done by tracked bulldozers, mulching by rotary drums, selective tree removal by feller bunchers (e.g., for removal of danger trees with minimal adverse effect to adjacent vegetation and trees) and hand clearing with chain saws in environmentally sensitive sites. Ground vegetation will not be “grubbed” except at tower sites, where the foundation area will typically be scraped to allow unencumbered access for equipment and safe walking areas for workers.

4.1.2 Keewatinoow Converter Station and Northern Ground Electrode Facility

The new Keewatinoow converter station will be located about 5 km southwest of the Conawapa generating station site on the Nelson River. The principal components of the converter station are a converter building, a high-voltage ac switchyard and a high voltage dc switchyard required to terminate the 230 kV transmission line connections to the northern collector system, to convert the ac power from the collector system to dc power, and to provide the HVdc switching facilities necessary for termination of the new Bipole III transmission line. The converter station site is estimated to require a footprint of approximately 640 m x 640 m in dimension for a total area of approximately 41 hectares.

Construction activities for the converter station development will typically involve site preparation (e.g., removal of existing vegetation and organic topsoil from the site; addition and compaction of inorganic fill material, installation of station surface material) and initial infrastructure development (e.g., installation of station access roads and associated drainage, followed by installation of perimeter fencing and gates). Areas of granular deposits have been identified in the vicinity of Keewatinoow along the Conawapa Road (see Project Components description in EIS), and will be used as sources of fill material for converter station components. Additionally, excavated material placement areas have been identified and will be used to stockpile excess materials excavated during component construction. Once general site improvements have been completed, other necessary civil works and systems will be installed (e.g., foundations for building and equipment, grounding arrangements, water supply, oil spill containment, site services and buildings). Station apparatus and equipment installation will follow, including filling of equipment with insulating oil, construction clean-up and commissioning.

The ground electrode required for the converter station will be located approximately 10 km south of the converter station site on the west side of the Conawapa access road. On the assumption of a shallow land ring electrode (similar to the electrodes used at the existing Henday and Radisson converter stations), the electrode will be a buried iron ring approximately 500 m in diameter and will require a site area in the order of one mile square, together with an access road for construction and ongoing maintenance. There will also be a low voltage (12 kV) overhead distribution line connection between the ground electrode site and the converter station. The low voltage line will be supported on guyed single wood poles and routed along an existing right-of-way.

A temporary construction camp will be established at the future Conawapa Generating Station site to house workers involved in the Keewatinoow converter station and ground electrode.

Construction power for the construction camp, converter station and electrode site will be provided by extending the existing 138 kV transmission line that runs from Kelsey Generating Station to the Limestone construction power substation about 31 km to a new construction power substation located near the Keewatinoow converter station site.

4.1.2.1 Connections to the Northern Collector System

The proposed connections include one 230 kV transmission line about 55 km in length, from the existing 230 kV switchyard at Long Spruce Generating Station to a new 230 kV switchyard to be developed at the site of the new Keewatinoow converter station. In addition, four 230 kV transmission lines, each about 27 km in length, will be constructed from the existing 230 kV switchyard at Henday Converter Station to the new 230 kV switchyard at the new Keewatinoow converter station. The lines will share a common right-of-way 310 m in width. Guyed lattice steel towers will be used for the collector lines.

4.1.3 Riel Converter Station and Southern Ground Electrode Facility

The new southern converter station will include the HVdc switchyard facilities necessary to terminate the new Bipole III transmission line, together with the converters and the ancillary facilities required to convert the dc power from the Bipole III transmission line to ac power at the 230 kV level necessary for injection into the southern receiving system. The southern converter station will be located at the existing Riel station site in the RM of Springfield, just east of Winnipeg, which is now under construction for sectionalization purposes. Site development under the sectionalization project will include the portion required for the converter station site.

Construction activities for the converter station development will involve necessary civil works and installation of systems (e.g., foundations for building and equipment, grounding arrangements, water supply, oil spill containment, site services and buildings). Station apparatus and equipment installation will follow, including filling of equipment with insulating oil, construction clean-up and commissioning.

The ground electrode required for Riel converter station will be located approximately 20 km from the station site. On the assumption of a shallow land ring electrode (similar to the electrodes used at the existing Henday and Radisson converter stations), the electrode will be a buried iron ring approximately 800 m in diameter and will require a site area in the order of one mile square, together with an access road for construction and ongoing maintenance. There will also be a low voltage line connection between the ground electrode site and the converter station. The line will be an overhead line supported by single wooden poles routed on a right-of-way on Manitoba Hydro property or within existing road allowances.

The low voltage connecting line between the ground electrode and the converter station dc switchyard will be an overhead pole line strung with two conductors and similar in scale to a distribution line. It is expected to be routed on its own right-of-way either within Manitoba Hydro property or right-of-ways associated with the existing station site, or within the road allowances of the municipal grid road system.

The electrode line will be designed using conventional distribution-class practice insulated by one or two HVdc bell units. The electrode line conductor will be similar to that of the pole conductors on the HVdc line, and will be supported on wood poles.

Construction power from the Riel sectionalization portion of the Riel station will be used for the Riel converter station and electrode site.

4.1.3.1 Connections to the Southern Receiver System

The BP III transmission line terminates at the Riel Station converter site, where the connections to the southern receiver system occur. The southern receiver system, serving Winnipeg and southern Manitoba, is fed from a network of 230 kV transmission lines originating at Dorsey Station and at a number of existing substations in the Winnipeg area. The Riel Sectionalization project includes sectionalization of several of these existing transmission lines, in order to enable injection of power from the sectionalized D602F at Riel. Although the resultant capacity of the 230 kV connections at Riel facilitates injection of power from Bipole III, additional transmission capacity will be required. The additional capacity will be provided by sectionalization of the existing Ridgeway-Richer 230 kV transmission line R49R at Riel Station.

4.1.4 Access Requirements

For Bipole III construction and maintenance purposes, Manitoba Hydro will use existing highways, municipal and forestry roads, trails and man-made linear features where possible, thereby minimizing the need to develop new access routes to the ROW. Access along the ROW will be restricted to the ROW as much as possible, with off-ROW deviations limited to natural terrain features such as rock outcrops, excessively steep slopes, and where ingress and egress to stream crossings are logistically challenging and/or environmentally risky.

Manitoba Hydro will limit all weather access development to spur roads extending from existing roads at the converter station sites, for the northern work camp, construction power station site and ground electrode sites. Access related to the construction and maintenance of the ground electrode lines, the construction power line (KN36), collector lines (L61C, C61H, C62H, C63H, C64H) and the Bipole III transmission line is limited to existing infrastructure and, where required, the development of seasonal trails for winter work.

4.1.5 Borrow Areas

Borrow areas and excavated material placement areas have been identified in the vicinity of Keewatinoow Converter Station for use at northern project components. While specific borrow sites have not yet been identified within these borrow areas, the terrain and soil conditions for these areas are generally understood. Additional existing and new borrow sites will be identified for other project components (i.e., HVdc Transmission Line and Access Roads); however, these locations are presently unknown.

Material from borrow sites will be excavated, and excavated material placement areas will be utilized for temporary storage, during Project construction and will generally be decommissioned prior to Project operation. Excavated material placement areas may also be utilized for medium-term storage of excavated materials; therefore, extending into the Project operation phase. Upland, mineral soil sites will generally be accessed for borrow materials.

Depending on the planned future use for the site, aggregate borrow sites should be closed, or reclaimed, in accordance with the Mine Closure Regulation, M.R. 67/99 and Manitoba Mine Closure Regulation 67-99 General Closure Plan Guidelines (Manitoba Industry, Trades and Mines, 2006).

4.2 PROJECT ACTIVITIES

For the purposes of effects assessment, project activities that have the potential to or are likely to affect the terrain and soil environment have been identified and are outlined in Table 4.1.

Activities are generally associated with the use of heavy equipment, removal of vegetation, grading, installing anchors and foundations and handling and storage of hazardous materials.

5.0 Existing Environment

5.1 EXISTING ENVIRONMENT DESCRIPTION

5.1.1 Study Area Overview

While the Project Study Area consists of a wide range of terrain, geology and soil properties, certain "high-level" observations can be made in terms of the baseline environment in relation to the proposed project.

5.1.1.1 Ecoregions Within the Study Area

The existing terrain and soil environment has been described on an ecosystem basis and generally summarized at the ecoregion level. Within the Local Study Area, the following ecozones and respective ecoregions are found:

- Hudson Plain Ecozone
    - Hudson Bay Lowland Ecoregion
- Taiga Shield Ecozone
    - Selwyn Lake Upland Ecoregion
- Boreal Shield Ecozone
    - Churchill River Upland Ecoregion
    - Hayes River Upland Ecoregion
- Boreal Plains Ecozone
    - Mid-Boreal Lowland Ecoregion
    - Interlake Plain Ecoregion
- Prairies Ecozone
    - Lake Manitoba Plain Ecoregion
    - Aspen Parkland Ecoregion

A map overview of the extent and distribution of the ecozones and ecoregions is found in Map 2 - Ecoregions of Manitoba. A summary of the existing terrain and soil environment for each ecozone and ecoregion, is found in Section 5.1.2, below.

5.1.1.2 Overview of Existing Geology Environment Information

To assist in the presentation and review of the existing geology environment, map figures are provided for bedrock geology (Map 3 - Bedrock Geology) and surficial geology (Map 4 - Surficial Geology) and should be referred to by the reader during review of the eco-region environment summary Section 5.1.2, below.

The proposed Bipole III transmission line preferred linear route will be constructed over the bedrock of the Precambrian Shield and the two large sedimentary basins defined below (Map 3 – Bedrock Geology, Figure 1).

Precambrian igneous and metamorphic bedrock occupies most of northern Manitoba stretching southeast to Ontario (Map 3 – Bedrock Geology). The Precambrian rock generally consists of granites and gneisses of the Churchill and Superior geological provinces. The Precambrian rocks divide two Phanerozoic sedimentary basins occupying the southwestern and northeastern parts of Manitoba.

In the southwestern portion of the Local Study Area, bedrock belongs to the Western Canada Sedimentary Basin (WCSB) and consists of Paleozoic, Mesozoic and Cenozoic deposits. Paleozoic rocks are generally carbonates with minor clastics and evaporites, while Mesozoic rocks are dominantly shales with lesser amounts of sandstones, carbonates and evaporites. Paleozoic and Mesozoic rocks dip gently toward the southwest. Cenozoic rocks are found only in the Turtle Mountain area, which is located far from the proposed project.

In the northeastern portion of the Local Study Area, sediments are primarily Paleozoic carbonates that form the Hudson Bay Basin (HBB). In this basin, sedimentary units gently dip toward the northeast.

In Manitoba, most of the bedrock is covered by surficial geological materials (overburden) consisting mainly of glacial tills (diamicton), **glaciofluvial**, **glaciolacustrine** sediments and **glaciomarine** deposits (Matile and Keller, 2007). The thickness of the overburden is highly variable from thin sediments and outcrops common in the Precambrian Shield to deposits over 100 m thick in locations of infilled bedrock channels and **moraines** primarily found in southern and western Manitoba (Betcher et al., 1995). These surficial geologic materials form the basis of soil parent materials.

In the southern portion of the Local Study Area, surficial geology is characterized as Pleistocene offshore and **distal** glaciofluvial sediments mainly consisting of clay, silt and fine sand deposited in a subaqueous environment (Map 4 – -Surficial Geology). The western part of the Local Study Area is generally comprised of poorly sorted/unsorted **calcareous** silty till (diamicton) of the Pleistocene age with rare occurrences of younger organic (peat) and **alluvial** sediments. In the northern part of the Local Study Area, Pleistocene offshore glaciofluvial clays and recent organic deposits are the most common surfical sediments.

5.1.1.3 Overview of Existing Soil Environment Information

To assist in the presentation and review of the existing environment, a series of thematic tables and map figures are provided and should be referred to by the reader during review of the following sections. Thematic products are based on the best available existing soil resource information, and include the following:

- Soil Order – dominant soil order classification (Map 100 - 1:17 – Soil Order; Table 5.1).
- Soil Drainage – dominant internal soil drainage regime (Map 200 - 1:17 – Soil Texture; Table 5.1).
- Surface Texture – dominant textural group of the upper most soil parent material (Map 300 – 1:17 – Soil Texture; Table 5.1).
- Permafrost – extent and distribution of continuous, extensive discontinuous, sporadic discontinuous and isolated patches of permafrost (Map 400 – 1:9 – Permafrost Distribution; Table 5.17).

Soil order describes a level of taxa in the Canadian Soil Classification System that reflect the nature of the soil environment and the effects of dominant, soil-forming process (Canada Expert Committee on Soil Survey 1998). The central concepts of the soil orders found throughout the Local Study Area are as follows:

- **Brunisolic** – well to poorly drained, forested, mineral soils with an intermediate level of development (i.e., presence of a B horizon).
- **Chernozemic** – well to imperfectly drained, grassland or grassland-forested, mineral soils with a surface horizon darkened by the accumulation of organic matter.
- **Crysolic** – mineral and organic soils affected by permafrost within 1 or 2 m which may or may not be affected by cryoturbation (mixing or disruption of soil horizons due to ice-action).
- **Gleysolic** – poorly to very poorly drained, mineral soils, affected by prolonged periods of intermittent or continuous wetting.
- **Luvisolic** – well to imperfectly drained, well developed, mineral soils, which generally have eluvial (characterized by the removal of material) and illuvial (characterized by the deposition of material) soil horizons.
- **Organic** – soil composed largely of organic materials and generally saturated for prolonged periods.
- **Regosolic** – weakly developed, mineral soils, **azonal** in distribution.

- **Vertisolic** – soils developed on lacustrine parent materials having a high clay content (> 60% clay) that exhibit unique shrinking and swelling properties.

- **Non-Soil** – the aggregate of surface materials that do not meet the definition of soil (e.g., bedrock).

A relatively even distribution areal extents of soil orders common to Manitoba was found throughout the Local Study Area (Table 5.1). However, these soil orders are not evenly distributed spatially throughout the Local Study Area (Map 100 - 1:17 – Soil Order). The northern portion of the Local Study Area, characterized primarily by wetland and forested land-uses, predominantly consists of Cryosolic and Organic orders in the low-lying and wetland areas, and the Brunisolic order in the upland, mineral soil areas. The Cryosolic soils are currently, or have been historically, influenced by permafrost. Agro-Manitoba predominantly consists of Chernozemic and Vertisolic orders, which are generally considered productive soils for agricultural production. The Regosolic, Gleysolic and Luvisolic soil orders, and Non-Soil are generally considered azonal in nature throughout the Local Study Area.

Soil drainage is predominantly very poorly, imperfect or well in the Local Study Area, with a combination of very poorly and well drained soils in the northern portion and predominantly imperfectly drained soils in the southern portion of the Local Study Area (Table 5.1, Map 200 - 1:17 – Soil).

Surface soil textures are an important consideration, as surficial soil horizons are relatively productive and maintenance of these typically thin and fragile horizons is a key consideration in the maintenance of soil productivity. Organic surface textures were found to be **mesic** and **fibric** in nature (Table 5.1). A large portion of the Local Study Area was found to have medium and very fine textured mineral surfaces (Table 5.1). Very fine and fine textured soils are important to consider, as they tend to be prone to compaction effects under trafficking. Another important consideration is coarse textured (very coarse, coarse and moderately coarse) surface materials, particularly when they occur on poorly developed soils, as they have little resistance to wind erosion. These surface textures occupy a minor portion of the Local Study Area (Table 5.1), and are distributed throughout the Local Study Area (Map 300 - 1:17 – Soil Texture).

5.1.2 Ecoregion-Based Summary of Existing Environment

5.1.2.1 Hudson Plain Ecozone

5.1.2.1.1 Hudson Bay Lowland

The bedrock in this ecoregion is primarily flat Paleozoic limestone with low relief (AAFC 1998). The area is dominated by organic deposits overlying marine sediments underlain by glacial till, which surfaces in some locations. The relief is characterized by post-glacial marine submergence and **isostatic rebound** of the land surface (AAFC 1998). The elevation ranges from 150 masl (meters above sea level) to 30 masl and slopes northward.

Soils are dominated by Organic Cryosols, and are **complexed** with Organic Mesisols. Common inclusions are **Terric Organic** soils in veneer bogs. Small occurrences of Brunisolic soils occur in association with exposed glaciofluvial deposits, beaches and outcropped loamy tills.

Approximately half of the Project Study Area in this ecoregion occupies an area dominated by Organic Cryosols, while the other half occupies an area largely dominated by **Eutric** Brunisols (Centre for Land and Biological Resources Research 1996[2]).

The Local Study Area occupies 27,447 ha within the Hudson Bay Lowland ecoregion, while the HVdc right-of-way occupies 367 ha. The study area here is dominated by soils of the Cryosolic and Brunisolic soil orders (Table 5.2a), the Cryosols being entirely composed of Organic Cryosols. Minor areas of Organic soils occur in association with the Cryosolic soils, while Luvisolic soils also occur in this ecoregion and are associated with better drained till, lacustrine and glaciofluvial deposits. The landscape is dominated by very poorly drained soils, which correlates with the Cryosols and Organics, and by rapid and well drained soils, which correlates with the Brunisols and Luvisols. The Cryosols and Organics are dominantly Mesic in parent material texture, indicating that these organic materials are at an intermediate stage of decomposition. The Brunisols are evenly distributed between the medium and moderately fine soil texture groups. A small proportion of the Brunisols have coarse skeletal texture, indicating high gravel content (>35%), with rapid drainage.

5.1.2.2 Taiga Shield Ecozone

5.1.2.2.1 Selwyn Lake Upland

The bedrock in this ecoregion is composed of crystalline Archean massive rocks tilted to the northeast (AAFC 1998). Elevation ranges from 510 masl in the western uplands to 120 masl in the southeast. Surficial deposits range greatly with ridged hummocky bedrock outcrops with veneers and blankets of acidic till in the west to extensive loamy calcareous till often overlain by lacustrine and peat deposits in the east. Prominent glaciofluvial features are widespread throughout the ecoregion.

The western portion of the ecoregion is dominated by **Dystric** Brunisols, with inclusions of Static Cryosols. In the eastern portion (lower elevations), the ecoregion is dominated by Organic Cryosols with inclusions of Gray Luvisols on lacustrine sediments, Eutric Brunisols on calcareous tills and Turbic Cryosols on loamy to clay sediments.

The portion of the Project Study Area in this ecoregion traverses an area dominated by Organic Cryosols (Centre for Land and Biological Resources Research 1996).

The Local Study Area occupies 4,360 ha within the eastern portion of the Selwyn Lake Upland ecoregion, while the HVdc right-of-way occupies 52 ha. The soils are dominated by soils of the

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[2] Soil Landscapes of Canada. Version 2.2b.

Brunisolic order (Table 5.2b). Minor areas of Cryosolic and Luvisolic soils are also present, the Cryosols being entirely composed of Organic Cryosols. The landscape is dominated by rapid and well drained soils, which correlates with the Brunisols and Luvisols, with minor inclusions of poorly and very poorly drained soils (the Cryosols). The majority of the Brunisols have coarse skeletal texture, indicating high gravel content (>35%), with rapid drainage. The Brunisols also have considerable areas of medium and moderately fine soil texture groups. The Cryosols are evenly split between Fibric and Mesic parent material texture, the former indicating relatively un-decomposed materials, the latter indicating that these organic materials are at an intermediate stage of decomposition.

5.1.2.2.2 Churchill River Upland

The ecoregion occupies part of the Kazan Upland and sits on massive crystalline Precambrian rocks (Precambrian Shield). Landforms in the western part of the ecoregion are dominated by ridged and hummocky bedrock outcrops covered with veneers and blankets of sandy tills. The eastern portion is characterized by depressed to hummocky lacustrine sediments, commonly covered by peat deposits of varying depths. Prominent glaciofluvial features are present in the eastern portion of the ecoregion. These features can have considerable relief of up to 60 m with steep slopes. Elevation ranges from 450 masl near the Saskatchewan border to 150 masl along the east boundary near Grass River (AAFC 1998).

Eutric Brunisols dominate on the sandy tills and glaciofluvial features, while Gray Luvisols dominate the well- and imperfectly-drained lacustrine clay deposits. Granitic outcrops are co-dominant in the ecoregion, characterized by Mesisols, Fibrisols and Cryosols in bog basins, peat plateaus and veneer bogs. Permafrost is common in the north of this ecoregion, but diminishes to sporadic in the south (AAFC 1998).

The portion of the Project Study Area in the northern part of this ecoregion traverses large extents of Organic Cryosols and Gray Luvisols with minor occurrences of Eutric Brunisols (Centre for Land and Biological Resources Research 1996). In the southern portion of the ecoregion, the Project Study Area traverses considerable extents of Mesisols, Fibrisols, Eutric Brunisols and exposed bedrock.

The Local Study Area occupies 53,565 ha within the Churchill River Upland ecoregion, while the HVdc right-of-way occupies 746 ha. The soils are evenly distributed between soils of the Cryosolic (35%), Organic (24%) and Luvisolic (32%) soil orders (Table 5.2c), the Cryosols being dominantly composed of Organic Cryosols. Minor areas of Brunisolic and Regosolic soils occur within this region. The landscape is dominated by very poorly drained soils, which correlates with the Cryosols and Organics, and by rapid, well and moderately well drained soils, which correlates with the Luvisols, Brunisols and Regosols. The Cryosols and Organics are dominantly Mesic in parent material texture, indicating that these organic materials are at an intermediate stage of decomposition; however a considerable portion of these soils are Fibric in texture, indicating relatively un-decomposed materials. The Brunisols are evenly distributed between the medium and moderately fine soil texture groups. The Luvisols, Brunisols and Regosols are represented by very fine, fine, medium and coarse skeletal textures. The Luvisols are generally correlated with the very fine and fine soil textures associated with lacustrine clay deposits, while the Brunisols are correlated to the coarser textured tills and glaciofluvial deposits.

5.1.2.2.3 Hayes River Upland

The ecoregion occupies part of the Severn Upland and sits on crystalline **Archaen** massive rocks. This ecoregion was strongly glaciated and exhibits ridged to hummocky bedrock outcrops with discontinuous veneers and blankets of acidic sandy till in the south, and calcareous, sandy to loamy till in the north. Large areas are also covered with glaciolacustrine clay veneers and blankets, veneer bogs and flat bogs. Elevation ranges within the Project Study Area from 250 masl at the southern edge of the ecoregions to 210 masl at the northern edge of the ecoregion (AAFC 1998).

The northern half of the ecoregion is dominated by Organic Cryosols developed on veneers and peat plateau bogs. In the southern portion of the ecoregion, Mesisols and Fibrisols are the dominant soils, with considerable extents of Eutric and Dystric Brunisols developed on glaciofluvial deposits and Gray Luvisols developed on silty to clayey glaciolacustrine and glaciofluvial sediments. The entire ecoregion is characterized by bedrock outcrops (AAFC 1998).

The Project Study Area follows the northern edge of the ecoregion characterized dominantly by Gray Luvisols developed on lacustrine sediments, with large extents of Organic Cryosols in the extreme northeast of the ecoregion (Centre for Land and Biological Resources Research 1996Centre for Land and Biological Resources Research 1996).

The Local Study Area occupies 142,718 ha within the Hayes River Upland ecoregion, while the HVdc right-of-way occupies 1,948 ha. The soils are evenly distributed between soils of the Luvisolic (42%), Cryosolic (28%) and Organic (13%) soil orders, with considerable portions of the land base represented by Brunisolic soils (Table 5.2d). The Cryosols are entirely composed of Organic Cryosols. Minor areas of Gleysolic soils occur within this region. The landscape is dominated by well drained soils, which correlates with the Luvisols and Brunisols and by very poorly drained soils, which correlates with the Cryosols and Organics. The Luvisols are dominantly within the very fine and fine soil texture groups associated with glaciolacustrine clay deposits. The Cryosols and Organics are dominantly Mesic in parent material texture, indicating that these organic materials are at an intermediate stage of decomposition; however a considerable portion of these soils are Fibric in texture, indicating relatively un-decomposed materials. The Brunisol soil textures vary considerably from moderately fine to coarse skeletal; these soils are associated with glaciofluvial landscape features.

5.1.2.3 Boreal Plains Ecozone

5.1.2.3.1 Mid-Boreal Lowland

This ecoregion occupies the northern part of the Manitoba Plain and extends from the west shore of Lake Winnipeg to the Saskatchewan border. The area is underlain by low relief Paleozoic limestone bedrock that is extensively covered by glacial deposits of varying thickness (AAFC 1998). The limestone is at or near the surface along escarpments, ridges and channels. The ecoregion is level with north to south drumlinoid or ridged topographic pattern slopes. Elevation ranges from 350 masl at the Saskatchewan border to 250 masl along the eastern edge of the Project Study Area (AAFC 1998).

Clay, silt and sand deposits originating from glacial Lake Agassiz have smoothed the plain, and were subsequently covered by extensive organic deposits forming flat bogs and horizontal fens. Limestone domes with slopes ranging from 5 to 10% occur north of Clearwater Lake. Beaches marking the various water levels of Lake Agassiz can be found along The Pas moraine and along the exposed limestone bedrock north of Grand Rapids on the northwest shore of Lake Winnipeg (AAFC 1998).

The co-dominant soils in the region are Eutric Brunisols developed on the loamy till materials, and Organic Mesisols and Fibrisols in very poorly drained areas. Other important soils are Gray Luvisols developed on the well- to imperfectly-drained loamy to clayey tills and clayey to silty glaciolacustrine deposits (AAFC 1998).

The Project Study Area traverses through the northwest and west portions of the ecoregion (Centre for Land and Biological Resources Research 1996). The dominant soils of importance are organic Mesisols and Fibrisols. A smaller component of Eutric Brunisols is traversed in the northern portion of the ecoregion.

The Local Study Area occupies 128,481 ha within the Mid-Boreal Lowland ecoregion, while the HVdc right-of-way occupies 1,767 ha. The soils are dominated by soils of the Organic Order, while considerable areas of Brunisolic and Gleysolic soils are also found (Table 5.2e). Minor areas of Regosolic, Luvisolic, and Chernozemic soils occur within the landscape. The Mid-Boreal Lowland ecoregion transitions from the northern forested soils to southern prairie soils as demonstrated by the inclusion of both Cryosolic and Chernozemic soils. The Organic soils are evenly distributed across the Fibric and Mesic textures and are characterized by very poor drainage. The Brunisolic soils have textures varying from coarse skeletal to medium and are predominantly imperfectly drained. The Gleysolic soils have medium to fine soil textures and are characterized by a poor drainage regime.

5.1.2.3.2 Interlake Plain

This ecoregion forms a broad arc from the USA-Canada border extending northwest across the Interlake region and ending at Red Deer Lake along the Saskatchewan border. This ecoregion also marks the southern limit of the boreal forest and the northern limit of commercial agriculture

(AAFC 1998). Low relief, flat, Paleozoic limestone bedrock underlies the Interlake Plain. The Interlake and Westlake sections are characterized by low relief, north to south ridge and swale topographic patterns with slopes from 1 to 3%. In these sections, the deposits are extremely calcareous, very stony water-worked tills over bedrock ranging from <20 m to >30 m thick. East and southeast of these sections, the water-worked till is covered by thin, discontinuous veneers and blankets of sandy to clayey glaciolacustrine deposits and sandy to gravelly beach deposits and bouldery near-shore deposits (AAFC 1998). Elevation in the ecoregion varies from 410 masl near the Manitoba Escarpment in the northwest to 260 masl along the eastern edge of the Project Study Area.

The Interlake Plain is dominated by well- to imperfectly- drained Dark Gray Chernozems with considerable inclusions of well to imperfectly-drained Black Chernozems, all developed on very to extremely calcareous, fine textured glaciolacustrine materials that overly glacial till. The occurrence of Eutric Brunisols and Gray Luvisols on till is limited; Organic Mesisols occupy the depressions while peaty Humic Gleysols are found in transitional areas (AAFC 1998). The Project Study Area traverses Regosols, Mesisols, Fibrisols and Eutric Brunisols north and south of the Swan River Valley, and Black Chernozems through the Swan River Valley (Centre for Land and Biological Resources Research 1996).

The Local Study Area occupies 91,574 ha within the Interlake Plain ecoregion, while the HVdc right-of-way occupies 1,252 ha. The soils are evenly distributed across the Gleysolic (33%), Organic (25%) and Chernozemic (25%) soil orders, while minor areas of Brunisolic, Regosolic and Luvisolic soils are also found (Table 5.2f). The Gleysolic soils are dominantly medium textured and have poor drainage. The Organic soils are evenly distributed across the Fibric and Mesic textures and are characterized by very poor drainage. The Chernozemic soils have textures varying from coarse to fine and are predominantly imperfectly drained.

5.1.2.4 Prairie Ecozone

5.1.2.4.1 Lake Manitoba Plain

This ecoregion occupies a large portion of southern Manitoba, extending from the International Border northward to Lake Dauphin, with the Manitoba Escarpment as its western boundary. It is located within the lowest level of the prairies, the Manitoba Plain. The Lake Manitoba Plain is a mixture of glacial till and glaciolacustrine silts and clays from glacial Lake Agassiz, all underlain by flat Paleozoic limestone bedrock (AAFC 1998).

The northern half of the ecoregion is characterized by a ridge and swale topographic pattern with a north-south orientation, with fluting or grooving along the ridges. The fluting is a result of iceberg scouring as Lake Agassiz retreated. Wave action also resulted in local texture variations with finer materials in the depressions and coarser textured materials on the ridges. The southern half of the ecoregion is a smooth, thick and generally varved glaciolacustrine deposit composed of clays and silts. Relic beaches are found along the Manitoba Escarpment and mark the successively lower water levels of Lake Agassiz (AAFC 1998). Elevation ranges from 410 masl at the Manitoba Escarpment to 240 masl in the Red River Valley (AAFC 1998).

The Project Study Area is dominated by Black Chernozems, with small areas of Gleysols and Vertisols in the glaciolacustrine sediments and Regosols associated with drainage channels (Centre for Land and Biological Resources Research 1996).

The Local Study Area occupies 216,256 ha within the Lake Manitoba Plain ecoregion, while the HVdc right-of-way occupies 2,994 ha. The soils are dominated by soils of the Chernozemic Order (43%), while considerable areas of Vertisolic (31%) and Gleysolic (17%) soils are also found (Table 5.2g). The Local Study Area intersects the Lake Manitoba Plain ecoregion in highly productive agricultural regions of the province that are dominated by grassland soils (Chernozems), most of which have been converted to agricultural land-use. The Chernozemic soils are dominantly medium or coarse in texture and have imperfect drainage (gleyed subgroups). The Vertisolic soils are developed on very fine textured soils and are dominantly poorly drained with considerable portions of imperfectly drained soils. The Gleysolic soils are distributed throughout all texture groups, all characterized by poor drainage.

5.1.2.4.2 Aspen Parkland

In Manitoba, the Aspen Parkland ecoregion occupies the southwest corner of the province and forms the transitional area between the boreal forest to the north and east and the grasslands to the west. The eastern boundary of the ecoregion is marked by the Manitoba Escarpment, which marks the step down to the Manitoba Plain from the Saskatchewan Plain. This ecoregion is characterized by a variety of glacial deposits: dominated by kettled to undulating loamy glacial till, with important areas of level to gently undulating sandy glaciofluvial and glaciolacustrine and eolian dunes with slopes that range to 30% and steeper (AAFC 1998). Elevation ranges from 320 masl at the Manitoba Escarpment to 600 masl in the uplands of the ecoregion along the western edge of the Project Study Area (AAFC 1998).

The soils of the Aspen Parkland are dominantly Black Chernozems developed from the moderately to very strongly calcareous glacial till, with considerable areas of Regosols in the coarse materials and Humic Gleysols in poorly drained areas (AAFC 1998). The Project Study Area skirts the northern edge of the ecoregion, mostly traversing Black Chernozems, but also Regosols associated with the Assiniboine River valley and the glacial Assiniboine Delta (Centre for Land and Biological Resources Research 1996).

The Local Study Area occupies 1,780 ha within the Aspen Parkland ecoregion, while the HVdc right-of-way occupies 9 ha. The soils are co-dominated by soils of the Regosolic (46%) and Chernozemic Order (45%), while minor areas of Gleysolic soils are also found (Table 5.2h). The Local Study Area intersects the eastern edge of the Aspen Parkland ecoregion. The Chernozemic soils are dominantly medium to moderately coarse in texture and are characterized by well drained (dominant) and imperfectly drained (significant) soils. The Regosols soils are developed predominantly on coarse textured soils and are dominantly imperfectly drained with considerable portions of well drained soils. The Gleysolic soils are distributed throughout all texture groups, all characterized by poor drainage.

5.1.3 Site-Specific Environment Descriptions

A review of the existing environment for specific project components is warranted where environmental effects and/or project life cycles differ from those of the transmission line components. These data are presented below.

5.1.3.1 Northern AC Collector Lines

The northern AC Collector Lines are located in a 310 metre corridor that parallels the north shore of the Nelson River in a northeast to southwest direction (Map 5 - Northern Infrastructure - Soil Baseline Conditions). The corridor is approximately 26 kilometres in length and covers an area of 822 hectares. The best available existing soil data for the area are from the Biophysical Reports of Hayes River (Mapsheet 54-C) and Kettle Rapids (Mapsheet 54-D) with soil data presented at a scale of 1:125,000. The corridor is located in an area dominated by Organic Cryosols which represents the dominant soil type mapped within the corridor itself (476 ha, 58%). Other important soils mapped in the proposed corridor are Organic soils (non-frozen, 255.5 ha, 31%) and Eutric Brunisols (83.3 ha, 10%). The Brunisols are associated with mineral deposits that border streams. The corridor is dominantly very poorly to poorly drained (731.4 ha, 89%) and consists mostly of mesic (509 ha, 62%) and fibric (222 ha, 27%) soil textures (Table 5.3).

5.1.3.2 Construction Power Site

The Construction Power site is located along the Conawapa road and is 2.3 ha in size (Map 6 - Construction Power Site - Soil Baseline Conditions). The best available existing soil data for the area is from the Biophysical Report of Kettle Rapids (Mapsheet 54-D) with soil data presented at a scale of 1:125,000. The site falls entirely within one soil polygon described as containing three soil types: a well-drained, medium-textured eluviated Eutric Brunisol (1.1 ha), a very poorly drained, fibric-textured Terric Mesic Organic Cryosol (0.7 ha), and a poorly drained, fibric-textured Mesic Organic Cryosol (0.5 ha, Table 5.5).

Four soil landscape inspections were completed at the site on October 7th, 2010. Three of the soil landscape inspection sites were classified as Terric Mesisols (MHCPS01, 03, 04), while the fourth site (MHCPS02) was classified as a Rego Gleysol.Gleysol The soils identified on the site during the soil landscape inspection differ slightly in terms of the absence of permafrost soils as described in the Biophysical Report; however the sequence of materials (mesic over mineral) is consistent with the existing data for the area. Organic materials at the surface (topsoil) ranged from 33 cm to 98 cm in thickness above the contact with mineral soil.

5.1.3.3 Keewatinoow Construction Camp

The Keewatinoow Construction Camp site is located along the Conawapa road and is 27.6 ha in size (Map 8 - Keewatinoow Conveter Station - Soil Baseline Conditions). The best available existing soil data for the area is from the Biophysical Report of Hayes River (Mapsheet 54-C) with soil data presented at a scale of 1:125,000. The site falls entirely within two soil polygons described as containing three soil types: a well-drained, medium-textured eluviated Eutric Brunisol (24.5 ha), a very poorly drained, fibric-textured Terric Mesic Organic Cryosol (1.9 ha), and a poorly drained, fibric-textured Mesic Organic Cryosol (1.3 ha, Table 5.7).

5.1.3.4 Keewatinoow Converter Station

The Keewatinoow Converter Station site is located along the Conawapa road and is 120 ha in size (Map 9 - Preferred Northern Ground Electrode - Soil Baseline Conditions). The best available existing soil data for the area is from the Biophysical Report of Hayes River (Mapsheet 54-C) with soil data presented at a scale of 1:125,000. The site falls within two soil polygons. The larger of the polygons is described as containing three soil types: a well-drained, medium-textured eluviated Eutric Brunisol (49 ha), a very poorly drained, fibric-textured Terric Mesic Organic Cryosol (29 ha), and a poorly drained, fibric-textured Mesic Organic Cryosol (20 ha, Table 5.8). The smaller polygon is described as containing two soil types: a very poorly drained, mesic-textured Terric Mesic Organic Cryosol (16 ha) and a very poorly drained, mesic-textured Typic Mesisol (7 ha).

Eight soil landscape inspections were completed at the site on October 7th, 2010. Five of the soil landscape inspection sites were classified as Terric Mesisols (MHCON01-03, 06, 08), one site was classified as a Terric Mesic Organic Cryosol (MHCON05), one site was classified as a Rego Gleysol (MHCON04) and the last site was classified as a Gleyed Regosol (MHCON07). The soils identified on the site during the soil landscape inspection differ slightly in terms taxonomy as described in the Biophysical Report; however the sequence of materials (mesic, mesic over mineral and mineral) is consistent with the existing data for the area. Organic materials at the surface (topsoil) ranged from 21 cm to 130 cm in thickness above the contact with mineral soil. A gravel pad exists at the site.

5.1.3.5 Northern Electrode Sites

Two ground electrode sites were assessed as part of this report: the Preferred Northern Ground Electrode, NES6 (Map 9 - Preferred Northern Ground Electrode - Soil Baseline Conditions) and the Alternate Northern Ground Electrode, NES7 (Map 10 - Alternate Northern Ground Electrode - Soil Baseline Conditions).). Existing biophysical reconnaissance soil resource information and field assessments were used to evaluate the sites, with a minimum of 2 soil landscape inspections per ground electrode site. Each site is 400 ha in size, located on the north bank of the Nelson River on the north side of the Conawapa gravel road; soil data for each potential site is summarized in Table 5.9.

Three soil landscape inspections were completed at the NES6 site on October 7th, 2010. Two of the soil landscape inspection sites were classified as Terric Mesic Organic Cryosols (MHNE06-1 and MHNE06-3), and one site was classified as a Typic Mesisol (MHNE06-2). The soils identified on the site during the soil landscape inspection are in agreement with the soils described in the Biophysical Report.

Three soil landscape inspections were completed at the NES7 site on October 7th, 2010. One of the soil landscape inspection sites were classified as a Gleyed Eluviated **Eutric** Brunisol (MHNE07-1), the second site was classified as a Gleyed Regosol (MHNE07-2); and the third site was classified as a Rego Gleysol (MHNE07-3). The soils identified on the site during the soil landscape inspections differ slightly in terms taxonomy as described in the Biophysical Report; however the sequence of materials (mesic, mesic over mineral and mineral) is consistent with the existing data for the area. Organic materials at the surface (topsoil) ranged from 19 cm to 50 cm in thickness above the contact with mineral soil.

5.1.3.6 Northern Electrode Line

The northern electrode line runs from Keewatinoow Converter Station to the Northern Electrode Site (Map 5 - Northern Infrastructure - Soil Baseline Conditions). A summary of soil information for the Northern Electrode Line is found in Table 5.10. The route is characterized by dominant occurrence of well drained, Eluviated Eutric Brunisols. A considerable portion of the route is characterized by poorly drained Organic Cryosols.

No soil inspections or mapping was conducted on this route, as it was not available at the time of the field and desktop assessment.

5.1.3.7 Southern Converter Station

The Southern Converter Station site is located within an existing developed site between the Red River Floodway and Deacon road, south of Highway 15, and is 69.6 ha in size (Map 11 - Riel Converter Station - Soil Baseline Conditions). The best available existing soil data for the area is from the Manitoba Land Initiative with digital soil data presented at a scale of 1:20,000. The site is characterized by three soil types: an imperfectly drained, very fine textured Gleyed **Humic** Vertisol (35.2 ha), a poorly and imperfectly drained, very fine textured **Gleysolic** Humic Vertisol (25.3 ha), and an imperfectly drained, fine textured Gleyed Rego Black Chernozem (9.2 ha). The site is dominantly rated as Agricultural Capability Class 2 (44.4 ha) and Agricultural Capability Class 3 (25.3 ha) (Table 5.12). No soil inspections were completed at the site in the fall of 2010 as the site is fully developed into a gravel pad.

5.1.3.8 Southern Electrode Sites

Two ground electrode sites were assessed as part of this report: the Preferred Southern Ground Electrode, SES1c (Map 12 - Preferred Southern Ground Electrode - Soil Baseline Conditions), and the Alternate Southern Ground Electrode, SES3 (Map 13 - Alternate Southern Ground Electrode - Soil Baseline Conditions). Existing reconnaissance soil resource information was used to evaluate the SES1c site, while existing detailed soil resource information and field assessments were used to evaluate the SES3 site. The SES1c site is 271 hectares and is located northwest of Anola, MB, at Section 21, Township 11, Range 6 East of Prime Meridian. The SES3 site is 259 hectares and is located northeast of Anola, MB, and occupies the south half of Section 13, Township 11, Range 7 East of Prime Meridian and the north half of Section

12, Township 11, Range 7 East of Prime Meridian; soil data for each potential site is summarized in Table 5.12.

The best available existing soil data for the SES1c site is from the Reconnaissance Survey of the Winnipeg-Morris map sheet, with soil data presented at a scale of 1:126,720. The site is dominated by an imperfectly drained, very fine textured, Gleysolic Humic Vertisol (250 ha) and has considerable areas of imperfectly drained, very fine textured, Gleyed Humic Vertisols (20 ha). The Gleysolic Humic Vertisols are classed as Class 2 while the Gleyed Humic Vertisols are classed as Class 3 for Agricultural Capability.

The best available existing soil data for the SES3 site is from the Detailed Survey of the Winnipeg Region, with soil data presented at a scale of 1:20,000. The site is dominated by a very poorly drained, mesic-textured, Terric Mesisol (136 ha) and an imperfectly drained, medium textured, Gleyed Dark Grey Chernozem (94 ha). The site also has areas of poorly drained, medium textured, Rego Humic Gleysols (17 ha) and areas of well drained, medium textured Orthic Dark Grey Chernozems (13 ha). The organic soils (136 ha) are classed as Class O, the Chernozemic soils (107 ha) are classed as Class 3 and the Gleysolic soils (17 ha) are classed as Class 5 for Agricultural Capability.

Three soil landscape inspections were completed at the SES3 site on September 30th, 2010. One of the soil landscape inspection sites were classified as an Orthic Dark Grey Chernozem (MHSE07), the second site was classified as a Terric Mesisol (MHSE08); and the third site was classified as a Gleyed Rego Black Chernozem (MHSE09). The soils identified on the site during the soil landscape inspections are in agreement with the soils described in the soil survey for the area.

5.1.3.9 Associated Components

Borrow Areas, Excavated Material Placement Areas and Lagoons

Borrow areas, excavated material placement areas and a lagoon siting area have been identified in the vicinity of Keewatinoow Converter Station and Construction Camp. A review of mapped data indicate these borrow sites and the lagoon siting area are located on primarily well drained Brunisolic soils; whereas, the excavated material placement areas are located on both very poor and well drained permafrost-affected (discontinuous) and Brunisolic soils.

As identified in Section 4.1.5, additional borrow areas required for the HVdc right-of-way and other project components have not yet been identified. It is anticipated that existing, permitted borrow sites will be utilized to the extent feasible, prior to the creation of new sites.

Access Routes

Preliminary routes for construction access to the HVdc right-of-way have been identified. These potential access routes are primarily located along existing access opportunities (e.g., other linear disturbances) within the Local Study Area.

Soil orders potentially traversed by access routes are predominantly Organic, Brunisolic and Luvisolic Soils, with a minor number of potential routes traversing Gleysolic, Regosolic and permafrost-affected soils. Drainage is predominantly very poor, imperfect and well along the proposed access routes, occupied by predominantly very fine, moderately coarse and mesic textured soils. The majority of access routes within Agro-Manitoba are located on the existing road network, with a minority of access routes located on lands with moderate limitations for arable agriculture (i.e., Class 3). Potential access routes in the northern portion of the Local Study Area in areas of permafrost-affected soils primarily traverse sporadic discontinuous and extensive discontinuous permafrost.

5.2 VALUED ENVIRONMENTAL COMPONENTS

Soil productivity, unique terrain/soil features and stable terrain have been identified as VECs of the terrain and soil environment. Descriptions of terrain and soil VECs, including rationale for selection, environmental indicators and measurable parameters, are discussed below and summarized in Table 5.13.

5.2.1 Soil Productivity

5.2.1.1 Agricultural Capability

In Agro-Manitoba, primarily in the southern portion of the Local Study Area, the productivity of soils for arable agriculture is valued by agricultural producers as a primary source of income. In addition, agricultural production is of general benefit to society and its importance was confirmed through Aboriginal Traditional Knowledge shared by First Nations, such as the Dakota Plains First Nation and Long Plain First Nation, during meetings, workshops and interviews conducted by Manitoba Hydro. The potential for loss of agricultural land due to tower placement in Agro-Manitoba was a concern raised by many participants of the Environmental Assessment Consultation Process for the Project. Maintenance of soil productivity for lands under annual and perennial agricultural crop production is important to minimize disruption to agricultural producers.

5.2.1.1.1 Environmental Indicators/Measurable Parameters

The primary environmental indicator of change to agricultural capability in Agro-Manitoba is the Agricultural Capability Rating (i.e., class) of soils. The Soil Capability for Agriculture (Canada Land Inventory 1965), commonly referred to as Agricultural Capability, is one of the most commonly used agricultural interpretations for soil productivity in agricultural lands in Manitoba.

The Agricultural Capability rating provides a numeric class rating between 1 and 7, which provides an overall indication of the capability of the land to support agricultural crop production, as determined by: soil moisture holding capacity, topography, soil structure and permeability, salinity, **sodicity**, erosion, stoniness, drainage and organic matter content.

Class 1 has the least limitation to support agriculture, with class 7 having the greatest limitation. Subclass ratings are used to provide detail on the specific soil and landscape limitation(s) resulting in the overall class rating; however, these were not considered as part of this evaluation.

Agricultural capability is summarized by class (Fraser et al. 2001) below:

- Class 1 – soils in this class have no important limitations for crop use.
- Class 2 – soils in this class have moderate limitations that reduce the choice of crops or require moderate conservation practices.
- Class 3 – soils in this class have moderate limitations that restrict the range of crops or require moderate conservation practices.
- Class 4 – soils in this class have severe limitations that restrict the choice of crops or require special conservation practices or both.
- Class 5 – soils in this class have very severe limitations that restrict their capability to producing perennial forage crops, and improvement practices are feasible.
- Class 6 – soils in this class are capable only of producing perennial forage crops and improvement practices are not feasible.
- Class 7 – soils in this class have no capability for arable culture or permanent pasture because of extremely severe limitations.
- Organic soils (represented as class "O") and non-soils are considered to have no capability for arable agriculture.

Individual soil and landscape limitations to agricultural capability are the basis for determining agricultural capability class, and include the following subclasses:

- Climate (C)
- Consolidated Bedrock (R)
- Moisture Limitation (M)
- Topography (T)
- Structure and/or Permeability (D)
- Salinity (N)
- Inundation (I)
- Excess Water (W)
- Stoniness (P)
- Erosion (E)
- Cumulative minor adverse characteristics (X)

Meaningful evaluations of agricultural capability post-disturbance could be conducted by comparing against existing (i.e., baseline) agricultural capability ratings for an area in question, or comparing to similar, undisturbed soil-landscapes.

5.2.1.1.2 Data Summary

Agriculturally capable land is primarily located within the Lake Manitoba Plain and Interlake Plain ecoregions of the Local Study Area. Approximately 42% of the right-of-way under agricultural production is rated as Classes 1 to 3 with no to moderate limitations for arable agriculture, while 38% is rated as Classes 4 and 5, with severe to very severe limitations. The remaining land has no capability for arable agriculture (9%) or is limited to perennial forage production (Class 6 - 7). A detailed summary of Agricultural Capability classes within the Local Study Area and HVdc right-of-way within agro-Manitoba is found in Table 5.14 and is displayed in Map 500 - 1:17 – Agricultural Capability.

Over half (52%) of the agricultural land in the Lake Manitoba Plain ecoregion was found to be in Classes 1 to 3 (Table 5.14), while 39% was found to be in Classes 4 and 5. The remaining 9% of the land within this ecoregion was found to have little or no capability for arable agriculture.

The Interlake Plain ecoregion contains approximately 20% of land in Classes 1 to 3, and approximately 36% in Classes 4 and 5. Approximately 16% of the ecoregion consists of Class 6 land with capability only for perennial forage production. A considerable portion of the land (24%) is classified as organic (i.e., non-mineral soils), with no capability for arable agriculture.

Only 9 ha of the Local Study Area within the Aspen Parkland ecoregion is considered under agricultural land use (Table 5.14).

For the transmission line right-of-way, the largest extent of arable agricultural soils (Class 1-3) occurs between PTH 13 and the Riel Converter Station, east of the Portage la Prairie Area (Map 500 – 16:17 – Agricultural Capability). The second largest extent occurs between the Whitemud River area east of Gladstone to where the right-of-way crosses PTH 1 west of Portage la Prairie (Map 500 - 15 – Agricultural Capability). The area between PTH 1 and PTH 13 contains soils (Class 3-4) with moderate to severe restrictions for arable agriculture, where special conservation practices are required.

Additional isolated regions of arable agricultural soils are located in the Steep Rock River area southwest of Dawson Bay (Map 500 - 10 – Agricultural Capability); the Swan River/Swan Lake area north and east of Minitonas (Map 5.17 J); the Duck, Pine, Garland and Point River areas (Map 500 - 11 – Agricultural Capability); the Mossy River and Lytwyns Lake area near east of Winnipegosis (Map 500 – 12 – Agricultural Capability); and the area west and southwest of Ebb and Flow Lake (Map 500 - 13 – Agricultural Capability).

Of the infrastructure components sites, the southern converter station (Riel site) and preferred and alternate southern ground electrode sites are located within agricultural areas. The preferred southern ground electrode site is primarily rated as Class 3 land (93%), requiring moderate conservation practices; whereas, the alternate southern ground electrode site has a mixture of mineral (47%) and organic soils (53%) and therefore has moderate to no capability for arable agriculture, respectively. The Riel site is not currently under agricultural production.

5.2.1.2 Topsoil Quality

Outside of agro-Manitoba, primarily in the northern portion of the Project Study Area, soil productivity is necessary to support natural ecosystems (e.g., vegetation, wildlife) and is therefore of value to resource users and society. The importance of vegetation, including blueberries and medicinal plants, was emphasized by community members in the Environmental Assessment and Consultation Process and Aboriginal Traditional Knowledge (ATK) workshops.

5.2.1.2.1 Environmental Indicators/Measurable Parameters

The primary indicator of soil productivity outside of agro-Manitoba is the quality of mineral topsoil and organic soils. Mineral soil quality in northern Manitoba is indicated by surface horizon thickness, bulk density and carbon content of organic-enriched surface horizons; whereas, organic soil quality is indicated by the thickness and nature of surface horizons. These indicators of mineral and organic soil quality are in turn related to other physical and chemical soil properties, such as pH, nutrient status, water holding capacity and drainage, which act to influence the capability of the soil to provide ecosystem function.

Individual parameters that can be measured to evaluate topsoil quality include, but are not limited to, topsoil thickness, topsoil colour, organic matter content, soil texture (particle size distribution and coarse fragment content), salinity, pH, nutrient/fertility status, bulk density, soil resistance to penetration as a measure of degree of compaction, and soil temperature.

Meaningful evaluations of topsoil productivity by measuring representative parameters post-disturbance could be conducted by comparing disturbed areas to similar, undisturbed soil-landscapes. Appropriate parameters to evaluate topsoil quality are dependent on the nature of the issue or effect to assess, and should be selected based on professional judgment. For example, if the effect of heavy equipment traffic on soil compaction needs to be assessed, soil resistance to penetration using a penetrometer could be measured at the disturbed site and a similar, non-disturbed site. Alternatively, soil samples could be taken to assess soil bulk density, using a variety of sampling approaches.

5.2.1.2.2 Data Summary

The nature of the soil productivity VEC in northern, non-agro Manitoba precludes a meaningful data summary.

5.2.2 Unique Terrain/Soil Features

Unique terrain/soil features are important to overall terrain/soil integrity as they represent relatively uncommon terrain/soil occurrences and have special physical, aesthetic, social, cultural or inherent terrain/soil diversity value.

There are two sub-categories of the unique terrain/soil features VEC – **rare occurrence** and/or **single occurrence** PAI enduring features located within ASIs and other unique terrain/soil features.

5.2.2.1 Protected Areas Initiative (PAI) Enduring Features

Identified through Manitoba Conservation's Protected Areas Initiative (PAI), enduring features, are unique combinations of soils, geology and terrain that are considered representative of the biodiversity within Manitoba's natural regions. Identification of enduring features (i.e., enduring features analysis) by Manitoba Conservation assists in determining Areas of Special Interest (ASIs) for protection. For this assessment, PAI enduring features that are rare or single occurrence and located within existing ASIs are considered valued.

5.2.2.1.1 Environmental Indicators/Measurable Parameters

The primary environmental indicators of change to PAI enduring features are landscape integrity or representation. Ecological integrity refers to the intactness of the natural state of a feature, which can be measured as total land area subject to impairment. Representation refers to the proportion of a given feature that is protected through conservation, measured as a proportion of the area of a given feature within a protected area. The size of contiguous units of enduring features is another metric of integrity, with 1,000 ha being considered the minimum area necessary for the maintenance of biodiversity within a feature (Manitoba Conservation, 2000).

The goal of conservation efforts is to capture an adequate representation of the diversity of a natural region, thereby increasing confidence that the integrity of that region will be maintained overtime (Manitoba Conservation, 2000).

5.2.2.1.2 Data Summary

A total of 15 rare and single occurrence enduring features were identified within 4 ASIs intersected by the Project Study Area (Map 600 - 1:17 – Unique Terrain/Soil Features), based on the data provided by PAI. Enduring features were further assessed using a combination of desktop mapping (i.e., stereo aerial photo interpretation), aerial reconnaissance and groundtruthing, as deemed appropriate.

These enduring features can be geographically separated into two key areas:

- Stephens Lake ASI – located in the Churchill River Upland, Hayes River Upland and Selwyn Lake Upland ecoregions.

- Tom Lamb Wildlife Management Area (WMA), Tom Lamb Addition Area and Summerberry Proposed WMA – located in the Mid-Boreal Lowland ecoregion.

Of these 15 identified enduring features, 8 (6 rare and 2 single) enduring features occur within the Local Study Area, and 4 (3 rare and 1 single) enduring feature occur within the HVdc right-of-way (Section 6.5.2.1). A summary of these 8 rare and single occurrence PAI enduring features found within the Local Study Area by ASI is found below:

Stephens Lake ASI

Within Stephens Lake ASI, 4 rare and 1 single occurrence PAI enduring features are intersected by the Local Study Area, as follows:

- A Deep Basin/Eutric Brunisol was identified as a rare occurrence PAI enduring feature (ID No. 9; Map 600 - 1 – Unique Terrain/Soil Features, Table 5.15; Photos 3 and 4, Appendix C) and occupies a total of 1,657 ha of land within the ASI, of which 100% occurs within the Local Study Area. Results from desktop mapping, aerial reconnaissance and groundtruthing of this feature are in general agreement with the feature as previously mapped. Similar PAI enduring features (i.e., deep basin / eutric brunisol features) are also identified within the ASI, to the northeast and southeast and occupying 56 ha, 9476 ha and 2110 ha of land (ID Nos. 5, 8, 10; Map 600 - 1 – Unique Terrain/Soil Features, Table 5.15).

- An Esker was identified as a rare occurrence PAI enduring feature (ID No. 7; Map 600 - 1 – Unique Terrain/Soil Features, Table 5.15; (Photos 13, 14, 15, 16 and 17, Appendix C) and occupies a total of 14 ha of land within the ASI, of which 100% occurs within the Local Study Area. It was determined by the study team through desktop mapping, aerial reconnaissance and groundtruthing that this Esker was not well represented by previous mapping. Mapping of this feature was refined (see Map 600 - 1 – Unique Terrain/Soil Features), and it was found that this esker occupies an area of approximately 1,900 ha over a length of approximately 75 km, and is discontinuous in nature. A total of approximately 580 ha (or 31%) of this re-mapped feature was found to be located in the Local Study Area. Another Esker was identified as a PAI enduring feature within the ASI, located to the northeast and occupying 51 ha (ID No. 6; Map 600 - 1 – Unique Terrain/Soil, Table 5.15).

- Two Glaciofluvial Deposits/Organic Cryosol (mesic woody forest) / Moraine features were identified as a rare occurrence PAI enduring features:
    - One of these features (ID No. 4; Map 600 - 1:2 – Unique Terrain/Soil Features, Table 5.15; (Photos 8, 9, 10, 11 and 12, Appendix C) occupies a total of 1,441 ha of land within the ASI, of which 95% occurs within the Local Study Area. Results from desktop mapping, aerial reconnaissance and groundtruthing were used to refine the boundaries of this feature, and were in general agreement with the feature as previously mapped.

- o The other feature (ID No. 12; Map 5.18 B, Table 5.15) occupies a total of 2,755 ha of land within the ASI, of which 1 ha or 0.1% occurs within the Local Study Area. Desktop mapping was used to refine the boundaries of this feature and were in general agreement with the feature as previously mapped.

- o Three similar PAI enduring features are also identified within the ASI, one to the west of the Local Study Area occupying 457 ha, and two to the east of the Local Study Area occupying 1,136 ha and 547 ha of land (ID Nos. 13, 14, 15; Map 600 - 1:2 – Unique Terrain/Soil Features, Table 5.15).

- A Nearshore and Intertidal Deposits/Organic Cryosol (mesic woody forest) / Glacial Spillway was identified as a single occurrence PAI enduring feature (ID No. 11; Map 600 - 1 – Unique Terrain/Soil, Table 5.15 Photos 5, 6 and 7, Appendix C)) and occupies a total of 15,130 ha of land within the ASI, 952 ha or 6% of which occurs within the Local Study Area. Results from desktop mapping, aerial reconnaissance and groundtruthing of this feature were used to refine the mapped boundaries; however were in general agreement with the feature as previously mapped.

Tom Lamb WMA, Tom Lamb Addition and Summerberry Proposed WMA

Within Tom Lamb WMA, Tom Lamb Addition and Summerberry Proposed WMA, 2 rare and 1 single occurrence PAI enduring features are intersected by the Local Study Area. A summary of these sensitive areas/sites within these ASIs is found below.

- An Alluvial Deposits/Organic Mesisol (mesic sedge) unit was identified as a single occurrence PAI enduring feature (ID No. 1; Map 600 - 3:4 – Unique Terrain/Soil Features, Table 5.15) and occupies a total of 36,396 ha of land within the ASI, 4,738 ha or 13% of which occurs within the

- Local Study Area. No additional desktop or field assessments were conducted on this feature.

- An Alluvial Deposits/Organic Mesisol (mesic woody forest) unit was identified as a rare occurrence PAI enduring feature (ID No. 2; Map 600 - 3 – Unique Terrain/Soil Features, Table 5.15) and occupies a total of 288 ha of land within the ASI, 126 ha or 44% of which occurs within the Local Study Area. No additional desktop or field assessments were conducted on this feature.

- An Alluvial Deposits/Organic Mesisol (mesic woody forest) unit was identified as a rare occurrence PAI enduring feature (ID No. 3; Map 600 - 3 – Unique Terrain/Soil Features, Table 5.15) and occupies a total of 2,485 ha of land within the ASI, 773 ha or 31% of which occurs within the Local Study Area. Aerial reconnaissance and groundtruthing was conducted on this feature and was found to be in general agreement with what was previously identified.

A summary of the 15 enduring feature occurrences noted above, including a summary of additional field data acquired as part of the assessment process, is found in Table 5.15.

5.2.2.2 Other Unique Terrain/Soil Features

Other unique terrain/soil features represent soil-landscape features that possess relatively unique terrain and/or soil properties compared to the dominant terrain and/or soil properties in the area which they are found, and warrant special consideration. These features have been identified based on a review of soil resource information and aerial photo interpretation. The identification of these features was not based on criteria per se, rather based on professional judgment of the data reviewers. In addition, Aboriginal Traditional Knowledge was a key source of information for the inclusion (i.e, scoping) of **salt flats** as a unique terrain/soil feature.

5.2.2.2.1 Environmental Indicators/Measurable Parameters

As described in Section 5.2.2.1.1 above, landscape integrity is an indicator of change to unique terrain/soil features. Ecological integrity can be measured as the total land area subject to impairment.

5.2.2.2.2 Data Summary

A total of three other unique terrain/soil features were identified in the Local Study Area, which were not already "captured" elsewhere for special consideration (Map 600 - 1:5 – Unique Terrain/Soil Features). The other terrain/soil features identified within the Local Study Area included:

- Beach deposits on ridged terrain within the Stephens Lake ASI in the Hudson Plain Lowland.
    - Former beach ridges on marine beach deposits in Stephens Lake ASI – this unique terrain and soil unit is found along the escarpment separating the Hudson Bay Lowland ecoregion and the Selwyn Lake Upland ecoregion. The soils occupying this unit (confirmed with a detailed soil landscape inspection) are described as rapidly drained, Eluviated Eutric Brunisols, developed on marine beach deposits and belonging to the Old soil series, while the terrain is described as ridged (Photos 1 and 2, Appendix C). The vegetation associated with these soils consists predominantly of reindeer moss on the ridges and black spruce and tamarack in the associated swales. The beach ridge unit occupies a total of 195 ha, and is located completely within the Local Study Area (Table 5.16; Map 600 - 1:17 – Unique Terrain/Soil Features). This feature is not located within the HVdc right-of-way.
- Salt flats within the proposed Red Deer WMA in the Mid-Boreal Lowlands, within the Lake Manitoba Plain, and within the Interlake Plain.

- Salt flats located in proposed Red Deer WMA – salt flat areas within the proposed Red Deer WMA developed due to the occurrence of salt springs provide relatively unique terrain/soil units. The salt flats occupy a total area of 354 ha, with 59 ha (or 16.3% of the total salt flats area identified within the WMA) occurring within the Local Study Area (Table 5.16, Map 600 - 1:17 – Unique Terrain/Soil Features). Within the Local Study Area, the salts flats occur in 3 distinct polygon units. The salt flats do not occur in the HVdc right-of-way.

- Salt flats located in the Interlake Plain ecoregion, southwest of the town of Winnipegosis, near the intersection of highway 364 and highway 20. This feature occupies a total area of 21 ha, 100 % of which occurs in the Local Study Area (Table 5.16, Map 600 - 1:17 – Unique Terrain/Soil Features). The salt flats do not occur in the HVdc right-of-way.

- Salt flats located in the Lake Manitoba Plain ecoregion adjacent to highway 276 and approximately 24 km east of Dauphin Lake. This feature occupies a total area of 157 ha, with 127 ha (or 81% of the total salt flats area) occurring within the Local Study Area (Table 5.16, Map 600 - 1:17 – Unique Terrain/Soil Features). The salt flats do not occur in the HVdc right-of-way.

A summary of the other unique terrain/soil features identified within the Local Study Area is found in Table 5.16.

5.2.3 Stable Terrain

Stable terrain, for the purposes of this assessment, is considered terrain that is unaffected or unmoved by non-natural, or artificial, instability resulting from project-related activity. Features of the terrain environment that are susceptible to human-induced instability include sloped terrain (e.g., slope creep, slope failure) and permafrost terrain (e.g., **subsidence**, **thermokarst**). The maintenance of stable terrain, has ecological and socioeconomic value, as a function of its role in supporting existing ecosystems and human infrastructure (Duan and Naterer, 2009).

5.2.3.1 Environmental Indicators/Measurable Parameters

Most indicators of unstable sloped terrain can be assessed by visual identification in the field (Schor and Gray, 2007), including scars, tension fractures, and/or jack-strawed (tilted) or curved trees (British Columbia Government, 1999; Chatwin *et al.,* 1994). Geotechnical-based calculations, such as factor of safety (ratio of shear strength to shear stress along a failure) may be used to identify unstable sloped terrain, with a threshold equal to 1, with 1.5 being considered stable (Das, 2004).

In the local study area, permafrost is most common in low-lying areas of the landscape associated with peatlands, and can occur in both bogs and fens. Bogs are generally characterized by tree cover of black spruce, ground cover of sphagnum mosses and have dry surfaces elevated above the water table, while fens are wetter and have ground cover of brown mosses or Sphagnum mosses and are treed (black spruce and/or larch/tamarack) or treeless (dwarf birch or willow or sedge). In the discontinuous permafrost zone, which best describes the majority of the permafrost-affected portions of the study area, permafrost occurrence in the southern fringe is absent in areas where the water table is at or near the ground surface (Brown, 1970). Therefore, permafrost occurrence can be expected to be limited to bog peatlands at the southern extent of permafrost distribution, while it may occur in some fen peatlands at the northern extent of permafrost distribution. Discontinuous permafrost occurs in two general types: large, expansive areas called peat plateaus, and small, isolated (or localized) permafrost occurrences usually less than 100 m^2 in area (i.e., palsas) in otherwise unfrozen peatlands (Beilman et al. 2001). In the discontinuous permafrost zone, Beilman et al. (2001) note that permafrost degradation is evident in throughout the discontinuous zone in western Canada and is manifested by collapse scars in most peat plateaus, and degraded internal lawns in localized permafrost or palsas. Degraded internal lawns are treeless depressions of carpet or lawn cover by Spagnum mosses and have surfaces depressed by about 50 cm below non-permafrost peatland, often tilted partially buried black spruce snags from the pre-existing permafrost mound (Beilman et al., 2001; Vitt et al., 1994).

Indicators of change to permafrost stability include visual identification and **active layer** thickness. The active layer is the seasonally thawed layer that separates the permafrost layer from air. Disturbed permafrost terrain results in visually-identifiable distinct landforms, including collapse scars (Photo 20, Appendix C), retrogressive thaw slumps (bowl or horseshoe-shaped), active layer detachments (material accumulates at toe), and thermokarst terrain (depressions that may collect water) (Kotler, 2003). An increase in the thickness of the active layer, as measured by a calibrated metal probe, can indicate thawing of permafrost as a result of disturbance; however, changes may not be evident until late in the season (Bronson et al., N.D.).

5.2.3.2 Data Summary

A total of four occurrences of unstable or steep slopes were identified in the northern portion of the Local Study Area, based on a combination of existing soil resource and digital stereo aerial photo interpretation. From north to south, these are located within the Local Study Area in the vicinity of Limestone River and its tributaries and the Odei River; and within the HVdc right-of-way in the area north of the Overflowing River. The unstable/steep slopes identified in the Overflowing River represent the largest area at approximately 1408 ha within the Local Study Area and 27 ha within the HVdc right-of-way.

A summary of the data for these steep and unstable slopes is found in Table 6.2.

The distribution and extent of permafrost was mapped to determine regions susceptible to melting or loss due to Project activities (Map 400 - 1:17 – Permafrost Distribution). Areas of permafrost were identified based on two data sources: Manitoba Wetlands (1:50,000) and the Soil Resource Information (varying scales). The extent of permafrost occurrence identified within each data source for a given area was classed according to generalized classes described by Natural Resources Canada (2010), as follows:

- Continuous - >90% ground coverage.
- Extensive discontinuous – 50-90% ground coverage.
- Sporadic discontinuous – 10-50% ground coverage.
- None or Isolated patches[3] - < 10% ground coverage.

The occurrence and permanence of permafrost throughout the Local Study Area generally increases in a northerly direction (Map 400 - 1:17 – Permafrost Distribution). Isolated and sporadic discontinuous permafrost begins to occur in the area north of The Pas (Natural Resources Canada 2010; Map 400 - 1:17 – Permafrost Distribution). Sporadic and extensive discontinuous permafrost dominate the soil landscape from the area of Thompson north. Limited areas of continuous permafrost occur in the northern portion of the Local Study Area, including in the vicinity of Conawapa generating station site.

While the Manitoba Wetlands and Soil Resource Inventory were in general agreement with the proportion of the Local Study Area affected by permafrost (Table 5.17), the spatial occurrence and classes were somewhat variable (Table 5.17; Map 400 - 1:17 – Permafrost Distribution). It is prudent to consider both datasets when assessing the occurrence and distribution of permafrost.

Based on the Manitoba Wetlands data, a total of 0.1% of the Local Study Area and the right–of-way was found to be classed as continuous permafrost (Table 5.17). A total of 3.9% of the Local Study Area and 3.4% of the right-of-way classed as extensive discontinuous permafrost, while 24.3% of the Local Study Area and 25.3% of the right-of-way was classed as sporadic discontinuous permafrost.

Based on the Soil Resource Inventory data, a total of 0.7 % of the Local Study Area and 0.5 % of the right-of-way was found to be classed as continuous permafrost (Table 5.17). A total of 12.2 % of the Local Study Area and 12.7 % of the right-of-way classed as extensive discontinuous permafrost, while 8.8 % of the Local Study Area and 8.7 % of the right-of-way was classed as sporadic discontinuous permafrost.

[3] The generalized categories from Natural Resources Canada (2010) consisting of Isolated patches and None had to be combined for the purposes of this evaluation, as the lowest extent of polygon coverage represented in the Manitoba Wetlands and Soil Resource Information is 10 %. In other words, the resolution of these data sets precluded the ability to otherwise categorize areas with < 10 % permafrost coverage.

6.0 Environmental Effects Assessment

The following is a description of potential environmental effects and proposed mitigation measures identified for the Project. The methodology for the effects assessment is described in Section 3.3. An interaction matrix between project phases and associated activities, and terrain, geology and soil environmental components is found in Table 6.1.

For the purposes of focusing the environmental effects assessment and identifying site-specific mitigation, environmental sensitive areas/sites (ESSs) were identified, and are presented in Section 6.1 below.

An overview of direct soil, terrain and geology environmental effects are presented in Sections 6.2 to 6.4 below, followed by a discussion of specific environmental effects associated with identified VECs in Section 6.5. A discussion of identified environmental sensitive sites/area, if applicable, and Proposed mitigation and environmental protection measures are provided in sequence with effects.

6.1 ENVIRONMENTAL SENSITIVE AREAS/SITES

Environmental sensitive areas/sites (ESSs) were determined through the assessment process, and generally correspond to the VEC categories discussed in Section 5.2. Environmental sensitive sites/areas were determined based on a variety of data sources, including existing soil resource information and other environmental resource information, Government of Manitoba supplied data, through aerial photography interpretation and field investigation.

Environmental sensitive sites/areas were summarized using the following categories, described in greater detail below. The context of ESSs in relation to the effects assessment and mitigation measures, is developed further in Sections 6.2 to 6.5 below.

6.1.1 ESSs for Soil Productivity

Environmentally sensitive sites and areas related to the Soil Productivity VEC are described below.

- Wind Erosion Prone Soils – include soils prone to wind erosion and were identified based on review of existing SRI and using the wind erosion risk index for Manitoba (Coote et al. 1989). Wind erosion prone soils identified as ESSs include two sub-categories:
    - Highly Wind-Erodible Soil Sites – these consist of active and stabilized, coarse textured, eolian (i.e., wind-modified) deposits, with high susceptibility to wind erosion if disturbed. These sites were identified using a combination of existing soil resource information (SRI) in the southern portion of the Local Study Area, where detailed and

reconnaissance SRI exists, and based on stereo aerial photo interpretation in the northern portion of the Local Study Area. A tabular summary of Highly Wind-Erodible Soil Sites by ecoregion is found in Table 6.2.

- High and Severe Wind Erosion Risk Areas – these consist of areas with high to severe wind erosion risk ratings, as identified based on Coote et al. (1989). A tabular summary of Wind Erosion Risk ratings[4] by ecoregion is found in Table 6.3.

- Water Erosion Prone Soils – include soils prone to water erosion and were identified using ratings contained in the existing SRI, which are based on the Universal Soil Loss Equation (USLE), and, specific areas of relatively steep and/or unstable slopes which could be susceptible to water erosion if disturbed. Water erosion prone soils identified as ESSs include two sub-categories:
  - Steep and/or Unstable Slopes – these consist of relatively steep and/or unstable slopes identified by a review of existing SRI and stereo photo interpretation.
  - High and Severe Water Erosion Risk Areas – these consist of areas with High to Severe Water Erosion Risk ratings, as identified in existing SRI. A tabular summary of Water Erosion Risk ratings[5] by ecoregion is found in Table 6.4.
- Compaction Prone Soils – soil areas identified as having a High risk for compaction effects. A compaction/rutting risk index was developed based on professional judgment and a review of existing compaction and rutting hazard systems developed by Archibald et al. (1967) and British Columbia Ministry of Forests (1999). The compaction/rutting risk rating matrix is presented in Table 6.5. A tabular summary of compaction/risk ratings by ecoregion is found in Table 6.6[6].

6.1.2 ESSs for Unique Terrain/Soil Features

Environmentally sensitive sites related to the Unique Terrain/Soil Features VEC are described below:

- PAI Enduring Features – these ESSs consist of Single and Rare occurrences of Protected Area Initiatives (PAI) identified enduring features located within Areas of Special Interest (ASIs), as discussed in Section 5.2.2, above.

[4] The summary includes all Wind Erosion Risk ratings (i.e., Negligible, Low, Moderate, High, Severe, Organic Soils (Not Rated)). However, only High and Severe Risk ratings are considered Environmental Sensitive Areas/Sites.
[5] The summary includes all Water Erosion Risk ratings (i.e., Negligible, Low, Moderate, High, Severe, Not Rated). However, only High and Severe Risk ratings are considered Environmental Sensitive Areas/Sites.
[6] The summary includes all Compaction/Rutting Risk ratings (i.e., Low, Moderate, High, Not Rated). However, only High and Severe Risk ratings are considered Environmental Sensitive Areas/Sites.

- Other unique terrain/soil features – these ESSs consist of unique terrain and/or soil features which warrant special consideration, as discussed in Section 5.2.2, above. These features were identified through the review of existing SRI (e.g., salt flats) and through stereo aerial photo interpretation and field investigations.

6.1.3 ESSs for Stable Terrain

Environmentally sensitive sites related to the Stable Terrain VEC are described below:

- Steep/Unstable Slopes – these ESSs consist of relatively steep and/or unstable slopes which could be susceptible to mass wasting due to slope failure if disturbed. These ESSs were identified based on a review of existing SRI and through stereo aerial photo interpretation.

- Permafrost – these ESSs consist of extensive discontinuous, sporadic discontinuous and isolated patches occurrences which are sensitive to land use changes and resulting soil temperature changes. These were identified based on existing SRI (i.e., Cryosolic soils) and the Manitoba Wetlands data set. A tabular summary of permafrost occurrence by ecoregion was presented in Table 5.17.

6.1.4 Comment on Scale of ESSs

Environmental Sensitive Areas/Sites (ESSs) for soils and terrain, as described above, were identified based on variable scales of information – existing resource information and data collected through field investigation and stereo aerial photo interpretation. As a result, some of the ESSs are local in nature, and have prescribed site-specific mitigation (identified in Sections 6.2 and 6.3), while other ESSs are regional in nature, and while they require more intensive mitigation than non-ESS areas, mitigations are to be applied to broad areas and regions.

Highly wind-erodible soils, steep/unstable slopes, PAI enduring features and other unique terrain/soil features are limited in occurrence and extent throughout the Local Study Area, and have unique and/or anomalous properties relative to the typical terrain and soil environment condition. Therefore, they should be considered on a site-specific basis in terms of mitigation of environmental effects. On the other hand, permafrost, compaction prone soils, high and severe wind erosion risk and high, and severe water erosion risk soils cover a considerable proportion of the Local Study Area and require broadly-applied effects mitigation.

Further discussion of ESSs in the context of the effects assessment and mitigations is found in Sections 6.2 to 6.5 below.

6.2 DIRECT SOIL EFFECTS

6.2.1 Compaction-related Effects

Soil compaction, measured as bulk density or resistance to surface pressure, refers to the squeezing together of soil particles resulting in reduced space available for soil/water, and thereby loss of soil structure. The static and dynamic ground pressure of heavy equipment can result in soil compaction (McNabb *et al.* 2001). The majority of compaction occurs within the first few passes, regardless of equipment (Grigal 2000; McNabb *et al*. 2001), which supports the use limited trails for reducing the land area affected by compaction. Unmitigated compaction on forest sites is assumed to persist for several decades (Grigal 2000).

Indirect effects associated with compaction of soils include increased run-off due to reduced water infiltration and holding capacity, decreased vegetative growth and potentially reduced crop yields (MAFRI 2008). Thresholds for determining if soil compaction has occurred include a sampled bulk density of 1.80 g/cm^3 (0-6" depth; MAFRI 2008) or measured surface pressure resistance of 300 pounds per square inch (psi), as measured by a penetrometer (Rooney et al. 2001). Heavy disturbance is considered to be compaction or rutting at least 10-15 cm deep (Grigal 2000).

Susceptibility to compaction and rutting generally increases with soil moisture content and clay content (Archibald et al. 1967; British Columbia Ministry of Forests 1999). Soil drainage regime and soil texture class are available soil resource information that can be used as relative measures of soil moisture and clay content, respectively, and as such can be used to estimate soil susceptibility to compaction and rutting. Based on existing compaction and rutting hazard systems developed by Archibald et al. (1967) and British Columbia Ministry of Forests (1999), the following combinations of drainage regime and soil textures are considered high risk for compaction-related effects:

- Very-poorly drained, organic soils.
- Imperfectly to poorly drained, fine textured (i.e., clays) mineral soils.
- Imperfectly to poorly drained, moderately-fine textured (i.e., clay loams) mineral soils.
- Poorly drained, medium textured (i.e., loams) mineral soils.

Soils with a high compaction and rutting risk were identified as sensitive areas within the Local Study Area. In order to determine compaction and rutting risk, an index of the susceptibility of soils to compaction and rutting was developed based on professional judgment and a review of existing compaction and rutting hazard systems developed by Archibald et al. (1967) and British Columbia Ministry of Forests (1999). The compaction and rutting risk index is based on the relative soil moisture status and clay content, as approximated by soil drainage regime and soil textural class, respectively. These data parameters were available within the existing soil resource information databases. A compaction/rutting risk rating was applied to all soils within the Local Study Area using the Compaction/Rutting Risk Rating Matrix presented in Table 6.5. A summary of compaction and rutting risk within the Local Study Area is displayed in Map 900 - 1:17 – Compaction/Rutting Risk and summarized by ecoregion and in Table 6.6. Areas of high risk have been identified by the study team as requiring detailed assessment and environmental protection planning.

Approximately 60% of the Local Study Area and right-of-way has a high compaction and rutting risk (Table 6.6). A considerable portion of the northern portion of the Local Study Area has a high risk for compaction (Map 900 - 1:17 – Compaction/Rutting Risk) and rutting due to the presence of organic soils, and moderately fine to fine textured, imperfectly drained mineral soils. In agro-Manitoba, considerable portions of high compaction risk soils occur in the Red River Valley south of Winnipeg, and north-west of Portage la Prairie (Map 900 - 1:17 – Compaction/Rutting Risk).

A review of forest harvesting activities found that typically over 25-50% of the harvest area was affected by altered soil properties as a result of compaction (Grigal 2000). On the Alberta Clipper Project, post-construction monitoring identified that the degree of compaction was the worst on sites where wet conditions were encountered and/or where work was stopped due to wet conditions. In addition, the temporary, strategic placement of geotextile fabric was used to mitigate the potential for rutting at wet locations (Enbridge Pipelines Inc. 2011).

The Project will result in a loss of soil structure within the transmission line and project component footprints as a result of heavy equipment and vehicle traffic, including frozen waterbody crossings and access provision primarily during construction and operation/maintenance phases.

Mitigation

While soil compaction can be naturally mitigated to some extent (60-90 cm depth) in mineral soils as a result of winter freezing and thawing cycles (MAFRI 2008), active mitigation of soil compaction can be undertaken in the form of deep-ploughing, depending on the existing and planned future use (e.g., agricultural production) of the land. Subsequent cultivation activities by the landowner will also act as a mitigating factor for soil compaction.

Measures to reclaim compaction effects to organic soils, generally located in northern portions of the HVdc right-of-way, is not possible. Minimization of the area affected as well as the access infrastructure can assist in reducing the unavoidable effects of soil compaction (Grigal 2000).

6.2.1.1 500 kV HVdc Transmission Line

Areas of high risk to compaction are nearly constant along the transmission line right-of-way. Approximately 60% of the 3-mile Local Study Area (393,789 ha) and transmission line right-of-way (5,471 ha) is considered at high risk of soil compaction. In the northern portion of the Local Study Area, soils with a high compaction and rutting risk include organic soils and minerals soils with high clay content and imperfect to poor drainage. In the southern portion of the Local Study Area, areas with considerable compaction risks include the clayey soils of the Red River Valley, south of Winnipeg, and clayey soils north-west of Portage la Prairie.

The following specific measures are proposed to reduce the effect of compaction along the transmission line right-of-way:

- Transmission line construction, monitoring/inspection and decommissioning activities in identified areas of high risk to compaction should be scheduled during late summer, early fall or winter to target dry, frozen and/or snow-covered conditions and prevent compaction on mineral and organic soils.
- The senior field authority should stop work on construction of the transmission line when ground conditions are such that no effective construction practice will prevent damage caused by severe rutting. The need to stop work may be evidenced by the excessive build-up of mud on tires/cleats and excessive ponding on the soil surface[i].
- Where persistently wet locations cannot be avoided, geotextile fabric overlain with soil/aggregate or construction mats should be placed beneath trafficking areas to reduce rutting during right-of-way construction, inspection and decommissioning activities. Any fabric, matting or imported materials should be removed prior to leaving the area.
- Low-ground pressure vehicles (i.e., wide-tracked or wide-rubber-tired machinery) should be utilized for transmission line construction, monitoring/inspection and decommissioning, where possible.
- Existing access routes should be utilized where possible and site traffic along the ROW should be minimized or contained to single paths.
- Temporary storage areas for machinery and equipment should be located on well drained, mineral soil types, where possible.
- If required, the ROW should be graded, disced or deep-ploughed to remove ruts caused by rubber-tired and tracked vehicles in agricultural areas. If an extensive area of Crown land is disturbed, the disturbed area should be reseeded with native seed mixes.
- A post-construction reclamation plan (see Section 6.7.1) for relieving compaction on agricultural lands should be implemented by Manitoba Hydro and carried out by the Contractor to remedy any compaction remaining on agricultural lands following construction. Arrangements could also be made with the landowner to perform this work.

6.2.1.2 Infrastructure Component Sites

The highest risk of compaction and rutting is located at the southern electrode site, followed by the northern electrode site and northern converter station. The construction power site and temporary northern construction camp have a low risk for compaction.

The following specific measures are proposed to reduce the effect of compaction at the electrode facilities and northern converter station. The adoption of proposed measures at component sites will be dependent on the intended interim and final land use:

- Construction and decommissioning of the northern electrode site, northern converter station site should be undertaken in winter to prevent compaction and rutting of organic soils.
- Construction of the southern ground electrode site should be scheduled during summer, early fall or winter to target dry or frozen conditions, to prevent compaction and rutting of mineral soils.
- If persistently wet conditions cannot be avoided, geotextile fabric overlain with soil/aggregate or construction mats should be placed beneath trafficking areas to reduce rutting during southern electrode construction, maintenance and decommissioning.
- Topsoil at the southern ground electrode site should be stripped and stockpiled separately prior to subsoil excavation for replacement following construction, to avoid compaction.
- Soils at temporary work sites (temporary work camps, marshalling yards) should have topsoil removed and stockpiled prior to site grading. Subsoils should be deep ploughed and stockpiled topsoil should be replaced, graded and disced on decommissioning of these facilities.

6.2.2 Erosion-related Effects

Erosion is a natural process and refers to the detachment, movement and removal of soil from the land surface by wind or water. Surface disturbance as a result of human activity can accelerate naturally occurring erosional processes. The loss of topsoil and surficial materials can result in lost productivity due to loss of organic matter and nutrients and deterioration of physical soil properties (MAFRI 2008). Indirect effects of erosion are primarily related to deposition of eroded materials in surface waterbodies (i.e., sedimentation) and low areas (e.g., ditches); however, may also affect crop yields and the integrity of unique terrain/soil features. While it is difficult to quantify the loss of soils due to erosion (Grigal 2000), The threshold for soil loss, measured as thickness lost, is 0.75 mm of topsoil or 10 tonnes/ha/yr (maximum tolerable loss; MAFRI 2008). Filled ditches and blackened drifts are indicators that soil erosion is occurring.

6.2.2.1 Wind Erosion-related Effects

Soils susceptible to wind erosion-related effects include sand textured soils and eolain (i.e., wind-modified) deposits or “duned sands”. Dry, loose soils with sparse or absent vegetation are also factors which influence wind erosion (Government of Alberta 2001).

Sand textured soils are the most susceptible texture class to wind erosion, particularly during early spring and proceeding fall tillage in agricultural lands (MAFRI 2008). “Duned sands” (Photos 21, 22, 23 and 24, Appendix C) consisting of active and stabilized, coarse textured, eolian (i.e., wind-modified) deposits typically have low productivity and very thin, fragile surface horizons and therefore have increased susceptibility to wind erosion when disturbed, as a result of reduced surface cover and destruction of soil structure.

On a regional basis, wind erosion risk maps (Map 700 - 8:16 - Wind Erosion Prone Soils) were developed based on erosion risk classes presented by Coote et al. (1989) to determine the regions and extents of wind erosion-prone soils within the Local Study Area in southern Manitoba (i.e., south of Waboden) where loss of topsoil due to accelerated water erosion may occur. Soils with a High to Severe wind erosion risk class have been identified by the study team as susceptible to accelerated wind erosion; thereby, requiring special consideration to ensure potential environmental effects are mitigated.

Approximately 1.7% of the Local Study Area and 1.4% of the right-of-way is considered highly susceptible to wind erosion, and 3.5% of the Local Study Area and 3.7% of the right-of-way is considered severely susceptible to wind erosion. A predominant wind erosion risk area is located in the agricultural lands in the vicinity south of the Portage la Prairie area (Map 700 - 1:17 – Wind Erosion Prone Soils), described further below. Additional areas of high wind erosion risk were identified northeast and southeast of the Cowan area (Map 700 - 10:11 - Wind Erosion Prone Soils) and northwest of the Steinbach Area (Map 700 - 16 - Wind Erosion Prone Soils) outside of the HVdc right-of-way, but within the 3-mile Local Study Area.

In addition to regional risk areas, highly wind erodible sites, or eolian (i.e., wind-modified) deposits, were mapped to determine their location within the HVdc right-of-way and Local Study Area of the 500 kV HVdc transmission line, where loss of material or terrain integrity due to accelerated wind erosion may occur (Map 700 - 1:17 - Wind Erosion Prone Soils). . Based on existing soil resource information and supplemental soil mapping based on stereo aerial photographs, a summary of highly erodible soils areas by ecoregion is summarized in Table 6.2. The Aspen Parkland/Lake Manitoba Plain had the greatest area of highly erodible soils within the ROW. Highly erodible soils were identified in 338 individual map unit occurrences within the Local Study Area and 65 occurrences within the RoW (Map 6.1).These sites are of particular importance as they represent soil-landscape of reduced stability (e.g., stabilized or unstabilized sand dunes) and have very little natural ability to resist wind erosion once disturbed. A total area of 247 ha of highly wind erodible soils have been identified within the HVdc right-of-way.

The use of straw crimping on identified erodible soils to reduce wind erosion was found to have a 93% success rate on the Alberta Clipper Project and was also found to be requested by land owners. Additional mitigation measures included re-seeding disturbed sites on erodible soils (Enbridge Pipelines Inc., 2011).

The Project will result in an increased loss of topsoil primarily during the construction phase in the transmission line and project component footprints due to accelerated wind erosion events on surfaces disturbed by activities such as, equipment traffic, off-road travel, vegetation clearing, creation of steep/unstable slopes and stripping and grading activities.

Mitigation

Mitigation measures to prevent wind erosion are generally related to maintaining ground cover, avoiding work in dry conditions and stabilizing any disturbed materials shortly following disturbance. Additional attention should be paid to prevent accelerating wind erosion adjacent to waterways, to prevent deposition of wind-blown sediments. The following is an overview of site-specific environmentally sensitive sites and areas identified during the study, and proposed mitigation to prevent accelerated wind erosion.

<u>Portage la Prairie (PTH 1 to PTH 13) Wind Erosion Risk Area</u>

Regionally, a High to Severe Wind Erosion Risk occurs southwest and south of the Portage la Prairie area within the HVdc right-of-way between Provincial Trunk Highway (PTH 1/TransCanada Highway) and PTH 13 (Map 700 - 15 - Wind Erosion Prone Soils).

The following specific measures are proposed to reduce the effect of wind erosion in High to Severe Wind Erosion Risk areas, particularly the Portage la Prairie (PTH 1 to PTH 13) Wind Erosion Risk Area:

- Construction, monitoring/inspection and decommissioning activities in High and Severe Wind Erosion Risk areas in southern Manitoba should be scheduled during winter to prevent accelerated wind erosion.
- If it is not possible to work during winter, soil conditions should be moist for work in High to Severe Wind Erosion Risk areas, to prevent accelerated wind erosion.
- Clearing and stripping should be minimized in High and Severe Wind Erosion Risk Areas to reduce the exposure of bare ground.
- Disturbed areas within High and Severe Wind Erosion Risk areas should be actively stabilized, vegetated and/or seeded as soon as possible following construction or disturbance.
- Straw crimping should be implemented on exposed soils within areas identified as having a High to Severe Risk of wind erosion to prevent erosion.

Limestone River and Nine Mile Creek (Hudson Bay Lowland) Eolian Deposit

An eolian deposit is located within and primarily south of the HVdc right-of-way in the Nine Mile Creek Area (Map 700 - 1:17 - Wind Erosion Prone Soils).

PTH 10 (Mid-Boreal Lowlands) Eolian Deposit

An eolian deposit is located within the HVdc right-of-way and Local Study Area where the right-of-way crosses PTH 10 south of The Pas (Map 700 - 1:17 - Wind Erosion Prone Soils).

Spence Lake (Interlake Plain) Eolian Deposit

An eolian deposit is located within the HVdc right-of-way and Local Study Area south of Spence Lake east of the Minitonas area (Map 700 - 1:17 - Wind Erosion Prone Soils).The following site-specific environmental protection measures are proposed for preventing and mitigating loss of material to eolian (wind-modified) deposits.

- Transmission line construction, monitoring/inspection and decommissioning activities within the Limestone River/Nine Mile Creek, PTH 10 and Spence Lake eolian deposits should be scheduled during winter when the ground is under frozen and/or snow-covered conditions to prevent erosion.
- Equipment traffic and associated disturbance should be limited in the Limestone River/Nine Mile Creek, PTH 10 and Spence Lake eolian deposits.
- Low ground pressure equipment (e.g., tracked vehicles) should be used for construction, monitoring/inspection and decommissioning activities in the Limestone River/Nine Mile Creek, PTH 10 and Spence Lake eolian deposits.
- Areas of disturbance during construction within the Limestone River/Nine Mile Creek, PTH 10 and Spence Lake eolian deposits should be stabilized immediately after exposure (e.g., addition of surface cover [straw crimping], active revegetation).

6.2.2.2 Water Erosion-related Effects

Clay or loam textured soils are most susceptible soil texture class to water erosion, particularly during spring snowmelt and during May and June (MAFRI 2008). Unstable/steep slopes are not generally a major concern in the southern portion of the study are due to the prevalence of agricultural land, where they are less common (Brady and Weil, 2008, pp.771).

On a regional basis, water erosion risk maps were developed, based on water erosion risk ratings in the existing SRI database, to determine the regions and extents of water erosion-prone soils within the Local Study Area in southern Manitoba (i.e., south of The Pas) where loss of topsoil due to accelerated water erosion may occur (Map 800 - 9:16 – Water Erosion Prone Soils). The water erosion risk is based on the Universal Soil Loss Equation, which considers soil erodibility, slope length-gradient, crop-vegetation and management practices. Areas of high (loss of 22-33 tonnes/ha/year) and severe (loss of >33 tonnes/ha/year) water erosion risk have been identified by the study team as susceptible to accelerated erosion; thereby, requiring environmental protection planning.

Approximately 0.2% of the Local Study Area and 0.3% of the right-of-way is considered highly susceptible to water erosion, and 0.2% of the Local Study Area and 0.2% of the right-of-way is considered severely susceptible to water erosion. The water erosion risk data is summarized in Table 5.19.

Steep and unstable slopes were mapped based on stereo aerial photography interpretation, due to a lack of existing information on surficial relief in the northern portion of the Project Study Area, to determine their location within the HVdc right-of-way and Local Study Area of the 500 kV HVdc transmission line, where loss of material due to accelerated water erosion or mass wasting may occur (Map 800 - 1:17 – Water Erosion Prone Soils). A data summary of unstable and/or steep slopes found within the northern portion of the Local Study Area is found in Table 6.2.

The Project will result in an increased loss of topsoil primarily during the construction phase in the transmission line and project component footprints due to accelerated water erosion events on surfaces disturbed by activities such as, equipment traffic, off-road travel, vegetation clearing, creation of steep/unstable slopes and stripping and grading activities.

Mitigation

The following is an overview of site-specific environmentally sensitive sites and areas identified during the study, and proposed mitigation to prevent accelerated water erosion.

<u>Sinclair River Water Erosion Risk Area</u>

There is a severe risk of soil loss due to water erosion along the north and south embankments of the Sinclair River northeast of the Minitonas area (Map 800 – 10 – Water Erosion Prone Soils). The risk area is primarily outside of the HVdc right-of-way, but within the Local Study Area.

<u>North Duck River Water Erosion Risk Area</u>

There is a moderate to high risk of soil loss due to water erosion in an area north and south of the North Duck River southeast of the Cowan area (Map 800 - 11 – Water Erosion Prone Soils) primarily due to soil texture. The risk area is located within the HVdc right-of-way and Local Study Area. The soils in this area are characterized as imperfectly drained, medium textured, and are prone to inundation due to flooding. Soils in the middle to upper slopes in this soil-landscape unit are particularly prone to losses to water erosion during periods of excess surface water (e.g., during spring runoff, following high rainfall events). Aboriginal traditional knowledge supplied by the adjacent Pine Creek First Nation confirms this region to be wet with swamp conditions.

Assiniboine River Water Erosion Risk Area

There is a severe risk of soil loss due to water erosion where the 500 kV HVdc transmission line right-of-way crosses the Assiniboine River southwest of Portage la Prairie (Map 800 - 15 – Water Erosion Prone Soils) due to sloped terrain.

The following site-specific environmental protection measures are proposed to reduce the effect of water erosion in High to Severe Water Erosion Risk areas described above:

- Construction, monitoring/inspection and decommissioning activities in the Sinclair, North Duck and Assiniboine rivers Water Erosion Risk Areas should be scheduled during winter, where possible.
- Clearing should be minimized in the Sinclair, North Duck and Assiniboine rivers Water Erosion Risk Areas to protect the existing ground cover and reduce the exposure of bare ground.
- Run-off should be directed away from disturbed areas. Some vegetation, slash or snow-covering should be maintained in the Sinclair, North Duck and Assiniboine rivers Water Erosion Risk Areas to protect soils.
- Site-specific Sediment Control Plans should be developed for the North Duck River and Assiniboine River watercourse crossings to manage water erosion risk. The Plan should incorporate the following measures:
    - Erosion control measures, such as silt fences, should be in place prior to site preparation activities/disturbance and removed after vegetation has re-established.
    - Where erosion and sediment control measures are employed, sites should be maintained, and the effectiveness of these measures should be monitored.
    - Existing cover should be maintained to the extent possible. A combination of seeding, tackifiers, erosion control blanketing and/or mulching should be utilized as required to prevent water erosion on bare soils.
    - Sufficient materials for erosion control should be maintained on-site, such as silt fencing, straw bales and erosion control matting.
- In the Sinclair, North Duck and Assiniboine rivers Water Erosion Risk Areas, banks should be restored to their original condition, if disturbed.

Overflowing River Area (Mid Boreal Lowlands) of Steep/Unstable Slopes

An area in the vicinity north of Overflowing River along the right-of-way in the area northwest of Overflow Bay has been identified as an area of steep/unstable slopes (Map 800 - 1:17 – Water Erosion Prone Soils).

The following site-specific environmental protection measures are proposed for preventing and mitigating loss of material due to water erosion or mass wasting at the "Overflowing River Area (Mid Boreal Lowlands) of Steep/Unstable Slopes".

- Construction activities should be scheduled during winter to target frozen ground conditions in the Overflowing River area.
- Natural vegetation along the Overflow Bay tributaries crossed by the right-of-way should be retained, to the greatest extent possible.
- A visual assessment of slope condition/stability should be conducted prior to construction, monitoring/inspection or decommissioning activities in the Overflowing River Area. Movement of heavy equipment and personnel on visually unstable sites should be avoided to prevent slope failure and/or potential injury.
- Borrow pits should not be located within 100 m of the Overflowing River Area, to prevent artificial destabilization of unstable slopes from any blasting activities, if undertaken.
- Run-off should be directed away from disturbed areas. Some vegetation, slash or snow-covering should be maintained in the Overflowing River Area to protect soils.
- Access trial grades should not exceed 12%. Grades near waterbodies should not exceed 5%. This gradient may be achieved through the use of snow or log ramps.

6.2.3 Soil Mixing Effects

Soil mixing, also referred to as admixing, refers to the blending of organic, nutrient-rich surface soils with less suitable (i.e., less productive) subsoil material, resulting in loss of soil capability (National Energy Board 1995) and can be due to increased salinity/sodicity of surface soils if mixed with saline or sodic (Solonetzic) subsoils (Enbridge Pipelines Inc. 2011), increased coarse fragment content, or alteration of soil texture. Indirect effects of soil admixing can potentially include decreased plant growth (Enbridge Pipelines Inc. 2011). Loss of soil capability due to admixing can be measured using a visual assessment of mixed horizons (i.e., colour change) and analytical testing of topsoil quality (e.g., salinity, particle size analysis), as required, to support determination of the Agricultural Capability Class Rating. Soils susceptible to a loss of capability due to admixing include soils with thin topsoil horizons or soils with Solonetzic subsoils.

Topsoil salvage, or the removal of topsoil prior to grading, excavation or site preparation activities, is the primary mitigation measure for preventing loss of valued topsoil as a result of admixing. On the Alberta Clipper Pipeline Project, follow-up monitoring concluded that soil admixing was correlated with sites where unseasonably wet conditions were encountered. It was also concluded that equipment operators were able to achieve "generally good" separation of topsoil from subsoil during salvage activities (Enbridge Pipelines Inc, 2011).

The Project would result in a loss of soil capability and potentially increased salinity/sodicity of surface soils within the Project Footprint as a result of grading infrastructure component sites, excavating tower and work camp trailer foundations and ground electrode ring sites and associated trenching, primarily during the construction phase.

Mitigation

The following is an overview of mitigation and environmental protection measures which may be used to prevent and mitigate soil admixing. The selection and implementation of mitigation measures will be dependent on the intended subsequent use of the affected footprint.

- Construction activities in northern Manitoba should be scheduled during winter to target frozen and/or snow-covered conditions.
- Construction activities in southern Manitoba should be undertaken during winter, where possible, and under dry conditions where there is a high rutting risk, where possible.
- Equipment operators should strip and stockpile topsoil separately (i.e., salvage topsoil) from subsoil based on a visual assessment of colour change, prior to excavation and preparation of marshaling yards, temporary work camps, and construction power site, where possible for re-use in construction site reclamation.
- If appropriate to the particular facility design, topsoil should be replaced upon completion of construction activities. When it is not appropriate to replace topsoil, disposal arrangements should be made with the landowner as a first option, in agricultural areas.
- Locate excess excavated soils in designated spoil areas on high ground, at least 30 m from the high water mark of a surface waterbody, in a manner which does not impede natural drainage.
- Excavated soils will be stored at designated work/spoil areas and will be fully replaced on the footprint of the excavation in the reverse order they were excavated. The senior field authority should stop work when ground conditions are such that no effective construction practice will prevent admixing caused by severe rutting. The need to stop work may be evidenced by the excessive build-up of mud on tires/cleats and excessive ponding on the soil surface[ii].

- At tower foundation locations, excavated soils should be replaced on the foundation footprint.
- In agricultural land, at least 300 mm of topsoil should be spread on any excavation site.

6.2.4 Soil Temperature Effects

Soil temperature is influenced by soil cover and may be increased when soil cover (i.e., canopy cover, low vegetation, forest litter) is removed. Direct effects of increased soil temperatures include adverse changes to moisture conditions causing droughty soils, loss of permafrost and potentially positive effects of increased productivity as a result of earlier spring thaw and an extended growing season. The optimum soil temperature for vegetative growth is 10-30°C (Brady and Weil 2008).

The Project may result in an increase in mean soil temperature, particularly in northern areas within the transmission line and project component footprints as a result of vegetation clearing along right-of-ways and grubbing at tower, station and electrode sites. Effects of increased soil temperature will primarily occur during the construction phase of the project, until soil cover (i.e., vegetation) is naturally or actively re-established.

Mitigation

The following is an overview of general mitigation and environmental protection measures which may be used to mitigate any increases to soil temperature:

- Clearing should be restricted to project sites and associated access routes. Existing access should be used wherever possible.
- Existing groundcover, including understory vegetation, should be maintained, where possible, to prevent an increase in soil temperature from exposure of uncovered or bare soils.
- Vegetation establishment in areas not identified as requiring special treatment should occur naturally or through annual cropping.
- Locate marshalling yards, construction camps and temporary storage/work areas in natural openings, where possible, to reduce clearing requirements.

6.2.5 Herbicide Residue Effects

Herbicide residue refers to herbicides which persist into seasons, beyond the application season due to slowed decay. The rate of breakdown for herbicides that are not bound to soil is influenced primarily by soil type, application rate, chemical and microbial degradation, photodecomposition, volatility and climatic factors (Horowitz et al. 1974). The climatic variables involved in herbicide degradation are moisture, temperature and sunlight (Hager and Nordby

2007). Under optimum climatic conditions, herbicides can have a soil residual life (persistence) of one month to more than 12 months, depending on the herbicide applied (Hager and Nordby 2007). Herbicide residuals may result in reduced soil productivity, which may have an indirect adverse effect of reduced vegetative growth (Government of Saskatchewan 2007); however, this is not expected if industry standards and best practices are used. Relevant criteria within the Canadian Council of Ministers of the Environment (CCME) Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (CCME 1999) would form the threshold level for a given herbicide residual concentration.

Since 1985, Manitoba Hydro has significantly reduced the use of soil residual herbicide products for management of vegetation (operation phase) along transmission line right-of-ways. Use of herbicide products is currently more selective than it has been in the past, resulting in minimal soil residue lingering into the next growing season. Manitoba Hydro does not use aircraft to apply herbicides to right-of-ways and scale herbicide use on northern transmission lines was discontinued in 1990, in favour of practicing the winter shearing method instead. In 2001, approximately 2 kg/ha of active ingredient was used to manage transmission and distribution lines combined (Manitoba Hydro 2007). Manitoba Hydro completes annual reporting of the product and quantity of herbicides, as well as the locations of application to Manitoba Conservation in accordance with Pesticide Use Permits issued pursuant to the provisions of *The* (Manitoba) *Environment Act*.

The Project would result in reduced soil productivity during the operation phase within portions of transmission line right-of-ways and at station sites where herbicides are used for vegetation management.

Mitigation

- Pesticide use shall be in accordance with the (Manitoba) *Pesticides Regulation, Manitoba Regulation M.R. 94/88*, which includes, but is not limited to:
  - Obtain/possess and use pesticides in accordance with a pesticide use permit.
  - Possess, or apply under the direct supervision of someone who possesses, a commercial applicator's licence issued under *The Pesticides and Fertilizers Control Act*.
  - Use only pesticide application equipment maintained in a manner that ensures its function as designed.
  - Not spraying pesticides in wind speeds <5 km/hr or >20 km/hr, except when using non-pressurized hand-operated equipment or drift-control equipment/additives.
  - Deposit effectively rinsed and punctured containers at a local pesticide container collection area or waste disposal ground designated by the municipality.

- Herbicide applications should be made by a licensed certified applicator.
- Herbicides should be applied according to product label directions.
- Spot spraying of target species should be conducted, where possible.

6.2.6 Effects of Accidental Releases

Accidental releases of hazardous materials may occur as a result of human-induced error (e.g., during refueling) or equipment malfunction (e.g., ruptured hydraulic line). The direct adverse effect of accidental releases is impairment of soil quality as a result of entry of contaminants to the soil environment. Indirect adverse effects of accidental releases of hazardous materials to the soil environment include reduced vegetative growth and potential adverse effects of decreased health of humans and other environmental receptors.

Project activities including, but not limited to, the use of heavy equipment during construction, decommissioning and transmission-line maintenance activities, the filling of converter station equipment with insulating oil during station commissioning and maintenance and the storage, transportation and handling of hazardous materials during all project phases, have the potential to result in accidental releases of hazardous materials to the environment. Releases of hazardous materials can be measured through analytical analysis of relevant parameters (e.g., Benzene, Toluene, Ethylbenzene, Xylenes [BTEX], Mineral Oil and Grease [MOG], Herbicides). Relevant criteria within the Canadian Council of Ministers of the Environment (CCME) Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (CCME 1999) would form the threshold level for a given contaminant concentration.

There is a potential for impairment of soil quality due to accidental releases, including spills or leaks, of hazardous materials, primarily within the transmission line and project component footprints during all phases of the Project. The likelihood of accidental releases is anticipated to be higher in marshalling yards and temporary workspaces, particularly during the construction and decommissioning phases of the Project.

Mitigation:

The following is an overview of general mitigation and environmental protection measures to prevent or mitigate the effect of accidental releases of hazardous materials. Site-specific considerations for the location of materials handling and storage areas is provided in Section 6.2.

- Fuel, lubricants and other potentially hazardous materials should be stored and handled within dedicated areas at work sites and marshalling yards in full compliance with regulatory requirements.
    - All storage sites should be located a minimum distance of 100 m from any waterbody.

- Marshalling yards should be located on low permeability soils and upland sites, where possible (i.e., areas of well drained soils, as identified regionally in Map 5.5 A and locally by the Senior Field Authority).
- Transfer of fuel must be attended at all times.
- An emergency response spill kit should be kept on-site at all times in case of fluid leaks or spills from machinery.
- All fuel spills or leaks should be reported to the Project Manager or delegate immediately upon discovery.
- General clean-up in storage areas, and sites where incidental spillage occurs, should be in accordance with regulatory standards.
    - All soil is to be remediated or disposed of in a manner approved by regulatory authorities and Manitoba Hydro.
- Hazardous materials, fuel containers and other materials should be removed from the site and disposed of according to Manitoba Hydro's Hazardous Materials Management Handbook and in accordance with regulatory requirements.

6.3 DIRECT TERRAIN EFFECTS

6.3.1 Terrain Stability

6.3.1.1 Mass Wasting Effects

Mass wasting refers to the downhill movement of soil under the influence of gravity, particularly on steep or unstable slopes and may occur in the form of slumps. The direct adverse effect of mass wasting is the loss of terrain material. Indirect effects include large increases of sediment to surface waters, loss of associated vegetation (Schuster and Highland 2007) and potential increase risk of personnel injury.

Very steep slopes (i.e.,>60%) and unstable soils are susceptible to mass wasting; however, mass wasting does not commonly occur in agricultural areas, with the exception of steep pasturelands (Brady and Weil 2008). Water is an important factor in slope instability, as water can add weight to the soil and reduce shear strength (Nelson 2010).

Approximately 1,584 ha of steep or unstable slopes have been identified within the 3-mile Local Study Area (Map 200 - 1:1 – Soil Drainage, Table 6.7). Only 27 ha of these slopes are located within the HVdc right-of-way and may potentially be affected.

The Project may result in loss of terrain material due to the initiation or acceleration of mass wasting primarily within the Local Study Area, but potentially including local areas beyond right-of-ways and component footprints, as a result of vegetation removal, grading (i.e., over steepening) and the use of explosives (Nelson 2010), where required. It is anticipated that the greatest likelihood of mass wasting is during the construction of transmission lines, particularly at steep or unstable waterbody crossings.

Mitigation

The following is an overview of general mitigation and environmental protection measures which may be used to prevent mass wasting or soil slumping.

- Construction activities in northern Manitoba should be scheduled during winter when the ground is under frozen and/or snow-covered conditions.

- Clearing and removal of natural vegetation should be limited to the greatest extent possible in identified steep/unstable slope areas and others, if encountered. Where vegetation is removed from sloped terrain, the area should be replanted with deep-rooted trees, such as willow, where feasible, to prevent slope degradation.

- Runoff should be directed away from disturbed areas to prevent further site degradation. some vegetation, slash or snow -covering should be maintained in areas of steep or unstable slopes to protect from soil erosion.

    - Diversion berms of compacted native soils or logs should be used on moderate and steep slopes (i.e., greater than 15-20%) to divert water away from the slope after construction. Berms should be spaced 45 m or less apart and skewed with a downstream gradient of 5-10%. Ensure berms end in natural vegetation[iii].

    - Borrow pits shall not be located within 100 m of identified steep slopes and/or unstable slopes, to prevent initiation or acceleration of instability due to blasting, if required.

Physical methods that could be used to stabilize unstable slopes in the identified areas, and others if encountered, include: lime stabilization by tamping calcium oxide (CaO or quicklime) into holes augered through the zone of failure to reduce plasticity and form a stabilizing pillar[iv];

6.3.1.2 Permafrost Effects

Permafrost is a layer of soil or rock material, typically within 100 cm of the surface (with the exception of areas of cryoturbation), which remains at temperatures below 0°C for more than two consecutive years (Brady and Weil 2008). Disturbance of the active layer can result in melting or changes to the thermal regime. Indirect effects of permafrost melting include increased erosion and ground subsidence which can affect infrastructure engineering and alter drainage, and increase greenhouse gas releases to the atmosphere. Fine-grained soils are considered more susceptible to instability as a result of disturbance due to the higher ice content associated with the typically wetter soil regime than coarse-grained soils[Mackenzie Gas Project 2004; Argonne National Laboratory (ANL) 2002; Resource Description and Analysis of the Vuntut National Park, undated; Heginbottom 1973]. The threshold for permafrost loss is an increase in soil temperature to above 0°C in baseline areas of permafrost. The loss of permafrost can be measured in area lost.

The activities identified as having the potential to contribute to permafrost thaw and ground subsidence include the physical disturbance or removal of insulating surface vegetation and soils that insulates or shades the ground and burning of disturbance to permafrost; whereas, tree removal without cutting the ground vegetation has been found to not have a notable effect. Winter disturbance has also been found to be of lesser magnitude than slash piles (Hegginbottom 1973; INAC 2011). Disturbance during summer in noted as more serious than winter disturbance (Hegginbottom, 1973).

A post-hoc study of the Radisson to Dorsey transmission line right-of-way (Magnusson and Stewart 1987) indicate that the effects of vegetation clearing, vehicle traffic and herbicide application resulted in visible scars along the right-of-way centre path and access routes. Johnston and Ladanyi (1974) found that the depth to permafrost increased by 1.2 to 1.4 m in a period of three years where vegetation and moss were cleared from engineering test sites in the discontinuous permafrost of Thompson, Manitoba. Further, long-term monitoring studies of permafrost thaw and surface settlement in zones of discontinuous permafrost along the buried pipeline of the Norman Wells Pipeline Project (Norman Wells, NWT to Zama, AB; Burgess and Smith 2003) found that thaw depths along the right-of-way ranged from 3 to >7 m, primarily occurring in the first 7 years with maximum surface settlement after 17 years ranging from 0.1 to 0.7 m.

Typical mitigation measures include placing an insulating cover of snow, ice, borrow material and/or slash (i.e., fills) below work areas or above cut surfaces (Mackenzie Gas Project 2004 , Crawford and Johnston 1971) and limiting or avoiding grading where possible (Mackenzie Gas Project 2004; Crawford and Johnston 1971). Disturbance on high-ice content (fine-grained permafrost-affected soils), including burning of brush piles (INAC 2011), should also be avoided. Conducting aerial inspections for the onset of erosion issues for the first number of years is also common to provide rapid response to developing conditions of instability (MacInnes 1989; ANL 2002).

The Project would result in a loss of permafrost within components of the transmission line and project component footprints in northern segments as a result of disturbance and compaction to overlying organic layers from site preparation and loss of some overlying organic materials due to burning of slash (Brown 1983) for brush disposal. These effects will be initiated during the construction phase of the Project and will also occur during maintenance and decommissioning activities.

Mitigation

6.3.1.3 500 kV HVdc Transmission Line and Associated Transmission Lines

Keewatinoow to Cormorant Lake Permafrost Risk Area

Discontinuous permafrost occurs within the HVdc right-of-way and Local Study Area of the 500 kV HVdc transmission line route from its origin at the Keewatinoow Converter Station in the north to the (Little) Cormorant Lake area (Map 400 - 1:7 – Permafrost Distribution).

Kelsey Lake Permafrost Risk Area

An isolated patch of sporadic discontinuous permafrost occurs within the HVdc right-of-way and Local Study Area of the 500 HVdc transmission line route in the area west of Kelsey Lake, located south of The Pas (Map 400 – 8 – Permafrost Distribution).

AC Collector Lines and Construction Power Line

The AC collector lines from Keewatinoow Converter Station to Longspruce Generating Station and the construction power line (KN36) traverse an area of primarily extensive discontinuous permafrost; whereas, the AC collector line (L61K)from Longspruce Generating Station to Henday Converter Station traverse areas of primarily sporadic discontinuous permafrost.

The following specific measures are proposed to reduce effects to permafrost along the transmission line right-of-ways:

- Construction, maintenance and decommissioning of the 500 kV HVdc right-of-way should not occur until the ground is frozen solid in the Kelsey Lake Permafrost Risk Area and north of the Little Cormorant Lake Area to prevent permafrost degradation.
- Construction, maintenance and decommissioning of the AC Collector Line and Construction Power Line should not occur until the ground is frozen solid to prevent permafrost degradation.
- The movement of equipment and inspection vehicles should be limited to a single path, where possible, to prevent compaction of the active layer resulting in reduced insulation of permafrost.
- Limit the exposure of soil due to right-of-way clearing to no more than 20% of the right-of-way in areas of discontinuous or isolated permafrost, where possible.
- Burning of slash from right-of-way clearing should be avoided on fine-grained, permafrost affected soils and on sloped terrain (>15%) to prevent melting and subsidence.
- Clearing should be minimized in known permafrost areas.

- Avoid stripping through organic vegetative layers to the extent possible. The top layer of organic soil and ground vegetation should be retained to prevent or minimize disturbance, where practical and feasible.
- Maintain natural drainage and prevent altering drainage or concentrating flows, in order to prevent ground ice from melting.
- Grade and compact snow in right-of-way work areas and along access routes, where possible or required for safety, to prevent thaw and increase frost penetration.

6.3.1.4 Infrastructure Component Sites

The Keewatinoow Converter Station site consists of extensive discontinuous permafrost (Map 8 - Keewatinoow Conveter Station - Soil Baseline Conditions). The northern electrode site consists of extensive discontinuous and sporadic discontinuous permafrost.

Permafrost will be removed from the Keewatinoow Converter Station footprint and replaced with suitable backfill material.

The following specific measures are proposed to reduce effects to permafrost within and adjacent to Keewatinoow Converter Station Site and northern electrode site:

- Construction and decommissioning of the northern electrode site should not occur until the ground is frozen solid to prevent permafrost degradation.
- Burning of slash from clearing of the Keewatinoow Converter Station Site and the northern electrode should be conducted within the site footprints.
- Avoid stripping through organic vegetative layers, to the extent possible, at the northern electrode site.
- Site drainage should direct flows to the existing natural and improved drainage network to avoid concentrating drainage flows to permafrost affected soils.

6.3.2 Terrain Diversity

Terrain diversity is positively correlated or associated with biological diversity (i.e., biodiversity) of plant and animal species (Manitoba Conservation n.d.); therefore, conservation of unique or diverse terrain (e.g., PAI enduring features) and associated biodiversity has been recognized as essential to maintaining healthy ecosystems. The maintenance of landscape integrity, or the intactness of a feature’s natural state, is the goal of conservation efforts. Direct adverse effects to terrain diversity may include impairment of landscape integrity of a unique terrain unit. Indirect adverse effects of impairment of landscape integrity include loss of biodiversity and impairment of aesthetic experiences which contribute to human physical and mental well-being (Manitoba Conservation n.d.). The maintenance of integrity is measured using “representation” or the proportion of unique/diverse terrain features (e.g., PAI enduring features) which are formally protected on a natural region basis. Representation may be adequate, moderate, partial or not captured based on the World Wildlife Fund Canada's ranking system (Manitoba Conservation 2000).

Single or rare occurrence PAI enduring features and other unique terrain/soil features (e.g., beach ridge, salt flats) identified from study results are considered unique/diverse terrain and are vulnerable to impairment or loss of landscape integrity. Approximately 1.5% or 9,910 ha of the Local Study Area contains single or rare occurrence PAI enduring features and other unique terrain/soil features (Map 600 - 1:17 – Unique Terrain/Soil Features, Tables 5.15 and 5.16). A total of 161 ha of diverse soil is located within the HVdc right-of-way and may be affected by the project.

There is a potential for the Project to result in the impairment or loss of landscape integrity of unique/diverse terrain features. Potential adverse effects to landscape integrity from fragmentation, impairment or loss as a result of the physical presence of the transmission line right-of-way would be limited to the transmission line right-of-way and persist for the life of the Project.

Mitigation

The following is an overview of general mitigation and environmental protection measures which may be used to prevent or mitigate impairment or loss of landscape integrity of unique/diverse terrain. Site-specific environmental protection measures for affected single or rare occurrence PAI enduring features and other unique terrain and soil features are identified in Section 6.5.2.

- Avoid routing transmission line right-of-ways through single or rare occurrence PAI enduring features or other unique terrain/soil features identified from study results, where possible.
    - Where avoidance is not possible, avoid blasting and grading activities within single or rare occurrence PAI enduring features or other unique terrain/soil features identified from study results, where possible.
- Borrow sources should not be established within identified PAI enduring features and other unique terrain/soil features.

6.4 DIRECT GEOLOGY EFFECTS

6.4.1 Surficial Geology Effects

The removal of mineral, organic and/or aggregate materials from existing and new off-site borrow areas for the backfill of excavations on soil and tower foundation construction will result in a loss of surficial materials (i.e., unconsolidated overburden or till) at those sites. Indirect effects include surface reconfiguration, including potential creation or destabilization of steep or unstable slopes which may initiate or accelerate mass movement of soils, increase the velocity of runoff; thereby increasing water erosion risk. The location of all borrow sources has not yet been identified for the Project. Volumetric and/or mass measurements could be utilized to measure the loss of surficial materials at borrow sites, which will primarily occur during the construction phase. There is no known threshold for removal of surficial material from a given site in Manitoba.

Mitigation

The following is an overview of mitigation and environmental protection measures which may be used to avoid or mitigate effects from the use or creation of borrow sources.

- Existing permitted borrow sources should be utilized, to the extent possible.
- Borrow pits should not be located within 100 m of steep slopes, where possible.
- Access trail grades should not exceed 12%. Grades near waterbodies should not exceed 5%. This gradient may be achieved through the use of snow or log ramps.
- Within borrow areas, the mineral or organic layer should be separated from other overburden soils for replacement.
- In borrow areas, runoff should be directed away from disturbed areas, to prevent erosion.
- Depending on the planned future use for the site, aggregate borrow pits should be closed, or reclaimed, in accordance with the *Mine Closure Regulation Manitoba Regulation M.R. 67/99.* Reclamation of the pit will restore the site condition and reduce the potential for erosion. Reclamation plans should be developed by Manitoba Hydro or their designate and carried out by a Contractor. Manitoba Hydro or their designate should be responsible for forwarding reclamation plans to the Mines Branch of Manitoba Conservation. According to the *Manitoba Mine Closure Regulation 67-99 General Closure Plan Guidelines* (Manitoba Industry, Trade and Mines, 2006) the reclamation plan should include, but not be limited to, the following activities:
    - Excavations should be backfilled if it is technically and economically feasible to do so. Salvaged soils should be respread over the area. If the excavation is not backfilled a fence meeting regulatory standards should be built with warning signs.
    - Steep slopes and benches must be rehabilitated (i.e., re-contoured) to prevent erosion.
    - Borrow pits should be revegetated to control erosion. Revegetation may include planting grass and bushes in areas prone to erosion, seeding or promotion of natural

encroachment with vegetation that resembles the natural environment. Vegetation should be self sufficient six years after planting.

- Contaminated soil should be removed and placed in a designated or contained area.
- Before closing access roads, municipal authorities should be consulted to determine if these authorities wish to maintain and accept legal responsibility for these roads. Road surfaces should be scarified, blended into natural contours and revegetated.

6.4.2 Bedrock Geology Effects

The use of explosives, or blasting, if any, in borrow pits and/or in foundation installation will result in a loss of bedrock (i.e., consolidated bedrock outcrops) at those sites within and outside the right-of-way. Indirect effects of blasting can include induced slope instability, fish mortalities and disruption of mammals. The location of foundation sites or borrow pits where blasting may be required has not yet been determined. Volumetric and/or mass measurements could be utilized to measure the loss of bedrock material at borrow pits and foundation sites. There is no known threshold for removal of bedrock material from a given site in Manitoba.

The Project will result in a loss of surficial geological material as a result of the use of existing and creation of new borrow sources, as required, for the importation of aggregate and mineral material from off-site to fill foundations and excavations. The loss of surficial geological material could be measured by volume (e.g., cubic meters removed). There is no known threshold for surficial geological material removal in Manitoba.

The following is an overview of mitigation and environmental protection measures which may be used to avoid or mitigate effects to the terrain and soil environment from the use of explosives:

- Explosives should be handled and detonated by a person holding a valid blaster's certificate (or under the direct supervision of a certified blaster) issued under The Workplace Safety and Health Regulation, M.R. 217/2006 [v].
- Explosives should be stored, transported and handled in accordance with the Explosives Act (Canada)[vi].
- Following detonation, the Contractor should ensure that the site of the shot hole(s) is filled in, with excess material, if any, spread evenly over the site. Drainage should not be obstructed[vii].
- The on-site storage of explosives at a quarry should meet the handling and storage requirements of the Operation of Mines Regulation, Man. Reg. 228/94, which include, but are not limited to:
  - A theft-resistant, locked receptacle with adequate ventilation.

- o Painted red and bearing the words “Danger Explosives.”
- o Located at least 8 m from another receptacle.

6.5 EFFECTS TO VALUED ENVIRONMENTAL COMPONENTS

The following is an assessment of effects to valued environmental components based on the anticipated direct soil, terrain and geology effects outlined in Sections 6.2 and 6.3 above.

Site-specific areas of Project right-of-ways and infrastructure component footprints which are susceptible to adverse effects to VECs as a result of Project activities are identified and the mitigation and environmental protection measures proposed to prevent or mitigate potential effects. A summary of these effects is found in Table 6.3.

6.5.1 Soil Productivity

6.5.1.1 Agricultural Capability

Construction and maintenance/inspection of the transmission line and southern ground electrode site will result in a reduction in agricultural capability class rating as a result of the mechanisms described in Section 6.2, namely compaction, erosion and soil mixing. These effects are primarily related to the use of heavy equipment and vehicles and surface disturbance, including excavation and grading. Reduced capability over baseline conditions as a result of the Project, resulting in an agricultural capability class rating change, is considered the threshold for agricultural capability effects, for the purpose of this assessment.

Mitigation

The following environmental protection measures are proposed for preventing a reduction in agricultural capability of arable soils. The site-specific mitigation measures previously identified in Section 6.2 will aid in protecting agricultural capability. The adoption of proposed measures will be dependent on the existing land use of right-of-way areas (i.e., implement if under agricultural production) and the intended interim and final land use of infrastructure component sites.

- Construction activities in southern Manitoba should be undertaken during winter, where possible, and under dry conditions for high compaction risk areas and moist conditions for high to severe wind erosion risk areas, where possible. Snow should be plowed or compacted to facilitate deeper frost penetration.
- Access routes should be located along existing traffic routes where possible and will be determined in advance. Vehicles should be restricted to those routes.
- Use low-ground pressure vehicles (i.e., wide-tracked machinery), particularly in areas of high compaction risk, where possible.

- If required, the right-of-way should be graded, disced or deep-ploughed to alleviate compaction and remove ruts caused by rubber-tired and tracked vehicles after construction.
- Remove all surface granular materials from sites and temporary workspaces on agricultural land and replace with clean, uncontaminated, stockpiled topsoil.
- Infrastructure component sites should be deep-ploughed as part of decommissioning to relieve compaction.

6.5.1.2 Topsoil Quality

Effects of the Project on topsoil quality will occur as discussed in Section 6.2, above, through effects of wind erosion, water erosion, compaction and rutting, soil temperature, herbicide residue, and accidental spills and malfunctions. In forestry harvesting operations, the effects of compaction and rutting have generally been found to result in a 10% reduction in soil productivity (Grigal 2000).

Mitigation

General mitigation, as discussed in Section 6.2, above, will be useful in minimizing effects to topsoil quality. Additional to those recommended above, the following mitigations are recommended for specific project components.

- Topsoils should be stripped and stockpiled prior to site grading for temporary project components (Temporary Work Camps, Marshalling Yards).
- Topsoils should be replaced on decommissioning of temporary project components (Temporary Work Camps, Marshalling Yards).

6.5.2 Unique Terrain/Soil Features

6.5.2.1 PAI Enduring Features

Of the total eight rare and single occurrence PAI enduring features (6 rare and 2 single) identified within the Local Study Area (Section 5.2.2), four enduring features (3 rare and 1 single) are intersected by the HVdc right-of-way. Avoidance of these features, particularly near The Pas area, was not possible due to limited corridor options. A summary of the four enduring features intersected by the HVdc right-of-way is included below, with a summary of rare and single occurrence PAI enduring features located within ASIs presented in Table 5.15.

In addition, a potential access route has been identified along an existing forestry ice road within a single-occurrence PAI enduring feature (Alluvial Deposit/Organic Mesisol (mesic sedge) unit - ID No. 1) within the Tom Lamb WMA north of the Saskatchewan River near The Pas. There are no other potential access routes located in identified unique terrain/soil features.

The Project right-of-way will coincide with a total of approximately 161 ha between the four affected enduring features; therefore, the maximum area (ha) of potentially impaired enduring features land is anticipated to be 161 ha. Two features (ID No. 1 and 3) are affected in less than 1% of their feature area (0.18% and 0.63% respectively) with the remaining two features (ID No. 4 and 9) affected in less than 3% of their feature area (2.88% and 2.17% respectively). It is anticipated that the proportion of these features that will remain unaffected by the Project and therefore available for being captured by protected areas to contribute to the representation of natural regions is 99.6% of the original features or 41,818 ha.

Rare Occurrence Deep Basin / Eutric Brunisol (ID No. 9; Map 600 - 1:17 – Unique Terrain/Soil Features, Table 5.16)

Approximately 36 ha, or 2% of this 1,657 ha rare occurrence PAI enduring feature, located within the Stephens Lake ASI east-northeast of Little Limestone Lake, is intersected by the HVdc right-of-way (Map 600 - 1 – Unique Terrain/Soil Features). Additional investigation conducted by Stantec based on stereo aerial photo interpretation and groundtruthing refined the boundaries of this feature and generally confirmed its extent and distribution (Map 600 - 1 – Unique Terrain/Soil Features). Similarly described deep basin/eutric brunisol features not affected by the project footprint are located within and beyond the ASI to the northeast and southeast, occupying 9,476 ha, 56 ha and 2,110 ha of land (ID Nos. 5, 8, 10, Map 600 - 1 – Unique Terrain/Soil Features, Table 5.15). This feature is predominantly a soil feature, rather than a topographic feature; therefore, effect to terrain integrity is considered minimal. It is estimated that the representation or total proportion of the Deep Basin / Eutric Brunisol feature which would remain available for protection within and outside the ASI (i.e., not affected by the Project) is 99.7% or 13,263 ha of this feature type.

Rare Occurrence Glaciofluvial Deposits / Organic Cryosol (mesic woody forest) Moraine (ID No. 4; Map 600 - 1:17 – Unique Terrain/Soil Features, Table 5.16)

Approximately 42 ha, or 3% of this 1, 441 ha rare occurrence PAI enduring feature, located within the Stephens Lake ASI southwest of Little Limestone Lake, is intersected by the HVdc right-of-way (Map 600 - 1:2 – Unique Terrain/Soil Features). The majority of this feature is within the corridor. Two similarly described enduring features not affected by the transmission line right-of-way are located within and outside the ASI, occupying 2,755 ha and 456 ha, respectively. Therefore, it is estimated that the representation or total proportion of Glaciofluvial Deposits / Organic Cryosol (mesic woody forest) Moraine feature which would remain available for protection (i.e., not affected by the Project) within and outside the ASI is 4,611 ha or 99% of this feature type.

Single Occurrence Alluvial Deposits/Organic Mesisol (mesic sedge) (ID No. 1; Map 600 - 1:17 – Unique Terrain/Soil Features, Table 5.16)

Approximately 67 ha, or 0.2% of this 36,396 ha single occurrence PAI enduring feature, located within the Tom Lamb WMA, Tom Lamb Addition and Summerberry Proposed WMA along the Saskatchewan River, east and southeast of The Pas, is intersected by the HVdc right-of-way

(Map 600 - 3:4 – Unique Terrain/Soil Features). This feature is primarily a soil feature, rather than a terrain feature and therefore, disturbance in this feature is considered to have a relatively lower effect to the landscape. Avoidance of this feature was not possible based on limited routing options in this area. It is estimated that the representation or total proportion of Alluvial Deposits / Organic Mesisol (mesic sedge) feature which would remain available for protection within and outside the ASI (i.e., not affected by the Project) is 99.8% or 36,329 ha of this feature.

Rare Occurrence Alluvial Deposits/Organic Mesisol (mesic woody forest) (ID No. 3; Map 600 - 1:17 – Unique Terrain/Soil Features, Table 5.16)

Approximately 16 ha, or 0.6% of this 2,485 ha rare occurrence PAI enduring feature, located within the Tom Lamb WMA, Tom Lamb Addition and Summerberry Proposed WMA between the Saskatchewan River and Kelsey Lake southeast of The Pas, is intersected by the HVdc right-of-way (Map 600 - 3 – Unique Terrain/Soil Features). A similarly described enduring feature not affected by the right-of-way is located immediately northwest of this feature within and extending beyond the ASI, occupying 288 ha (ID No. 2, Map 600 - 3 – Unique Terrain/Soil Features). Therefore, it is estimated that the representation or total proportion of Alluvial Deposits/Organic Mesisol (mesic woody forest) feature which would remain available for protection within and outside the ASI (i.e., not affected by the Project) is 99.4% or 2,757 ha of this feature type.

Mitigation

The following site-specific environmental protection measures are proposed for mitigating loss of landscape integrity in the four PAI enduring features traversed by the ROW.

- No off-ROW activities including construction of access trails or establishment of new borrow sources shall be conducted within any of the enduring features described by this study.
- Off-ROW activities shall maintain a buffer distance of 100 m from the enduring features described by this study, where feasible.
- Construction within enduring features shall be conducted in the winter, under frozen conditions, to protect site-specific features (e.g., organic deposits).
- Topsoil and subsoils should be excavated and stockpiled separately, where excavation is required for tower foundations. These soils should be replaced in the manner in which they were removed within the tower footprint.
- Minimize equipment movement within enduring features to minimize soil disturbance.
- Existing access routes should be utilized and machinery shall not operate outside of the Project areas within enduring features.

- Excavated soils will be stored at designated work/spoil areas and will be fully replaced on the footprint of the excavation in the reverse order they were excavated.

6.5.2.2 Other Unique Terrain/Soil Features

Other unique terrain/soil features identified from study results were mapped to determine their location within the Local Study Area of the 500 kV HVdc transmission line, where loss of terrain integrity from off right-of way activities during right-of-way establishment may occur (Map 600 - 1:5 – Unique Terrain/Soil Features).The Project Local Study Area will coincide with a total of approximately 400 ha of other unique terrain/soil features.

Beach Deposits on Ridged Terrain

Beach deposits, occupying an area of approximately 195 ha, are located within the Local Study Area, outside of the HVdc right-of-way east of the Stephens Lake ASI (Map 600 - 1 – Unique Terrain/Soil Features).

Red Deer WMA Salt Flats

An area with three occurrences of salt flats, with a total of approximately 59 ha, has been identified within the Local Study Area, outside of the HVdc right-of-way, west of PTH 10 in the Red Deer WMA - Overflow Bay Area (Map 600 - 4 – Unique Terrain/Soil Features).

Salt Flats in Interlake Plain

An area of salt flats, approximately 21 ha in size, has been identified within the Local Study Area, outside of the HVdc right-of-way, southwest of Winnipegosis in the Interlake Plain ecoregion (Map 600 - 5 – Unique Terrain/Soil Features).

Salt Flats in Lake Manitoba Plain

An area of salt flats, approximately 127 ha in size, has been identified within the Local Study Area, outside of the HVdc right-of-way, east of PTH 276 between Lake Manitoba and Dauphin Lake (Map 600 - 5 – Unique Terrain/Soil Features).

Mitigation

The following site-specific environmental protection measures are proposed to prevent loss of terrain integrity within the other unique terrain/soil features identified:

- No off-ROW activities including the construction of access trails and establishment of new borrow sources shall be conducted in the vicinity of the identified beach deposits and salt flats (Map 600 - 1:4-5 – Unique Terrain/Soil Features).

- Off-ROW activities shall maintain a buffer distance of 100 m from the other unique terrain/soil features described by this study, where feasible.

6.5.3 Stable Terrain

Construction and maintenance activities along the transmission line right-of-way could result in a loss of terrain stability as a result of permafrost thaw causing subsidence and mass wasting events, as described in Section 6.3.1. These effects are primarily related to the removal of surface vegetation, use of heavy equipment and vehicles and alteration or concentration of natural drainage patterns.

The following environmental protection measures are proposed for preventing a loss of terrain stability. The site-specific mitigation measures previously identified in Section 6.3.1 will also aid in protecting terrain stability.

- The removal of natural vegetation on sloped terrain, particularly adjacent to waterways, should be avoided to the greatest extent possible.
- Where vegetation is removed from sloped terrain, the area should be replanted with deep-rooted shrubs, such as willow, where feasible to prevent sloped degradation.
- Slope undercutting and slope modification at angles greater than 30° should be avoided, to prevent sliding or slumping. Any slopes over steepened beyond 30° should be graded to reduce the slope.
- The introduction of water to slopes should be limited to the greatest extent possible. Drainage should not be altered to concentrate flows, especially in sloped terrain.

6.6 RESIDUAL EFFECTS

An assessment of the significance of anticipated residual effects to the terrain and soil environment, based on proposed mitigation measures, is presented in Table 6.4. Following the implementation of the mitigation measures proposed, residual effects will be primarily related to some loss of soil structure due to compaction and rutting along portions of right-of-ways in northern Manitoba; increased soil temperatures in areas of cleared vegetation; impairment of landscape integrity of three single and one rare occurrence PAI enduring features traversed by the right-of-way, loss of surficial and bedrock geological materials, some potential for loss of terrain stability due to mass wasting and permafrost thaw and some impairment of soil quality in the event of a major spill.

Despite the use of best management practices and environmental protection planning, unmitigated compaction will occur at Project sites and along Project right-of-ways in Northern Manitoba. Previously forested segments of Project right-of-ways will experience an increase in annual mean soil temperature over baseline conditions, resulting from soil surface exposure and subsequent change in vegetative cover. The landscape integrity of the four enduring features traversed by the right-of-way will be permanently altered; however, it is not anticipated to impede conservation goals of achieving adequate representation.

Residual effects to the terrain and soil environment would primarily be limited to the Project sites and right-of-ways, occurring infrequently and persisting over the long-term, with moderate magnitude and moderate ecological and societal importance.

6.7 FOLLOW-UP/INSPECTION AND MONITORING

In addition to environmental protection planning measures to be implemented, follow-up and monitoring activities would be merited for assessing the success of proposed mitigation measures and verifying the effects related to compaction mitigation on agricultural lands and potential accidental releases to the soil environment. Additional monitoring may be required on site-specific measures during construction, such as erosion and sediment control measures condition, as described below.

6.7.1 Post-construction Follow-up

Post-construction follow-up or reclamation plans are a typical extension of mitigation and environmental protection measures for terrain and soil environs in other linear infrastructure developments (Conoco Phillips and TCPL 2008, Enbridge Pipelines Inc. 2011; Stantec Consulting Ltd., 2010; Universal Ensco Inc. 2006).

The primary focus of post-construction follow-up is loss of agricultural capability. Approximately 42.5% or 1810 ha of the HVdc footprint in agro-Manitoba has an Agricultural Capability rating of Class 1 to Class 3 with no limitations to moderate limitations to agricultural crop production, while approximately 38.5% or 1637 ha has an Agricultural Capability rating of Class 4 to Class 5 with moderately severe to severe limitations. This land is subject to effects that are reversible given satisfactory mitigation and reclamation; and is a valued environmental component. The following post-construction follow-up plan should be undertaken to confirm that a loss of agricultural capability is not experienced as a result of the Project.

Monitoring of crops or vegetation condition is the key indicator of land productivity (Enbridge Pipelines Inc. 2011, CH2M Hill 2008). Semi-annual monitoring of crops using aerial or ground patrols should be undertaken for two years following construction on agricultural lands, as is typically the standard on pipeline projects (CH2MHill 2008). Project footprints encountered to have vegetation issues relative to non-Project areas, that are obviously soil-related should be identified for reclamation to approximate pre-construction conditions.

It is anticipated that any effects to soil productivity persisting beyond the end of the construction phase will be compaction-related where proposed Project mitigation measures were not wholly effective. The following are typical post-construction reclamation measures for relieving compaction on agricultural land, primarily used by the pipeline industry, which should be implemented on Project lands identified during recommended follow-up as requiring reclamation, to the extent feasible:

- Compacted cropland should be ripped for a minimum of three passes of approximately 18 inches deep. The depth of the tine should be positioned to ensure the base of the tine passes through the compacted layer or just below it (Batey 2009) and that it is not at a depth that could damage drainage tiles.
- Ripping of compacted soils should be conducted in summer or fall. Soil moisture conditions should be low enough to achieve loosening or shattering of compacted soils, but not too low to result in pulling up large blocks (Duiker and Micsky, 2009), to prevent contributing to compaction (CH2MHill, 2008).
- The ripped area should be disced and harrowed to ensure the surface is smooth and soil clumps are broken:
    - Rutted areas should be restored to proper surface condition for planting, particularly on lands under irrigated production to reduce ponding.
- A penetrometer should be used by the Contractor to test the level of compaction of the decompacted area at regular intervals relative to undisturbed areas with a similar moisture regime to confirm the relief of compaction.
- If mechanical post-construction measures are not sufficient in relieving compaction, alternative measures including the plowing under of organic matter, such as wood chips or a green manure crop planting (e.g., alfalfa) should be considered to improve lost soil structure (Conoco Phillips and TCPL 2008).

6.7.2 Inspection

During construction of right-of-ways, the work areas, marshalling yard sites, trafficking paths and access trails, if any, should be inspected by the Manitoba Hydro inspector for staining and/or stressed vegetation that may have been caused by equipment leaks or accidental spills and debris, prior to decommissioning. Any instances of staining or stressed vegetation should be documented by the inspector. Soil samples of suspect areas may be required to confirm and delineate any contamination. Any contaminated soil should be remediated on-site or removed to an approved landfill or other soil treatment facility. Similar inspections should be conducted at infrastructure component sites.

6.7.3 Monitoring

The condition of any erosion and sediment control environmental protection measures implement should be monitored by the Contractor and/or Manitoba Hydro Inspector during construction of the Project. Any deficiencies in the condition of the control measures should be addressed as soon as possible, to prevent loss of soil material or potential deposition in waterways. Erosion and sediment control measures should remain in place until vegetation has re-established.

6.8 POTENTIAL CUMULATIVE EFFECTS

Cumulative environmental effects refer to environmental effects which are likely to result from a project in combination with the environmental effects of other past, existing and future actions. For the purposes of this assessment, project, activities (human or project-related) and natural events are considered actions. In addition, this assessment also considered induced actions, or actions which may foreseeably occur if the Project is approved.

This cumulative effects assessment is presented in the following sequence after CEAA (1994) and Hegmann *et al.* (1999):

1. Scoping
2. Analysis of effects
3. Identification of mitigation
4. Evaluation of significance
5. Follow-up

6.8.1 Scoping

6.8.1.1 Regional Issues of Concern

To assist with effect scoping, regional soil and terrain issues of concern have been identified. The following regional soil and terrain issues have been identified based on information gained from stakeholder consultations, including public, Aboriginal and regulator consultations, and from expert opinion. Regional soil and terrain issues of concern identified to-date and considered relevant to this cumulative effect assessment include:

- Loss or fragmentation of PAI enduring features available for protection.
- Degradation of soil quality (i.e., capability/productivity) for supporting agriculture and other plant life.
- Effects of increased access (e.g., soil compaction).

- Melting or loss of permafrost.

6.8.1.2 Valued Environmental Components

The VECs identified in Table 6.11 form the central focus of this cumulative effects assessment.

6.8.1.3 Spatial and Temporal Boundaries

The spatial boundary selected for the identification of actions that may contribute to a cumulative effect on the soil and terrain environment is the Project Footprint. This relatively narrow spatial boundary was selected for the cumulative effects assessment due to the site specificity of soil and terrain concerns. There is a need to provide consideration towards activities occurring outside of this spatial boundary, if they affect the same PAI enduring feature type within the same natural regions as the Project, as this geographically-separate activity can reduce the overall representation of a given enduring feature, which is evaluated on a natural region-basis.

A 20-year before present temporal boundary was selected for the Bipole III Project, to identify past actions that were not considered or accounted for in the baseline for existing environmental components. A future temporal boundary of 20-years was chosen based on typical planning horizons for future actions, such as projects or developments.

6.8.1.4 Residual Environmental Effects

The residual environmental effects of the Project, summarized in Section 6.6 and Table 6.10, primarily relate to a residual loss of or alteration to components of soil productivity; stability of permafrost or sloped terrain; and landscape integrity of unique terrain/soil features in the northern portion of the Project Footprint. There is a potential that other actions within the Project Footprint, or greater region, have the potential to act cumulatively with these residual effects.

6.8.2 Other Actions

The following is a description of other actions (i.e., activities, projects, and induced actions) that have the potential to affect valued environmental components (Section 5.2) common to the Bipole III Project, including soil productivity, terrain stability and unique terrain or soil features.

6.8.2.1 Activities

For the purposes of this assessment, activities are considered to include resource development and development projects. These activities are generally not anticipated to overlap spatially with the Project (i.e., occur within the Project Footprint); however, these general mining and forest harvesting operations could potentially have spatial overlap with other single or rare occurrence PAI enduring feature types located within ASIs in natural regions common to the Bipole III Project.

Past development projects, such as the Radisson-Churchill; Jenpeg –Ponton; and Herblet Lake-Ponton transmission lines, were completed outside of the temporal boundary of this assessment. Additionally, modern projects, both existing and future planned projects, such as the existing Wuskwatim Generating Project Access Route and planned Nunavut-Manitoba All-Weather Access Road (Gillam to Rankin Inlet) and East Side Road Transportation Initiative Recommended East-West Link appear to have been routed in consideration of existing enduring features, particularly within ASIs.

Due to the areal and linear footprint of these activities, there is the potential to have a nibbling effect on the landscape integrity or intactness of unique/diverse terrain within PAI enduring features located within ASIs (i.e., candidates for representation in the protected areas network) in addition to the nominal loss of landscape integrity as a result of the Project. A further analysis of the effects of these activities is provided in Section 6.8.3.

6.8.2.2 Actions and Events

Actions and events are considered to include induced actions, or actions that result from the approval and undertaking of the Project, and natural or anthropogenic events. These other actions are anticipated to and/or have the potential to overlap spatially with the Project (i.e., within the Project Footprint). It is not anticipated that these other actions would contribute to cumulative effects beyond the Project footprint, as it is not anticipated that activities with the potential to affect the soil and terrain environment will be induced beyond the Project Footprint and the soils and landforms of PAI enduring features remain stable despite natural events (Manitoba Conservation 2010).

Induced Actions

If the Project is approved, it is reasonable to believe based on previous project experience that the established transmission line ROW would be utilized particularly for opportunistic motorized travel between existing communities and places of interest (Wildlife Resource Consulting Services Manitoba Inc. *et al.* 2003). This use has the potential to result primarily in additive effects to soil productivity within the Project Footprint.

Natural and/or Anthropogenic Events

It is anticipated that the areal footprint of past and future fires, particularly fires due to lightning in northern forested areas, will and could directly overlap with the Project footprint (i.e., HVdc right-of-way). This use has the potential to have an additive and/or a masking effect to soil productivity and stability of permafrost-affected soils within the Project Footprint.

6.8.3 Environmental Effects Analysis, Mitigation and Significance

The environmental effects of identified specific and generalized other actions are described below and summarized in Table 6.12.

6.8.3.1 Alteration to Landscape Integrity of Areas Available for Protection/Representation

There is a potential for future resource use and linear infrastructure developments to contribute to an alteration of landscape integrity of enduring features available for protection within and beyond ASIs as a result of accommodating future forestry, mining or project developments. The potential land area (ha) of PAI enduring features which may be affected within natural regions common to the Project would be possible to quantify, once the footprint of infrastructure and future resource development footprints are known. This potential alteration of landscape integrity of PA enduring features, particularly loss of landscape integrity within portions of similar single or rare-occurrence enduring features located within and outside of ASIs, in addition with the nominal loss of landscape integrity caused by the Project, may result in a cumulative nibbling loss of lands available for protection or representation of the natural region.

Mineral Development and Exploration (E.g., Kimberlite Exploration)

Active exploration for kimberlites in Manitoba has begun over the last six years, following discoveries in Ontario, Saskatchewan and Nunavut. The collection of Kimberlite Indicator Mineral Samples has been generally focused in areas including west of Molson Lake and west of God's Lake in northeastern Manitoba (Manitoba Innovation, Energy and Mines, 2010). Further the general prevalence of regional mineral exploration activities was raised by participants in the ATK workshops. It is reasonably foreseeable that mining projects may be initiated in the constituent natural regions of the enduring features affected by the Project, which may necessitate boundary changes to existing or future areas for protection (i.e., ASIs).

Mitigation of nibbling losses is difficult to mitigate at the single project level and are generally best addressed through regional strategies (Hegmann *et al*., 1999). The regional planning and industry consultation activities conducted by PAI, including their representation on the Environment Act Licensing Technical Advisory Committee (TAC), will continue to play a vital role in minimizing industry and resource allocation conflicts with the potential to result in cumulative nibbling losses at ASIs and other features for protection of landscape integrity and representation.

The potential cumulative nibbling loss of landscape integrity within portions of single or rare enduring features located in ASIs is considered a long-term negative effect of medium magnitude, high ecological and moderate societal importance. The footprint loss may occur on an infrequent to sporadic basis during the life cycle of the Project would be irreversible.

Loss of Soil Productivity due to Induced Actions

There is a potential for the induced opportunistic motorized vehicle access of transmission line right-of-ways to contribute to a loss of soil structure and resultant reduction in soil productivity along northern right-of-ways due to repeated passes of motorized vehicles during variable weather and soil moisture conditions. This potential loss of soil structure, in addition to the anticipated residual loss of organic soil structure due to unmitigable heavy equipment traffic, may result in a cumulative temporal or space crowding effect of compaction, primarily within transmission line right-of-ways.

There are currently no mitigation measures proposed to minimize or prevent anticipated cumulative effects to soil productivity along northern right-of-ways as a result of motorized vehicle access. The nature of private land ownership and the absence of a residual effect to soil productivity in the southern portion is considered sufficient to not result in a cumulative effect to soil productivity in the southern portion.

The potential cumulative spatial and temporal crowding of effects to soil productivity on transmission line right-of-ways in the northern portion of the Project Study Area would be a long-term, negative effect of moderate ecological and societal importance. This medium magnitude effect would primarily affect the Project footprint on a sporadic basis and would be reversible.

Loss of Organic Matter due to Natural/Anthropogenic Events

There is a potential for future natural, and to a lesser extent anthropogenic or human-related, fires within the Local Study Area to contribute to a loss of soil organic matter and resultant reduction in soil productivity due to destruction or combustion in forest fires. Forest fires can result in the loss of soil organic matter due to the combustion of carbon in surficial soil layers (Neff et al., 2005). The potential loss of organic matter, in addition to the anticipated residual effects on overall soil productivity, may result in an additive cumulative effect to soil productivity.

Where site-specific soil investigations were undertaken, the effects of any past forest fires which may have affected the region were included in the baseline environmental condition. The majority of forest fires in northeastern and northwestern Manitoba are reported to be ignited by lightning, with the minority of fires, reported to be ignited as a result of human activities (Manitoba Conservation, 2010). However, Manitoba Parks and Natural Areas Branch (2010) notes that natural fires generally do not occur in the vicinity of infrastructure. Further, Manitoba Hydro construction and operational practices for the provision of a reliable energy source, will further reduce the potential for fires in the vicinity of transmission infrastructure.

The potential cumulative additive effect to soil productivity along transmission line right-of-ways as a result of forest fires is considered a long-term, negative effect of moderate ecological and societal importance. This medium magnitude, infrequent effect would be cumulative within the right-of-way footprint and irreversible within the Project life cycle.

Loss of Terrain Stability due to Natural/Anthropogenic Events

There is a potential for future natural forest fires within the Local Study Area to contribute to a loss of terrain stability as a function of permafrost subsidence due to thawing. Permafrost locations on warmer, drier landscape positions (e.g., elevated sites, and east, west or south-facing midslopes) may be particularly susceptible to deep thawing, depending on the severity or frequency of the fire (Swanson, 1996). The potential loss of terrain stability, in addition to residual loss of terrain stability due to permafrost subsidence, may result in an additive loss of terrain stability within the Local Study Area.

In addition to general fire suppression and Manitoba Hydro reliability operating practices, there are no additional mitigation measures proposed to minimize or prevent the effect of forest fires on permafrost subsidence.

The potential additive cumulative effect of terrain stability losses along transmission line right-of-ways in the northern portion of the Project Study Area are considered long-term, negative effects with moderate ecological and societal importance. This medium magnitude, infrequent effect would be irreversible.

7.0 Conclusions

The Project is anticipated to result in primarily infrequent, long-term, medium to large magnitude effects to the Land Component. These effects are primarily adverse, of moderate to high ecological and societal importance, variable reversibility and primarily located within the Project Footprint.

Identified cumulative effects to the Land Component are anticipated to be primarily infrequent, long-term and medium in magnitude. The effects are adverse, with moderate ecological and societal importance, primarily irreversible and primarily within the Project Footprint.

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Glossary

active layer	The top layer of soil in a permafrost zone, subjected to seasonal freezing and thawing which during the melt season becomes very mobile.
alluvial	Pertaining to materials (e.g., clay, silt, sand, and gravel) deposited by running water, including the sediments laid down in riverbeds, floodplains, lakes, and estuaries.
archaen	A geologic eon (time unit) before the Paleoproterozoic Era of the Proterozoic Eon, before 2.5 Ga (billion years, or 2,500 Ma) ago.
azonal	Soil without distinct genetic horizons.
brunisolic	An order of soils in which the horizons are developed sufficiently to exclude them from the Regosolic order but lack the degrees or kinds of horizon development specified for soils of the other orders. These soils which occur under a wide variety of climatic and vegetative conditions all have Bm or Btj horizons.
calcareous	Descriptive of materials containing calcium carbonate.
chernozemic	An order of soils that have developed under xerophytic or mesophytic grasses and forbs or under grassland-forest transition vegetation in cool to cold subarid to subhumid climates. The soils have a dark-colored surface (Ah or Ahe or Ap) horizon and a B or C horizon, or both, of high base saturation. The order consists of Brown, Dark Brown, Black, and Dark Gray great groups.
complexed	Pertaining to two or more defined soil units that are so intimately intermixed geographically that it is impractical because of the scale used to separate them.
cryosolic	An order of soils proposed for adoption in the Canadian taxonomic system. Cryosolic soils are mineral or organic soils that have perennially frozen material within 1 m (3 ft) of the surface in some part of the soil body, or pedon. The mean annual soil temperature is less than 0°C (32°F). They are the dominant soils of the zone of continuous permafrost and become less widespread to the south in the zone of discontinuous permafrost; their maximum development occurs in organic and poorly drained, fine textured materials.

distal	Relating to or denoting the outer part of an area affected by geological activity.
eutric	A great group of soils in the Brunisolic order. The soils may have mull Ah horizons less than 5 cm (2 inches) thick, and they have Bm horizons in which the base saturation (NaCl) is l00%.
fibric	Descriptive of organic soil material containing large amounts of weakly decomposed fiber whose botanical origin is readily identifiable.
glaciofluvial	Descriptive of material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and may occur in the form of outwash plains, deltas, kames eskers, and kame terraces.
glaciolacustrine	Pertaining to, derived from, or deposited in glacial lakes; especially said of the deposits and landforms composed of suspended material brought by meltwater streams flowing into lakes bordering the glacier, such as deltas, kame deltas, and varved sediments.
glaciomarine	Pertaining to materials that are deposited on the sea floor by glacial meltwater, by debris flows from the surface of a glacier or by melting icebergs.
gleysolic	An order of soils developed under wet conditions and permanent or periodic reduction. These soils have low chromas, or prominent mottling, or both, in some horizons.
humic	A great group of soils in the Gleysolic order. A dark-colored A (Ah or Ap) horizon more than 8 cm (3 inches) thick is underlain by mottled gray or brownish gleyed mineral material. It may have up to 40 cm (16 inches) of mixed peat (bulk density 0.1 or more) or up to 60 cm (24 inches) of fibric moss peat (bulk density less than 0.1) on the surface. This group includes soils formerly classified as Dark Gray Gleysolic and Meadow.
isostatic rebound	The rise of land masses that were depressed by the huge weight of ice sheets during the last glacial period, through a process known as isostasy.
luvisolic	An order of soils that have eluvial (Ae) horizons, and illuvial (Bt) horizons in which silicate clay is the main accumulation product. The soils developed under forest or forest-grassland transition in a moderate to cool climate.

mesic	Descriptive of soil organic material at a stage of decomposition intermediate that of fibric and humic materials.
moraines	An accumulation of heterogeneous rubbly material, including angular blocks of rock, boulders, pebbles, and clay, that has been transported and deposited by a glacier or ice-sheet.
non-soil	The collection of soil material or soil-like material that does not meet the definition of soil. It includes soil displaced by unnatural processes and unconsolidated material unaffected by soil-forming processes, except for the material that occurs within 15 cm (6 inches) below soil as defined. Non-soil also includes unconsolidated mineral or organic material thinner than 10 cm (4 inches) overlying bedrock; organic material thinner than 40 cm (16 inches) overlying a hydric layer; and soil covered by more than 60 cm (24 inches) of water in the driest part of the year.
organic	Of, relating to, or derived from living matter. Also refers to an order of soils that have developed dominantly from organic deposits. The majority of Organic soils are saturated for most of the year, unless artificially drained, but some of them are not usually saturated for more than a few days. They contain 17% or more organic carbon, and: (1) if the surface layer consists of fibric organic material and the bulk density is less than 0.1 [with or without a mesic or humic Op less than 15 cm (6 inches) thick], the organic material must extend to a depth of at least 60 cm (24 inches); or (2) if the surface layer consists of organic material with a bulk density of 0.1 or more, the organic material must extend to a depth of at least 40 cm (16 inches); or (3) if a lithic contact occurs at a depth shallower than stated in 1) or 2) above, the organic material must extend to a depth of at least 10 cm (4 inches).
permafrost	Perennially frozen material underlying the solum, or a perennially frozen soil horizon. Permafrost is subdivided into continuous and discontinuous permafrost, while sporadic permafrost is confined to alpine environments.
rare occurrence	A particular type of enduring feature identified by Manitoba’s Protected Areas Initiative occurring as two or four distinct areas concentrated in one or two localized geographic area(s) within a natural region.
regosolic	An order of soils having no horizon development or development of the A and B horizons insufficient to meet the requirements of the other orders.

salt flat	The dried-up bed of a former salt lake, sometimes called a salt prairie.
single occurrence	A particular type of enduring feature identified by Manitoba's Protected Areas Initiative occurring in only one distinct area that may be large or small, within a natural region.
sodicity	The level of exchangeable sodium and its influence on a soil.
subsidence	The gradual settling of the ground when permafrost thaws and the soil previously held up by the ice collapses.
terric organic	Descriptive of an unconsolidated mineral substratum underlying organic soil material.
thermokarst	The landscape which results from permafrost-thaw induced subsidence and is characterized by irregular surfaces of marshy hollows and small hummocks.
veener	A mantle of unconsolidated materials too thin to mask the minor irregularities of the underlying unit surface. A veneer sis generally less than 1 m in thickness.
vertisolic	An order of soils that occur in heavy-textured materials (> 60% clay, of which at least half is smectite) and have a shrink-swell character. They lack the degree of horizon development diagnostic of soils of the other soil orders, and the surface (Ah) horizon, when dry, has a massive structure and is hard. It consists of the Vertisol and Humic Vertisol great groups.

[i] Conoco Phillips and TCPL 2008.
[ii] Conoco Phillips and TCPL 2008.
[iii] CAPP, CEPA and CGA 2005.
[iv] Welsh et al. 2010
[v] (Manitoba) *Geophysical Regulation, Man. Reg. 110/94*
[vi] Ibid
[vii] *Operation of Mines Regulation, Man. Reg. 228/94.*

APPENDIX A – TABLES

Table 3.1: Significance Assessment Factors Criterion

Assessment Factor	Criteria	Explanation
Direction	Positive	Beneficial or desirable change in the environment.
	Negligible	No detectable or measurable change in the environment.
	Negative	Adverse or undesirable change in the environment.
Ecological Importance	High	• Protected species or habitat (i.e., threatened). • Fragile area, ecosystem or habitat. • Important to ecological function or relationships.
	Moderate	• Moderately rare, unique or fragile. • Moderately / seasonally fragile environmental component. • Somewhat important to ecosystem function or relationships. • Some importance to scientific investigations.
	Low	• Not rare or unique (i.e., common). • Resilient environmental component. • Minor ecosystem importance. • Limited scientific importance (i.e., no research/study).
Societal Importance	High	• Designated areas (e.g., parks) or infrastructure that is protected nationally or internationally. • Areas, activities, infrastructure and services, or components of the biophysical environment that have been identified as being important to sustaining the economic, social and cultural well-being of communities through the EA public consultation/ATK processes or EA regulatory guidance.
	Moderate	• Designated areas or infrastructure that is protected (locally, regionally or provincially). • Areas, activities, infrastructure and services, or components of the biophysical environment that have been identified as being somewhat important to sustaining the economic, social and cultural wellbeing of individuals (e.g., domestic resource use, sport fishing/hunting) through the EA public consultation/ATK processes or EA regulatory guidance.

Table 3.1: Significance Assessment Factors Criterion		
Assessment Factor	**Criteria**	**Explanation**
	Low	• Areas of infrastructure that have no formal designation. • Public has not identified through the EA consultation/ATK processes that affected components of the socio-economic environment or biophysical environment as important for individuals' overall well-being.
Magnitude	Large	• Effect on a population in sufficient magnitude to cause a decline in abundance and/or change in distribution lasting several generations. • For socio-economics, effect on an entire community. • Effect on the physical environment exceeds regulated limits, standards or guidelines. • Effect can be easily observed, measured and described, and may be widespread.
	Medium	• Effect on part of a population that result in a short-term change in abundance and/or distribution over one or more generations. • For socio-economics, effect on part of a community. • Effect on the physical environment meets and may occasionally exceed regulated limits, standards or guidelines. • Effect can be measured with a well-designed monitoring program.
	Small	• Effect on a group of individuals within a population or stick over one generation or less; similar to random changes in the population. • For socio-economics, effect on a group of individuals. • Effect on the physical environment does not exceed regulated limits, standards or guidelines. • No measurable effect on population as a whole.
Geographic Extent	Regional Assessment Area	• Effect extends into regional study area. • Area where indirect or cumulative effects occur.

Table 3.1: Significance Assessment Factors Criterion		
Assessment Factor	**Criteria**	**Explanation**
	Local Assessment Area	• Effect extends beyond the project footprint into the surrounding areas, including potentially affected communities within a ~5 km wide corridor of the route (i.e., ~2.5 km) on either side of the RoW and around other project components. • Area where direct and indirect effects may occur.
	Project Site/Footprint	• Effect confined to the footprint for all project components (RoW 66 m). Effects would be limited to directly affected environmental components. • Area where direct effects would occur.
Duration	Long term	• Effect is greater than 50 years.
	Medium-term	• Effect extends throughout the construction and operation phases of the project (up to 50 years).
	Short-term	• Effect occurs during the site-preparation or construction phase of the project (i.e., one to five years).
Frequency	Regular / Continuous	• Effect may occur continuously or periodically during the life of the project or more than once per day.
	Sporadic / Intermittent	• Effect may occur without any predictable pattern during the life of the project (e.g., wildlife collisions) or less than once per week.
	Infrequent	• Effect may occur only once during the life of the project or less than once per year (e.g., clearing).
Reversibility	Irreversible	• A long-term effect that is permanent (i.e., remains indefinite as a residual effect).
	Reversible	• Effect is reversible during the life of the project.

Table 4.1: Bipole III Transmission Project Activities Likely to Affect Terrain and Soils	
Component	**Activity**
Pre-licensing Activities	• Soil drilling and sampling • Clearing of sample sites and access trails • Installation of piezometers
Construction:	
Transmission Lines	• Clearing • Using heavy equipment • Constructing winter access trails • Transporting materials • Crossing frozen waterbodies • Installing anchors and foundations • Using explosives (borrow pit operation, foundation installation) • Obtaining fill material (borrow sources) • Infilling foundation excavations with clean, excavated soils
Converter Stations	• Removing existing vegetation and organic topsoil • Obtaining inorganic fill (borrow sources) • Earthmoving and grading • Compacting inorganic fill • Installing surface material • Installing access roads • Installing drainage • Filling equipment with insulating oil • Commissioning
Ground Electrode Sites	• Removing and stockpiling surface soils from metallic ring location • Excavating subsurface soils metallic ring location • Infilling with material (e.g., coke) • Trenching underground feeder cables • Replacing surface soils • “Dishing” surface above ring to retain moisture
Marshalling Yards and Construction Camp(s)	• Installing screw pile foundations (trailer units) • Storing hazardous material • Refueling
Operations and Maintenance:	
Vegetation Management	• Using heavy equipment • Applying herbicides
Converter Station Maintenance	• Filling equipment with insulating oil, etc.
Decommissioning:	
Borrow pits, access trails, marshalling yards, construction camp(s)	• Cleaning up/reclaiming/remediating commensurate to local environmental conditions

Table 5.1: Soil Properties Within the Local Study Area				
Study Area	**Local Study Area**		**HVdc Footprint**	
	ha	**%**	**ha**	**%**
Soil Order				
Brunisolic	68,571	10.3	937	10.3
Chernozemic	118,035	17.7	1,620	17.7
Cryosolic	73,502	11.0	1,021	11.2
Gleysolic	90,057	13.5	1,294	14.2
Luvisolic	83,237	12.5	1,191	13.0
Organic	128,226	19.2	1,727	18.9
Regosolic	19,792	3.0	262	2.9
Vertisolic	66,194	9.9	938	10.3
Non-Soil	18,567	2.8	141	1.5
Drainage				
Rapid	9,312	1.4	144	1.6
Well	127,673	19.2	1,743	19.1
Moderately Well	3,472	0.5	56	0.6
Imperfect	220,449	33.1	3,114	34.1
Poor	61,200	9.2	829	9.1
Very Poor	225,639	33.9	3,107	34.0
Non-Soil	18,437	2.8	139	1.5
Soil Texture				
Coarse Skeletal	13,833	2.1	148	1.6
Very Coarse	4,730	0.7	70	0.8
Coarse	43,723	6.6	623	6.8
Moderately Coarse	18,949	2.8	264	2.9
Medium	159,038	23.9	2,241	24.5
Moderately Fine	33,288	5.0	409	4.5
Fine	39,136	5.9	586	6.4
Very Fine	133,865	20.1	1,897	20.8
Fibric	71,402	10.7	1,011	11.1
Mesic	128,819	19.3	1,725	18.9
Undifferentiated	714	0.1	17	0.2
Non-Soil	18,685	2.8	141	1.5
Study Area				
	666,181	100.0	9,133	100.0

Table 5.2a: Soil Properties Within the Hudson Bay Lowland Ecoregion				
Hudson Bay Lowland	**Local Study Area**		**HVdc Footprint**	
	ha	**%**	**ha**	**%**
Soil Order				
Brunisolic	10,565	38.5	138	37.6
Chernozemic	0	0.0	0	0.0
Cryosolic	13,770	50.2	191	52.0
Gleysolic	0	0.0	0	0.0
Luvisolic	547	2.0	9	2.4
Organic	2,219	8.1	29	8.0
Regosolic	0	0.0	0	0.0
Vertisolic	0	0.0	0	0.0
Non-Soil	346	1.3	0	0.0
Drainage				
Rapid	1,205	4.4	21	5.7
Well	9,908	36.1	126	34.3
Moderately Well	0	0.0	0	0.0
Imperfect	0	0.0	0	0.0
Poor	372	1.4	0	0.1
Very Poor	15,617	56.9	220	59.9
Non-Soil	346	1.3	0	0.0
Soil Texture				
Coarse Skeletal	1,004	3.7	16	4.5
Very Coarse	200	0.7	4	1.2
Coarse	0	0.0	0	0.0
Moderately Coarse	0	0.0	0	0.0
Medium	3,983	14.5	42	11.5
Moderately Fine	5,377	19.6	75	20.4
Fine	547	2.0	9	2.4
Very Fine	0	0.0	0	0.0
Fibric	1,103	4.0	9	2.5
Mesic	14,886	54.2	211	57.4
Undifferentiated	0	0.0	0	0.0
Non-Soil	346	1.3	0	0.0
Ecoregion Area				
	27,447	100.0	367	100.0

Table 5.2b: Soil Properties Within the Selwyn Lake Upland Ecoregion				
Selwyn Lake Upland	Local Study Area		HVdc Footprint	
	Ha	%	ha	%
Soil Order				
Brunisolic	3,945	90.5	50	95.8
Chernozemic	0	0.0	0	0.0
Cryosolic	327	7.5	1	2.6
Gleysolic	0	0.0	0	0.0
Luvisolic	88	2.0	1	1.6
Organic	0	0.0	0	0.0
Regosolic	0	0.0	0	0.0
Vertisolic	0	0.0	0	0.0
Non-Soil	0	0.0	0	0.0
Drainage				
Rapid	2,664	61.1	44	84.8
Well	1,369	31.4	7	12.6
Moderately Well	0	0.0	0	0.0
Imperfect	0	0.0	0	0.0
Poor	72	1.7	0	0.0
Very Poor	255	5.8	1	2.6
Non-Soil	0	0.0	0	0.0
Soil Texture				
Coarse Skeletal	2,664	61.1	44	84.8
Very Coarse	0	0.0	0	0.0
Coarse	0	0.0	0	0.0
Moderately Coarse	0	0.0	0	0.0
Medium	558	12.8	2	4.3
Moderately Fine	722	16.6	3	6.7
Fine	88	2.0	1	1.6
Very Fine	0	0.0	0	0.0
Fibric	138	3.2	1	1.6
Mesic	189	4.3	1	1.0
Undifferentiated	0	0.0	0	0.0
Non-Soil	0	0.0	0	0.0
Ecoregion Area				
	4,360	100.0	52	100.0

Table 5.2c: Soil Properties Within Churchill River Upland Ecoregion				
Churchill River Upland	**Local Study Area**		**HVdc Footprint**	
	ha	**%**	**ha**	**%**
Soil Order				
Brunisolic	3,656	6.8	42	5.6
Chernozemic	0	0.0	0	0.0
Cryosolic	18,695	34.9	258	34.6
Gleysolic	0	0.0	0	0.0
Luvisolic	17,261	32.2	271	36.3
Organic	13,001	24.3	175	23.5
Regosolic	951	1.8	0	0.0
Vertisolic	0	0.0	0	0.0
Non-Soil	1	0.0	0	0.0
Drainage				
Rapid	2,236	4.2	11	1.4
Well	13,887	25.9	209	28.0
Moderately Well	3,472	6.5	56	7.5
Imperfect	2,884	5.4	41	5.5
Poor	226	0.4	7	0.9
Very Poor	30,859	57.6	422	56.6
Non-Soil	1	0.0	0	0.0
Soil Texture				
Coarse Skeletal	2,236	4.2	11	1.4
Very Coarse	0	0.0	0	0.0
Coarse	0	0.0	0	0.0
Moderately Coarse	0	0.0	0	0.0
Medium	5,285	9.9	67	9.0
Moderately Fine	557	1.0	21	2.8
Fine	4,238	7.9	62	8.3
Very Fine	10,162	19.0	157	21.0
Fibric	12,233	22.8	178	23.9
Mesic	18,852	35.2	251	33.6
Undifferentiated	0	0.0	0	0.0
Non-Soil	1	0.0	0	0.0
Ecoregion Area				
	53,565	100.0	746	100.0

Table 5.2d: Soil Properties Within the Hayes River Upland Region				
Hayes River Upland	Local Study Area		HVdc Footprint	
	ha	%	ha	%
Soil Order				
Brunisolic	13,109	9.2	162	8.3
Chernozemic	0	0.0	0	0.0
Cryosolic	40,328	28.3	571	29.3
Gleysolic	3,624	2.5	53	2.7
Luvisolic	60,206	42.2	840	43.1
Organic	18,348	12.9	244	12.5
Regosolic	0	0.0	0	0.0
Vertisolic	0	0.0	0	0.0
Non-Soil	7,103	5.0	78	4.0
Drainage				
Rapid	95	0.1	0	0.0
Well	55,435	38.8	739	37.9
Moderately Well	0	0.0	0	0.0
Imperfect	18,420	12.9	267	13.7
Poor	8,041	5.6	115	5.9
Very Poor	53,625	37.6	749	38.5
Non-Soil	7,103	5.0	78	4.0
Soil Texture				
Coarse Skeletal	95	0.1	0	0.0
Very Coarse	4,529	3.2	66	3.4
Coarse	0	0.0	0	0.0
Moderately Coarse	1,232	0.9	15	0.8
Medium	2,860	2.0	36	1.8
Moderately Fine	4,816	3.4	48	2.5
Fine	8,024	5.6	109	5.6
Very Fine	56,017	39.3	785	40.3
Fibric	23,369	16.4	334	17.2
Mesic	34,673	24.3	478	24.5
Undifferentiated	0	0.0	0	0.0
Non-Soil	7,103	5.0	78	4.0
Ecoregion Area				
	142,718	100.0	1,948	100.0

Table 5.2e: Soil Properties Within the Mid-Boreal Lowland Region				
Mid-Boreal Lowland	Local Study Area		HVdc Footprint	
	ha	%	ha	%
Soil Order				
Brunisolic	28,425	22.1	436	24.7
Chernozemic	931	0.7	7	0.4
Cryosolic	381	0.3	0	0.0
Gleysolic	18,932	14.7	281	15.9
Luvisolic	2,219	1.7	35	2.0
Organic	67,421	52.5	926	52.4
Regosolic	2,522	2.0	31	1.8
Vertisolic	0	0.0	0	0.0
Non-Soil	7,650	6.0	50	2.8
Drainage				
Rapid	471	0.4	4	0.2
Well	9,491	7.4	165	9.4
Moderately Well	0	0.0	0	0.0
Imperfect	25,256	19.7	374	21.2
Poor	11,311	8.8	161	9.1
Very Poor	74,302	57.8	1,013	57.3
Non-Soil	7,650	6.0	50	2.8
Soil Texture				
Coarse Skeletal	1,848	1.4	15	0.9
Very Coarse	0	0.0	0	0.0
Coarse	44	0.0	0	0.0
Moderately Coarse	10,415	8.1	157	8.9
Medium	29,697	23.1	468	26.5
Moderately Fine	5,318	4.1	65	3.7
Fine	5,611	4.4	85	4.8
Very Fine	38	0.0	0	0.0
Fibric	25,525	19.9	392	22.2
Mesic	42,278	32.9	535	30.3
Undifferentiated	0	0.0	0	0.0
Non-Soil	7,709	6.0	50	2.8
Ecoregion Area				
	128,481	100.0	1,767	100.0

Table 5.2f: Soil Properties Within the Interlake Plain Region				
Interlake Plain	Local Study Area		HVdc Footprint	
	Ha	%	ha	%
Soil Order				
Brunisolic	6,546	7.1	86	6.9
Chernozemic	22,744	24.8	303	24.2
Cryosolic	0	0.0	0	0.0
Gleysolic	30,538	33.3	464	37.1
Luvisolic	2,740	3.0	30	2.4
Organic	23,257	25.4	304	24.3
Regosolic	3,971	4.3	54	4.3
Vertisolic	22	0.0	0	0.0
Non-Soil	1,756	1.9	11	0.9
Drainage				
Rapid	563	0.6	3	0.3
Well	9,309	10.2	129	10.3
Moderately Well	0	0.0	0	0.0
Imperfect	31,511	34.4	440	35.1
Poor	11,711	12.8	160	12.7
Very Poor	36,786	40.2	510	40.7
Non-Soil	1,695	1.9	10	0.8
Soil Texture				
Coarse Skeletal	3,615	3.9	43	3.4
Very Coarse	0	0.0	0	0.0
Coarse	12,963	14.2	190	15.2
Moderately Coarse	3,962	4.3	43	3.4
Medium	31,687	34.6	432	34.5
Moderately Fine	7,800	8.5	111	8.9
Fine	5,711	6.2	110	8.8
Very Fine	1,073	1.2	14	1.1
Fibric	9,033	9.9	97	7.7
Mesic	13,935	15.2	202	16.1
Undifferentiated	18	0.0	0	0.0
Non-Soil	1,776	1.9	11	0.9
Ecoregion Area				
	91,574	100.0	1,252	100.0

Table 5.2g: Soil Properties Within the Lake Manitoba Plain Region				
Lake Manitoba Plain	**Local Study Area**		**HVdc Footprint**	
	Ha	**%**	**ha**	**%**
Soil Order				
Brunisolic	2,325	1.1	24	0.8
Chernozemic	93,554	43.3	1,308	43.7
Cryosolic	0	0.0	0	0.0
Gleysolic	36,850	17.0	496	16.6
Luvisolic	176	0.1	6	0.2
Organic	3,977	1.8	49	1.6
Regosolic	11,524	5.3	170	5.7
Vertisolic	66,172	30.6	938	31.3
Non-Soil	1,680	0.8	3	0.1
Drainage				
Rapid	1,884	0.9	61	2.0
Well	27,654	12.8	369	12.3
Moderately Well	0	0.0	0	0.0
Imperfect	141,562	65.5	1,985	66.3
Poor	29,363	13.6	386	12.9
Very Poor	14,182	6.6	193	6.4
Non-Soil	1,611	0.7	1	0.0
Soil Texture				
Coarse Skeletal	2,371	1.1	19	0.6
Very Coarse	0	0.0	0	0.0
Coarse	30,105	13.9	426	14.2
Moderately Coarse	3,280	1.5	49	1.6
Medium	84,567	39.1	1,193	39.8
Moderately Fine	8,207	3.8	86	2.9
Fine	14,889	6.9	212	7.1
Very Fine	66,574	30.8	941	31.4
Fibric	0	0.0	0	0.0
Mesic	4,003	1.9	49	1.6
Undifferentiated	541	0.3	17	0.6
Non-Soil	1,718	0.8	3	0.1
Ecoregion Area				
	216,256	100.0	2,994	100.0

Table 5.2h: Soil Properties Within the Aspen Parkland Region				
Aspen Parkland	Local Study Area		HVdc Footprint	
	ha	%	ha	%
Soil Order				
Brunisolic	0	0.0	0	0.0
Chernozemic	807	45.3	1	16.3
Cryosolic	0	0.0	0	0.0
Gleysolic	114	6.4	0	0.4
Luvisolic	0	0.0	0	0.0
Organic	4	0.2	0	0.0
Regosolic	824	46.3	7	83.2
Vertisolic	0	0.0	0	0.0
Non-Soil	31	1.8	0	0.0
Drainage				
Rapid	194	10.9	1	11.7
Well	620	34.8	0	0.0
Moderately Well	0	0.0	0	0.0
Imperfect	817	45.9	8	87.8
Poor	104	5.8	0	0.4
Very Poor	13	0.8	0	0.0
Non-Soil	31	1.8	0	0.0
Soil Texture				
Coarse Skeletal	0	0.0	0	0.0
Very Coarse	0	0.0	0	0.0
Coarse	612	34.4	7	84.1
Moderately Coarse	60	3.4	0	0.0
Medium	401	22.5	1	15.9
Moderately Fine	491	27.6	0	0.0
Fine	27	1.5	0	0.0
Very Fine	0	0.0	0	0.0
Fibric	0	0.0	0	0.0
Mesic	4	0.2	0	0.0
Undifferentiated	155	8.7	0	0.0
Non-Soil	31	1.8	0	0.0
Ecoregion Area				
	1,780	100.0	9	100.0

Table 5.3: Northern AC Collector Lines		
Soil Type	**ha**	**%**
Soil Order:		
Eluviated Eutric Brunisol	83.3	10.1
Cumulic Regosol	7.5	0.9
Mesic Organic Cryosol	220.8	26.9
Terric Mesic Organic Cryosol	255.2	31.0
Typic Mesisol	255.5	31.1
Drainage:		
Rapid	72.1	8.8
Well	11.2	1.4
Imperfect	7.5	0.9
Poor	220.8	26.9
Very Poor	510.6	62.1
Soil Texture:		
Coarse Skeletal	72.1	8.8
Medium	18.7	2.3
Fibric	222.1	27.0
Mesic	509.4	61.9
Northern AC Collector Lines Summary:		
Total	**822.3**	**100.0**

Table 5.4: L61K Henday to Long Spruce		
Soil Type	**ha**	**%**
Soil Order:		
Eluviated Eutric Brunisol	31.7	19.8
Mesic Organic Cryosol	51.2	32.0
Terric Mesic Organic Cryosol	16.9	10.5
Typic Mesisol	55.1	34.5
Water	5.0	3.1
Drainage:		
Rapid	9.0	5.6
Well	22.7	14.2
Poor	51.2	32.0
Very Poor	71.9	45.0
Soil Texture:		
Coarse Skeletal	9.0	5.6
Medium	22.7	14.2
Fibric	68.0	42.6
Mesic	55.1	34.5
L61K Henday to Long Spruce Summary:		
Total	**159.8**	**100.0**

Table 5.5: Potential Construction Power Site		
Soil Type	**ha**	**%**
Soil Subgroup:		
Eluviated Eutric Brunisol	1.1	50
Mesic Organic Cryosol	0.5	20
Terric Mesic Organic Cryosol	0.7	30
Drainage:		
Well	1.1	50
Poor	0.5	20
Very Poor	0.7	30
Soil Texture:		
Medium	1.1	50
Fibric	1.1	50
Construction Power Site Summary:		
Total	**2.3**	**100**

Table 5.6: KN36 Keewatinoow to Construction Power		
Soil Type	**ha**	**%**
Soil Order:		
Eluviated Eutric Brunisol	40.3	11.9
Cumulic Regosol	2.7	0.8
Mesic Organic Cryosol	82.4	24.4
Terric Mesic Organic Cryosol	111.8	33.1
Typic Mesisol	100.5	29.8
Drainage:		
Rapid	27.0	8.0
Well	13.3	3.9
Imperfect	2.7	0.8
Poor	82.4	24.4
Very Poor	212.3	62.9
Soil Texture:		
Coarse Skeletal	27.0	8.0
Medium	16.0	4.7
Fibric	85.1	25.2
Mesic	209.6	62.1
KN36 Keewatinoow to Construction Power Summary:		
Total	**337.8**	**100.0**

Table 5.7: Keewatinoow Construction Camp		
Soil Type	**ha**	**%**
Soil Subgroup:		
Eluviated Eutric Brunisol	24.5	88.5
Mesic Organic Cryosol	1.3	4.6
Terric Mesic Organic Cryosol	1.9	6.9
Drainage:		
Well	24.5	88.5
Poor	1.9	6.9
Very Poor	1.3	4.6
Soil Texture:		
Medium	24.5	88.5
Fibric	3.2	11.5
Northern Camp Summary:		
Total	**27.6**	**100**

Table 5.8: Keewatinoow Converter Station Site		
Soil Type	**ha**	**%**
Soil Subgroup:		
Eluviated Eutric Brunisol	49	40.7
Mesic Organic Cryosol	20	16.3
Terric Mesic Organic Cryosol	45	37.5
Typic Mesisol	7	5.6
Drainage:		
Well	49	40.7
Poor	20	16.3
Very Poor	52	43.0
Soil Texture:		
Medium	49	40.7
Fibric	49	40.7
Mesic	22	18.6
Northern Converter Station Site Summary:		
Total	**120**	**100.0**

Table 5.9: Keewaintoow Electrode Sites				
Soil Type	**Preferred**		**Alternate**	
	ha	**%**	**ha**	**%**
Soil Subgroup:				
Eluviated Eutric Brunisol	132.3	33.0	191.4	47.7
Mesic Organic Cryosol	2.1	0.5		
Terric Mesic Organic Cryosol	187.5	46.8	146.7	36.6
Typic Mesisol	79.0	19.7	62.9	15.7
Drainage:				
Well	132.3	33.0	191.4	47.7
Poor	2.1	0.5		
Very Poor	266.5	66.5	209.5	52.3
Soil Texture:				
Medium	132.3	33.0	191.4	47.7
Fibric	5.3	1.3		
Mesic	263.4	65.7	209.5	52.3
Potential Northern Electrode Sites Summary:				
Total	**400.9**	**100.0**	**400.9**	**100.0**

Table 5.10: Keewatinoow Electrode Line		
Soil Type	**ha**	**%**
Soil Order:		
Eluviated Eutric Brunisol	30.3	69.2
Mesic Organic Cryosol	4.2	9.7
Terric Mesic Organic Cryosol	8.4	19.1
Typic Mesisol	0.9	2.0
Drainage:		
Well	30.3	69.2
Poor	4.2	9.7
Very Poor	9.2	21.1
Soil Texture:		
Medium	30.3	69.2
Fibric	10.6	24.2
Mesic	2.9	6.6
Northern Electrode Line Summary:		
Total	**2.26**	**100.0**

Table 5.11: Riel Converter Station Site		
Soil Type	**ha**	**%**
Soil Subgroup:		
Gleyed Humic Vertisol	35.2	50.5
Gleysolic Humic Vertisol	25.3	36.3
Gleyed Rego Black Chernozem	9.2	13.2
Drainage:		
Imperfect	58.1	83.5
Poor	11.5	16.5
Soil Texture:		
Fine	9.2	13.2
Very Fine	60.4	86.8
Agricultural Capability:		
1		
2	44.4	63.7
3	25.3	36.3
4		
5		
6		
7		
O		
Non-soil		
Southern Converter Station Site Summary:		
Total	**69.6**	**100.0**

Table 5.12: Riel Electrode Sites				
Soil Type	**Preferred**		**Alternate**	
	ha	**%**	**ha**	**%**
Soil Subgroup:				
Orthic Dark Grey Chernozem			13	5.0
Gleyed Dark Grey Chernozem			94	36.2
Rego Humic Gleysol			17	6.4
Terric Mesisol			136	52.4
Gleyed Humic Vertisol	20	7.5		
Gleysolic Humic Vertisol	250	92.5		
Drainage:				
Well			13	5.0
Imperfect	271	100	94	36.2
Poor			17	6.4
Very Poor			136	52.4
Soil Texture:				
Medium			123	47.6
Very Fine	271	100		
Mesic			136	52.4
Agricultural Capability:				
1				
2	20.4	7.5		
3	250.2	92.5	106.9	41.2
4				
5			16.6	6.4
6				
7				
O			136.0	52.4
Non-soil				
Southern Electrode Sites Summary:				
Total	**271**	**100**	**259**	**100**

Table 5.13: Valued Environmental Components			
Valued Environmental Component	**Rationale for VEC Selection**	**Environmental Indicator**	**Measurable Parameter/ Variable**
Soil Productivity (Agro-Manitoba/South): Agricultural Capability	The productivity of soils for arable agriculture is valued by agricultural producers as a primary source of income and is beneficial to society. The potential for disruption of prime agricultural lands in Agro-Manitoba was a concern raised by many participants of the Environmental Assessment Consultation Process for the Project (MMM Group Limited 2010). Maintenance of soil productivity for lands under annual and perennial agricultural crop production is important in order to minimize disruption to agricultural producers.	Agricultural Capability Class (Canada Land Inventory 1965)	Agricultural Capability Rating Class, as determined by: • Soil moisture holding capacity • Topography • Soil structure • Permeability • Salinity/sodicity • Erosion • Stoniness • Drainage • Organic matter content
Soil Productivity (non-Agro Manitoba/North): Topsoil Quality	Soil productivity is necessary to support natural ecosystems (e.g., vegetation, wildlife) and is therefore of value to resource users and society. The importance of vegetation, including blueberries and medicinal plants, was emphasized by community members in the Environmental Assessment and Consultation Process (MMM Group Limited 2010) and Aboriginal Traditional Knowledge (ATK) workshops. Productive soil is considered necessary to support the ecosystems of these valued vegetative components.	Topsoil (mineral or organic) Soil Quality	Topsoil (mineral or organic) Soil Quality, as determined by: • Topsoil thickness • Topsoil colour • Organic matter content • Soil texture/Salinity • pH • Nutrient/fertility status • Bulk density • Degree of compaction (i.e., resistance to penetration) • Soil temperature
Unique Terrain/Soil Features: Single or rare occurrence Protected Areas Initiative (PAI) Enduring Features	Unique terrain/soil features are important to overall terrain/soil integrity as they represent relatively uncommon terrain/soil occurrences and have special physical, aesthetic, social, cultural or inherent terrain/soil diversity value. Single or rare occurrences of PAI enduring features are considered ecologically unique.	• Landscape integrity • Representation	• Hectares of impaired land • Proportion protected (Area protected/available area)
Unique Terrain/Soil Features: Other Unique Terrain and Soil Features	Unique terrain/soil features are important to overall terrain/soil integrity as they represent relatively uncommon terrain/soil occurrences and have special physical, aesthetic, social, cultural or inherent terrain/soil diversity value. Other Unique Terrain/Soil Features consist of unique features identified through the assessment process and not identified as PAI Enduring Features.	• Landscape Integrity	• Hectares of impaired land • Proportion of feature impaired
Stable Terrain	The maintenance of stable terrain, has ecological and socioeconomic value, as a function of its role in supporting existing ecosystems and human infrastructure (Duan and Naterer, 2009).	• Visual assessment • Geotechnical calculations • Active layer thickness	• Factor of Safety • Increase in Active Layer Thickness (length)

Table 5.14: Summary of Agricultural Capability

	Aspen Parkland				Interlake Plain				Lake Manitoba Plain				Study Area (Agro-Manitoba only)			
	Local Study Area		HVdc Footprint		Local Study Area		HVdc Footprint		Local Study Area		HVdc Footprint		Local Study Area		HVdc Footprint	
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
1	608	34.2	0	0.0	0	0.0	0	0.0	2,938	1.4	31	1.0	3,547	1.1	31	0.7
2	95	5.3	0	0.0	8,967	9.8	118	9.4	47,719	22.1	652	21.8	56,781	18.3	770	18.1
3	272	15.3	1	16.3	9,459	10.3	131	10.5	61,705	28.5	877	29.3	71,436	23.1	1,009	23.7
4	462	26.0	6	71.5	19,167	20.9	277	22.1	57,032	26.4	810	27.1	76,661	24.8	1,093	25.7
5	104	5.8	0	0.4	12,132	13.3	171	13.7	28,945	13.4	372	12.4	41,181	13.3	544	12.8
6	204	11.4	1	11.7	13,625	14.9	202	16.2	11,738	5.4	201	6.7	25,566	8.3	404	9.5
7	0	0.0	0	0.0	119	0.1	1	0.1	597	0.3	2	0.1	716	0.2	2	0.1
O	4	0.2	0	0.0	23,173	25.3	303	24.2	3,977	1.8	49	1.6	27,153	8.8	352	8.3
Non-soil	31	1.8	0	0.0	4,848	5.3	47	3.8	1,606	0.7	1	0.0	6,485	2.1	49	1.1
Total	**1,780**	**100.0**	**9**	**100.0**	**91,490**	**100.0**	**1,251**	**100.0**	**216,256**	**100.0**	**2,994**	**100.0**	**309,527**	**100.0**	**4,254**	**100**

Table 5.15: Summary of Enduring Features

Ecoregion(s)	Area of Special Interest	ID No.[3]	PAI Data Summary: Description of Enduring Feature	PAI Data Summary: Occurrence (Single/Rare)	Area: Total (ha)	Area: Local Study Area (ha)	Area: Local Study Area (%[1])	Area: HVdc Footprint (ha)	Area: HVdc Footprint (%[2])	Additional Data Summary – Data Source Summary: Desktop Mapping	Data Source Summary: Aerial Recon.	Data Source Summary: Ground-truthing	Summary Comment
Mid-Boreal Lowland	Tom Lamb WMA, Tom Lamb Addition, Summerberry Proposed WMA	1	Alluvial Deposits/Organic Mesisol (mesic sedge)	Single	36396	4738	13.0	67	0.18				-
Mid-Boreal Lowland	Summerberry Proposed WMA	2	Alluvial Deposits/Organic Mesisol (mesic woody forest)	Rare	288	126	43.7						RoW does not intersect this Enduring Feature.
Mid-Boreal Lowland	Tom Lamb WMA, Tom Lamb Addition, Summerberry Proposed WMA	3	Alluvial Deposits/Organic Mesisol (mesic woody forest)	Rare	2485	773	31.1	16	0.63		X	X	-
Churchill River Upland/Hayes River Upland	Stephens Lake	4	Glaciofluvial Deposits/Organic Cryosol (mesic woody forest)/Moraine	Rare	1441	1374	95.3	42	2.88	X	X	X	Desktop mapping, aerial reconnaissance and groundtruthing has confirmed the presence of this Enduring Feature and is in general agreement with the area that was previously mapped.
Hudson Bay Lowland/Selwyn Lake Upland	Stephens Lake	5	Deep Basin/Eutric Brunisol	Rare	9476								Study corridor and RoW do not intersect this Enduring Feature.
Hudson Bay Lowland/Selwyn Lake Upland	Stephens Lake	6	Esker	Rare	51								Study corridor and RoW do not intersect this Enduring Feature.
Hudson Bay Lowland/Selwyn Lake Upland	Stephens Lake	7	Esker	Rare	14	14	100.0			X	X	X	RoW does not intersect the mapped Enduring Feature, as provided by PAI. Additional desktop mapping, aerial reconnaissance and groundtruthing have confirmed the presence of this esker; however, the feature is approximately 75 km long, occupies approximately 1900 ha, and is discontinuous in nature. Approximately 580 ha (or 31%) of the esker is located within the study corridor, and 0 ha (or 0 %) of the esker is located in the RoW.
Hudson Bay Lowland/Selwyn Lake Upland	Stephens Lake	8	Deep Basin/Eutric Brunisol	Rare	56								Study corridor and RoW do not intersect this Enduring Feature.
Hudson Bay Lowland/Selwyn Lake Upland	Stephens Lake	9	Deep Basin/Eutric Brunisol	Rare	1657	1657	100.0	36	2.17	X	X	X	Desktop mapping, aerial reconnaissance and groundtruthing has confirmed the presence of this Enduring Feature and is in general agreement with the area that was previously mapped.
Hudson Bay Lowland	Stephens Lake	10	Deep Basin/Eutric Brunisol	Rare	2110								Study corridor and RoW do not intersect this Enduring Feature.
Hudson Bay Lowland/Hayes River Upland	Stephens Lake	11	Nearshore and Intertidal Deposits/Organic Cryosol (mesic woody forest)/Glacial Spillway	Single	15130	952	6.3			X	X	X	RoW does not intersect this Enduring Feature. Desktop mapping, aerial reconnaissance and groundtruthing has confirmed the presence of this Enduring Feature and is in general agreement with the area that was previously mapped, for the extent that was able to be mapped based on stereo-aerial photo coverage.
Churchill River Upland/Hayes River Upland	Stephens Lake	12	Glaciofluvial Deposits/Organic Cryosol (mesic woody forest)/Moraine	Rare	2755	1	0.1			X	X		RoW does not intersect this Enduring Feature.
Churchill River Upland/Hayes River Upland	Stephens Lake	13	Glaciofluvial Deposits/Organic Cryosol (mesic woody forest)/Moraine	Rare	457								Study corridor and RoW do not intersect this Enduring Feature.
Hayes River Upland	Stephens Lake	14	Glaciofluvial Deposits/Organic Cryosol (mesic woody forest)/Glacial Spillway	Rare	1136								Study corridor and RoW do not intersect this Enduring Feature.
Hayes River Upland	Stephens Lake	15	Glaciofluvial Deposits/Organic Cryosol (mesic woody forest)/Glacial Spillway	Rare	547								Study corridor and RoW do not intersect this Enduring Feature.

Notes:[1] % of total enduring feature area within the Local Study Area. [2] % of total enduring feature area within the HVdc Footprint. [3] ID No corresponds to unique terrain/soil features map.

Table 5.16: Other Unique Terrain/Soil Features											
Ecoregion	Category	ID No.[1]	Description	Data Source Summary				Area[3]			
				Existing SRI[2]	Desktop Mapping	Aerial Reconnai-ssance	Ground-truthing	Local Study Area		HVdc Footprint	
								ha	%	ha	%
Hudson Bay Lowlands	Unique Terrain/Soil Unit	16	beach ridges and ridged terrain	x	x	x	x	195	100		
Mid-Boreal Lowlands	Unique Terrain/Soil Unit	17	salt flats within proposed Red Deer WMA	x				3.7	1.0		
Mid-Boreal Lowlands	Unique Terrain/Soil Unit	18	salt flats within proposed Red Deer WMA	x				18.9	5.3		
Mid-Boreal Lowlands	Unique Terrain/Soil Unit	19	salt flats within proposed Red Deer WMA	x				36.6	10.0		
Interlake Plain	Unique Terrain/Soil Unit	20	salt flats	x				20.6	100		
Lake Manitoba Plain	Unique Terrain/Soil Unit	21	Salt flats	x				127	83.7		

Notes:
[1] ID No corresponds to unique terrain/soil features map. [2] Existing Soil Resource Information. [3] % of areas indicate proportion of the feature located within the study area.

Table 5.17: Permafrost								
	Manitoba Wetlands				Soil Resource Inventory			
	Local Study Area		HVdc Footprint		Local Study Area		HVdc Footprint	
	ha	%	ha	%	ha	%	ha	%
Hudson Bay Lowland Ecoregion								
Continuous	789	3	10	3				
Extensive Discontinuous	5297	19	71	19	18832	69	257	70
Sporadic Discontinuous	19468	71	278	76	4773	17	77	21
Isolated Patches/None	1893	7	8	2	3843	14	33	9
Selwyn Lake Upland Ecoregion								
Continuous								
Extensive Discontinuous	6	0			72	2	3	5
Sporadic Discontinuous	2567	59	37	72	1166	27		
Isolated Patches/None	1788	41	15	28	3122	72	49	95
Churchill River Upland Ecoregion								
Continuous		0			1374	3	11	1
Extensive Discontinuous	5264	10	18	2	20888	39	293	39
Sporadic Discontinuous	46609	87	728	98	10138	19	172	23
Isolated Patches/None	1692	3			21164	40	271	36
Hayes River Upland Ecoregion								
Continuous					3201	2	35	2
Extensive Discontinuous	13391	9	193	10	41457	29	607	31
Sporadic Discontinuous	68046	48	950	49	42477	30	548	28
Isolated Patches/None	61257	43	804	41	55558	39	758	39
Mid-Boreal Lowland Ecoregion								
Continuous					305	1		
Extensive Discontinuous	2228	8	30	2				

Table 5.17: Permafrost								
	Manitoba Wetlands				**Soil Resource Inventory**			
	Local Study Area		**HVdc Footprint**		**Local Study Area**		**HVdc Footprint**	
	ha	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**
Sporadic Discontinuous	24970	91	316	18	254	1		
Isolated Patches/None	249	1	1421	80	26888	98	1767	100
Study Area								
Continuous	789	0.1	10	0.1	4880	0.7	45	0.5
Extensive Discontinuous	26185	3.9	313	3.4	81249	12.2	1160	12.7
Sporadic Discontinuous	161660	24.3	2308	25.3	58808	8.8	797	8.7
Isolated Patches/None	477547	71.7	6502	71.2	521244	78.2	7131	78.1

Table 6.1: Environmental Interaction Matrix for the Bipole III Project and Soil and Terrain Environment

Component	Activity																																				
	Preconstruction	Construction																	Operation & Maintenance								Decommissioning									Accidents and Malfunctions	
		Transmission Lines							Converter Stations					Ground Electrodes (Shallow Ring Design)		Marshalling Yards & Construction Camp(s)			Transmission Lines						Converter Stations		Marshalling Yards, Temporary Camp(s), Borrow Pits[1]		Transmission Lines[2]			Converter Station[3]					
	Clearing sampling sites and access trails	Clearing and disposing of trees	Grubbing at tower sites	Using heavy equipment	Installing anchors and foundations	Using explosives (e.g., borrow pits)	Importing inorganic fill	Crossing frozen waterbodies	Removing vegetation and organic topsoil	Importing inorganic fill	Earthmoving and grading	Installing building and equipment foundations	Filling equipment with insulating oil	Clearing land	Excavating electrode trench (backhoe)	Installing screw pile foundations (trailer units)	Storing hazardous material	Refuelling	Conducting annual inspections (by ground or air)	Building winter roads	Brushing (every 8-10 years)	Applying broad leaf herbicides	Using heavy equipment	Establishing mobile work camps	Commissioning	Filling equipment with insulating oil	Restoring the station site to future intended use	Remediating the site	Using Heavy Equipment	Removing / salvaging insulators, conductors and groundwires	Cleaning up and/or remediating the site	Restoring the station site to future intended use	Using Heavy Equipment	Salvaging, removing and/or disposing of station components	Remediating the site	Spills and Leaks	Operational Failure
Landform						x															x						x					x					
Unique Physical Features	x	x	x	x		x														x	x						x					x					
Soil Erodability	x		x	x			x	x	x	x	x			x						x	x		x				x		x			x	x	x			
Soil Compaction	x	x	x	x				x	x		x			x		x			x	x	x		x	x			x		x	x		x	x				
Stability	x	x	x	x		x													x	x			x						x	x			x				
Soil Stratification					x		x		x	x	x	x			x																						
Soil Quality (chemical)				x									x				x	x				x	x	x	x	x		o	x		o		x		o	x	x
Soil Temperature	x	x	x						x					x							x																
Permafrost	x	x	x	x					x		x	x		x					x	x	x		x						x				x				

Notes:

[1]Following construction

[2]50+ years following construction

[3]Effectively permanent, decommissioning unlikely

Table 6.2: Summary of Highly Erodible Soil Sites

Ecoregion	Category	Description	Data Source Summary				Area			
			Existing SRI[1]	Desktop Mapping	Aerial Reconnai-ssance	Ground-truthing	Local Study Area		HVdc Footprint	
							ha	%	ha	%
Hudson Bay Lowland	Highly Erodible Soils	coarse textured, eolian sand deposits		x	x	x	1201	0.180	23	0.252
	Unstable and/or Steep Slopes	coarse textured, eolian sand deposits		x			42	0.006		
Hayes River Upland	Unstable and/or Steep Slopes	coarse textured, eolian sand deposits		x			130	0.020		
Mid-Boreal Lowlands	Highly Erodible Soils	coarse textured, eolian sand deposits	x	x	x	x	763	0.115	21	0.225
	Unstable and/or Steep Slopes	coarse textured, eolian sand deposits		x			1408	0.211	27	0.291
Interlake Plain	Highly Erodible Soils	coarse textured, eolian sand deposits	x				873	0.131	19	0.208
Aspen Parkland/Lake Manitoba Plain	Highly Erodible Soils	coarse textured, eolian sand deposits	x			x	12526	1.880	192	2.107

Notes:
[1] Existing Soil Resource Information

Table 6.3: Wind Erosion Risk				
	Local Study Area		HVdc Footprint	
	ha	%	ha	%
Hudson Bay Lowland Ecoregion				
No Data	27447	100	367	100
Selwyn Lake Upland Ecoregion				
No Data	4360	100	52	100
Churchill River Upland Ecoregion				
Negligible				
Low				
Moderate				
High				
Severe				
Organic Soil (Not Rated)	10022	18.7	139	18.6
No Data	43543	81.3	607	81.4
Hayes River Upland Ecoregion				
Negligible	27086	19.0	371	19.1
Low				
Moderate				
High				
Severe				
Organic Soil (Not Rated)	4246	3.0	57	2.9
No Data	111361	78.0	1519	78.0
Mid-Boreal Lowland Ecoregion				
Negligible	57755	45.0	740	41.9
Low				
Moderate				
High				
Severe				
Organic Soil (Not Rated)	70633	55.0	1027	58.1
No Data	94	0.1		
Interlake Plain Ecoregion				
Negligible	35534	38.8	494	39.5
Low	19362	21.1	266	21.2
Moderate				
High	1834	2.0		
Severe				

Table 6.3: Wind Erosion Risk				
	Local Study Area		HVdc Footprint	
	ha	%	ha	%
Organic Soil (Not Rated)	34007	37.1	487	38.9
No Data	838	0.9	5	0.4
Lake Manitoba Plain Ecoregion				
Negligible	2417	1.1	1	0.0
Low	96413	44.6	1340	44.8
Moderate	84880	39.2	1193	39.8
High	9363	4.3	125	4.2
Severe	23183	10.7	335	11.2
Organic Soil (Not Rated)				
No Data				
Aspen Parkland Ecoregion				
Negligible				
Low				
Moderate	1624	91.2	9	100.0
High	156	8.8		0
Severe				
Organic Soil (Not Rated)				
No Data				
Study Area				
Negligible	122792	18.4	1607	17.6
Low	115775	17.4	1606	17.6
Moderate	86504	13.0	1202	13.2
High	11353	1.7	125	1.4
Severe	23183	3.5	335	3.7
Organic Soil (Not Rated)	118907	17.8	1709	18.7
No Data	187643	28.2	2550	27.9

Table 6.4: Water Erosion Risk				
	Local Study Area		HVdc Footprint	
	ha	%	ha	%
Hudson Bay Lowland Ecoregion				
Not Rated	27447	100	367	100
Selwyn Lake Upland Ecoregion				
Not Rated	4360	100	52	100
Churchill River Upland Ecoregion				
Not Rated	53565	100	746	100
Hayes River Upland Ecoregion				
Not Rated	142718	100	1948	100
Mid-Boreal Lowland Ecoregion				
Not Rated	128481	100	1767	100
Interlake Plain Ecoregion				
Negligible	76574	83.6	1066	85.2
Low	4220	4.6	53	4.3
Moderate	4634	5.1	65	5.2
High	1036	1.1	20	1.6
Severe	179	0.2		
Not Rated	4932	5.4	48	3.8
Lake Manitoba Plain Ecoregion				
Negligible	145584	67.3	2052	68.5
Low	59139	27.3	811	27.1
Moderate	8802	4.1	108	3.6
High	215	0.1	4	0.1
Severe	911	0.4	18	0.6
Not Rated	1606	0.7	1	0.0
Aspen Parkland				
Negligible	670	37.6	7	84.1
Low	184	10.3	1	15.9
Moderate	647	36.4		
High	60	3.3		
Severe	188	10.6		
Not Rated	31	1.8		
Study Area				
Negligible	222828	33.4	3125	34.2
Low	63543	9.5	865	9.5

Table 6.4: Water Erosion Risk				
	Local Study Area		HVdc Footprint	
	ha	%	ha	%
Moderate	14082	2.1	173	1.9
High	1311	0.2	24	0.3
Severe	1278	0.2	18	0.2
Not Rated	363140	54.5	4928	54.0

Table 6.5: Compaction / Rutting Risk Rating Matrix						
Drainage Regime	Texture					
	Sand	Sandy Loam	Loam	Clay Loam	Clay	Organic
Rapid	Low	Low	-	-	-	-
Well	Low	Low	Low	Moderate	Moderate	-
Imperfect	Low	Low	Moderate	High	High	-
Poor	Moderate	Moderate	High	High	High	-
Very Poor	-	-	-	-	-	High

Table 6.6: Compaction/Rutting Risk				
	Local Study Area		**HVdc Footprint**	
	ha	**%**	**ha**	**%**
Hudson Bay Lowland Ecoregion				
Low	5187	18.9	63	17.2
Moderate	5925	21.6	84	22.8
High	15989	58.3	220	60.0
Not Rated	346	1.3	0	0.0
Selwyn Lake Upland Ecoregion				
Low	3223	73.9	46	89.1
Moderate	810	18.6	4	8.3
High	327	7.5	1	2.6
Not Rated	0	0.0	0	0.0
Churchill River Upland Ecoregion				
Low	7521	14.0	78	10.4
Moderate	12074	22.5	198	26.6
High	33893	63.3	470	63.0
Not Rated	77	0.1	0	0.0
Hayes River Upland Ecoregion				
Low	9155	6.4	117	6.0
Moderate	46727	32.7	622	32.0
High	79577	55.8	1129	58.0
Not Rated	7259	5.1	79	4.1
Mid-Boreal Lowland Ecoregion				
Low	19780	15.4	307	17.4
Moderate	13653	10.6	211	11.9
High	87398	68.0	1199	67.9
Not Rated	7650	6.0	50	2.8
Interlake Plain Ecoregion				
Low	20844	22.8	272	21.7
Moderate	16954	18.5	251	20.1
High	52081	56.9	719	57.4
Not Rated	1695	1.9	10	0.8
Lake Manitoba Plain Ecoregion				
Low	55772	25.8	797	26.6
Moderate	34558	16.0	462	15.4
High	124316	57.5	1733	57.9

Table 6.6: Compaction/Rutting Risk				
	Local Study Area		HVdc Footprint	
	ha	%	ha	%
Not Rated	1611	0.7	1	0.0
Aspen Parkland Ecoregion				
Low	986	55.4	7	83.7
Moderate	554	31.1	1	16.3
High	209	11.7	0	0.0
Not Rated	31	1.8	0	0.0
Study Area				
Low	122468	18.4	1687	18.5
Moderate	131256	19.7	1834	20.1
High	393789	59.1	5471	59.9
Not Rated	18669	2.8	140	1.5

Table 6.7:Summary of Environmentally Sensitive Sites							
ESS Site		Location	Coordinates	ESS Description	Environmental Effects	Mitigation Measures	Comment
WI-03 WI-04 WI-06	Wind Erosion Risk – High and Severe Rating Areas	Various (see Map 700)	531088E 5532714N 530361E 5513995N 552608E 5496673N	Soils prone to soil loss by wind erosion as indicated by High and Severe wind erosion risk ratings.	Loss of topsoil due to wind erosion (e.g., creep, saltation, suspension) on disturbed surfaces.	• Undertake construction activities in southern Manitoba during winter, where possible. • Avoid dry soil conditions during construction for soils with high and severe wind erosion risk, where possible. • Utilize selective clearing in erosion-prone areas. • Construction sites requiring extensive grubbing shall be stabilized (graded, seeded, etc.) as soon as practical, to minimize erosion.	Regional wind erosion risk index requiring regionally-applied mitigation.
WA-03 WA-11 WA-20 WA-20 WA-28 WA-29 WA-30 WA-32 WA-32 WA-42	Water Erosion Risk – High and Severe Rating Areas	Various (see Map 800)	529869E 5514526N 531640E 5512892N 534283E 5510612N 532597E 5512067N 538853E 5505243N 538860E 5503937N 538995E 5501831N 539820E 5498429N 539825E 5498808N 398033E 5762019N	Soils prone to soil loss by water erosion as indicated by High and Severe water erosion risk ratings.	Loss of topsoil due to water erosion (e.g., sheet, rill, gully) on disturbed surfaces.	• Avoid construction on steep slopes or the creation of steep slopes. • Selective clearing in erosion-prone areas. • Construct during winter, where possible. • Appropriate site drainage and erosion control measures will be implemented for borrow sites which are no longer needed. • Direct run-off away from disturbed areas. Maintain some vegetation, slash or snow covering to protect soils. • Construction sites requiring extensive grubbing shall be stabilized (graded, seeded, etc.) as soon as practical, to minimize erosion. • Sediment control measures shall be in place prior to stripping, where feasible. • Retain natural vegetation near stream crossings to minimize erosion.	Regional water erosion risk index requiring regionally-applied mitigation.
CR-01 to CR-1858	Compaction/Rutting Risk – High Index Rating Areas	Various (see Map 900)	Various	Soils prone to compaction and rutting indicated by High compaction/rutting index rating.	Loss of soil structure due to compaction from heavy equipment and vehicle traffic, including frozen waterbody crossings and access provision.	• Construction activities in northern Manitoba will be undertaken during winter when the ground is under frozen and/or snow-covered conditions. • Construction activities in southern Manitoba will be undertaken during winter, where possible, and under dry conditions elsewhere, where possible. • Utilize existing access routes, where possible, and minimize site traffic. • Locate storage areas on well drained, mineral soil types, where possible. • Avoid installing overhead lines during wet, rainy conditions, where possible. • The senior field authority will stop work when ground conditions are such that no effective construction practice will prevent damage caused by severe rutting. • Use low-ground pressure vehicles (i.e., wide-tracked machinery), where possible. • If required, the right-of-way will be graded, disced or deep-ploughed to remove ruts caused by rubber-tired and tracked vehicles. If an extensive area of Crown land is disturbed, the disturbed area will be reseed with native seed mixes. • Decommissioned road beds will be reclaimed.	Regional compaction/rutting risk rating requiring regionally-applied mitigation.

Table 6.7:Summary of Environmentally Sensitive Sites

ESS Site		Location	Coordinates	ESS Description	Environmental Effects	Mitigation Measures	Comment
ED-01 to 350	Eolian (i.e., wind-modified) Deposits	Various (see Map 800)	Various	Sandy textured modified by wind (e.g., duned sands) and highly susceptible to wind erosion.	Loss of topsoil due to wind erosion (e.g., creep, saltation, suspension) on disturbed surfaces.	• Undertake construction activities in southern Manitoba during winter, where possible. • Avoid dry soil conditions during construction for soils with high and severe wind erosion risk, where possible. • Utilize selective clearing in erosion-prone areas. • Construction sites requiring extensive grubbing shall be stabilized (graded, seeded, etc.) as soon as practical, to minimize erosion.	
UE-01	Enduring Features (Unique Terrain/Soil Features)	Tom Lamb WMA, Tom Lamb Addition, Summerberry Proposed WMA (see Map 600-3:4, ID No. 1).	363571E 5969151N	Alluvial Deposits/Organic Mesisol (mesic sedge); Single occurrence enduring feature; Tom Lamb WMA, Tom Lamb Addition, Summerberry Proposed WMA.	Impairment or loss of approximately 67 ha (0.18%) of single occurrence PAI enduring feature from right-of-way establishment.	• No off-RoW activities including construction of access trails or establishment of new borrow sources shall be conducted within any of the enduring features described by this study. • Construction within enduring features shall be conducted in the winter, under frozen conditions, to protect site-specific features (e.g., organic deposits). • Topsoil and subsoils should be excavated and stockpiled separately, where excavation is required for tower foundations. These soils should be replaced in the manner in which they were removed within the tower footprint. • Minimize equipment movement within enduring features to minimize terrain disturbance. • Existing access routes will be utilized and machinery shall not operate outside of the project areas within enduring features.	
UE-02	Enduring Features (Unique Terrain/Soil Features)	Summerberry Proposed WMA (see Map 600-4, ID No. 2).	N/A	Alluvial Deposits/Organic Mesisol (mesic woody forest); Rare occurrence enduring feature; Summerberry Proposed WMA.	No Impairment or loss of rare occurrence PAI enduring feature from right-of-way establishment.	• No off-RoW activities including construction of access trails or establishment of new borrow sources shall be conducted within any of the enduring features described by this study. • Off-RoW activities shall maintain a buffer distance of 100 m from the enduring features described by this study, where feasible. • Existing access routes will be utilized and machinery shall not operate outside of the project areas within enduring features.	Not intersected by the 66.0 m RoW.
UE-03	Enduring Features (Unique Terrain/Soil Features)	Tom Lamb WMA, Tom Lamb Addition, Summerberry Proposed WMA (see Map 600-4, ID No. 3).	361967E 5961615N	Alluvial Deposits/Organic Mesisol (mesic woody forest); Rare occurrence enduring feature; Tom Lamb WMA, Tom Lamb Addition, Summerberry Proposed WMA.	Impairment or loss of approximately 16 ha (0.63%) of rare occurrence PAI enduring feature from right-of-way establishment.	• No off-RoW activities including construction of access trails or establishment of new borrow sources shall be conducted within any of the enduring features described by this study. • Construction within enduring features shall be conducted in the winter, under frozen conditions, to protect site-specific features (e.g., organic deposits). • Topsoil and subsoils should be excavated and stockpiled separately, where excavation is required for tower foundations. These soils should be replaced in the manner in which they were removed within the tower footprint. • Minimize equipment movement within enduring features to minimize terrain disturbance. • Existing access routes will be utilized and machinery shall not operate outside of the project areas within enduring features.	

Table 6.7:Summary of Environmentally Sensitive Sites

ESS Site		Location	Coordinates	ESS Description	Environmental Effects	Mitigation Measures	Comment
UE-04	Enduring Features (Unique Terrain/Soil Features)	Stephens Lake ASI (see Map 600-2, ID No. 4).	735643E 6279261N	Glaciofluvial Deposits/Organic Cryosol (mesic woody forest)/Moraine; Rare occurrence enduring feature; Stephens Lake ASI.	Impairment or loss of approximately 42 ha (2.9%) of rare occurrence PAI enduring feature from right-of-way establishment.	• No off-RoW activities including construction of access trails or establishment of new borrow sources shall be conducted within any of the enduring features described by this study. • Construction within enduring features shall be conducted in the winter, under frozen conditions, to protect site-specific features (e.g., organic deposits). • Topsoil and subsoils should be excavated and stockpiled separately, where excavation is required for tower foundations. These soils should be replaced in the manner in which they were removed within the tower footprint. • Minimize equipment movement within enduring features to minimize terrain disturbance. • Existing access routes will be utilized and machinery shall not operate outside of the project areas within enduring features.	
UE-05	Enduring Features (Unique Terrain/Soil Features)	Stephens Lake ASI (see Map 600-2, ID No. 7).	N/A	Esker; Rare occurrence enduring feature; Stephens Lake ASI.	No Impairment or loss of rare occurrence PAI enduring feature from right-of-way establishment.	• No off-RoW activities including construction of access trails or establishment of new borrow sources shall be conducted within any of the enduring features described by this study. • Off-RoW activities shall maintain a buffer distance of 100 m from the enduring features described by this study, where feasible. • Existing access routes will be utilized and machinery shall not operate outside of the project areas within enduring features.	Not intersected by the 66.0 m RoW.
UE-06	Enduring Features (Unique Terrain/Soil Features)	Stephens Lake ASI (see Map 600-1, ID No. 9).	761574E 6285484N 766762E 6289678N	Deep Basin/Eutric Brunisol; Rare occurrence enduring feature; Stephens Lake ASI.	Impairment or loss of approximately 36 ha (2.2%) of rare occurrence PAI enduring feature from right-of-way establishment.	• No off-RoW activities including construction of access trails or establishment of new borrow sources shall be conducted within any of the enduring features described by this study. • Construction within enduring features shall be conducted in the winter, under frozen conditions, to protect site-specific features (e.g., organic deposits). • Topsoil and subsoils should be excavated and stockpiled separately, where excavation is required for tower foundations. These soils should be replaced in the manner in which they were removed within the tower footprint. • Minimize equipment movement within enduring features to minimize terrain disturbance. • Existing access routes will be utilized and machinery shall not operate outside of the project areas within enduring features.	
UE-07	Enduring Features (Unique Terrain/Soil Features)	Stephens Lake ASI (see Map 600-1:2, ID No. 11).	N/A	Nearshore and Intertidal Deposits/Organic Cryosol (mesic woody forest)/Glacial Spillway; Rare occurrence enduring feature; Stephens Lake ASI.	No Impairment or loss of single occurrence PAI enduring feature from right-of-way establishment.	• No off-RoW activities including construction of access trails or establishment of new borrow sources shall be conducted within any of the enduring features described by this study. • Off-RoW activities shall maintain a buffer distance of 100 m from the enduring features described by this study, where feasible. • Existing access routes will be utilized and machinery shall not operate outside of the project areas within enduring features.	Not intersected by the 66.0 m RoW.

Table 6.7:Summary of Environmentally Sensitive Sites

ESS Site		Location	Coordinates	ESS Description	Environmental Effects	Mitigation Measures	Comment
UE-08	Enduring Features (Unique Terrain/Soil Features)	Stephens Lake ASI (see Map 600-2, ID No. 12).	N/A	Glaciofluvial Deposits/Organic Cryosol (mesic woody forest)/Moraine; Rare occurrence enduring feature; Stephens Lake ASI.	No Impairment or loss of rare occurrence PAI enduring feature from right-of-way establishment.	• No off-RoW activities including construction of access trails or establishment of new borrow sources shall be conducted within any of the enduring features described by this study. • Off-RoW activities shall maintain a buffer distance of 100 m from the enduring features described by this study, where feasible. • Existing access routes will be utilized and machinery shall not operate outside of the project areas within enduring features.	Not intersected by the 66.0 m RoW.
UO-01	Other Unique Terrain/Soil Features	Between Keewatinoow and Stephens Lake ASI (see Map 600-1, ID No. 16)	N/A	Beach ridges and ridged terrain.	No Impairment or loss of unique terrain/soil feature from right-of-way establishment.	• No off-RoW activities including construction of access trails or establishment of new borrow sources shall be conducted within any of the enduring features described by this study. • Off-RoW activities shall maintain a buffer distance of 100 m from the unique feature described by this study, where feasible. • Existing access routes will be utilized and machinery shall not operate outside of the project areas within unique feature.	Not intersected by the 66.0 m RoW.
UO-02	Other Unique Terrain/Soil Features	Red Deer WMA (see Map 600-5, ID No. 17)	N/A	Salt flats within proposed Red Deer WMA.	No Impairment or loss of unique terrain/soil feature from right-of-way establishment.	• No off-RoW activities including construction of access trails or establishment of new borrow sources shall be conducted within any of the enduring features described by this study. • Off-RoW activities shall maintain a buffer distance of 100 m from the unique feature described by this study, where feasible. • Existing access routes will be utilized and machinery shall not operate outside of the project areas within unique feature.	Not intersected by the 66.0 m RoW.
UO-03	Other Unique Terrain/Soil Features	Red Deer WMA (see Map 600-5, ID No. 18)	N/A	Salt flats within proposed Red Deer WMA.	No Impairment or loss of unique terrain/soil feature from right-of-way establishment.	• No off-RoW activities including construction of access trails or establishment of new borrow sources shall be conducted within any of the enduring features described by this study. • Off-RoW activities shall maintain a buffer distance of 100 m from the unique feature described by this study, where feasible. • Existing access routes will be utilized and machinery shall not operate outside of the project areas within unique feature.	Not intersected by the 66.0 m RoW.
UO-04	Other Unique Terrain/Soil Features	Red Deer WMA (see Map 600-6, ID No. 19)	N/A	Salt flats within proposed Red Deer WMA.	No Impairment or loss of unique terrain/soil feature from right-of-way establishment.	• No off-RoW activities including construction of access trails or establishment of new borrow sources shall be conducted within any of the enduring features described by this study. • Off-RoW activities shall maintain a buffer distance of 100 m from the unique feature described by this study, where feasible. • Existing access routes will be utilized and machinery shall not operate outside of the project areas within unique feature.	Not intersected by the 66.0 m RoW.
UO-05	Other Unique Terrain/Soil Features	Interlake Plain (see Map 600-6, ID No. 20)	N/A	Salt flats within Interlake Plain.	No Impairment or loss of unique terrain/soil feature from right-of-way establishment.	• No off-RoW activities including construction of access trails or establishment of new borrow sources shall be conducted within any of the enduring features described by this study. • Off-RoW activities shall maintain a buffer distance of 100 m from the unique feature described by this study, where feasible. • Existing access routes will be utilized and machinery shall not operate outside of the project areas within unique feature.	Not intersected by the 66.0 m RoW.

Table 6.7:Summary of Environmentally Sensitive Sites

ESS Site		Location	Coordinates	ESS Description	Environmental Effects	Mitigation Measures	Comment
UO-06	Other Unique Terrain/Soil Features	Lake Manitoba Plain (see Map 600-6, ID No. 21)	N/A	Salt flats in Lake Manitoba Plain	No Impairment or loss of unique terrain/soil feature from right-of-way establishment.	• No off-RoW activities including construction of access trails or establishment of new borrow sources shall be conducted within any of the enduring features described by this study. • Off-RoW activities shall maintain a buffer distance of 100 m from the unique feature described by this study, where feasible. • Existing access routes will be utilized and machinery shall not operate outside of the project areas within unique feature.	Not intersected by the 66.0 m RoW.
SS-04	Steep/Unstable Slopes	Various (see Map 800)	358031E 5894354N	Steep and/or unstable slopes that are prone to soil loss by water erosion and mass movement.	Loss of topsoil due to water erosion (e.g., sheet, rill, gully) on disturbed surfaces; mass-movement due to slope destabilization.	• Avoid construction on steep slopes or the creation of steep slopes. • Construct during winter, where possible. • Prior to constructing ice bridges or snow fills, install sediment and erosion control measures. Inspect them regularly during the course of construction and decommissioning activities and make all necessary repairs if any damage occurs.* • Create a v-notch in the centre of the ice bridge when the crossing season is over and where it is safe to do so to prevent channel erosion.* • Sediment control measures shall be in place prior to stripping, where feasible. • Retain natural vegetation near stream crossings to minimize erosion. Selective clearing, where necessary.	
PS-01 to 146	Permafrost Distribution – Soils Database	Northern Study Area (see Map 400)	Various	Permafrost Distribution – Soils	Melting or loss of permafrost due to disturbance of the active layer.	• Clearing will be restricted to project sites and associated access routes. Existing access will be used wherever possible. • Maintain understory vegetation, where possible. • Preserve existing vegetation, where possible. • Vegetation establishment in areas not identified as requiring special treatment will occur naturally or through annual cropping. • Locate marshalling yards, construction camps and temporary storage/work areas in natural openings, where possible, to reduce clearing requirements.	Regional permafrost environmental sensitive areas requiring regionally-applied mitigation.
PW-01 to 170	Permafrost Distribution – Wetlands Database	Northern Study Area (see Map 400)	Various	Permafrost Distribution - Wetlands	Melting or loss of permafrost due to disturbance of the active layer.	• Clearing will be restricted to project sites and associated access routes. Existing access will be used wherever possible. • Maintain understory vegetation, where possible. • Preserve existing vegetation, where possible. • Vegetation establishment in areas not identified as requiring special treatment will occur naturally or through annual cropping. • Locate marshalling yards, construction camps and temporary storage/work areas in natural openings, where possible, to reduce clearing requirements.	Regional permafrost environmental sensitive areas requiring regionally-applied mitigation.

Table 6.8: Anticipated Environmental Effects to the Terrain and Soil Environment

Environment Effect	Environmental Indicators	Measurable Parameters	Mitigation Measures	Residual Environmental Effect	Follow-up
PRECONSTRUCTION					
Compaction of soils from heavy equipment traffic (e.g., clearing sampling sites)	• Topsoil quality (north) • Agricultural capability (south)	• Penetration resistance • Bulk density	N/A	N/A	None
CONSTRUCTION					
Transmission Lines					
Loss of soil structure due to compaction from heavy equipment and vehicle traffic, including frozen waterbody crossings and access provision.	• Topsoil quality (south) • Agricultural capability (north)	• Penetration resistance • Bulk density	• Transmission line construction, monitoring/inspection and decommissioning activities in identified areas of high risk to compaction should be scheduled during late summer, early fall or winter to target dry, frozen and/or snow-covered conditions and prevent compaction on mineral and organic soils. • The senior field authority should stop work on transmission line construction when ground conditions are such that no effective construction practice will prevent damage caused by severe rutting. The need to stop work may be evidenced by the excessive build-up of mud on tires/cleats and excessive ponding on the soil surface. • Where persistently wet locations cannot be avoided, geotextile fabric overlain with soil/aggregate or construction mats should be placed beneath trafficking areas to reduce rutting during right-of-way construction. Any fabric, matting or imported materials should be removed prior to leaving the area. • Low-ground pressure vehicles (i.e., wide-tracked or wide-rubber-tired machinery) should be utilized for transmission line construction, where possible. • Existing access routes should be utilized where possible and site traffic along the RoW should be minimized or contained to single paths, which should not exceed 6 m in width[i]. • Temporary storage areas for machinery and equipment should be located on well drained, mineral soil types, where possible. • If required, the RoW should be graded, disced or deep-ploughed to remove ruts caused by rubber-tired and tracked vehicles in agricultural areas. If an extensive area of Crown land is disturbed, the disturbed area should be reseeded with native seed mixes. • A post-construction reclamation plan for relieving compaction on agricultural lands should be implemented by Manitoba Hydro and carried out by the Contractor to remedy any compaction remaining on agricultural lands following construction. Arrangements could also be made with the landowner to perform this work.	Some compaction and rutting along portions of right of way in northern Manitoba.	A Post-Construction Reclamation Plan should be undertaken on compacted soils located on agricultural lands.

Table 6.8: Anticipated Environmental Effects to the Terrain and Soil Environment

Environment Effect	Environmental Indicators	Measurable Parameters	Mitigation Measures	Residual Environmental Effect	Follow-up
Loss of topsoil due to wind erosion (e.g., creep, saltation, suspension) on disturbed surfaces.	• Topsoil quality (south) • Agricultural capability (north)	• Topsoil thickness • Agricultural capability class • Visible evidence of soil movement • Soil deposition (e.g., drifts)	• Construction, monitoring/inspection and decommissioning activities in High and Severe Wind Erosion Risk Areas in southern Manitoba and within the Limestone River/Nine Mile Creek, PTH 10, Brigg's Spur and Portage la Prairie area eolian deposits should be scheduled during winter to prevent accelerated wind erosion. • If it is not possible to work during winter, soil conditions should be moist for work in High to Severe Wind Erosion Risk areas, to prevent accelerated wind erosion. • Low ground pressure equipment (e.g., tracked vehicles) should be used for construction activities in the Limestone River/Nine Mile Creek, PTH 10, Brigg's Spur and Portage la Prairie area eolian deposits. • Clearing and stripping should be minimized in High and Severe Wind Erosion Risk Areas to reduce the exposure of bare ground. • Equipment traffic and associated disturbance should be limited in the Limestone River/Nine Mile Creek, PTH 10, Brigg's Spur and Portage la Prairie area eolian deposits. • Disturbed areas within High and Severe Wind Erosion Risk areas and the Limestone River/Nine Mile Creek, PTH 10, Brigg's Spur and Portage la Prairie area eolian deposits should be actively stabilized, vegetated and/or seeded as soon as possible following construction or disturbance. • Straw crimping should be implemented on exposed soils within areas identified as having a High to Severe Risk of wind erosion following construction or disturbance to prevent erosion.	Negligible following general and site-specific mitigation.	None

Table 6.8: Anticipated Environmental Effects to the Terrain and Soil Environment

Environment Effect	Environmental Indicators	Measurable Parameters	Mitigation Measures	Residual Environmental Effect	Follow-up
Loss of topsoil due to water erosion (e.g., sheet, rill, gully) on disturbed surfaces.	• Topsoil quality (north) • Agricultural capability (south)	• Topsoil thickness • Agricultural capability class • Soil accumulation in lower slopes	• Construction, monitoring/inspection and decommissioning activities in the Sinclair, North Duck and Assiniboine rivers High and Severe Water Erosion Risk Areas and Overflowing River area should be scheduled during winter, where possible, to target frozen ground conditions. • A visual assessment of slope condition / stability should be conducted prior to construction activities in the Overflowing River Area. Movement of heavy equipment and personnel on visually unstable sites should be avoided to prevent slope failure and/or potential injury. • Borrow pits should not be located within 100 m of the Overflowing River Area, to prevent artificial destabilization of unstable slopes from any blasting activities, if undertaken. • Clearing should be minimized in the Sinclair, North Duck and Assiniboine rivers High and Severe Water Erosion Risk Areas to protect the existing ground cover and reduce the exposure of bare ground. • Natural vegetation along the Overflow Bay tributaries crossed by the right-of-way should be retained, to the greatest extent possible. • Access trail grades should not exceed 12%. Grades near waterbodies should not exceed 5%. This gradient may be achieved through the use of snow or log ramps. • Run-off should be directed away from disturbed areas. Some vegetation, slash or snow-covering should be maintained in the Sinclair, North Duck and Assiniboine rivers High and Severe Water Erosion Risk Areas and Overflowing River area to protect soils. o Site-specific Sediment Control Plans should be developed for the North Duck River and Assiniboine River watercourse crossings to manage water erosion risk. The Plan should incorporate the following measures: Erosion control measures, such as silt fences, should be in place prior to site preparation activities / disturbance and removed after vegetation has re-established. o Where erosion and sediment control measures are employed, sites should be maintained, and the effectiveness of these measures should be monitored. o Existing cover should be maintained to the extent possible. A combination of seeding, tackifiers, erosion control blanketing and/or mulching should be utilized as required to prevent water erosion on bare soils. o Sufficient materials for erosion control should be maintained on-site, such as silt fencing, straw bales and erosion control matting. • In the Sinclair, North Duck and Assiniboine rivers High and Severe Water Erosion Risk Areas, banks should be restored to their original condition, if disturbed.	Negligible following general and site-specific mitigation	None

Table 6.8: Anticipated Environmental Effects to the Terrain and Soil Environment

Environment Effect	Environmental Indicators	Measurable Parameters	Mitigation Measures	Residual Environmental Effect	Follow-up
Loss of soil capability due to admixing of poor quality subsoil with topsoil during excavation and backfilling of tower foundations	• Topsoil quality (north) • Agricultural capability (south)	• Visual assessment of topsoil and subsoil • Agricultural capability class • Analytical testing (e.g., salinity, particle size analysis)	• Construction activities in northern Manitoba should be scheduled during winter to target frozen and/or snow-covered conditions. • Construction activities in southern Manitoba should be undertaken during winter, where possible, and under dry conditions where there is a high rutting risk, where possible. • Equipment operators should strip and stockpile topsoil separately (i.e., salvage topsoil) from subsoil based on a visual assessment of colour change, prior to excavation and preparation of temporary workspaces, where possible. • If appropriate to the particular facility design, topsoil should be replaced upon completion of construction activities. When it is not appropriate to replace topsoil, disposal arrangements should be made with the landowner as a first option, in agricultural areas. • Locate excess excavated soils in designated spoil areas on high ground, at least 30 m from the high water mark of a surface waterbody, in a manner which does not impede natural drainage. • Excavated soils should be stored at designated work/spoil areas and should be fully replaced on the footprint of the excavation in the reverse order they were excavated. • The senior field authority should stop work when ground conditions are such that no effective construction practice will prevent admixing caused by severe rutting. The need to stop work may be evidenced by the excessive build-up of mud on tires/cleats and excessive ponding on the soil surface. • At tower foundation locations, excavated soils should be replaced on the foundation footprint. • In agricultural land, at least 300 mm of topsoil should be spread on any excavation site.	Negligible following mitigation.	None
Increased soil temperature due to clearing of vegetation	Soil temperature	Soil temperature	• Clearing should be restricted to project sites and associated access routes. Existing access should be used wherever possible. • Existing groundcover, including understory vegetation, should be maintained, where possible, to prevent an increase in soil temperature from exposure of uncovered or bare soils. • Vegetation establishment in areas not identified as requiring special treatment should occur naturally or through annual cropping. • Locate marshalling yards, construction camps and temporary storage/work areas in natural openings, where possible, to reduce clearing requirements.	Increased soil temperature resulting in positive (e.g., increased productivity with earlier spring thaw) and negative (e.g., more droughty soils) effects.	None

Table 6.8: Anticipated Environmental Effects to the Terrain and Soil Environment

Environment Effect	Environmental Indicators	Measurable Parameters	Mitigation Measures	Residual Environmental Effect	Follow-up
Loss of terrain stability due to initiation or acceleration of mass movement / wasting (e.g., slides, creeping) from clearing and grading, where required.	• Terrain Stability	• Visual assessment of slope condition • Factor of Safety	• Construction activities in northern Manitoba should be scheduled during winter when the ground is under frozen and/or snow-covered conditions. • Clearing and removal of natural vegetation should be limited to the greatest extent possible in identified and other steep/unstable slope areas, if encountered. Where vegetation is removed from sloped terrain, the area should be replanted with deep-rooted shrubs, such as willow, where feasible, to prevent slope degradation. • Runoff should be directed away from disturbed areas to prevent further site degradation. some vegetation, slash or snow -covering should be maintained in areas of steep or unstable slopes to protect from soil erosion. • Diversion berms of compacted native soils or logs should be used on moderate and steep slopes (i.e., greater than 15-20%) to divert water away from the slope after construction. Berms should be spaced 45 m or less apart and skewed with a downstream gradient of 5-10%. Ensure berms end in natural vegetation. • Borrow pits should not be located within 100 m of identified steep slopes and/or unstable slopes, to prevent initiation or acceleration of instability due to blasting, if required. • Physical methods that could be used to stabilize unstable slopes in the identified and other areas, if encountered, include: lime stabilization by tamping calcium oxide (CaO or quicklime) into holes augered through the zone of failure to reduce plasticity and form a stabilizing pillar.	Potential for loss of terrain stability due to mass wasting following disturbance.	None
Loss of permafrost as a result of disturbance and compaction of overlying organic layers and burning of slash for brush disposal.	• Visual assessment • Increased active layer thickness	• Visual assessment of subsidence (slumps, depressions) • Active layer thickness	• Construction, maintenance and decommissioning of the 500 kV HVdc right-of-way should not occur until the ground is frozen solid in the Kelsey Lake Permafrost Area and north of the Little Cormorant Lake Area to prevent permafrost degradation. • Construction, maintenance and decommissioning of the AC Collector Line and Construction Power Line should not occur until the ground is frozen solid to prevent permafrost degradation. • The movement of equipment should be limited to a single path, which should not exceed 6 m, where possible, to prevent compaction of the active layer resulting in reduced insulation of permafrost. • Limit the exposure of soil due to right-of-way clearing to no more than 20% of the right-of-way in areas of discontinuous or isolated permafrost, where possible. Burning of slash from right-of-way clearing should be avoided on fine-grained, permafrost affected soils and on sloped terrain (>15%) to prevent melting and subsidence. • Clearing should be minimized in known permafrost areas. • Avoid stripping through organic vegetative layers to the extent possible. The top layer of organic soil and ground vegetation should be retained to prevent or minimize disturbance, where practical and feasible. • Maintain natural drainage and prevent altering drainage or concentrating flows, in order to prevent ground ice from melting. • Grade and compact snow in right-of-way work areas and along access routes, where possible or required for safety, to prevent thaw and increase frost penetration.	Potential for loss of terrain stability due to permafrost thaw following disturbance.	None

Table 6.8: Anticipated Environmental Effects to the Terrain and Soil Environment

Environment Effect	Environmental Indicators	Measurable Parameters	Mitigation Measures	Residual Environmental Effect	Follow-up
Impairment or loss of landscape integrity from right-of-way establishment	• Landscape integrity • Representation	• Hectares of impaired land • Proportion protected (Area protected/available area)	• Routing of transmission line right-of-ways through single or rare occurrence PAI enduring features or other unique terrain/soil features identified from study results should be avoided, where possible. • Where avoidance is not possible, blasting and grading activities within single or rare occurrence PAI enduring features or other unique terrain/soil features identified from study results should be avoided, where possible. • Borrow sources should not be established within identified PAI enduring features and other unique terrain/soil features.	Impairment of landscape integrity may occur where disturbance to single and rare occurrence enduring features or other unique terrain/soil features is unavoidable.	None

Table 6.8: Anticipated Environmental Effects to the Terrain and Soil Environment

Environment Effect	Environmental Indicators	Measurable Parameters	Mitigation Measures	Residual Environmental Effect	Follow-up
Loss of surficial (mineral soil or aggregate) or bedrock geological material as a result of the creation/use of existing and creation of new borrow sources, as required.	• Volume removed	• Cubic meters of material removed	• Existing permitted borrow sources should be utilized, to the extent possible. • Borrow pits should not be located within 100 m of steep slopes, where possible. • Access trail grades should not exceed 12%. Grades near waterbodies should not exceed 5%. This gradient may be achieved through the use of snow or log ramps. • Within borrow areas, the mineral or organic layer should be separated from other overburden soils for replacement and runoff should be directed away from disturbed areas, to prevent erosion. • Depending on the planned future use for the site, aggregate borrow pits should be closed, or reclaimed, in accordance with the *Mine Closure Regulation Manitoba Regulation M.R. 67/99*. Reclamation of the pit will restore the site condition and reduce the potential for erosion. Reclamation plans should be developed by Manitoba Hydro or their designate and carried out by a Contractor. Manitoba Hydro or their designate should be responsible for forwarding reclamation plans to the Mines Branch of Manitoba Conservation. According to the *Manitoba Mine Closure Regulation 67-99 General Closure Plan Guidelines* (Manitoba Industry, Trade and Mines, 2006) the reclamation plan should include, but not be limited to, the following activities: o Excavations should be backfilled if it is technically and economically feasible to do so. Salvaged soils should be respread over the area. If the excavation is not backfilled a fence meeting regulatory standards should be built with warning signs. o Steep slopes and benches must be rehabilitated (i.e., re-contoured) to prevent erosion. o Borrow pits should be revegetated to control erosion. Revegetation may include planting grass and bushes in areas prone to erosion, seeding or promotion of natural encroachment with vegetation that resembles the natural environment. Vegetation should be self sufficient six years after planting. o Contaminated soil should be removed and placed in a designated or contained area. o Before closing access roads, municipal authorities should be consulted to determine if these authorities wish to maintain and accept legal responsibility for these roads. Road surfaces should be scarified, blended into natural contours and revegetated. • Explosives should be handled and detonated by a person holding a valid blaster's certificate (or under the direct supervision of a certified blaster) issued under *The Workplace Safety and Health Regulation, M.R. 217/2006*; • Explosives should be stored, transported and handled in accordance with the *Explosives Act* (Canada) ; • Following detonation, the Contractor should ensure that the site of the shot hole(s) is filled in, with excess material, if any, spread evenly over the site. Drainage should not be obstructed. • The on-site storage of explosives at a quarry should meet the handling and storage requirements of the *Operation of Mines Regulation, Man. Reg. 228/94*, which include, but are not limited to : o A theft-resistant, locked receptacle with adequate ventilation; o Painted red and bearing the words "Danger Explosives"; o Located at least 8 m from another receptacle.	Loss of surficial materials required to infill foundations and other excavations.	None

Table 6.8: Anticipated Environmental Effects to the Terrain and Soil Environment

Environment Effect	Environmental Indicators	Measurable Parameters	Mitigation Measures	Residual Environmental Effect	Follow-up
Converter Stations					
Loss of soil structure due to compaction from heavy equipment and vehicle traffic, including site preparation and grading.	• Topsoil quality (south)	• Penetration resistance • Bulk density	• Construction of the northern converter station (Keewatinoow) site should be undertaken in winter to prevent compaction and rutting of organic soils. • The senior field authority should stop work on construction of the northern converter station when ground conditions are such that no effective construction practice will prevent damage caused by severe rutting. The need to stop work may be evidenced by the excessive build-up of mud on tires/cleats and excessive ponding on the soil surface. • Where persistently wet locations cannot be avoided, geotextile fabric overlain with soil/aggregate or construction mats should be placed beneath trafficking areas to reduce rutting during site preparation. Any fabric, matting or imported materials should be removed prior to leaving the site. • Low-ground pressure vehicles (i.e., wide-tracked or wide-rubber-tired machinery) should be utilized for construction, where possible. • Existing access routes should be utilized where possible and site traffic should be minimized. • Temporary storage areas for machinery and equipment should be located on well drained, mineral soil types, where possible.	Negligible	None
Loss of permafrost as a result of disturbance and compaction of overlying organic layers and burning of slash for brush disposal.	• Visual assessment • Increased active layer thickness	• Visual assessment of subsidence (slumps, depressions) • Active layer thickness	• Burning of slash from clearing of the Keewatinoow Converter Station Site should be conducted within the site footprint. • Site drainage should direct flows to the existing natural and improved drainage network to avoid concentrating drainage flows to permafrost affected soils.	Loss of permafrost soils within the Keewatinoow Converter Station Footprint.	None
Ground Electrodes					
Loss of soil structure due to compaction from heavy equipment and vehicle traffic.	• Agricultural capability (north)	• Penetration resistance • Bulk density	• Construction and decommissioning of the southern ground electrode site should be undertaken in winter to prevent compaction and rutting of mineral soils. • The senior field authority should stop work on construction of the southern ground electrode when ground conditions are such that no effective construction practice will prevent damage caused by severe rutting. The need to stop work may be evidenced by the excessive build-up of mud on tires/cleats and excessive ponding on the soil surface. • Where persistently wet locations cannot be avoided, geotextile fabric overlain with soil/aggregate or construction mats should be placed beneath trafficking areas to reduce rutting during site preparation. Any fabric, matting or imported materials should be removed prior to leaving the site. • Low-ground pressure vehicles (i.e., wide-tracked or wide-rubber-tired machinery) should be utilized for construction, where possible. • Topsoil at the southern ground electrode site should be stripped and stockpiled separately prior to subsoil excavation for replacement following construction, to avoid compaction. • Existing access should be utilized where possible and site traffic should be minimized.	None	None

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Table 6.8: Anticipated Environmental Effects to the Terrain and Soil Environment

Environment Effect	Environmental Indicators	Measurable Parameters	Mitigation Measures	Residual Environmental Effect	Follow-up
Loss of soil capability due to admixing of poor quality subsoil with topsoil during excavation and backfilling of the ground electrode ring.	• Topsoil quality (north) • Agricultural capability (south)	• Visual assessment of topsoil and subsoil • Agricultural capability class • Analytical testing (e.g., salinity, particle size analysis)	• Construction activities on the southern ground electrode should be undertaken during winter and/or under dry conditions. • Equipment operators should strip and stockpile topsoil separately (i.e., topsoil salvage) from subsoil based on a visual assessment of colour change prior to excavation, where possible, for re-use in construction site reclamation. • The senior field authority should stop work when ground conditions are such that no effective construction practice will prevent admixing caused by severe rutting. The need to stop work may be evidenced by the excessive build-up of mud on tires/cleats and excessive ponding on the soil surface. • At least 300 mm of topsoil should be spread on the southern ground electrode excavation site.	Negligible following mitigation	None
Increased soil temperatures due to clearing of vegetation	• Soil temperature	• Soil temperature	• Clearing should be restricted to project sites and associated access routes. Existing access should be used wherever possible. • Existing groundcover, including understory vegetation, should be maintained, where possible, to prevent an increase in soil temperature from exposure of uncovered or bare soils. • Vegetation establishment in areas not identified as requiring special treatment should occur naturally. • Locate marshalling yards, construction camps and temporary storage/work areas in natural openings, where possible, to reduce clearing requirements.	Increased soil temperature resulting in positive (e.g., increased productivity with earlier spring thaw) and negative (e.g., more droughty soils) effects	None
Loss of permafrost as a result of disturbance and compaction of overlying organic layers and burning of slash for brush disposal.	• Visual assessment • Increased active layer thickness	• Visual assessment of subsidence (slumps, depressions) • Active layer thickness	• Construction of the northern ground electrode should not occur until the ground is frozen solid to prevent permafrost degradation. • Burning of slash from clearing of the northern ground electrode site should be conducted within the site footprint. • Avoid stripping through organic vegetative layers, to the extent possible, at the northern ground electrode site. • Site drainage should direct any off-site flows to the existing natural and improved drainage network to prevent concentrating drainage flows to permafrost affected soils.	Negligible following mitigation	None

Table 6.8: Anticipated Environmental Effects to the Terrain and Soil Environment

Environment Effect	Environmental Indicators	Measurable Parameters	Mitigation Measures	Residual Environmental Effect	Follow-up
Marshalling Yards and Temporary Construction Camp					
Loss of soil structure due to compaction from heavy equipment and vehicle traffic, temporary facilities and material storage.	• Topsoil quality (south) • Agricultural capability (north)	• Penetration resistance • Bulk density	• The establishment and decommissioning of marshaling yards and temporary construction camps in northern Manitoba should be undertaken in winter to prevent compaction and rutting of organic soils. • The establishment and decommissioning of marshaling yards and temporary construction camps in southern Manitoba should be scheduled during summer, early fall or winter to target dry or frozen conditions, to prevent compaction and rutting of mineral soils. • If persistently wet conditions cannot be avoided, geotextile fabric overlain with soil/aggregate or construction mats should be placed beneath storage and trafficking areas to reduce compaction and rutting at marshalling yards and temporary work camps. • Soils at temporary work sites (temporary work camps, marshalling yards) should have topsoil removed and stockpiled prior to site grading. Subsoils should be deep ploughed and stockpiled topsoil should be replaced, graded and disced on decommissioning of these facilities.	Negligible following mitigation	None
Loss of soil capability due to admixing of poor quality subsoil with topsoil in temporary workspaces.	• Topsoil quality (north) • Agricultural capability (south)	• Visual assessment of topsoil and subsoil • Agricultural capability class • Analytical testing (e.g., salinity, particle size analysis)	• Construction activities in northern Manitoba should be scheduled during winter to target frozen and/or snow-covered conditions. • Construction activities in southern Manitoba should be undertaken during winter, where possible, and under dry conditions where there is a high rutting risk, where possible. • Equipment operators should strip and stockpile topsoil separately from subsoil based on a visual assessment of colour change, prior to preparation of marshalling yards, temporary work camps, and construction power site, where possible for re-use in construction site reclamation. • If appropriate to the particular facility design, topsoil should be replaced upon completion of construction activities. When it is not appropriate to replace topsoil, disposal arrangements should be made with the landowner as a first option, in agricultural areas. • Locate excess excavated soils in designated spoil areas on high ground, at least 30 m from the high water mark of a surface waterbody, in a manner which does not impede natural drainage. • Excavated soils should be stored at designated work/spoil areas and should be fully replaced on the footprint of the excavation in the reverse order they were excavated. • The senior field authority should stop work when ground conditions are such that no effective construction practice will prevent admixing caused by severe rutting. The need to stop work may be evidenced by the excessive build-up of mud on tires/cleats and excessive ponding on the soil surface.	Negligible following mitigation	None

Table 6.8: Anticipated Environmental Effects to the Terrain and Soil Environment					
Environment Effect	**Environmental Indicators**	**Measurable Parameters**	**Mitigation Measures**	**Residual Environmental Effect**	**Follow-up**
OPERATION AND MAINTENANCE					
Transmission Lines					
Loss of soil structure due to compaction from inspection / maintenance vehicles and heavy equipment.	• Soil productivity	• Penetration resistance • Bulk density	• Transmission line monitoring/maintenance activity in identified areas of high risk to compaction should be scheduled during late summer, early fall or winter to target dry, frozen and/or snow-covered conditions and prevent compaction on mineral and organic soils. • Where persistently wet locations cannot be avoided, geotextile fabric overlain with soil/aggregate or construction mats should be placed beneath trafficking areas to reduce rutting during right-of-way maintenance. Any fabric, matting or imported materials should be removed prior to leaving the area. • Existing access routes should be utilized where possible and site traffic along the RoW should be minimized or contained to single paths, which should not exceed 6 m in width[ii]. • Use low-ground pressure vehicles (i.e., wide-tracked machinery), where possible. • If required, the right-of-way should be graded, disced or ploughed to remove ruts caused by rubber-tired and tracked vehicles after construction.	Some compaction and rutting along portions of right of way in northern Manitoba	None
Loss of topsoil due to wind erosion (e.g., creep, saltation, suspension) on surfaces disturbed during transmission line inspection / maintenance.	• Topsoil quality (south) • Agricultural capability (north)	• Topsoil thickness • Agricultural capability class • Visible evidence of soil movement • Soil deposition (e.g., drifts)	• Inspection and maintenance activities in High and Severe Wind Erosion Risk Areas in southern Manitoba and within the Limestone River/Nine Mile Creek, PTH 10, Brigg's Spur and Portage la Prairie area eolian deposits should be scheduled during winter to prevent accelerated wind erosion. • If it is not possible to work during winter, soil conditions should be moist for work in High to Severe Wind Erosion Risk Areas, to prevent accelerated wind erosion. • Low ground pressure equipment (e.g., tracked vehicles) should be used for inspection and maintenance activities in the Limestone River/Nine Mile Creek, PTH 10, Brigg's Spur and Portage la Prairie area eolian deposits. • Disturbance should be limited in the Limestone River/Nine Mile Creek, PTH 10, Brigg's Spur and Portage la Prairie area eolian deposits. • Disturbed areas within High and Severe Wind Erosion Risk areas and the Limestone River/Nine Mile Creek, PTH 10, Brigg's Spur and Portage la Prairie area eolian deposits should be actively stabilized, vegetated and/or seeded as soon as possible following inspection or maintenance-related disturbance. • Straw crimping should be implemented on sites and areas identified as having a High to Severe Risk of wind erosion following inspection or maintenance-related disturbance to prevent erosion.	Negligible following general and site-specific mitigation	None

Table 6.8: Anticipated Environmental Effects to the Terrain and Soil Environment

Environment Effect	Environmental Indicators	Measurable Parameters	Mitigation Measures	Residual Environmental Effect	Follow-up
Loss of permafrost as a result of disturbance and compaction of overlying organic layers and burning of slash for brush disposal during inspection / maintenance	• Visual assessment • Increased active layer thickness	• Visual assessment of subsidence (slumps, depressions) • Active layer thickness	• Inspection/maintenance activities should not occur until the ground is frozen solid in the Kelsey Lake Permafrost Area and north of the Little Cormorant Lake Area to prevent permafrost degradation. • The movement of vehicles/equipment should be limited to a single path, which should not exceed 6 m, where possible, to prevent compaction of the active layer resulting in reduced insulation of permafrost. • Burning of slash from vegetation brushing should be avoided on fine-grained, permafrost affected soils and on sloped terrain (>15%) to prevent melting and subsidence. • Avoid stripping through organic vegetative layers to the extent possible. The top layer of organic soil and ground vegetation should be retained to prevent or minimize disturbance, where practical and feasible. • Maintain natural drainage and prevent altering drainage or concentrating flows, in order to prevent ground ice from melting. • Grade and compact snow in right-of-way work areas and along access routes, where possible or required for safety, to prevent thaw and increase frost penetration.	Potential for loss of terrain stability due to permafrost thaw following disturbance.	None
Loss of topsoil due to water erosion (e.g., sheet, rill, gully) on surfaces disturbed during transmission line inspection / maintenance.	• Topsoil quality (north) • Agricultural capability (south)	• Topsoil thickness • Agricultural capability class • Soil accumulation in lower slopes	• Inspection / maintenance activities in the Sinclair, North Duck and Assiniboine rivers High and Severe Water Erosion Risk Areas and Overflowing River area should be scheduled during winter, where possible, to target frozen ground conditions. • A visual assessment of slope condition / stability should be conducted prior to inspection / maintenance activities in the Overflowing River Area. Movement of heavy equipment and personnel on visually unstable sites should be avoided to prevent slope failure and/or potential injury. • In the Sinclair, North Duck and Assiniboine rivers High and Severe Water Erosion Risk Areas, banks should be restored to their original condition, if disturbed.	Negligible following general and site-specific mitigation	None

Table 6.8: Anticipated Environmental Effects to the Terrain and Soil Environment					
Environment Effect	**Environmental Indicators**	**Measurable Parameters**	**Mitigation Measures**	**Residual Environmental Effect**	**Follow-up**
Reduced soil productivity due to residual herbicide levels	• Soil productivity	• Soil residual herbicide concentration (i.e., select analytical parameters)	• Pesticide use should be in accordance with the requirements of the *Pesticides Regulation, Manitoba Regulation M.R. 94/88*, which includes, but is not limited to: o Pesticides should be obtained, possessed and used in accordance with a pesticide use permit. o Pesticides should be possessed, or applied under the direct supervision of someone who possesses, a commercial applicator's licence issued under *The Pesticides and Fertilizers Control Act.* o Only pesticide application equipment maintained in a manner that ensures its function as designed should be used. o Pesticides should not be sprayed in wind speeds <5 km/hr or >20 km/hr, except when using non-pressurized hand-operated equipment or drift-control equipment/additives. o Effectively rinsed and punctured containers should be deposited at a local pesticide container collection area or waste disposal ground designated by the municipality and / or local authority. • Herbicide applications should be made by a licensed certified applicator. • Herbicides should be applied according to product label directions. • Spot spraying of target species should be conducted, where possible.	Negligible following mitigation	None
DECOMMISSIONING					
Loss of soil structure due to compaction from heavy equipment and vehicle traffic, including frozen waterbody crossings and access provision during decommissioning.	• Topsoil quality (south) • Agricultural capability (north)	• Penetration resistance • Bulk density	• In identified areas of high risk to compaction, transmission line decommissioning should be scheduled during late summer, early fall or winter to target dry, frozen and/or snow-covered conditions and prevent compaction on mineral and organic soils. • The senior field authority should stop work on transmission line decommissioning when ground conditions are such that no effective practice will prevent damage caused by severe rutting. The need to stop work may be evidenced by the excessive build-up of mud on tires/cleats and excessive ponding on the soil surface. • Where persistently wet locations cannot be avoided, geotextile fabric overlain with soil/aggregate or construction mats should be placed beneath trafficking areas to reduce rutting during right-of-way decommissioning activities. Any fabric, matting or imported materials should be removed prior to leaving the area. • Low-ground pressure vehicles (i.e., wide-tracked or wide-rubber-tired machinery) should be utilized for transmission line decommissioning, where possible. • Existing access routes should be utilized where possible and site traffic along the RoW should be minimized or contained to single paths, which should not exceed 6 m in width[iii]. • Temporary storage areas for machinery and equipment should be located on well drained, mineral soil types, where possible. • If required, the RoW should be graded, disced or deep-ploughed to remove ruts caused by rubber-tired and tracked vehicles in agricultural areas. If an extensive area of Crown land is disturbed, the disturbed area should be reseeded with native seed mixes.	Some compaction and rutting along portions of right of way in northern Manitoba	None

Table 6.8: Anticipated Environmental Effects to the Terrain and Soil Environment

Environment Effect	Environmental Indicators	Measurable Parameters	Mitigation Measures	Residual Environmental Effect	Follow-up
Loss of topsoil due to wind erosion (e.g., creep, saltation, suspension) on disturbed surfaces.	• Topsoil quality (south) • Agricultural capability (north)	• Topsoil thickness • Agricultural capability class • Visible evidence of soil movement • Soil deposition (e.g., drifts)	• Decommissioning activities in High and Severe Wind Erosion Risk areas in southern Manitoba and within the Limestone River/Nine Mile Creek, PTH 10, Brigg's Spur and Portage la Prairie area eolian deposits should be scheduled during winter to prevent accelerated wind erosion. • If it is not possible to work during winter, soil conditions should be moist for decommissioning work in High to Severe Wind Erosion Risk areas, to prevent accelerated wind erosion. • Low ground pressure equipment (e.g., tracked vehicles) should be used for decommissioning activities in the Limestone River/Nine Mile Creek, PTH 10, Brigg's Spur and Portage la Prairie area eolian deposits. • Equipment traffic and associated disturbance should be limited in the Limestone River/Nine Mile Creek, PTH 10, Brigg's Spur and Portage la Prairie area eolian deposits. • Disturbed areas within High and Severe Wind Erosion Risk areas and the Limestone River/Nine Mile Creek, PTH 10, Brigg's Spur and Portage la Prairie area eolian deposits should be actively stabilized, vegetated and/or seeded as soon as possible following construction or disturbance. • Straw crimping should be implemented on exposed soil areas in areas identified as having a High to Severe Risk of wind erosion following construction or disturbance to prevent erosion.	Negligible following general and site-specific mitigation	None

Table 6.8: Anticipated Environmental Effects to the Terrain and Soil Environment

Environment Effect	Environmental Indicators	Measurable Parameters	Mitigation Measures	Residual Environmental Effect	Follow-up
Loss of topsoil due to water erosion (e.g., sheet, rill, gully) on disturbed surfaces.	• Topsoil quality (north) • Agricultural capability (south)	• Topsoil thickness • Agricultural capability class • Soil accumulation in lower slopes	• Decommissioning activities in the Sinclair, North Duck and Assiniboine rivers High and Severe Water Erosion Risk Areas and Overflowing River area should be scheduled during winter, where possible, to target frozen ground conditions. • A visual assessment of slope condition/stability should be conducted prior to decommissioning activities in the Overflowing River Area. Movement of heavy equipment and personnel on visually unstable sites should be avoided to prevent slope failure and/or potential injury. • Run-off should be directed away from disturbed areas. Some vegetation, slash or snow-covering should be maintained in the Sinclair, Duck and Assiniboine rivers High and Severe Water Erosion Risk Areas and Overflowing River area to protect soils. o Site-specific Sediment Control Plans should be developed for the North Duck River and Assiniboine River watercourse crossings to manage water erosion risk . The Plan should incorporate the following measures: o Erosion control measures, such as silt fences, should be in place prior to decommissioning activities/disturbance and removed after vegetation has re-established. o Where erosion and sediment control measures are employed, sites should be maintained, and the effectiveness of these measures should be monitored. o Sufficient materials for erosion control should be maintained on-site, such as silt fencing, straw bales and erosion control matting. • In the Sinclair, North Duck and Assiniboine rivers High and Severe Water Erosion Risk Areas, banks should be restored to their original condition, if disturbed.	Negligible following general and site-specific mitigation	None
Loss of permafrost as a result of disturbance and compaction of overlying organic layers and burning of slash for brush disposal.	• Visual assessment • Increased active layer thickness	• Visual assessment of subsidence (slumps, depressions) • Active layer thickness	• Decommissioning of the 500 kV HVdc right-of-way should not occur until the ground is frozen solid in the Kelsey Lake Permafrost Area and north of the Little Cormorant Lake Area to prevent permafrost degradation. • Decommissioning of the AC Collector Line and Construction Power Line should not occur until the ground is frozen solid to prevent permafrost degradation. • The movement of equipment should be limited to a single path, which should not exceed 6 m, where possible, to prevent compaction of the active layer resulting in reduced insulation of permafrost. • Burning of slash from right-of-way brushing should be avoided on fine-grained, permafrost affected soils and on sloped terrain (>15%) to prevent melting and subsidence. • Maintain natural drainage and prevent altering drainage or concentrating flows, in order to prevent ground ice from melting. Grade and compact snow in right-of-way work areas and along access routes, where possible or required for safety, to prevent thaw and increase frost penetration.	Potential for loss of terrain stability due to permafrost thaw following disturbance.	None

Table 6.8: Anticipated Environmental Effects to the Terrain and Soil Environment					
Environment Effect	**Environmental Indicators**	**Measurable Parameters**	**Mitigation Measures**	**Residual Environmental Effect**	**Follow-up**
ACCIDENTS AND MALFUNCTIONS					
Impairment of soil quality as a result of entry of contaminants to the soil environment from accidental releases of hazardous materials.	• Soil productivity	• Soil concentration of relevant analytical parameters (e.g., BTEX, MOG) depending on fugitive material.	• Fuel, lubricants and other potentially hazardous materials should be stored and handled within dedicated areas at work sites and marshalling yards in full compliance with regulatory requirements. o All storage sites should be located a minimum distance of 100 m from any waterbody. • Marshalling yards should be located on low permeability soils and upland sites, where possible (i.e., areas of well drained soilsand locally by the Senior Field Authority). • Transfer of fuel must be attended at all times. • An emergency response spill kit should be kept on-site at all times in case of fluid leaks or spills from machinery. • All fuel spills or leaks should be reported to the Project Manager or delegate immediately upon discovery. • General clean-up in storage areas, and sites where incidental spillage occurs, should be in accordance with regulatory standards. o All soil is to be remediated or disposed of in a manner approved by regulatory authorities and Manitoba Hydro. • Hazardous materials, fuel containers and other materials should be removed from the site and disposed of according to Manitoba Hydro's Hazardous Materials Management Handbook and in accordance with regulatory requirements.	Possible residual effects in the event of a major spill.	Inspection for staining and stressed vegetation.

Table 6.9: Anticipated Environmental Effects to the Valued Environmental Components of the Terrain and Soil Environment

Category	Valued Environmental Component	Environmental Indicator	Measurable Parameter/ Variable	Environmental Effect	Mitigation Measures	Residual Environmental Effect
PRECONSTRUCTION						
Soil	Soil productivity	• Topsoil quality (north) • Agricultural capability (south) • Surface rutting	• Penetration resistance • Bulk density	Compaction and rutting from drill rigs	N/A	N/A
CONSTRUCTION						
Transmission Line						
Terrain	Unique Terrain/Soil Features • PAI Enduring Features	• Landscape integrity • Representation	• Hectares of impaired land • Proportion protected (Area protected/available area)	Impairment or loss of approximately 161 ha of rare or single occurrence PAI enduring features from right-of-way establishment.	• No off-RoW activities including construction of access trails or establishment of new borrow sources shall be conducted within any of the enduring features described by this study. • Off-RoW activities shall maintain a buffer distance of 100 m from the enduring features described by this study, where feasible. • Construction within enduring features shall be conducted in the winter, under frozen conditions, to protect site-specific features (e.g., organic deposits). • Topsoil and subsoils should be excavated and stockpiled separately, where excavation is required for tower foundations. These soils should be replaced in the manner in which they were removed within the tower footprint. • Minimize equipment movement within enduring features to minimize terrain disturbance. • Existing access routes should be utilized and machinery shall not operate outside of the project areas within enduring features.	Impairment or loss of landscape integrity from traversing unique/diverse terrain features.
Terrain	Unique Terrain/Soil Features • Other Unique Terrain/Soil Features	• Landscape integrity	• Hectares of impaired land	Potential for impairment or loss of approximately 400 ha of other unique terrain/soil features identified from study results from off-RoW activities.	• No off-RoW activities including the construction of access trails and establishment of new borrow sources shall be conducted in the vicinity of the identified beach deposits and salt flats (Map 600 - 1:4-5 – Unique Terrain/Soil Features). • Off-RoW activities shall maintain a buffer distance of 100 m from the other unique terrain/soil features described by this study, where feasible.	None following identified mitigation measures

Table 6.9: Anticipated Environmental Effects to the Valued Environmental Components of the Terrain and Soil Environment

Category	Valued Environmental Component	Environmental Indicator	Measurable Parameter/ Variable	Environmental Effect	Mitigation Measures	Residual Environmental Effect
Terrain	Stable Terrain	• Terrain Stability	• Visual Assessment • Active layer thickness • Factor of Safety	Loss of terrain stability , due to: • Loss of terrain material due to initiation or acceleration of mass movement/wasting (e.g., slides/creeping) from clearing and grading activities. • Loss of permafrost as a result of disturbance and compaction of overlying organic layers and burning of slash for brush disposal.	• The removal of natural vegetation on sloped terrain, particularly adjacent to waterways, should be avoided to the greatest extent possible. • Where vegetation is removed from sloped terrain, the area should be replanted with deep-rooted shrubs, such as willow, where feasible to prevent sloped degradation. • Slope undercutting and slope modification at angles greater than 30° should be avoided, to prevent sliding or slumping. Any slopes over steepened beyond 30° should be graded to reduce the slope. • The introduction of water to slopes should be limited to the greatest extent possible. Drainage should not be altered to concentrate flows, especially in sloped terrain.	Potential for loss of terrain stability due to mass wasting and permafrost thaw following disturbance.
Soil	Soil Productivity	• Agricultural Capability	Agricultural Capability Rating Class, as determined by: • Soil moisture holding capacity • Topography • Soil structure • Permeability • Salinity/sodicity • Erosion • Stoniness • Drainage • Organic matter content.	Reduction of agricultural capability class rating, due to: • Loss of soil structure due to compaction of soils from heavy equipment and vehicle traffic, including frozen waterbody crossings and access provision. • Loss of topsoil due to accelerated wind and water erosion from surface disturbance, clearing and creation of steep/unstable slopes. • Loss of soil capability due to soil mixing from grading and foundation excavating.	• Construction activities in southern Manitoba should be undertaken during winter, where possible, and under dry conditions for high compaction risk areas and moist conditions for high to severe wind erosion risk areas, where possible. Snow should be plowed or compacted to facilitate deeper frost penetration. • Access routes should be located along existing traffic routes where possible and will be determined in advance. Vehicles should be restricted to those routes. • Use low-ground pressure vehicles (i.e., wide-tracked machinery), particularly in areas of high compaction risk, where possible. • If required, the right-of-way should be graded, disced or deep-ploughed to alleviate compaction and remove ruts caused by rubber-tired and tracked vehicles after construction. • Remove all surface granular materials from sites and temporary workspaces on agricultural land and replace with clean, uncontaminated, stockpiled topsoil. • Infrastructure component sites should be deep-ploughed as part of decommissioning to relieve compaction.	None

Table 6.9: Anticipated Environmental Effects to the Valued Environmental Components of the Terrain and Soil Environment

Category	Valued Environmental Component	Environmental Indicator	Measurable Parameter/ Variable	Environmental Effect	Mitigation Measures	Residual Environmental Effect
Soil	Soil Productivity	• Topsoil / Organic Soil Quality	Individual Parameters: • Topsoil thickness • Salinity • Bulk density • Resistance to penetration • Soil temperature	Impairment of topsoil/organic soil quality, due to: • Loss of soil structure due to compaction of soils/organic layers from heavy equipment and vehicle traffic, including frozen waterbody crossings and access provision. • Loss of topsoil due to accelerated wind and water erosion from surface disturbance, clearing and creation of steep/unstable slopes. • Increase in mean soil temperature from clearing.	• Topsoil should be stripped and stockpiled prior to site grading for temporary project components (Temporary Work Camps, Marshalling Yards). • Topsoil should be replaced on decommissioning of temporary project components (Temporary Work Camps, Marshalling Yards). • General mitigation measures for preventing soil compaction, erosion and increased soil temperature (Table 6.8).	Loss of soil structure from compaction and rutting of heavy equipment in areas of northern Manitoba.
Converter Stations						
Soil	Soil Productivity	• Agricultural Capability	Agricultural Capability Rating Class	N/A – Southern Converter Station Site not under Agricultural Production	N/A	N/A
Soil	Soil Productivity	• Topsoil/Organic Soil Quality	Individual Parameters: • Bulk density • Resistance to penetration • Soil temperature	Impairment of topsoil/organic soil quality, due to: • Loss of soil structure due to compaction from site preparation.	• Topsoil should be stripped and stockpiled prior to site grading for temporary project components (Temporary Work Camps, Marshalling Yards). • Topsoil should be replaced on decommissioning of temporary project components (Temporary Work Camps, Marshalling Yards). • General mitigation measures for preventing soil compaction, erosion and increased soil temperature (Table 6.8).	Loss of soil structure from compaction and rutting of heavy equipment in areas of northern Manitoba.

Table 6.9: Anticipated Environmental Effects to the Valued Environmental Components of the Terrain and Soil Environment

Category	Valued Environmental Component	Environmental Indicator	Measurable Parameter/ Variable	Environmental Effect	Mitigation Measures	Residual Environmental Effect
Ground Electrodes						
Soil	Soil Productivity	• Agricultural Capability	Agricultural Capability Rating Class, as determined by: • Soil moisture holding capacity • Soil structure • Permeability • Salinity/sodicity • Erosion • Stoniness • Drainage • Organic matter content.	Reduction of agricultural capability class rating, due to: • Loss of soil structure due to compaction from heavy equipment/vehicle traffic. • Loss of topsoil due to accelerated erosion events from equipment/vehicle traffic, clearing. • Loss of soil capability due to admixing soil from electrode ring excavation and trenching.	• Construction activities in southern Manitoba should be undertaken during winter, where possible, and under dry conditions for high compaction risk areas and moist conditions for high to severe wind erosion risk areas, where possible. Snow should be plowed or compacted to facilitate deeper frost penetration. • Access routes should be located along existing traffic routes where possible and will be determined in advance. Vehicles should be restricted to those routes. • Use low-ground pressure vehicles (i.e., wide-tracked machinery), particularly in areas of high compaction risk, where possible. • If required, the right-of-way should be graded, disced or deep-ploughed to alleviate compaction and remove ruts caused by rubber-tired and tracked vehicles after construction.	None
Soil	Soil Productivity	• Topsoil / Organic Soil Quality	Individual Parameters: • Topsoil thickness • Soil texture • Bulk density • Resistance to penetration • Soil temperature	Impairment of topsoil/organic soil quality, due to: • Loss of soil structure due to compaction from site preparation. • Loss of topsoil due to accelerated wind and water erosion from surface disturbance, clearing and creation of steep/unstable slopes. • Increase in mean soil temperature from clearing.	• Topsoil should be stripped and stockpiled prior to site grading for temporary project components (Temporary Work Camps, Marshalling Yards). • Topsoil should be replaced on decommissioning of temporary project components (Temporary Work Camps, Marshalling Yards). • General mitigation measures for preventing soil compaction, erosion and increased soil temperature (Table 6.8).	Loss of soil structure from compaction and rutting of heavy equipment in areas of northern Manitoba.
Construction Power Site						
Soil	Soil Productivity	• Topsoil / Organic Soil Quality	Individual Parameters: • Soil temperature	Impairment of topsoil/organic soil quality, due to: • Loss of soil structure due to compaction from site preparation. • Loss of topsoil due to accelerated wind and water erosion from surface disturbance, clearing and creation of steep/unstable slopes. • Increase in mean soil temperature from clearing.	• Topsoil should be stripped and stockpiled prior to site grading for temporary project components (Temporary Work Camps, Marshalling Yards). • Topsoil should be replaced on decommissioning of temporary project components (Temporary Work Camps, Marshalling Yards). • General mitigation measures for preventing soil compaction, erosion and increased soil temperature (Table 6.8).	Loss of soil structure from compaction and rutting of heavy equipment in areas of northern Manitoba.

Table 6.9: Anticipated Environmental Effects to the Valued Environmental Components of the Terrain and Soil Environment

Category	Valued Environmental Component	Environmental Indicator	Measurable Parameter/ Variable	Environmental Effect	Mitigation Measures	Residual Environmental Effect
Associated Lines						
Soil	Soil Productivity	• Topsoil/Organic Soil Quality	Individual Parameters: • Soil temperature	Impairment of topsoil/organic soil quality, due to: • Loss of soil structure due to compaction from site preparation. • Loss of topsoil due to accelerated wind and water erosion from surface disturbance, clearing and creation of steep/unstable slopes. • Increase in mean soil temperature from clearing.	• Topsoil should be stripped and stockpiled prior to site grading for temporary project components (Temporary Work Camps, Marshalling Yards). • Topsoil should be replaced on decommissioning of temporary project components (Temporary Work Camps, Marshalling Yards). • General mitigation measures for preventing soil compaction, erosion and increased soil temperature (Table 6.8).	Loss of soil structure from compaction and rutting of heavy equipment in areas of northern Manitoba.
Marshalling Yards and Temporary Northern Construction Camp						
Soil	Soil Productivity	• Agricultural Capability	Agricultural Capability Rating Class, as determined by: • Soil moisture holding capacity • Soil structure • Permeability • Stoniness • Drainage.	Reduction of agricultural capability class rating, due to: • Loss of soil structure due to compaction of soils from heavy equipment and vehicle traffic. • Loss of soil capability due to soil mixing and mixing with imported materials (e.g., aggregate).	• Construction activities in southern Manitoba should be undertaken during winter, where possible, and under dry conditions for high compaction risk areas and moist conditions for high to severe wind erosion risk areas, where possible. Snow should be plowed or compacted to facilitate deeper frost penetration. • Access routes should be located along existing traffic routes where possible and will be determined in advance. Vehicles should be restricted to those routes. • Use low-ground pressure vehicles (i.e., wide-tracked machinery), particularly in areas of high compaction risk, where possible.	None
Soil	Soil Productivity	• Topsoil/Organic Soil Quality	Individual Parameters: • Topsoil thickness • Soil texture • Bulk density • Resistance to penetration • Soil temperature	Impairment of topsoil/organic soil quality, due to: • Loss of soil structure due to compaction from site preparation. • Loss of topsoil due to accelerated wind and water erosion from surface disturbance, clearing and creation of steep/unstable slopes. • Increase in mean soil temperature from clearing.	• Topsoil should be stripped and stockpiled prior to site grading for temporary project components (Temporary Work Camps, Marshalling Yards). • Topsoil should be replaced on decommissioning of temporary project components (Temporary Work Camps, Marshalling Yards). • General mitigation measures for preventing soil compaction, erosion and increased soil temperature (Table 6.8).	Loss of soil structure from compaction and rutting of heavy equipment in areas of northern Manitoba.

Table 6.9: Anticipated Environmental Effects to the Valued Environmental Components of the Terrain and Soil Environment

Category	Valued Environmental Component	Environmental Indicator	Measurable Parameter/ Variable	Environmental Effect	Mitigation Measures	Residual Environmental Effect
OPERATION AND MAINTENANCE						
Transmission Line						
Soil	Soil Productivity	• Agricultural Capability	Agricultural Capability Rating Class, as determined by: • Soil moisture holding capacity • Soil structure • Permeability • Drainage Residual herbicide concentration (i.e., select analytical parameters).	Reduction of agricultural capability class rating, due to: • Loss of soil structure due to compaction of soils from inspection/maintenance vehicle and heavy equipment traffic. • Reduced soil productivity due to herbicide residuals from RoW herbicidal vegetation management activities.	• Conduct inspection/maintenance activities during frozen or dry conditions, where feasible. • Apply herbicides according to product label directions.	None
Soil	Soil Productivity	• Topsoil/Organic Soil Quality	Individual Parameters: • Topsoil thickness • Bulk density • Resistance to penetration. Residual herbicide concentration (i.e., select analytical parameters).	Impairment of topsoil/organic soil quality, due to: • Loss of soil structure due to compaction of soils/organic layers from inspection/maintenance vehicle and heavy equipment traffic. •	• Conduct inspection/maintenance activities during frozen conditions, where feasible. •	Loss of soil structure from compaction and rutting of heavy equipment in areas of northern Manitoba.
DECOMMISSIONING PHASE						
Converter Stations						
Soil	Soil Productivity	• Agricultural Capability	Agricultural Capability Rating Class, as determined by: • Soil moisture holding capacity • Soil structure • Permeability • Drainage	Reduction of agricultural capability class rating, due to: • Loss of soil structure due to compaction of soils from site use.	Depending on the intended future land use of the site: • Conduct subsoil compaction mitigation (i.e., deep ripping) across entire site. • Replace topsoil across site. • Re-contour the surface of the site.	None

Table 6.10: Summary of Significance Assessment for Anticipated Residual Effects to the Terrain and Soil Environment

1. Residual Environmental Effect	2. Direction	3. Ecological Importance	4. Societal Importance	5. Magnitude	6. Geographic Extent	7. Duration	8. Frequency	9. Reversibility	Comments
Loss of soil structure from compaction and rutting of heavy equipment in areas of northern Manitoba.	Negative	Moderate	Moderate	Medium	Project Site/Footprint	Medium	Infrequent	Reversible	
Rationale: There are limited mitigation measures available for organic soils, resulting in a medium-term effect. Ecological importance is considered low, as effects to enduring features are considered separately under landscape integrity effects. The residual environmental effect of loss of soil structure in areas of northern Manitoba from heavy equipment compaction and rutting is negative with moderate ecological and societal importance, Project Site /Footprint extent, medium-term duration, infrequent occurrence throughout Project life and reversible.									
Potential for loss of terrain stability due to mass wasting and permafrost thaw following disturbance.	Negative	Moderate	Low to Moderate	Medium	Project Site/Footprint	Long-term	Infrequent	Irreversible	
Rationale: Mass wasting and permafrost subsidence could occur in areas somewhat important to ecological function (e.g., riparian areas); however, these areas were not specifically identified as important during consultation and workshops. The potential residual environmental effects of loss of terrain stability due to mass wasting and permafrost thaw following disturbance is negative with moderate ecological and low-moderate societal importance. This medium magnitude effect would be located within the Project footprint and be permanent.									
Increased soil temperatures due to clearing of vegetation.	Positive and Negative	Moderate	Moderate	Medium	Project Site/Footprint	Short-term	Infrequent	Irreversible	
Rationale: Increased soil temperatures would lead to positive effects of earlier spring thaw and negative effects of contributing to droughty soils. Soil temperature is important for the ecological function of soils in supporting vegetation. The short-term residual effect could be measured with a well-designed program, during the soil exposure timeframe. The residual environmental effect of increased soil temperatures is considered of moderate ecological and moderate societal importance. The medium magnitude effect would be confined to the Project site, be short-term, occur infrequently (i.e., vegetation management cycles) and reversible.									
Impairment of landscape integrity from traversing an enduring feature.	Negative	High	Moderate	Medium to large	Project Site/Footprint	Medium-term	Infrequent	Irreversible	
Rationale: The maintenance of landscape integrity is important to ecological importance and occurs in areas nominated for protection. The effect to landscape integrity could be measured in some areas using a program, and readily visible in other areas. The right-of-way establish would have a medium-term effect on the site. The residual effect of impairing the landscape integrity of single and rare occurrence PAI enduring features is negative, with high ecological and moderate societal importance. The magnitude of the effect would be medium to large, occurring within the 66 m right-of-way only with a long-term duration, infrequent (i.e., once) occurrence, and is irreversible within the life of the Project.									
Impairment of soil quality due to entry of contaminants from spills.	Negative	Moderate	Moderate	Medium to Large	Project Site/Footprint	Long-term	Sporadic	Reversible	
Rationale: The residual effect of an unremediated release of contaminants as a result of a major spill would be negative, with moderate ecological and societal importance, medium to large magnitude, within the Project Site/Footprint, of a long-term duration, infrequent occurrence and reversible over the life of the project, with a well constructed program.									

Table 6.10: Summary of Significance Assessment for Anticipated Residual Effects to the Terrain and Soil Environment									
1. Residual Environmental Effect	**2. Direction**	**3. Ecological Importance**	**4. Societal Importance**	**5. Magnitude**	**6. Geographic Extent**	**7. Duration**	**8. Frequency**	**9. Reversibility**	**Comments**
Loss of surficial and bedrock materials required to infill foundations and other excavations.	Negative	Low	Low	Small	Local Assessment Area	Long-term	Infrequent	Irreversible	
Rationale: Surficial and bedrock geological materials were not identified through the study as valued components of the environment. Furthermore, these materials were not identified as important to society in the public consultation meetings or in ATK workshops. It is anticipated that these activities could be carried out within the current regulatory and guidance framework and that no standards would be exceeded. Due to logistical constraints, it is anticipated that existing or new borrow sources utilized by the Project will be located within approximately 2.5 km of the Project footprint. The residual effect of the loss of surficial and bedrock materials is considered a small magnitude, negative effect of low ecological and societal importance, with long-term, irreversible yet infrequent effects on the local assessment area.									

Table 6.11: Valued Environmental Components Summary for Cumulative Effects Assessment			
Valued Environmental Component	**Environmental Indicator**	**Measurable Parameter/Variable**	**Residual Environmental Effect**
Unique Terrain/Soil Features	• Representativeness • Fragmentation	• Proportion protected (Area protected/available area) • Fragmentation of previously contiguous parcels	Impairment of landscape integrity (i.e., loss of representation) from traversing an enduring feature.
Soil Productivity	• Topsoil (mineral or organic) Soil Quality	• Bulk Density	Loss of soil structure from compaction and rutting of heavy equipment in areas of northern Manitoba.
Soil Productivity	• Topsoil (mineral or organic) Soil Quality	• Soil Temperature	Increased soil temperatures due to clearing of vegetation.
Stable Terrain	• Terrain Stability	• Visual Evidence (e.g., sinking) • Active Layer Thickness	Potential for loss of terrain stability due to mass wasting and permafrost thaw following disturbance.

Table 6.12: Other Action Summary for Cumulative Effects Assessment				
Other Action Category	**Other Action Description**	**Valued Environmental Component Affected**	**Measurable Parameters / Variables**	**Environmental Effects**
Resource Activity	Resource Use Activities (Forestry, Mining – e.g., initiation of kimberlite mining in Manitoba)	Unique Terrain/Soil features	Representativeness	Nibbling loss of area (ha) of ASIs (i.e., boundary changes) available for protection to increase natural area representation to accommodate forestry or mining developments, in addition to area lost due to physical presence of 66.0 m RoW.
Infrastructure Development	Linear Infrastructure Developments (e.g., construction of proposed all-weather roads in north eastern Manitoba)	Unique Terrain/Soil Features	Representativeness Fragmentation	Nibbling fragmentation of contiguous ASIs available for protection to increase natural area representation from any future intersecting roadways, in addition to fragmentation caused by physical presence of 66.0 m RoW.
Induced Action	Motorized access of the Bipole III RoW during operation	Soil Productivity	Bulk Density	Temporal and spatial crowding of loss of organic soil structure effects due to soil compaction from motorized RoW access, in addition to compaction caused by RoW traffic and access during construction.
Natural/Anthropogenic Events	Climate Change	Soil Productivity	Soil Temperature	Additive increase in soil temperature effects due to anticipated increased solar radiation as a result of climate change, in addition to increased soil temperature of areas cleared during RoW/Sites preparation
Natural/Anthropogenic Events	Forest Fires	Soil Productivity	Organic Matter	Additive loss of organic matter due to destruction in future forest fires, in addition to loss or degradation of soil organic matter due to project construction activities.
Natural/Anthropogenic Events	Forest Fires	Terrain Stability	Visual evidence of subsidence (or sinking); Active layer thickness	Additive loss of terrain stability due to melting of permafrost layers as a result of forest fire, in addition to melting of permafrost as a result of construction activities.

[i] Bonneville Power Administration, 2002

Bonneville Power Administration. 2002. Grand Coulee-Bell 500-kV Transmission Line Project. Final Environmental Impact Statement (DOE/EIS-0344). December 2002.

[ii] Bonneville Power Administration, 2002

Bonneville Power Administration. 2002. Grand Coulee-Bell 500-kV Transmission Line Project. Final Environmental Impact Statement (DOE/EIS-0344). December 2002.

[iii] Bonneville Power Administration, 2002

Bonneville Power Administration. 2002. Grand Coulee-Bell 500-kV Transmission Line Project. Final Environmental Impact Statement (DOE/EIS-0344). December 2002.