North American Oil Sands Corporation
A wholly-owned affiliate of StatoilHydro ASA
Upgrader Project

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9 SOILS

9.1 Introduction

The Soils section provides information specified in clause 4.9.2 in the Terms of Reference (TOR) for the North American Upgrader Project (Project). The topics addressed in the Soils section include baseline soil conditions and interpretations of their characteristics with respect to environmental sensitivities, as well as mitigative measures and potential environmental impacts. The Soils section provides:

- detailed baseline information on soil types, including their characteristics and distribution in the Local Study Area (LSA) and Regional Study Area (RSA);
- interpretations of the soil characteristics for land suitability for agricultural crop production and reclamation suitability, as well as soil sensitivities to potential impacts such as acid deposition and erosion; and
- an evaluation of anticipated effects of the Project in the LSA and the Project contribution to cumulative effects in the RSA, including mitigative measures to prevent or minimize potential impacts.

9.2 Study Area

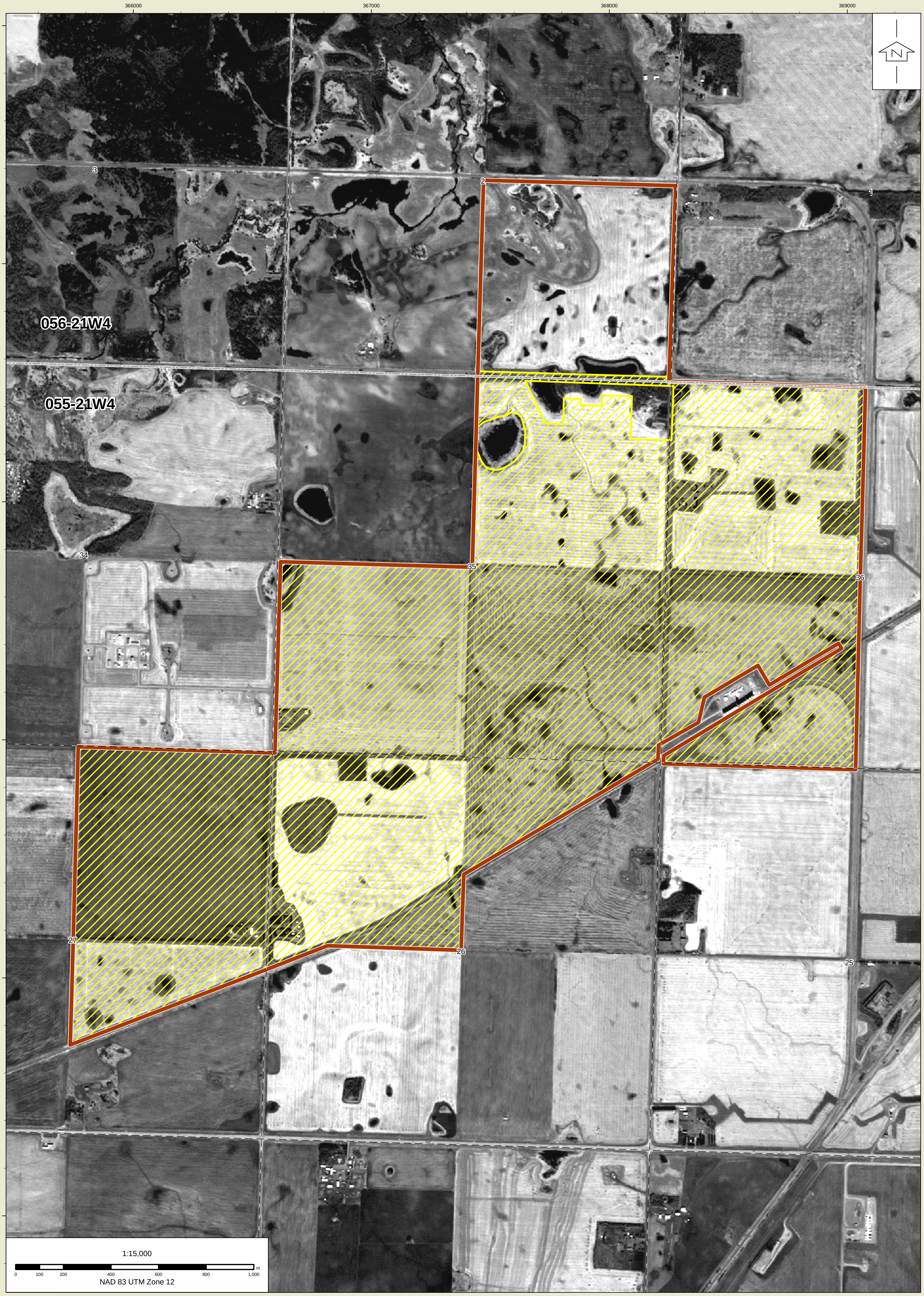
9.2.1 Spatial Boundaries

The Project footprint includes all lands subject to potential direct surface disturbance (e.g., soil salvage) for the construction, operation or reclamation phases of the Project. The Project footprint covers approximately 485 ha (Figure 9.2-1).

The LSA is located in portions of Sections 22, 23, 25, 26, 27, 35 and 36 in Township 55 Range 21 W4M and Section 2 in Township 56 Range 21 W4M, and covers approximately 562 ha. It includes all lands in the area owned by North American, as well as portions of road and rail rights-of-way within these lands. The RSA was selected to evaluate potential regional impacts related to air emission modelling for potential acid inputs (PAI), and cumulative effects relating to physical disturbance associated with future announced projects. The RSA includes lands identified through the air modelling of the cumulative case as having PAI levels 0.25 keq H^+/ha/y or greater. These lands include two isolated areas around Morinville and Redwater. The RSA is the same for soils and vegetation (Figure 9.2-2), and covers approximately 243,830 ha. The RSA includes significant urban development and disturbance. The undisturbed portion of the RSA is 144,537 ha.

9.2.2 Temporal Boundaries

The temporal scope of the EIA reflects the timing and nature of the Project's phases, as well as information available for other proposed projects. The Upgrader will be developed in multiple phases. The Project schedule is outlined in Volume 1, Section 1.4.



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- PROJECT FOOTPRINT
- ALBERTA TOWNSHIP / RANGE
- ATS SECTION LINE

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SOILS LOCAL STUDY AREA

NORTH AMERICAN OIL SANDS CORPORATION

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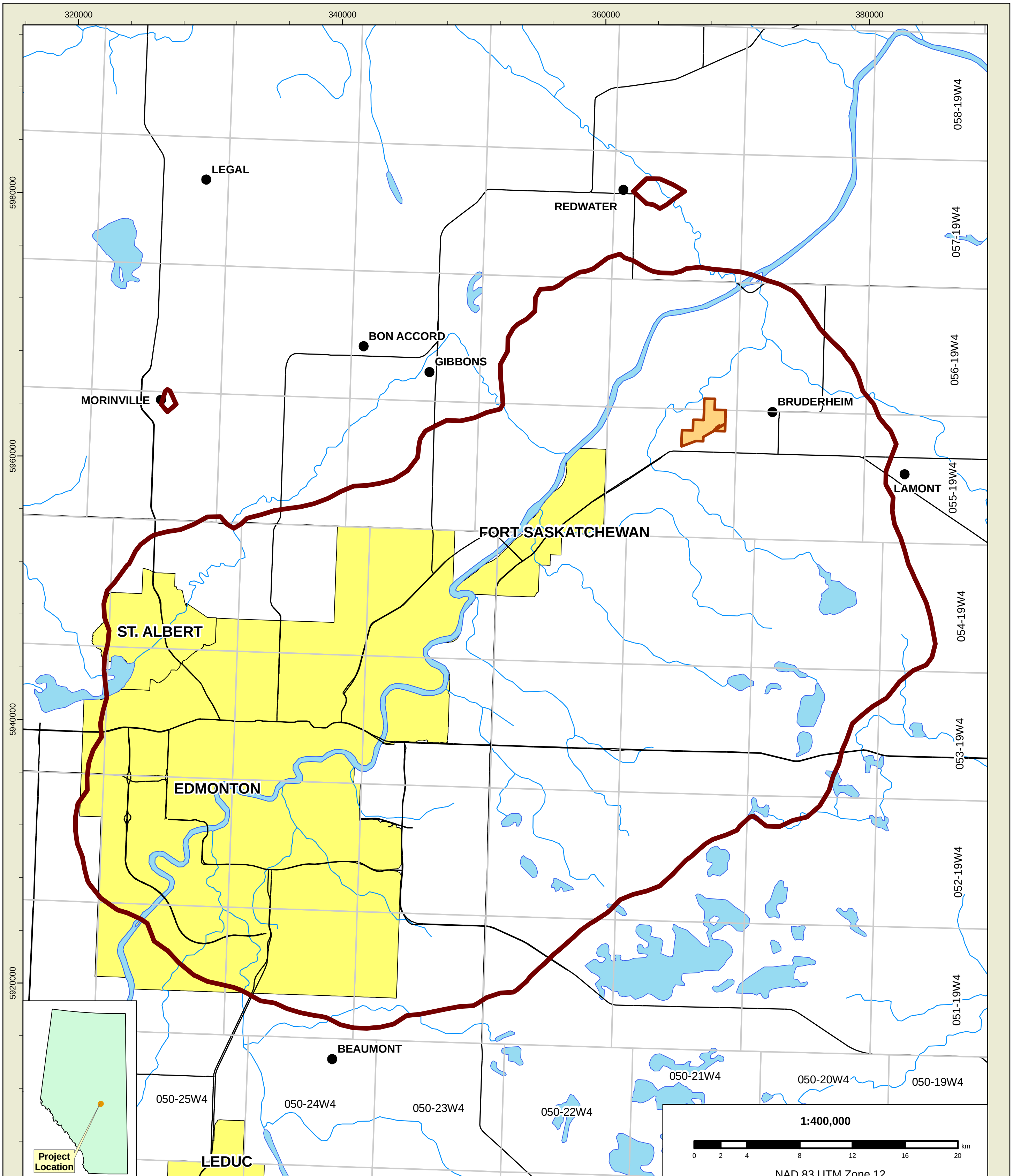

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- SOILS LOCAL STUDY AREA
- CITY
- TOWN
- WATERBODY
- RIVER/STREAM
- HIGHWAY
- ALBERTA TOWNSHIP/RANGE

Title:

SOILS RSA AND LSA

NORTH AMERICAN OIL SANDS CORPORATION

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9.3 Issues and Assessment Criteria

Issues scoping for soils and terrain involved a review of previous EIAs for upgrader projects, including:

- Shell Canada Limited Scotford Upgrader Expansion 1 (2005), and Scotford Upgrader 2 (2007);
- Synenco Energy Inc. Northern Lights Upgrader (2006);
- North West Upgrading Inc. North West Upgrader (2006);
- BA Energy Heartland Upgrader (2004); and
- Petro-Canada Oil Sands Inc. Sturgeon Upgrader (PCOSI, 2006).

The primary soils issues identified were associated with impacts to the soil resources during construction, operation and reclamation phases, and included:

- changes to land capability as a result of changes to soil resources;
- potential soil acidification; and
- potential impacts to soils as a result of dewatering activities during construction and operation of the Project.

The issues are also reflected in the Project's TOR (Volume 1, Appendix A), which provides the framework for this assessment.

9.4 Methods

9.4.1 Soil Mapping in the LSA

Soil inspection and sample locations for the Project are shown in Figure 9.4-1, and the list of sample locations is included in Appendix 9A. Table 9.4-1 provides a summary of the number of soil inspections conducted within the LSA, as well as the survey inspection level (SIL) density acquired.

Table 9.4-1 Soil Inspections Completed within the Project Footprint and LSA

Study Area	Number of Inspections [1]	Total Area (ha)	SIL
Project Footprint (undisturbed area)	121	376 [2]	SIL 1 (1 inspection/3 ha)
LSA	178	562	SIL 1 (1 inspection/3 ha)

Notes.
1 The number of inspections is cumulative. That is, the inspections conducted for the undisturbed Project footprint are included in the total for the LSA.
2 The total area excludes existing disturbances and waterbodies.

Soil profiles at the inspection sites were described in detail in the field to a depth of 120 cm. Landform, surficial materials, slope, texture, stoniness, topsoil thickness, drainage conditions and profile morphology were examined at each inspection site. Inspections were conducted using a punch probe mechanical drill.

Soils were described according to the Manual for Describing Soils in the Field (Agriculture Canada, 1982) and the Canadian System of Soil Classification (Soil Classification Working Group, 1998).

Soils identified in the LSA were named using the Alberta Soil Names File, Version 3.0 (ASIC, 2001).

Soil map units are based on the classification presented in Agricultural Region of Alberta Soil Inventory Database Version 3.0 (AGRASID 3.0) (ASIC 2001). The soils in the LSA were classified and described using criteria outlined in Soil Survey Handbook (Agriculture Canada, 1987). Soil map unit boundaries were drawn and identified using stereo pairs of aerial photographs with scales ranging from 1:10,000 to 1:20,000, combined with field reconnaissance survey data acquired during the soil survey of the LSA. Soils were mapped by extrapolating point observations of soils to larger areas using principles of geomorphology and surficial geology, combined with vegetation indicators. The soil map unit boundaries were then delineated on the basis of parent surficial geological material, landform and soil development.

Soil map unit names are made up of the dominant soil types that occur within the soil map unit boundaries, and come from the Alberta Soil Names File, Generation 3.0 (ASIC, 2001). For example, Beaverhill soil map units are designated as BVH 1 and BVH 2. The three-letter code (i.e., BVH) is the soil series abbreviation for Beaverhill soils as defined by ASIC. The number following the three-letter designation indicates the relative complexity of the soils found within the map unit boundary (e.g., BVH 1 has the least soil series variability within a map unit). In the BVH 1 map unit, Beaverhill soils are dominant, with 60% or greater of soil map unit area being Beaverhill soils. In the BVH 2 soil map unit, 10% to 30% of the map unit is poorly drained (Gleysols).

9.4.2 Soil Mapping in the RSA

Soil mapping of the RSA was obtained from the AGRASID 3.0 published at a 1:100,000 scale (ASIC, 2001). The air modelling potential acidifying input (PAI) isopleth of 0.25 keq H^+/ha/y for the cumulative case was used as the RSA boundary. The RSA covers approximately 243,830 ha.

Some soils mapped in AGRASID 3.0 appear as single soil series, indicating that that series is dominant in the mapped segment. Other soils are designated with two soil series names, indicating that two co-dominant soil series occur together over the mapped segment; in this case, both soils were accounted for while preparing the RSA map.

9.4.3 Analytical Program

Of the 74 inspection sites sampled, 30 inspection sites were analyzed to provide baseline soil chemistry data. Laboratory tables are included in Appendix 9B, and the laboratory reports are included in Appendix 9C. The samples were placed in plastic bags provided by the laboratory and shipped to an accredited laboratory for analysis. Soil samples were submitted for some or all of the following analyses:

- percent base saturation;
- pH;

- electrical conductivity (EC);
- texture;
- soluble cations and anions;
- sodium adsorption ratio (SAR);
- theoretical gypsum requirement (TGR);
- total organic carbon (TOC);
- cation exchange capacity (CEC); and
- organic matter content.

9.4.4 Soil Suitability and Sensitivity Assessment Criteria

Using soil chemistry data and physical properties, soil series were interpreted to determine:

- soil suitability for agriculture crops;
- soil suitability for reclamation;
- soil sensitivity to acid deposition; and
- wind and water erosion potential.

Methods of interpretation were based on:

- Land Suitability Rating System for Agricultural Crops, 1. Spring seeded small grains (Agriculture Interpretation Working Group (AIWG), 1995);
- Soil Quality Criteria Relative to Disturbance and Reclamation (Revised) (Alberta Agriculture, 1987);
- Soil Series Information for Reclamation Planning in Alberta, Vols. 1 and 2 (Pedocan 1993);
- Wind Erosion Risk (Coote and Pettapiece, 1989);
- Water Erosion Risk (Tajek and Coote, 1993);
- Soil Sensitivity to Acid Deposition (Holowaychuk and Fessenden, 1987);
- Critical Loads for Organic (Peat) Soils in Alberta (Turchenek et al., 1998); and
- Application of Critical, Target and Monitoring Loads for the Evaluation and Management of Acid Deposition (CASA, 1999).

9.4.4.1 Land Suitability Classification for Agricultural Crops

Baseline (pre-disturbance) ratings for the suitability of land for the production of spring-seeded small grains (and hardy oilseeds) in Canada were developed for each soil series in the LSA (AIWG, 1995). The land suitability ratings were determined from soil physical and analytical information obtained by field site inspections and laboratory analysis of soil samples. For the land suitability classification, climate, soil and landscape components were considered separately, and the final land suitability rating was based on the most limiting of the three components. Subclasses were assigned to identify specific limiting factors. The classification system is a planning tool that can be used for soil salvage and handling to facilitate conservation and reclamation. The seven land suitability classes are described in Table 9.4-2. Land suitability subclasses are described in Table 9.4-3.

Table 9.4-2 Land Suitability Classes for Agricultural Crops

Suitability Class		Land Suitability
1	None to Slight	Land in this class has no significant limitations for production of the specified crops (80-100 index points).
2	Slight	Land in this class has slight limitations that may restrict the growth of the specified crops or require modified management practices (60-79 index points).
3	Moderate	Land in this class has moderate limitations that restrict the growth of the specified crops or require special management practices (45-59 index points).
4	Severe	Land in this class has severe limitations that restrict the growth of the specified crops or require special management practices or both. **This class is marginal for sustained production** of the specified crops (30-44 index points).
5	Very Severe	Land in this class has very severe limitations for sustained production of the specified crops. Annual cultivation using common cropping practices is not recommended (20-29 index points).
6	Extremely Severe	Land in this class has extremely severe limitations for sustained production of the specified crops. Annual cultivation is not recommended even on an occasional basis (10-19 index points).
7	Unsuitable	Land in this class is not suitable for the production of the specified crops (0-9 index points).

Source: Adapted from AIWG (1995).

Table 9.4-3 Land Suitability Subclasses for Agricultural Crops

Climate (C)	Soils (S)		Landscape (L)
Temperature (H)	Water holding capacity and texture (M)	Organic surface (O)	Slope (T)
Moisture (A)	Soil structure (D)	Drainage (W)	Landscape pattern (K)
	Organic matter (F)	Organic soil temperature (Z)	Stoniness and coarse fragments (P)
	Depth of topsoil (E)	Rock (R)	Inundation (I)
	Soil reaction (V)	Degree of decomposition or fibre content (B)	
	Salinity (N)	Depth and substrate (G)	
	Sodicity (Y)		

Source: Adapted from AIWG (1995).

9.4.4.2 Soil Suitability for Reclamation

Reclamation suitability ratings were determined for the upper lift and lower lift using the Soil Quality Criteria Relative to Disturbance and Reclamation (Alberta Agriculture, 1987). The ratings (Good, Fair, Poor and Unsuitable) were applied to pre-disturbance data to determine what level of management practices would be required at reclamation for the soils in the LSA. Table 9.4-4 describes the ratings.

Table 9.4-4 Soil Suitability Rating Descriptions for Application in Pre-disturbance Conditions

Rating	Rating Description
Good	No limitation to slight soil limitations that affect use as plant growth medium. No additional soil management will be required for reclamation.
Fair	Moderate soil limitations that affect use as plant growth medium. Some soil management at reclamation may be required.
Poor	Severe soil limitations that affect use as plant growth medium. Careful soil management at reclamation will be required.
Unsuitable	Chemical or physical properties of the soil are so severe that reclamation would not be economically feasible, or in some cases would be impossible.

Source: Adapted from Alberta Agriculture (1987).

Criteria for evaluating the suitability of surface (upper lift) and subsurface (lower lift) soils for reclamation purposes in the Plains Region are listed in Table 9.4-5 and Table 9.4-6.

Table 9.4-5 Reclamation Suitability Criteria for Surface Soil in the Plains Region

Rating/Property	Good	Fair	Poor	Unsuitable
Reaction (pH)	6.5-7.5	5.5-6.4 &7.6-8.4	4.5-5.4 & 8.5-9.0	<3.5 & >9.0
Salinity (EC, dS/m)	<2	2–4	4–8	>8
Sodicity (SAR)	<4	4–8	8–12	>12
Saturation (%)	30–60	20–30 60–80	15–20 80–120	<15 & >120
Stoniness (% Area)	SO, S1	S2	S3, S4	S5
Texture	FSL, VFSL, L, SiL, SL	CL, SCL, SiCL	LS, SiC, C, HC, S	---
Moist Consistency	Very friable, friable	Loose	Firm, very firm	Extremely firm
Organic Carbon	>2	1-2	<1	---
$CaCO_3$ Equivalent (%)	<2	2–20	20–70	>70

Source: Adapted from Alberta Agriculture (1987).

Table 9.4-6 Reclamation Suitability Criteria for Subsurface Soil in the Plains Region

Rating/Property	Good	Fair	Poor	Unsuitable
Reaction (pH)	6.5-7.5	5.5-6.4 & 7.6-8.4	4.5-5.4 & 8.6-9.0	<4.5 & >9.0
Salinity (EC, dS/m)	<3	3–5	5–8	>8
Sodicity (SAR)	<4	4–8	8–12	>12
Saturation (%)	30–60	20–30 60–80	15–20 80–120	<15 & >120
Stone Content (% Vol)	<3	3-25	25-50	>50
Texture	FS, VFSL, L, SiL, SL	CL, SiC, SiCL	S, LS, SiC, C, HC	Bedrock
Moist Consistency	Very friable, friable	Loose, firm	Very firm	Extremely rock

Source: Adapted from Alberta Agriculture (1987).

9.4.4.3 Soil Sensitivity to Acid Deposition

Sensitivity to acidification refers to the degree to which a soil is susceptible to a change in pH, change in base saturation and mobilization of exchangeable bases in response to a given input of acidity (Turchenek and Lindsay, 1982). In mineral soils, properties that influence the sensitivity of a soil to acidic deposition include buffering capacity (measured as CEC), texture, organic matter content, permeability, moisture-holding capacity and drainage (Holowaychuk and Fessenden, 1987).

The soil sensitivity to acidification rating was based on the criteria developed by Holowaychuk and Fessenden (1987). While numerous soil properties contribute to a soil's sensitivity to acidification, that rating system for mineral soils is based on pH and CEC values, as shown in Table 9.4-7. The laboratory analysis of the top 20 cm of the profile was used in the sensitivity rating assessment. For regional soils, soil data from AGRASID 3.0 was used to derive a rating.

Table 9.4-7 Criteria for Rating Sensitivity of Mineral Soils to Acid Deposition

CEC (meq/100 g)	pH	Soil Sensitivity Rating
<6	<4.6	High
	4.6–5.0	High
	5.1–5.5	High
	5.6–6.0	High
	6.1–6.5	High
	>6.5	Low
6 to 15	<4.6	High
	4.6–5.0	Medium
	5.1–5.5	Medium
	5.6–6.0	Medium
	>6.0	Low
>15	<4.6	High
	4.6–5.0	Medium
	5.1–5.5	Medium
	5.6–6.0	Low
	>6.0	Low

Source: Adapted from Holowaychuk and Fessenden (1987).

Critical loads are defined as the sustained level of acidic deposition that does not lead to long-term, harmful changes to the soil (CASA, 1999). Critical loads have been modelled for soils in the Athabasca Oil Sands area (Abboud et al., 2002), but have not been modelled for soils in other areas of Alberta. However, the generic critical load of PAI was determined for each soil series using the CASA (1999) designation of generic critical load associated with the soil sensitivity ratings of high, medium and low (Holowaychuk and Fessenden, 1987). These generic critical loads and their relation to soil sensitivity rating are shown in Table 9.4-8. Soils which were mapped in the RSA as co-dominant units, and which had a dual sensitivity rating, such as low-moderate, were assigned the more stringent critical load. This approach provides a conservative estimate of the area considered at risk of having PAI greater than critical load.

Table 9.4-8 Generic Critical and Monitoring Loads for Mineral Soils of Varying Sensitivity to Acidification in Alberta

Soil Sensitivity Rating	Generic Critical Loads* (keq H^+/ha/y)
High	0.25
Moderate	0.50
Low	1.00

*From CASA, 1999.

The modelled PAI isopleths were compared to the soil critical loads using geographic information systems (GIS). Where PAI exceeded or was equal to the generic critical load, soils were deemed to have potential for acidification.

9.4.4.4 Soil Sensitivity to Wind and Water Erosion

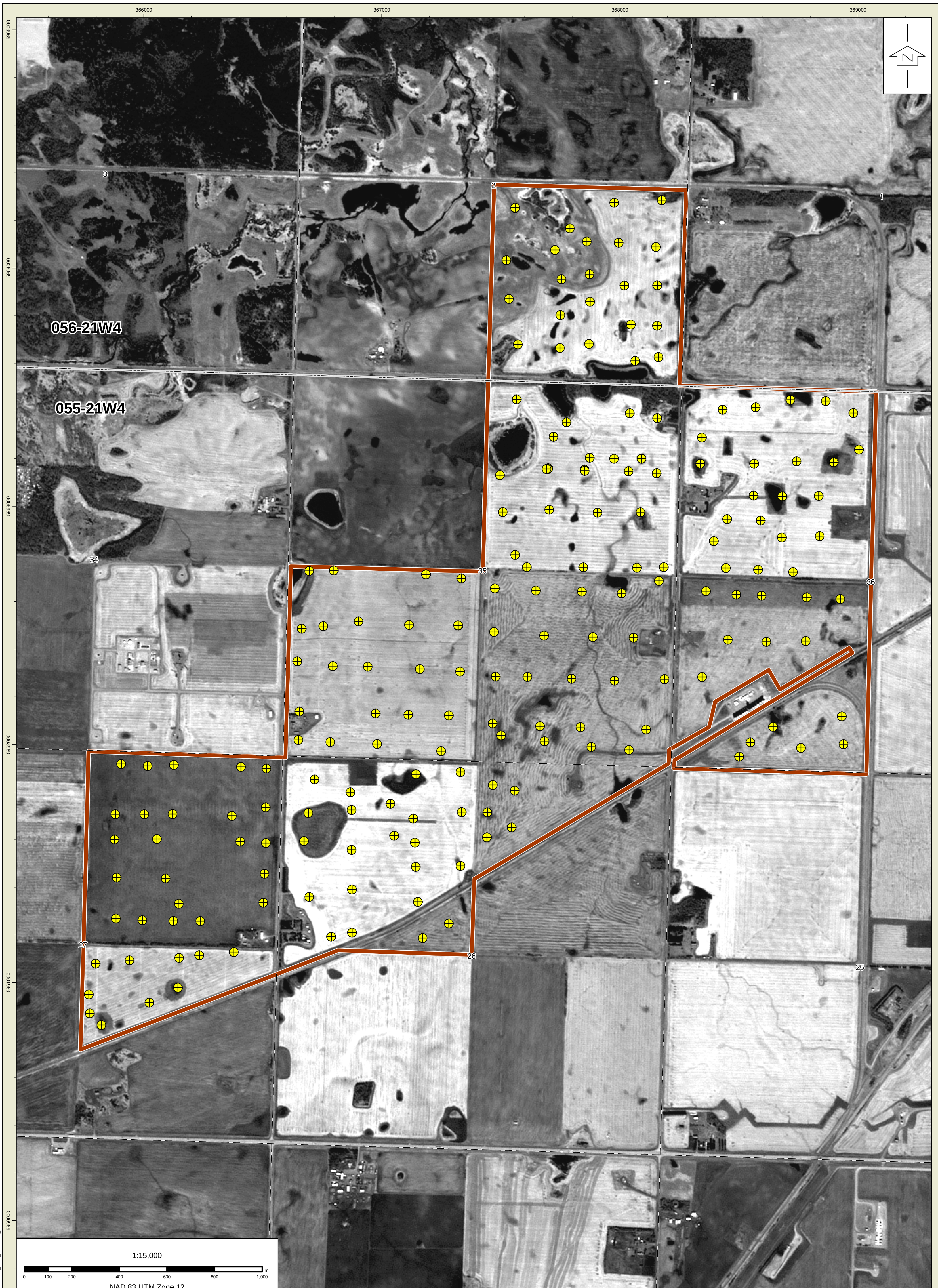
Rating of sensitivity to wind erosion is derived through an equation which accounts for the surface roughness and aggregation, soil resistance to movement, drag velocity of surface wind, soil moisture, shear resistance and available moisture of the soil surface (Coote and Pettapiece, 1989). The resulting ratings are based on soil under agricultural production with no cover. The sensitivity to wind erosion ratings were obtained from the ratings applied to the soil series in Pedocan (1993), as well as polygon information from Coote and Pettapiece (1989).

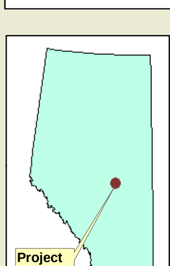
Sensitivity to water erosion is estimated through an equation that accounts for erosivity of rainfall and snowmelt, soil erodibility, slope length and steepness, crop cover and management and conservation practices (Tajek and Coote, 1993). Erosivity for rainfall and snowmelt (R) has been estimated for various parts of the province, including the LSA. Slope length is considered as well as topographical expression, as very long slopes may increase erosion potential of fine-grained material just as steep slopes also increase erosion potential. Soil erodibility (K factor) and the length-slope factor (LS factor) have been estimated for various topographical expressions and slope lengths. The rating system used to evaluate soils is based on the approximate R, K and LS values presented in both Pedocan (1993) and Tajek and Coote (1993) for various soil textures, slopes and length of slopes found in each map unit in the LSA. Fine-textured soils in the silty clay loam to clay loam range have a K factor of approximately 0.021 to 0.042. More sandy soils have a K factor of 0.02. The rating system used for soils in the LSA is shown in Table 9.4-9.

Table 9.4-9 Water Erosion Potential for Soils in the LSA

Water Erosion Potential	Slope Class	Slope Percentage	Slope Length (m)	LS Factor	K Factor
Low	1–3	<5	0–500	0.4-1.4	0.042-0.021
Moderate	4	5–9	50–500	1.5-2.0	0.021-0.026
High	5+	9 +	50–500	2.1-3.5	0.025-0.02

Source: Adapted from Pedocan (1993) and Tajek and Coote (1993).





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- LOCAL STUDY AREA
- SOIL INSPECTION LOCATION
- ALBERTA TOWNSHIP / RANGE
- ATS SECTION LINE

Title:

SOIL INSPECTION AND SAMPLE LOCATIONS

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9.5 Existing Conditions

9.5.1 Surficial Geology

A variety of surficial material deposits were encountered in the LSA. The topography of the LSA is fairly uniform, with undulating surface expression. Slopes are predominantly 2-10%, with the exception of the dunes located in the most northerly quarter section of the LSA (SE 2-56-21 W4M). Slopes of the dunes range from 5% to 15%.

A summary of the surficial material deposits and their geographical extent is listed on Table 9.5-1 and shown on Figure 9.5-1.

Table 9.5-1 Extent of Surficial Geology in the LSA

Geological Unit	Comments	Area (ha)	Proportion of LSA (%)
Glaciolacustrine (GLLC)	These GLLC deposits are the dominant surficial material encountered, and are located throughout the LSA.	343	61.0
Morainal Till (Till)	Till deposits dominate the higher elevations of the LSA. Units are located in NE and SE 27 and NE 26-55-21 W4M.	93	16.6
Glaciofluvial (GLFL)	GLFL deposits were generally localized to NE 35-55-21 W4M, with some inclusions in other units.	61	10.8
Fluvioeolian (FLEO)	The FLEO unit is characterized by dunes and steeper slopes (5-15%) in SE 2-56-21 W4M.	27	4.8
Glaciofluvial/Glaciolacustrine (GLFL/GLLC)	This small unit is located in NE 35-55-21 W4M. The GLFL deposit is generally a sand interval located beneath the topsoil to a maximum depth of 90 cm.	6	1.1
Non-soil	Water, municipal roads, railway tracks and oil and gas wells/access roads.	32	5.7
Total		**562**	**100**

9.5.2 Soils in the LSA

9.5.2.1 Soil Series and Map Units

Twelve soil series were identified during the survey of the LSA, predominantly from soil correlation area SCA 10. Typical descriptions of soil profiles observed in the LSA are provided in Appendix 9D. A summary of the soil series identified and their geographical extent is shown in Table 9.5-2, and a brief description of each series is provided in the following sections.

Table 9.5-2 Geographic Extent of Identified Soil Series in the LSA

Soil Series	Code	Soil Subgroup	Parent Material	Area (ha)	Proportion of LSA (%)
Angus Ridge	AGS	Eluviated Black Chernozem	Till	20	3.6
Beaverhills	BVH	Orthic Black Chernozem	Till	47	8.4
Beaverhills –gl	BVHgl	Gleyed Orthic Black Chernozem	Morainal Till	26	4.6
Cucumber	CCB	Orthic Black Chernozem	Glaciolacustrine	217	38.6
Jarvie-fi	JVEfi	Humic Luvic Gleysol	Glaciolacustrine (fine)	13	2.3
Mundare	MDR	Orthic Black Chernozem	Fluvioeolian	27	4.8
Malmo	MMO	Eluviated Black Chernozem	Glaciolacustrine	95	16.9
Malmo-gl	MMOgl	Gleyed Eluviated Black Chernozem	Glaciolacustrine	13	2.3
Malmo-glxs	MMOglxs	Gleyed Eluviated Black Chernozem	Glaciolacustrine over Glaciofluvial	5	0.9
Peace Hills	PHS	Orthic Black Chernozem	Glaciofluvial	58	10.3
Peace Hills-glxc	PHSglxc	Gleyed Orthic Black Chernozem	Glaciofluvial over Glaciolacustrine	6	1.1
Peace Hills-gr	PHSgr	Orthic Black Chernozem	Glaciofluvial (Gravelly)	3	0.5
Water				13	2.3
Disturbed Areas				19	3.4
Total				**562**	**100**

Series Modifiers: Fine (fi), gleyed (gl), sand within 0-99 cm (xs), gravel (gr), clay within 0-99 cm (xc).

Chernozems

Chernozems are the dominant soil order in the LSA developing on various parent materials covering approximately 517 ha, or 92% of the LSA. Chernozems are soils that typically developed under well- to imperfectly drained grassland ecosystems, resulting in deep topsoil darkened by the accumulation of organic matter. Soil series were determined by the type and texture of parent material. Cucumber (CCB) and Malmo (MMO) soils have developed on fine glaciolacustrine deposits, while Beaverhills (BVH) and Angus Ridge (AGS) soils have developed on till deposits. Mundare (MDR) and Peace Hills (PHS) soils have developed on fluvioeolian (FLEO) and glaciofluvial (GLFL) parent material, respectively. Beaverhills, Cucumber, Peace Hills and Mundare soils do not have an eluviated layer (soil layer which leaches fines down the profile) or illuviated layer (depositional layer for fines), whereas Malmo and Angus ridge have highly developed illuviated layers. Some Malmo and Angus ridge eluviated layers were not evident, but were classified as such due to the strong illuviated horizons.

All of the above soils (except MDR) have imperfectly drained variants in the LSA, which are classified as gleyed phases of the soil series. The gleyed phases often occupy low-lying slope positions, and are mapped as a different map unit if their dominance is 60% or greater.

Gleysols

Gleysolic soils have developed in association with poorly to very poorly drained depressional areas in the LSA, and occur as a dominant (JVEfi1) and significant (MMO2) soil type in many soil map units. These soils are distributed throughout the LSA, covering approximately 13 ha, or

2.3%. The most common Gleysol in the LSA is Jarvie (JVEfi), which is a Humic Luvic Gleysol, developed on fine (fi) glaciolacustrine deposits. While uncommon, some Jarvie soils also developed on glaciolacustrine over glaciofluvial (JVEfixs) and glaciolacustrine over till (JVEfixt).

Map Units

The 15 map units identified in the LSA are shown in Figure 9.5-2. The composition and extent of each map unit are summarized in Table 9.5-3.

Table 9.5-3 Soil Map Unit Composition

Map Symbol	Soil Name	Dominant Soil and Parent Material	Significant Soil and Parent Material	Inclusions	Area (ha)	Proportion of LSA (%)
AGS1	Angus Ridge	Eluviated Black Chernozem on till or glaciolacustrine over till	---	---	20	3.6
BVH1	Beaverhills	Orthic Black Chernozem on till	---	---	2	0.3
BVH2	Beaverhills	Orthic Black Chernozem on till	Various Gleysols on glaciolacustrine or till	---	45	8.1
BVHgl8	Beaverhills-gl	Gleyed Black Chernozem on till	Various Gleysols and rego profiles on till and glaciolacustrine	---	26	4.6
CCB1	Cucumber	Orthic Black Chernozem on glaciolacustrine or glacial lacustrine over till	---	---	217	38.6
JVEfi1	Jarvie-fi	Humic Luvic Gleysol on glaciolacustrine	---	---	13	2.3
MDR2	Mundare	Orthic Black Chernozem on fluvioeolian	Various gleysol on glaciofluvial over glaciolacustrine and Gleyed Black Chernozem on glaciofluvial	---	9	1.6
MDR4	Mundare	Orthic Black Chernozem on fluvioeolian	Rego Black Chernozem and Orthic Regosol on fluvioeolian	---	18	3.2
MMO2	Malmo	Eluviated Black Chernozem on glaciolacustrine	Various Gleysols on glaciolacustrine	---	42	7.5
MMO4	Malmo	Eluviated Black Chernozem on glaciolacustrine	Rego Black Chernozem on glaciolacustrine and various gleyed soils	Gleyed Eluviated Black Chernozem on glaciolacustrine over glaciofluvial or Rego Black Chernozem on glaciolacustrine over glaciofluvial	53	9.4
MMOglxs1	Malmo-glxs	Gleyed Eluviated Black Chernozem on glaciolacustrine over glaciofluvial	---	---	5	0.9
MMOgl1	Malmo-gl	Gleyed Eluviated Black Chernozem on glaciolacustrine	---	---	13	2.3
PHS8	Peace Hills	Orthic Black Chernozem on glaciofluvial	Gleyed Rego Black Chernozem on glaciofluvial and various Gleysols	---	58	10.3
PHSglxc1	Peace Hills-glxc	Orthic Black Chernozem on glaciofluvial over glaciolacustrine	---	---	6	1.1
PHSgr1	Peace Hills-gr	Rego Black Chernozem on glaciofluvial	---	---	3	0.5
Water					13	2.3
Disturbed Areas					19	3.4
Total					**562**	**100**

Series Modifiers: Fine (fi), gleyed (gl), sand within 0-99 cm (xs), gravel (gr), clay within 0-99 cm (xc).

9.5.3 Soils in the RSA

The mapping for soils in AGRASID 3.0 is developed at a scale of 1:100,000, suitable for regional level assessments. Therefore, some of the specific soil series identified over small areas on the LSA do not appear in the larger scale used to map the RSA. Soil series that are mapped in AGRASID 3.0 in the RSA are shown in Table 9.5-4.

Table 9.5-4 Soil Series of the RSA

Soil Series	Abbreviation	Soil Series	Abbreviation	Soil Series	Abbreviation
Angus Ridge	AGS	Manatokan aa	MNTaa	Rolly View	RLV
Camrose	CMO	Maywood	MYW	Uncas	UCS
Cooking Lake	COA	Mico	MCO	Ukalta	UKT
Duagh	DUG	Millwoods	MLS	Wetaskiwin	WKN
Elk Point	ELP	Miquelon	MIQ	Winterburn	WTB
Ferintosh	FTH	Mundare	MDR	Miscellaneous Coarse	ZCO
Gabriel	GBL	Navarre	NVR	Miscellaneous Gleysol	ZGL
Hobbema	HBM	Peace Hills	PHS	Miscellaneous Gleysol	ZGW
Kavanagh	KVG	Ponoka	POK	Miscellaneous Organics	ZOR
Kawood	KWO	Primula	PRM	Miscellaneous Undifferentiated	ZUN
Looma	LOM	Red Water	RDW	Miscellaneous Water	ZWA
Malmo	MMO	Rimbey	RMY		

The soil map units in AGRASID 3.0 are presented as either singly dominant, as represented by the soil series code of three letters (e.g., MDR1), or co-dominant. Co-dominant soils are represented by a combination of the first two letters of the soil series abbreviation for each soil. For instance, an AGLO designation indicates that Angus Ridge and Looma soils are co-dominant in the mapped area, and cannot be separated at the scale of mapping. The soil map units found in the RSA, and their areal extents, are summarized in Table 9.5-5. The total area of the RSA is 243,830 hectares. Approximately 38% of the RSA is currently disturbed land, including the City of Edmonton. Open water and miscellaneous water accounts for 6,695 ha of the RSA, or approximately 3%. Therefore, approximately 59%, or 144,537 ha, of the RSA is considered soil. Soils mapped in the RSA are shown on Figure 9.5-3.

Table 9.5-5 Soil Map Units of the RSA

Soil Map Unit	Area (ha)	Soil Map Unit	Area (ha)	Soil Map Unit	Area (ha)
BASE DISTURBANCE	92,599	LOM6	67	PHRD	635
AGLO	134	LOM9	530	PHS1	1,985
AGMM	1,036	LOMC	4,228	PHS2	125
AGRL	3,579	LOML	1,488	PHS5	637
AGS1	3,778	LOMM	1,218	POK1	803
AGS2	16,762	LORL	319	POK2	1,115
AGS5	129	LOUC	811	POK7	378
AGS7	760	MCML	585	POWT	16
CMMD	47	MCRL	745	PRM1	421
CMO1	1,781	MCUC	210	PRM2	102
CMO2	144	MDPH	783	PRZO	4,665
COA1	17,587	MDR1	2,756	RLUC	2,010
COA2	203	MDR2	2,633	RLV1	11
COMI	486	MDR4	1,557	RLV2	2,223
COUC	16,925	MDUK	15	RMUC	541

Soil Map Unit	Area (ha)	Soil Map Unit	Area (ha)	Soil Map Unit	Area (ha)
COZC	213	MLMY	333	UCS1	7,998
DUG1	1,120	MMNV	1,042	UKT5	540
DUWK	663	MMO1	6,073	WTB1	20
ELGB	200	MMO2	5,206	WTB6	321
FTPO	143	MMO6	1,136	ZGW2	229
HBM1	1,486	MMO7	22	ZGZO	190
HBPO	3,393	MMO9	1,836	ZGZU	83
KVG1	2	MMWK	1,157	ZUN1	2,389
KVG8	1,427	MNaaPR	1,576	ZUN2	799
KVPH	2,780	NVR1	1,487	ZUZW	1,458
KWML	160	NVR2	387	ZWA1	37
KWUC	1,152	OPEN WATER	6,658		
LOM2	537	PHPR	17		

9.5.4 Soil Map Unit Evaluations

9.5.4.1 Land Suitability for Agriculture Crops

The land suitability ratings for agricultural crops are presented in Table 9.5-6 and Figure 9.5-4. The majority of map units in the LSA were rated as Class 3 soils (moderate limitations) for agricultural crops covering approximately 487 ha, or 86.6%, of the LSA. Limitations to productivity of Class 3 soils in the LSA are primarily associated with temperature, slope, drainage or water-holding capacity.

Approximately 43 ha, or 7.7%, of the LSA is rated as Class 4 soil (severe limitations) for agricultural crops. These map units typically are sandy loam to sand profiles with steeper, shorter slopes, or are Gleysol units. Resulting limitations to production include slope, water-holding capacity and drainage.

Table 9.5-6 Land Suitability Ratings in the LSA by Soil Map Unit

Map Unit	Suitability for Agricultural Crops	Subclass Limitations	Area (ha)	Proportion of LSA (%)
AGS1	3H	Temperature	20	3.6
BVH1	3HT	Temperature, slope	2	0.3
BVH2	3HT	Temperature, slope	45	8.1
BVHgl8	3HW	Temperature, drainage	26	4.6
CCB1	3H	Temperature	217	38.6
JVEFI1	4W	Drainage	13	2.3
MDR2	4M	Water holding capacity/texture	9	1.6
MDR4	4TM	Slope and water holding capacity/texture	18	3.2
MMO2	3HT	Temperature, slope	42	7.5
MMO4	3H	Temperature	53	9.4
MMOgl1	3H	Temperature	13	2.3
MMOglxs1	3HW	Temperature, drainage	5	0.9
PHS8	3HM	Temperature, water holding capacity/texture	58	10.3
PHSglxc	3HW	Temperature, drainage	6	1.1
PHSgr	4TM	Slope, water holding capacity/texture	3	0.5
Water			13	2.3
Disturbed Land			19	3.4
Total			**562**	**100**

Series Modifiers: Fine (fi), gleyed (gl), sand within 0-99 cm (xs), gravel (gr), clay within 0-99 cm (xc).

9.5.4.2 Soil Suitability for Reclamation

Reclamation suitability ratings for topsoil and subsoil materials were determined for each soil series in the LSA (Alberta Agriculture, 1987). Soil suitability for reclamation ratings are presented in Table 9.5-7.

Table 9.5-7 Reclamation Suitability of Mineral Soils in the LSA

Soil Series	Code	Topsoil Reclamation Suitability	Limitations	Subsoil Reclamation Suitability	Limitations
Angus Ridge	AGS	Fair	Texture, pH, saturation (%)	Poor	Texture
Beaverhills	BVH	Fair	Stoniness or saturation (%)	Poor	Consistency or stoniness
Beaverhills-gl	BVHgl	Poor	Stoniness	Poor	Consistency, stoniness
Cucumber	CCB	Good	---	Fair	pH, texture
Jarvie-fi	JVEfi	Fair	Saturation (%),pH	Poor	Consistency, texture, TOC
Mundare	MDR	Poor	TOC, texture	Poor	Texture
Malmo	MMO	Fair-Poor	Saturation (%), pH	Poor	Consistency, texture
Malmo-gl	MMOgl	Fair	TOC, pH	Poor	Texture
Malmo-glxs	MMOglxs	Good	---	Poor	Texture
Peace Hills	PHS	Poor	TOC, texture	Poor	Texture
Peace Hills-glxc	PHSglxc	Fair	Electrical conductivity	Poor	Electrical conductivity
Peace Hills-gr	PHSgr	Fair	pH	Poor	Texture

Series Modifiers: Fine (fi), gleyed (gl), sand within 0-99 cm (xs), gravel (gr), clay within 0-99 cm (xc).

Reclamation suitability maps are presented in Figures 9.5-5 and 9.5-6. Reclamation suitability ratings calculated for each mineral soil map unit in the LSA are presented in Table 9.5-8.

Soils rated “good” for topsoil included the Cucumber and Malmo-glxs series, indicating that 223 ha of soils (39.7% of the LSA) have no topsoil limitations for use as a plant growth medium (Table 9.5-8). No additional management will be required for these soils at reclamation. A “fair” rating of suitability for reclamation of the surface lift was assigned to six of the soil series, indicating that 127 ha of soils, or 22.6% of the LSA, may require some additional soil management at reclamation; the most common limitations were pH and saturation percent. One soil, Malmo, was rated “fair” to “poor,” with the same limitations as above (pH and saturation percent), covering 96 ha or 17% of the LSA. A poor rating was assigned to Peace Hills, Mundare and Gleyed Beaverhills, accounting for 84 ha of soil, or 15% of the LSA. Limitations for these soils included TOC, texture and stoniness.

One soil series had salinity as a limiting factor. Peace Hills-glxc was rated as “fair” and “poor” for electrical conductivity in both topsoil and subsoil, respectively. Peace Hills-glxc is a small map unit comprising only 1%, or 6 ha, of the LSA.

Subsurface reclamation suitability ranged from “fair” to “poor.” In general, very fine or coarse soil texture and consistency were the most limiting soil properties for reclamation of mineral subsoils.

Table 9.5-8 Reclamation Suitability Ratings of Soil Map Units in the LSA

Map Unit	Surface Reclamation Suitability	Subsurface Reclamation Suitability	Area (ha)	Proportion of LSA (%)
AGS1	Fair	Poor	20	3.6
BVH1	Fair	Poor	2	0.3
BVH2	Fair	Poor	45	8.1
BVHgl8	Fair	Poor	26	4.6
CCB1	Good	Fair	217	38.6
JVEfi1	Fair	Poor	13	2.3
MDR2	Poor	Poor	9	1.6
MDR4	Poor	Poor	18	3.2
MMO2	Fair-Poor	Poor	42	7.5
MMO4	Fair-Poor	Poor	53	9.4
MMOgl1	Fair	Poor	13	2.3
MMOglxs1	Good	Poor	5	0.9
PHS8	Poor	Poor	58	10.3
PHSglxc1	Fair	Poor	6	1.1
PHSgr1	Fair	Poor	3	0.5
Water			13	2.3
Disturbed Land			19	3.4
Total			**562**	**100**

Series Modifiers: Fine (fi), gleyed (gl), sand within 0-99 cm (xs), gravel (gr), clay within 0-99 cm (xc).

The reclamation suitability classes within the LSA are presented in Table 9.5-9.

Table 9.5-9 Extent of Reclamation Suitability Classes in the LSA

Reclamation Suitability Rating	Topsoil Rating		Subsoil Rating	
	Area (ha)	Proportion of LSA (%)	Area (ha)	Proportion of LSA (%)
Good	222	39.5	---	--
Fair	128	22.8	217	38.6
Fair to Poor	95	16.9	---	--
Poor	85	15.1	313	55.7
Water	13	2.3	13	2.3
Disturbed Land	19	3.4	19	3.4
Total	**562**	**100**	**562**	**100**

9.5.4.3 Sensitivity to Acidification

Sensitivity to acidification is assessed on a regional scale, since air emissions are modelled on a regional scale. Ratings were assigned to map units in the RSA based on the rating assigned to each of the co-dominant soil series, or the dominant soil series if mapped alone. Whereas a co-dominant soil had similar ratings for each soil, only one rating is recorded. However, where a co-dominant soil map unit had two different ratings, both are shown. The sensitivity of each soil map unit to acid deposition is presented in Table 9.5-10.

Table 9.5-10 Sensitivity of Soils in the RSA to Acid Deposition, by Series

Soil Series	Estimated Sensitivity to Acidification		Soil Series	Estimated Sensitivity to Acidification	
	Rating	Critical Load (kmol H^+/ha/y)		Rating	Critical Load (kmol H^+/ha/y)
Angus Ridge	Low	1.0	Mundare	Medium	0.5
Camrose	Low	1.0	Navarre	Low	1.0
Cooking Lake	Low	1.0	Peace Hills	Low	1.0
Duagh	Low	1.0	Primula	High	0.25
Elk Point	Medium	0.5	Ponoka	Low	1.0
Ferintosh	Low	1.0	Redwater	Low	1.0
Gabriel	Low	1.0	Rimbey	Low	1.0
Hobbema	Low	1.0	Rolly View	Low	1.0
Kavanagh	Medium	0.5	Ukalta	Low	1.0
Kawood	Medium	0.5	Uncas	Low	1.0
Looma	Low	1.0	Wetaskwin	Low	1.0
Malmo	Low	1.0	Winterburn	Low	1.0
Manatokan	Medium	0.5	Miscellaneous Gleysols	Low	1.0
Maywood	Medium	0.5	Miscellaneous Organics	Medium	0.5
Miquelon	Medium	0.5	Miscellaneous Undifferentiated	Low	1.0
Mico	Medium	0.5	Miscellaneous Water	Not Applicable	0.0
Millwoods	Low	1.0			

A summary of sensitivity ratings for each map unit in the RSA is shown in Table 9.5-11. Soil sensitivity to acidification in the RSA is presented on Figure 9.5-7.

Table 9.5-11 Acidification Sensitivity of Soil Map Units in the RSA

Soil Map Unit	Acid Sensitivity Rating	Soil Map Unit	Acid Sensitivity Rating	Soil Map Unit	Acid Sensitivity Rating
BASE DISTURBANCE	Not Applicable	LOM6	L	PHRD	L
AGLO	Low (L)	LOM9	L	PHS1	L
AGMM	L	LOMC	L-M	PHS2	L
AGRL	L	LOML	L	PHS5	L
AGS1	L	LOMM	L	POK1	L
AGS2	L	LORL	L	POK2	L
AGS5	L	LOUC	L	POK7	L
AGS7	L	MCML	L-M	POWT	L
CMMD	Low-Medium (L-M)	MCRL	L-M	PRM1	H
CMO1	L	MCUC	L-M	PRM2	H
CMO2	L	MDPH	L-M	PRZO	M-H
COA1	L	MDR1	M	RLUC	L
COA2	L	MDR2	M	RLV1	L
COMI	L-M	MDR4	M	RLV2	L
COUC	L	MDUK	L-M	RMUC	L
COZC	L	MLMY	L-M	UCS1	L
DUG1	L	MMNV	L	UKT5	L
DUWK	L	MMO1	L	WTB1	L

Soil Map Unit	Acid Sensitivity Rating	Soil Map Unit	Acid Sensitivity Rating	Soil Map Unit	Acid Sensitivity Rating
ELGB	L-M	MMO2	L	WTB6	L
FTPO	L	MMO6	L	ZGW2	L
HBM1	L	MMO7	L	ZGZO	L-M
HBPO	L	MMO9	L	ZGZU	L
KVG1	M	MMWK	L	ZUN1	L
KVG8	M	MNaaPR	Medium-High (M-H)	ZUN2	L
KVPH	L-M	NVR1	L	ZUZW	L
KWML	L-M	NVR2	L	ZWA1	Not Applicable
KWUC	L-M	OPEN WATER	Not Applicable		
LOM2	L	PHPR	L-H		

The area and percentage of the RSA occupied by soils of various acidification sensitivity ratings are shown in Table 9.5-12.

Table 9.5-12 Extent of Acidification Sensitivity of Soils in the RSA

Acidification Sensitivity Rating	Area (ha)	Proportion of RSA (%)
Low	117,466	48
Low-Medium	11,914	5
Medium	8,375	3
Low-High	17	0
Medium-High	6,241	3
High	523	0
Water	6,695	3
Disturbed Lands	92,599	38
Total	**243,830**	**100**

9.5.4.4 Erosion risk

Soil erosion risk ratings for wind and water were assigned and mapped by soil series, with reference to the topographical expression and soil texture of the mapped soils. These are shown in Table 9.5-13. The risk of erosion is interpreted to increase with increasing slope (water) and exposure of soil faces (wind and water).

Table 9.5-13 Risk of Soils to Wind and Water Erosion

Soil Series	Risk to Water Erosion	Risk to Wind Erosion
Angus Ridge	Moderate	Low
Beaverhills	Moderate	Low
Beaverhills-gl	Moderate	Low
Cucumber	Moderate	Low
Jarvie-fi	Moderate	Low
Mundare	Low, increasing with slope steepness to high at slopes greater than 9%	High
Malmo	Moderate	Low
Malmo-gl	Low	Low
Malmo-glxs	Low	Low
Peace Hills	Moderate	High
Peace Hills-glxc	Low	High
Peace Hills-gr	Moderate	High

Series Modifiers: Fine (fi), gleyed (gl), sand within 0-99 cm (xs), gravel (gr), clay within 0-99 cm (xc).

Erosion potential ratings were assigned to map units based on the rating assigned to the dominant soil series in the map unit. Wind erosion potential is presented in Figure 9.5-8. Water erosion potential is presented in Figure 9.5-9. A summary of wind and water erosion risk ratings calculated for each map unit in the LSA are shown in Tables 9.5-14 and 9.5-15, respectively.

Table 9.5-14 Risk of Wind Erosion of Soil Map Units in the LSA

Map Unit	Wind Erosion Risk	Area (ha)	Proportion of LSA (%)
AGS1	Low	20	3.6
BVH1	Low	2	0.3
BVH2	Low	45	8.1
BVHgl8	Low	26	4.6
CCB1	Low	217	38.6
JVEfi1	Low	13	2.3
MDR2	High	9	1.6
MDR4	High	18	3.2
MMO2	Low	42	7.5
MMO4	Low	53	9.4
MMOgl1	Low	13	2.3
MMOglxs1	Low	5	0.9
PHS8	High	58	10.3
PHSglxc1	Moderate	6	1.1
PHSgr1	High	3	0.5
Water		13	2.3
Disturbed Lands		19	3.4
Total		**562**	**100**

Series Modifiers: Fine (fi), gleyed (gl), sand within 0-99 cm (xs), gravel (gr), clay within 0-99 cm (xc).

Table 9.5-15 Risk of Water Erosion of Soil Map Units and Topographical Relief in the LSA

Map Unit	Topographical Class	Water Erosion Risk	Area (ha)	Proportion of LSA (%)
AGS1	4	Moderate	20	3.6
BVH1	4	Moderate	2	0.3
BVH2	4	Moderate	45	8.1
BVHgl8	4	Moderate	26	4.6
CCB1	4	Moderate	217	38.6
JVEfi1	1-3	Low	13	2.3
MDR2	1-3	Low	9	1.6
MDR4	5+	High	18	3.2
MMO2	4	Moderate	42	7.5
MMO4	4	Moderate	53	9.4
MMOgl1	3	Low	13	2.3
MMOglxs1	1-3	Low	5	0.9
PHS8	4	Moderate	58	10.3
PHSglxc1	1-3	Low	6	1.1
PHSgr1	1-3	Low	3	0.5
Water			13	2.3
Disturbed Lands			19	3.4
Total			**562**	**100**

Series Modifiers: Fine (fi), gleyed (gl), sand within 0-99 cm (xs), gravel (gr), clay within 0-99 cm (xc).

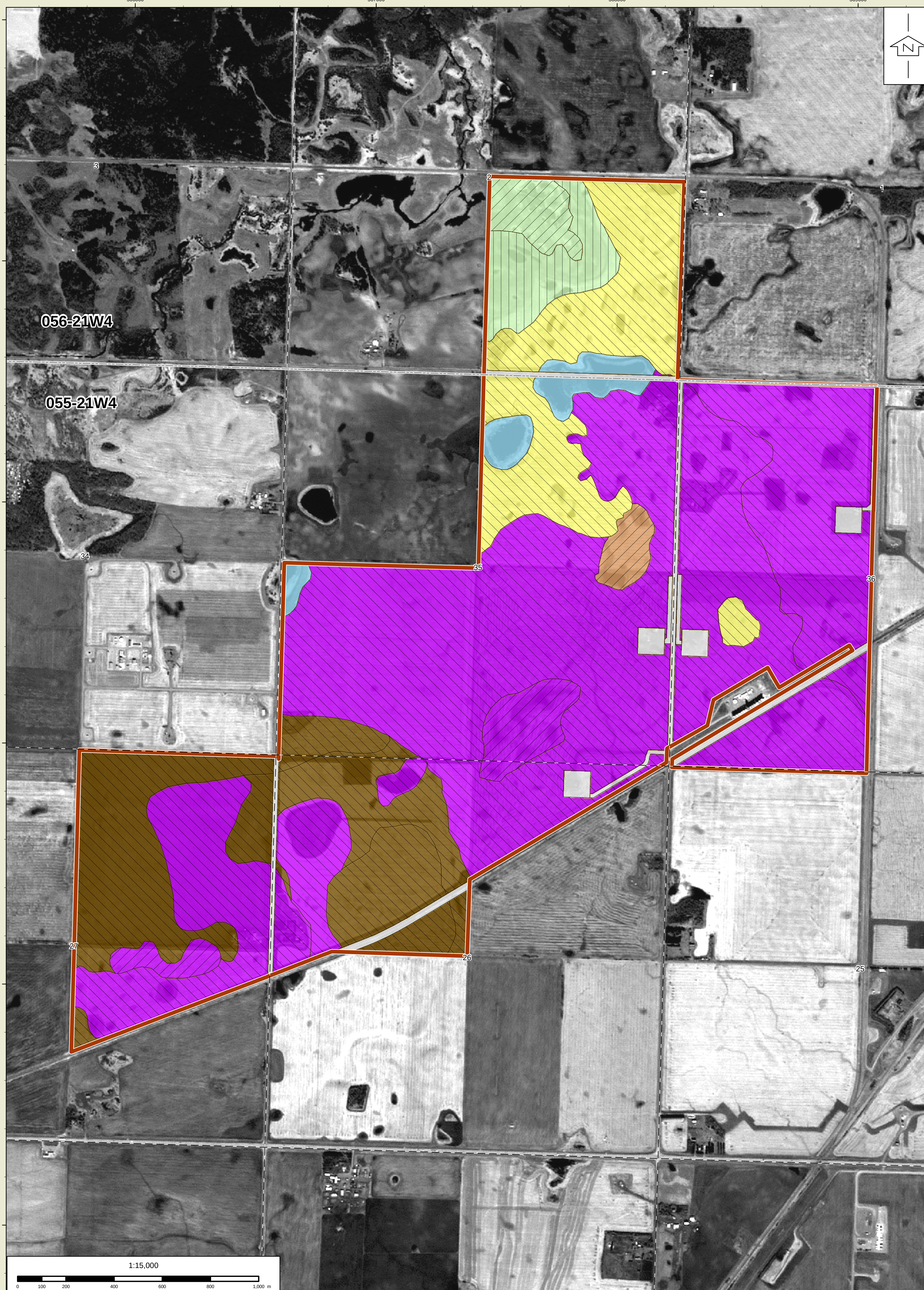
Generally, the loamy to clay soil textures present in the majority of soils in the LSA contribute to an estimation of relatively low wind erosion potential. The Peace Hills and Mundare soils have high sand content and are at a high risk of wind erosion.

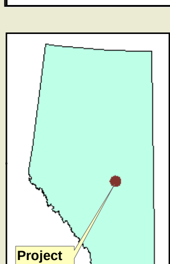
Gleysolic and gleyed soils are generally found in depressional positions and, due to poor drainage, are less susceptible to wind and water erosion unless they are dry, have exposed faces or are excavated.

In all cases, slope gradient affects the potential for water erosion. Most of the soils found in the LSA are undulating terrain with gentle to moderate slopes, resulting in low to moderate risk to water erosion. The Mundare4 in the SE 2-56-21 W4M is the only soil unit with steep slopes and, therefore, high water erosion potential. The areal extent of erosion risk rating for soils in the LSA is shown in Table 9.5-16.

Table 9.5-16 Summary of Erosion Ratings for Soils in the LSA

Water Erosion Rating	Area (ha)	Proportion of LSA (%)	Wind Erosion Rating	Area (ha)	Proportion of LSA (%)
Low	49	8.7	Low	436	77.6
Moderate	463	82.4	Moderate	6	1.0
High	18	3.2	High	88	15.7
Water	13	2.3	Water	13	2.3
Disturbed Lands	19	3.4	Disturbed Lands	19	3.4
Total	**562**	**100**	**Total**	**562**	**100**





Legend

- LOCAL STUDY AREA
- DISTURBED LAND
- WATER
- ALBERTA TOWNSHI/RANGE
- ATS SECTION LINE

Surficial Material

- FLEO
- GLFL
- GLFL/GLLC
- GLLC
- TILL

Topographic Classes

LEVEL TO NEARLY LEVEL	1-2
GENTLY UNDULATING	2-3
UNDULATING	3-4
MODERATE TO STRONG SLOPES	4-6

Title:

SURFICIAL MATERIALS AND TOPOGRAPHIC CLASSES

NORTH AMERICAN OIL SANDS CORPORATION

Approved: BE	Revision Date: Oct.15, 2007
File: FIGURE_9.5-1_SURF_MATS_AND TOPO _CLASSES_IN_LSA.mxd	

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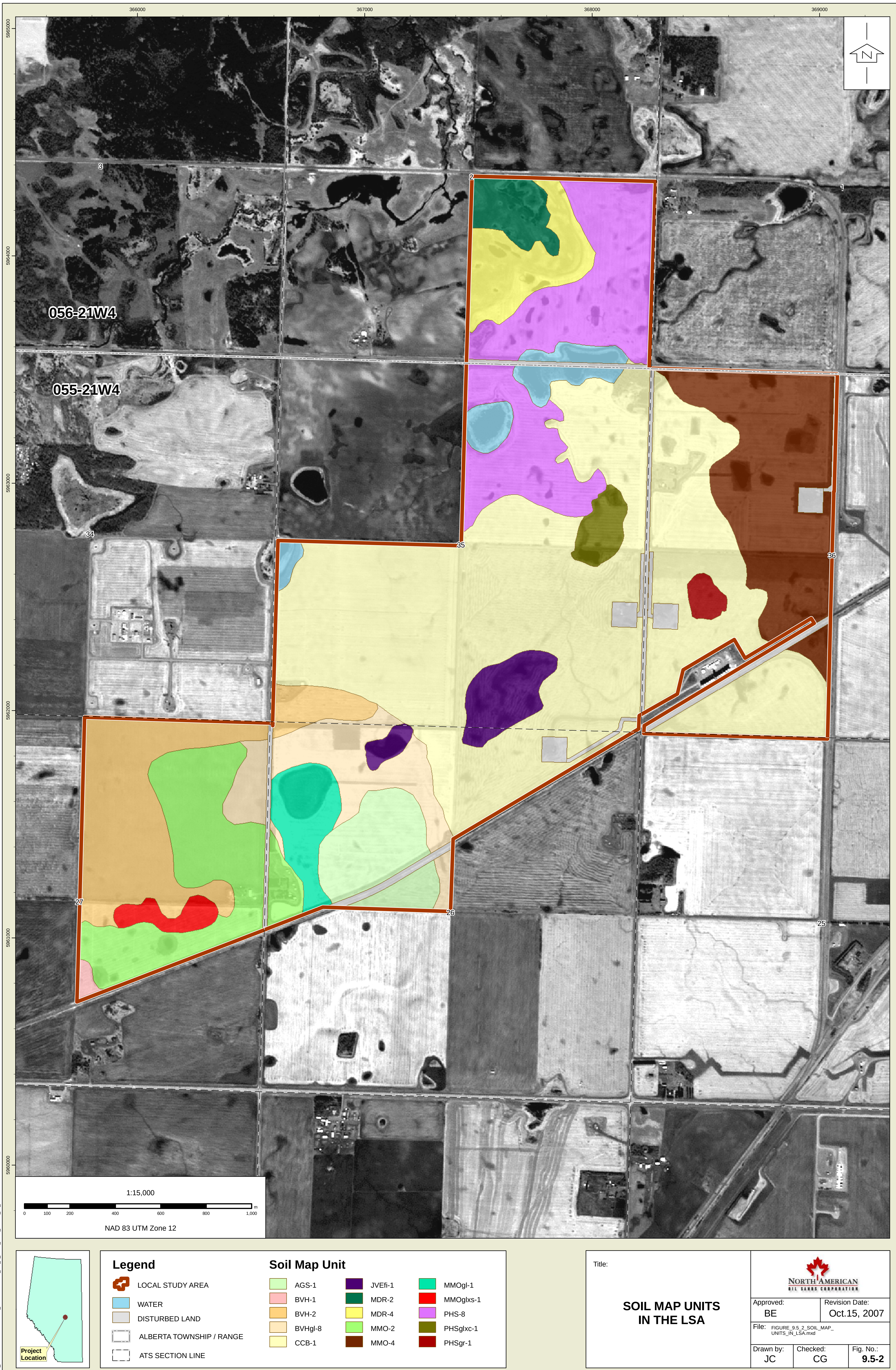

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Project Location
Legend
LOCAL STUDY AREA
WATER
DISTURBED LAND
ALBERTA TOWNSHIP / RANGE
ATS SECTION LINE
Soil Map Unit
AGS-1
BVH-1
BVH-2
BVHgl-8
CCB-1
JVEfi-1
MDR-2
MDR-4
MMO-2
MMO-4
MMOgl-1
MMOglxs-1
PHS-8
PHSglxc-1
PHSgr-1
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SOIL MAP UNITS IN THE LSA
Approved: BE
Revision Date: Oct.15, 2007
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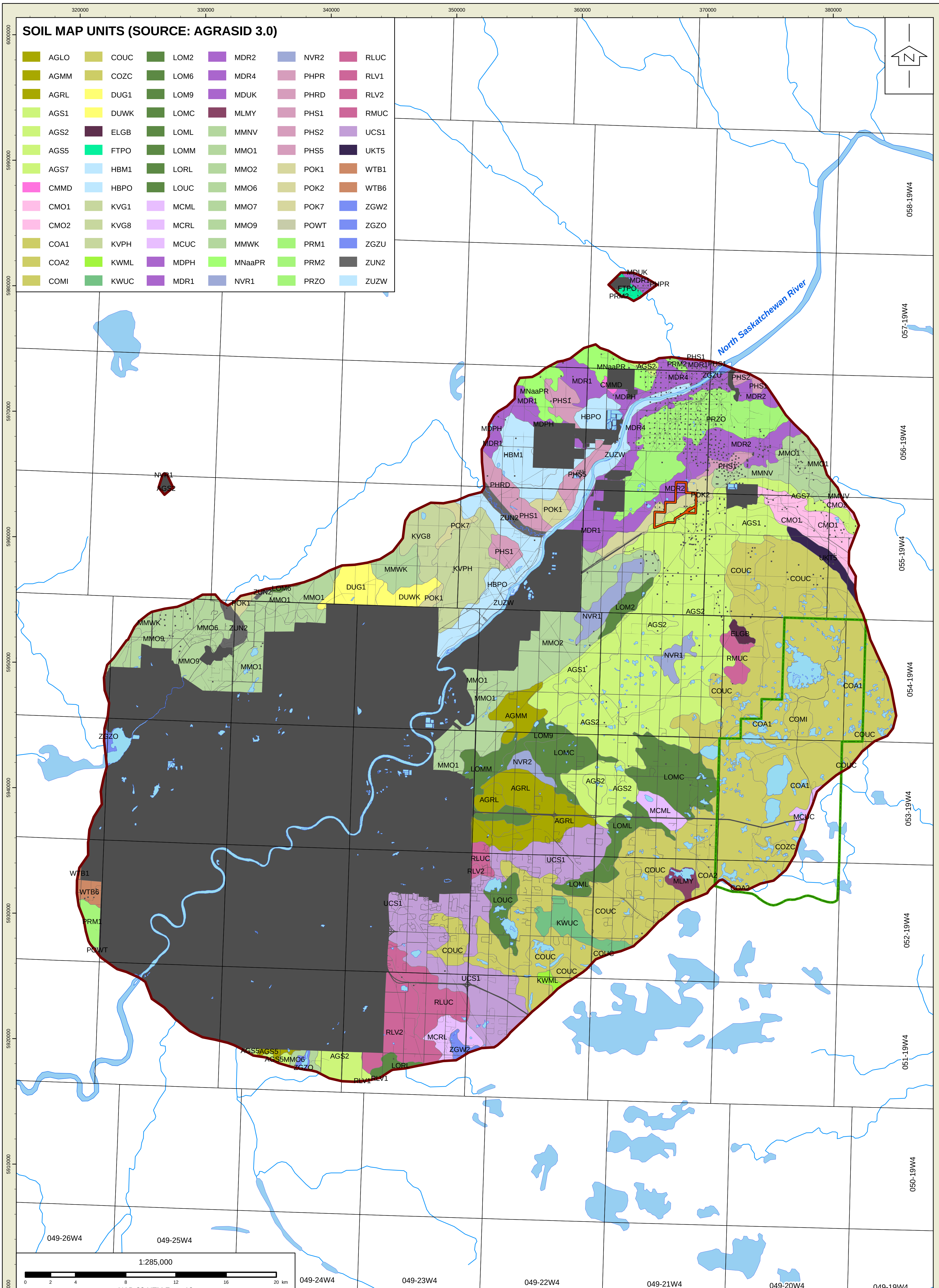

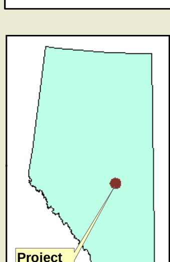

Legend

- NORTH AMERICAN UPGRADER RSA
- NORTH AMERICAN UPGRADER LSA
- ELK ISLAND NATIONAL PARK
- ALBERTA TOWNSHIP/RANGE
- BASELINE DISTURBANCE
- WATERBODY
- RIVER/STREAM

Title:

SOIL SERIES IN THE RSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:	
BE	Oct.15, 2007	
File: FIGURE_9.5_3_RSA_SMU_TABLOID.mxd		
Drawn by: JC	Checked: BM	Fig. No.: 9.5-3

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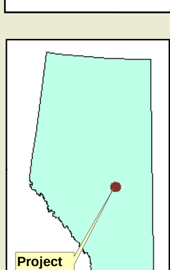

Legend

- LOCAL STUDY AREA
- WATER
- DISTURBED LAND
- ALBERTA TOWNSHIP/RANGE
- ATS SECTION LINE

Land Capability

- CLASS 3 MODERATE LIMITATIONS TO PLANT GROWTH
- CLASS 4 SEVERE LIMITATIONS TO PLANT GROWTH

Title:

LAND SUITABILITY FOR AGRICULTURAL CROPS

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
BE	Oct.15, 2007

File: FIGURE_9.5-4_LAND_CAPABILITY_IN_LSA.mxd

Drawn by:	Checked:	Fig. No.:
JC	CG	9.5-4

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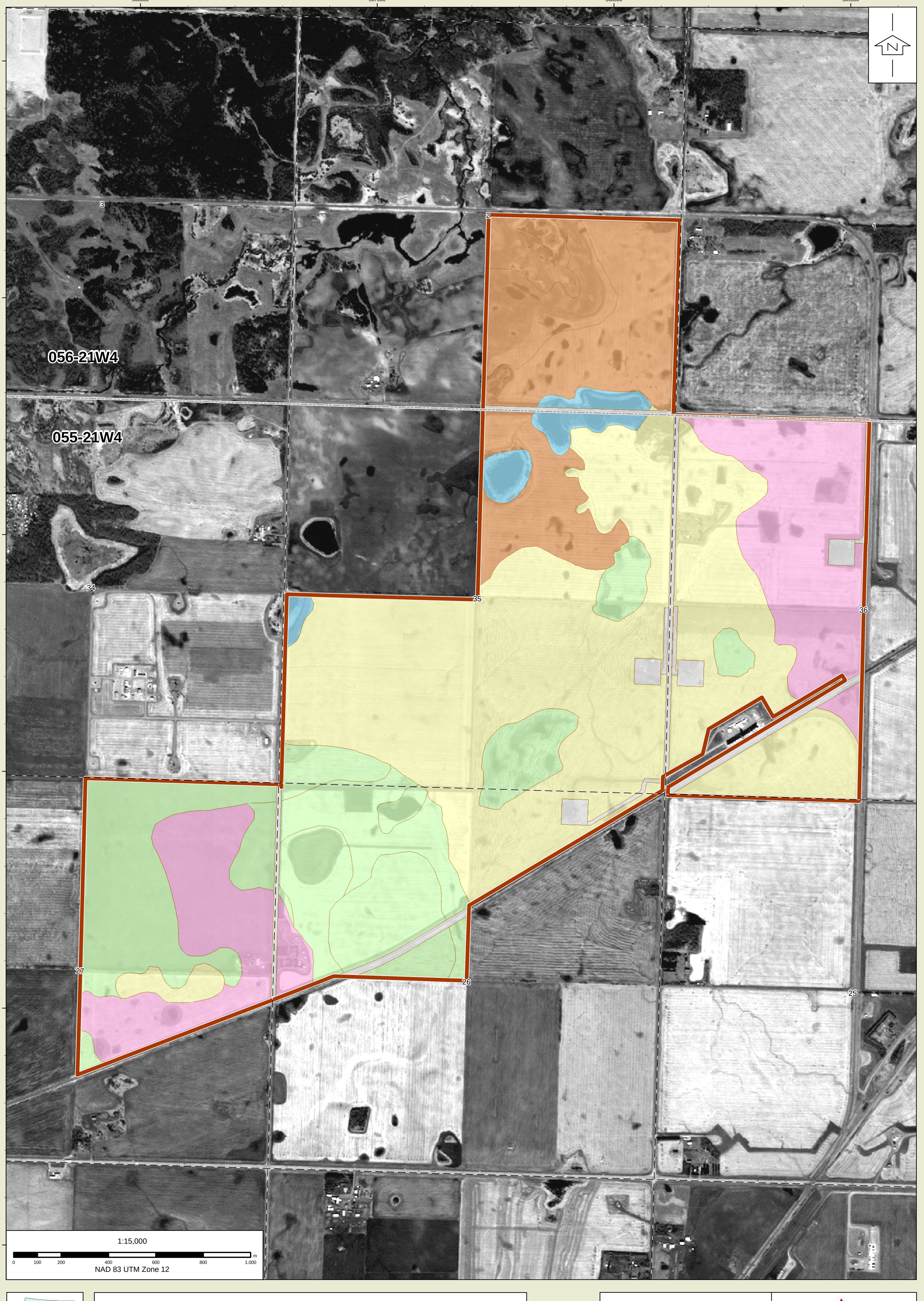

Project Location

Legend

LOCAL STUDY AREA
ALBERTA TOWNSHIP / RANGE
ATS SECTION LINE

Topsoil Suitability for Reclamation

WATER
DISTURBED LAND
GOOD
FAIR
FAIR - POOR
POOR

Title:

TOPSOIL SUITABILITY FOR RECLAMATION

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
BE	Oct.19, 2007

File: FIGURE_9.5_5_TOPSOIL_SUITABILITY_FOR_RECLAMATION_IN_LSA.mxd

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JC	CG	9.5-5

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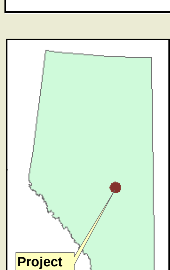

Legend

- LOCAL STUDY AREA
- ALBERTA TOWNSHIP / RANGE
- ATS SECTION LINE
- WATER
- DISTURBED LAND

Subsoil Suitability for Reclamation

- FAIR
- POOR

Title:

SUBSOIL SUITABILITY FOR RECLAMATION

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
BE	Oct. 19, 2007

File: FIGURE_9.5-6_SUBSOIL_SUITABILITY_FOR_RECLAMATION_IN_LSA.mxd

Drawn by:	Checked:	Fig. No.:
JC	CG	9.5-6

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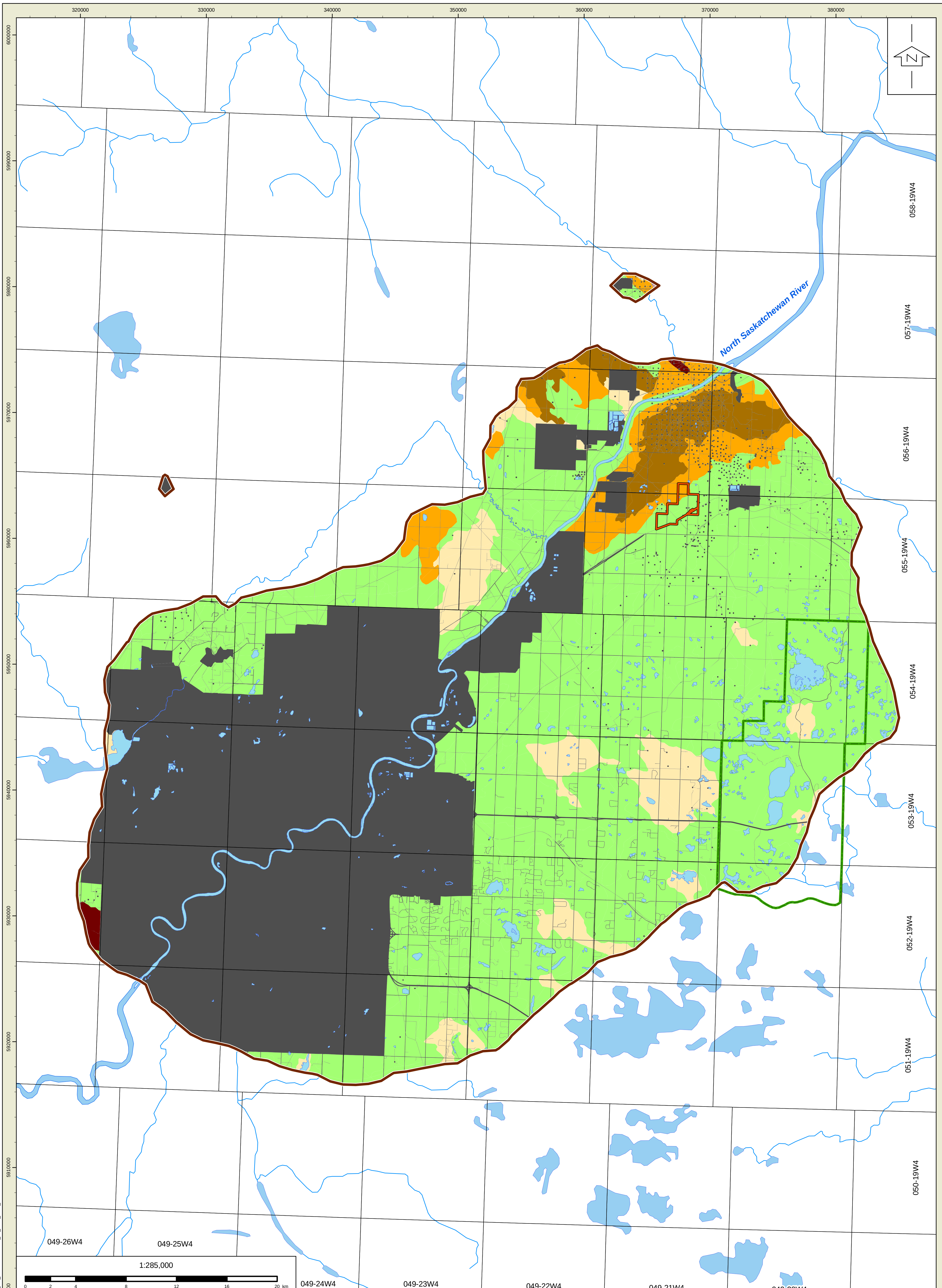

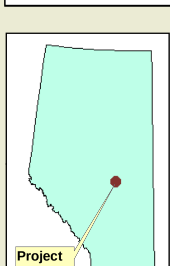

Legend

- NORTH AMERICAN UPGRADER RSA
- NORTH AMERICAN UPGRADER LSA
- ELK ISLAND NATIONAL PARK
- ALBERTA TOWNSHIP/RANGE
- BASELINE DISTURBANCE
- WATERBODY
- RIVER/STREAM

SOIL SENSITIVITY TO ACIDIFICATION

- HIGH
- MEDIUM-HIGH
- LOW-HIGH
- MEDIUM
- LOW-MEDIUM
- LOW

Title:

SOILS SENSITIVITY TO ACIDIFICATION IN THE RSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: BE	Revision Date: Oct.15, 2007

File: FIGURE_9.5_7_SOILS_SENS_TO_ACIDIFICATION_IN_THE_RSA_TABLOID.mxd

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JC	BM	9.5-7

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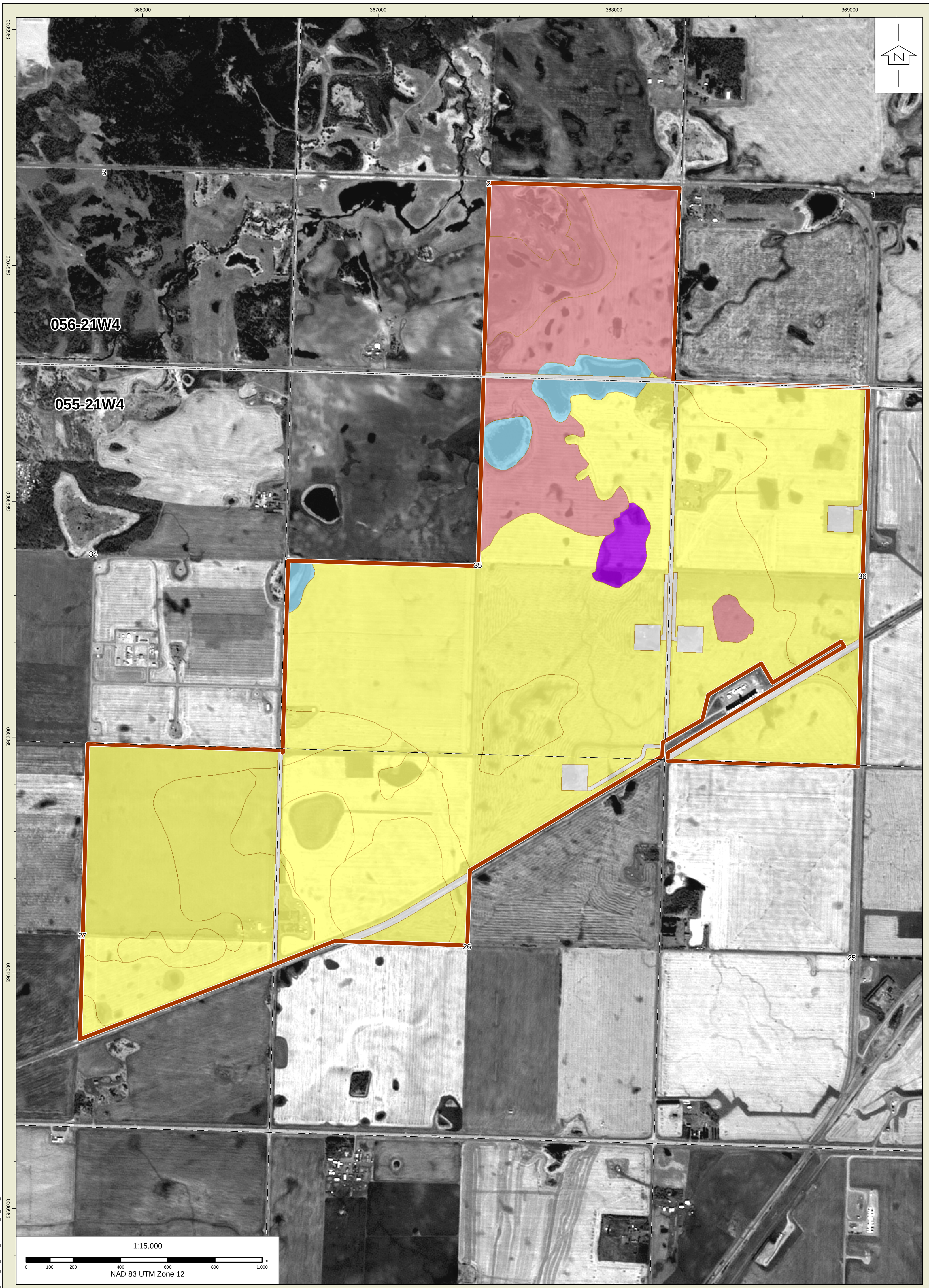

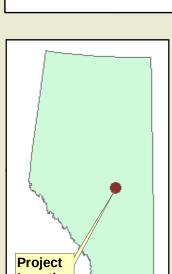

Legend

LOCAL STUDY AREA

ALBERTA TOWNSHIP / RANGE

ATS SECTION LINE

WATER

DISTURBED LAND

Soils Sensitivity to Wind Erosion

HIGH

MODERATE

LOW

Title:

SOIL SENSITIVITY TO WIND EROSION

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
BE	Nov.19, 2007

File: FIGURE_9.5-8_SOILS_SENS_TO_WIND_EROSION_IN_THE_LSA.mxd

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JC	CG	**9.5-8**

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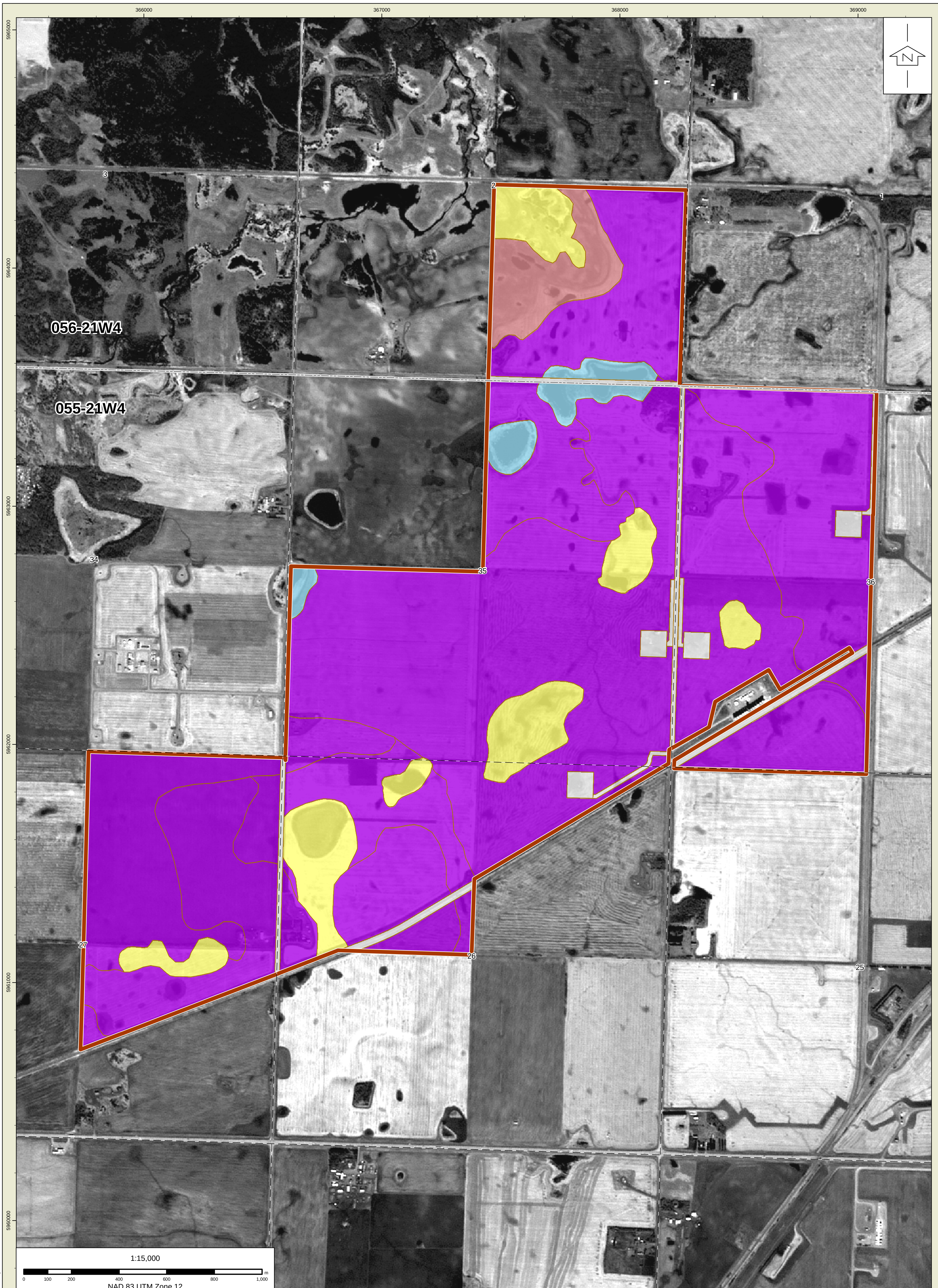

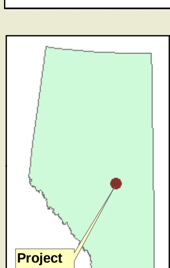

Legend

LOCAL STUDY AREA

ALBERTA TOWNSHIP / RANGE

ATS SECTION LINE

WATER

DISTURBED LAND

Soil Sensitivity to Water Erosion

HIGH

MODERATE

LOW

Title:

SOIL SENSITIVITY TO WATER EROSION

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
BE	Oct. 19, 2007

File: FIGURE_9.5_9_SOIL_SENS_TO_WATER_EROSION_IN_LSA.mxd

Drawn by:	Checked:	Fig. No.:
JC	CG	**9.5-9**

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9.6 Summary of Existing Conditions

The soil LSA covers approximately 562 ha. Dominant surficial materials in the LSA include glaciolacustrine, till, glaciofluvial, fluvioeolian and glaciofluvial over glaciolacustrine. Glaciolacustrine deposits cover approximately 344 ha (61.2%) of the LSA. Morainal till deposits are dominant on the higher elevations and account for approximately 94 ha (16.7%) of the LSA. Fluvioeolian materials are associated with the Mundare soil series, and they are characterized by dunes and steeper slopes and are located in the northern portion of the LSA.

Approximately 92% (517 ha) of the LSA was mapped as Chernozems; predominantly Orthic Black Chernozems of the Cucumber soil series (217 ha, or 38.6% of LSA). Gleysolic soils cover approximately 2.3% (13 ha) of the LSA, with the most common Gleysol being a Humic Luvic Gleysol of the Jarvie-fi soil series. Gleyed variants were mapped for Beaverhills, Malmo and Peace Hills.

The land capability for agricultural crops for soils occurring on the LSA range from Class 3 to Class 4. Approximately 86.6% of the soil in the LSA are rated Class 3 (moderate limitations), covering 487 ha. Limitations to productivity of Class 3 soils are primarily associated with low soil temperature, steep slopes, poor drainage (e.g., Gleysols or gleyed soil variants) and poor water-holding capacity (i.e., coarse-textured soils). Only 7.7% of the LSA soils are rated as Class 4 (severe limitations), and they cover approximately 43 ha of the LSA. The map units rated Class 4 are typically associated with sandy soil profiles, with steeper shorter slopes or poorly drained Gleysolic soils or gleyed soil variants.

Reclamation suitability of topsoil is rated “good” for 39.5% of the LSA (223 ha); most of the soils rated good for topsoil are of the Cucumber series. “Fair,” “fair to poor” and “poor” topsoil ratings are identified in the LSA; however, “poor” suitability ratings were assigned to only 85 ha (15.1%) of the LSA topsoils. Limitations to reclamation are characterized by alkaline pH, saturation percent, total organic carbon, texture and stoniness. In general, subsoil ratings range from “fair” to “poor.” Generally, very fine or coarse soil texture and consistency are the most limiting factors to reclamation. Peace Hills-glxc soils, a small map unit (6 ha, or 1% of the LSA), is limited in its suitability for reclamation due to the presence of saline topsoil and subsoil. In general, the limiting factors to reclamation are not considered sufficient to restrict reclamation success, as long as appropriate soil-handling procedures are followed during soil salvage and reconstruction.

Approximately 48%, or over 117,466 ha, of the RSA is rated low for sensitivity to acid deposition. Soils having medium sensitivity to acid deposition occur over approximately 20,289 ha (8% of the RSA), while high-sensitivity soils cover approximately 3% of the RSA (6,781 ha). Approximately 41% of the RSA is disturbed land and unrated for sensitivity to acidification.

Approximately 77.6% of soils within the LSA, or 436 ha, is rated as having low risk to wind erosion. The rating is consistent with the occurrence of soils with relatively high clay content in the LSA. Mineral soils of the Peace Hills and Mundare soil series account for approximately 15.7% of the LSA (88 ha), and are rated as highly sensitive to wind erosion due to the sandy soil texture.

Water erosion risk for soils in the LSA is predominantly moderate (82.4%, or 463 ha) in rating due to the undulating terrain. Approximately 3.2% of the LSA (18 ha) is rated high for water erosion, due largely to steeper slope gradients. The 49 ha (8.7%) rated low generally occurs in imperfectly to poorly drained depressional areas.

The soils found within the RSA are highly variable. One soil series (Primula) was rated as having a high risk for acidification. The Primula soil series is mapped as dominant or co-dominant over approximately 6,781 ha (3%) of the RSA.

9.7 Impact Assessment and Mitigative Measures

The Project will require an estimated 485 ha of the 562 ha LSA for facility development. Approximately 19 ha of the footprint area (3.4% of LSA) has previously been disturbed.

Potential impacts over the proposed 50-year lifespan of the Project relate to changes to resources from the construction, operations, decommissioning and reclamation phases of the Project. Impacts may include:

- change in soil moisture due to dewatering during the construction and operations phases;
- changes to agricultural land suitability; and
- potential soil acidification.

Activities such as site clearing, as well as facility and road construction during the construction phase will have adverse effects, as soils will be susceptible to compaction and erosion. Physical disturbances and contamination during the operations phase could also have adverse effects on soil.

Many management strategies to avoid or reduce impacts to soils involve the application of design, construction or scheduling principles during construction, operation and reclamation of the Project. Additional details are provided in the Conservation and Reclamation Plan (Volume 1, Section 7). AENV reclamation guidelines will be used as a reference for conserving soil and terrain properties, and to set reclamation targets. AENV guidelines, as amended, include the following:

- Reclamation Criteria for Wellsites and Associated Facilities (AENV, 2000a);
- Environmental Protection Guidelines for Oil Production Sites (AENV, 2002);
- Environmental Protection Guidelines for Pipelines (AEP, 1994);
- Native Plant Revegetation Guidelines for Alberta (Native Plant Working Group, 2000); and
- Environmental Protection Guidelines for Roadways (AENV, 2000b).

The main potential impacts to soils and landforms, as well as general mitigation methods are discussed in the following sections. Mitigation strategies are also described in the Conservation and Reclamation (C&R) Plan (Volume 1, Section 7).

9.7.1 Change in Soil Moisture

Changes to the soil moisture regime can occur as a result of the development of the Project infrastructure; however, the objective of mitigation is to reduce the nature and extent of these changes. Effects on the soil moisture regime can be lessened through development planning, as well as the use of appropriate construction practices and drainage control structures. Maintenance of natural drainage through the operation phase will enable more effective restoration of natural drainage conditions during reclamation.

Construction and operations may cause compaction of operational surfaces. Compaction of fine-textured soil could decrease soil moisture-holding capacity, and cause excess moisture to accumulate above compacted layers. Mitigation and amelioration of soil compaction is addressed in the C&R Plan (Volume 1, Section 7).

Construction and operation of the Project will require the lowering of the shallow water table to approximately 6 m below ground surface in the vicinity of the ponds. A groundwater tile drainage system will be installed below the ponds to maintain the water table below the pond bottoms (Volume 3, Section 5 - Hyrdogeology). Based on groundwater modelling results, assuming a required water drawdown of approximately 6 m for a period of 50 years, the measurable drawdown is predicted to be less than 0.4 m at 100 m from the ponds, and negligible at a distance of 200 m from the ponds. Soils surrounding the ponds and within 200 m of the ponds are dominated by the Beaverhills and Malmo series. These soils are moderately to well drained, and have developed on fine-textured parent materials; they have a low wind erosion potential.

Soil receptors potentially at risk of dewatering include the wetland complex in NE 35-55-21 W4M, as well as the sandy soils in NE 35-55-21 W4M and SE 2-56-21 W4M (Volume 1, Section 7 – C&R Plan). Both receptors are more than 200 m from the pond, and are therefore outside the drawdown effect area. Following cessation of dewatering activities, groundwater recharge is expected to occur within 50 years. The variability in the groundwater recharge estimate is due to exclusion of precipitation from the modelling.

The residual impact to soil moisture following the completion of reclamation will be neutral to negative in direction, subregional in geographic extent, low in magnitude, of long-term duration and continuous, but reversible in the medium-term. Therefore, a final impact rating of low has been assigned to changes in soil moisture within the LSA.

9.7.2 Changes to Land Suitability for Agricultural Crops

The goal of reclamation activities at site closure is to achieve land capability equivalent to pre-disturbance conditions. End land use objectives will be the same as prior to the disturbance, thereby maintaining the same land suitability rating as pre-disturbance soils. Current zoning for most of the Project area is Heavy Industrial, with a small area zoned as a Transition Zone. The actual land use following closure will depend on the zoning at that time; however, much of the land in the Project footprint is currently cropped. For assessment and planning purposes, an agricultural end land use was assumed.

Approximately 485 ha of mineral soils are expected to be disturbed by the Project. In general, the soils underlying the Project footprint are rated as Class 3, having moderate limitations to crop production. Approximately 461 ha of soils underlying the footprint are rated Class 3 for production of agricultural crops. The Mundare (sandy soils) and Jarvie (Gleysols) soils are rated as Class 4, having severe limitations to crop production; the Mundare soils will not be disturbed by the Project.

Soil suitability for reclamation was assessed, and the majority of the topsoil was rated good to fair (63% of LSA), while the majority of subsoil was rated poor (56% of LSA) for reclamation. Limitations to reclamation for topsoil include (but are not limited to) factors relating to fine soil texture and percent saturation, while factors limiting subsoil are related to fine texture and poor consistency. The limiting factors are not considered sufficient to restrict reclamation success, as long as appropriate soil-handling procedures are followed during the construction, operation and reclamation phases. Details regarding proposed soil-handling procedures are presented in the C&R Plan (Volume 1, Section 7).

Mitigative measures to reduce the effects of physical disturbances during the construction and operations phases will be required to reduce residual effects following reclamation and site closure. Progressive reclamation will be carried out during the operations phase of the Project as facilities are decommissioned. Implementation of mitigative measures during the construction and operations phases will enable soil disturbed by the Project to be reclaimed to meet equivalent land capability with respect to pre-Project conditions. Mitigation strategies may include:

- minimizing disturbance to soil underlying the Project footprint;
- avoiding working under wet soil conditions on mineral soils to reduce the likelihood of soil compaction;
- implementing erosion control measures, where appropriate, by minimizing soil exposure and controlling runoff; and
- reducing admixing of topsoil and subsoil during stripping and stockpiling of mineral soils.

The residual impact to land capability following the completion of reclamation will be neutral in direction, subregional in geographic extent, of low magnitude, long-term in duration and will occur regularly throughout the life of the Project. A final impact rating of low has been assigned to the key indicator of land suitability for agricultural crops in the LSA.

9.7.3 Impact to Soils from Potential Acid Inputs

9.7.3.1 Baseline Case

The PAI modelled for the Baseline Case are compared to the critical loads assigned to the soils in the RSA. Areas of soil where PAI may exceed the predicted generic critical load have been identified and quantified, and are shown in Table 9.7-1. Of the soils in the RSA, 3,552 ha are at risk of PAI greater than critical load. This represents 1.5% of the overall RSA and 2.5% of the 144,537 ha of undisturbed soil in the RSA. These areas are shown on Figure 9.7-1 for the Baseline Case. For purposes of comparison, the Application Case will be compared to the undisturbed portion of the RSA, or 144,537 ha.

Table 9.7-1 Soils Where PAI May Exceed Critical Load in the Baseline Case

Soil	Soil Map Units	Area Where PAI Exceeds Critical Load (ha)	Proportion of RSA (%)	Proportion of Undisturbed Soils in RSA (%)
Primula	PRM1	370	0.2	0.3
	PRZO	2,445	1.0	1.7
Mundare	MDR1	109	0.0	0.1
	MDR4	131	0.1	0.1
Malmo	MMO1	181	0.1	0.1
Uncas	UCS1	295	0.1	0.2
Miscellaneous Undifferentiated	AUN1	21	0.0	0.0
Total	Not Applicable	3,552	1.5%	2.5%

9.7.3.2 Application Case

For the Application Case, the soils potentially at risk from PAI greater than critical load levels are summarized in Table 9.7-2. The Application Case PAI and soil sensitivity are shown in Figure 9.7-2. Comparison to the Baseline Case indicates that the Application Case results in an increase of 369 ha of soil where the PAI may exceed the critical load for the soils. This increase occurs over 165 ha of Primula soil, 5 ha of Malmo soil, 2 ha of Uncas soil and 197 ha of Mundare soil. The soils at risk of PAI exceeding critical load represent 2.7% of the undisturbed soils of the RSA (144,537 ha), or a change of 0.2% from the Baseline Case.

Table 9.7-2 Soils Where PAI May Exceed Critical Load in the Application Case

Soil Series At Risk	Soil Map Units	Area Where PAI Exceeds Critical Load (ha)	Proportion of Undisturbed Soils in RSA (%)	Change from Baseline Case (ha; %)
Primula	PRM1	375	0.3	5 (0.0)
	PRZO	2,605	1.8	160 (0.1)
Mundare	MDR1	126	0.2	17 (0.0)
	MDR4	311	0.1	180 (0.1)
Malmo	MMO1	186	0.1	5 (0.0)
Uncas	UCS1	297	0.2	2 (0.0)
Miscellaneous Undifferentiated	AUN1	21	0.0	0 (0.0)
Total	Not Applicable	3,921	2.7%	369 ha (0.2%)

The potential risk from PAI will occur throughout the operation of the Project, but will cease at closure. Potential residual impact from PAI following the completion of reclamation will be negative in direction, regional in geographic extent and low in magnitude, resulting in a final impact rating of low impact to soils from changes in PAI in the RSA for the Application Case.

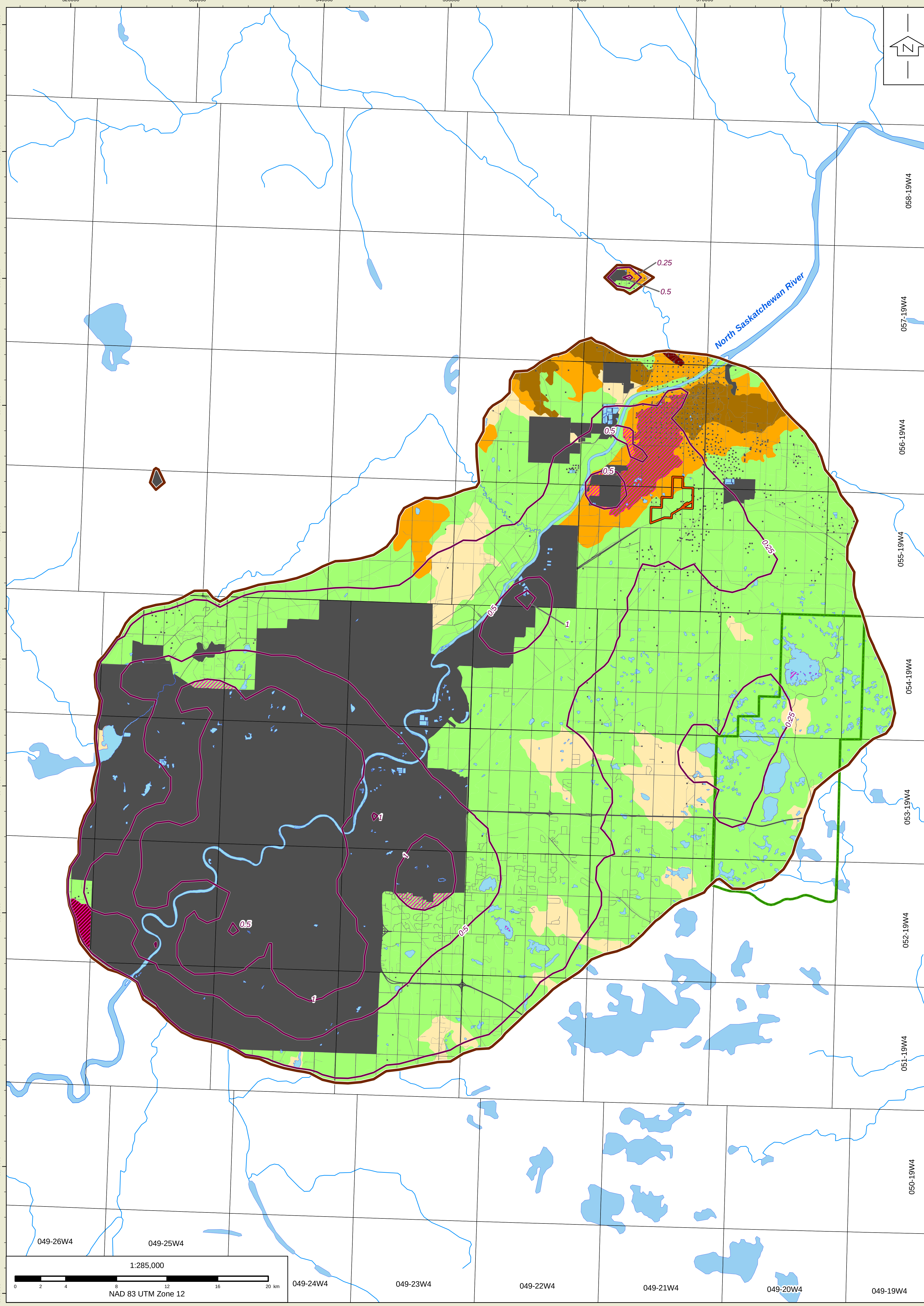
9.7.4 Impact Classification

A summary and classification of impacts for the Application scenario are presented in Table 9.7-3.

Table 9.7-3 Summary of Impact Classification for Soils in the Application Scenario

Parameter	Direction	Geographic Extent	Magnitude	Duration	Frequency of Occurrence	Permanence	Confidence	Final Impact Rating
Change in Soil Moisture	Neutral to Negative	Subregional	Low	Long-term	Continuous	Reversible in medium-term	Medium	Low
Changes to Land Suitability for Agricultural	Neutral	Subregional	Low	Long-term	Regular	Reversible in medium-term	High	Low
Potential Acidification	Negative	Regional	Low	Long-term	Continuous	Reversible in long-term	Medium	Low

The residual impact to the key soil parameters (soil moisture, land suitability and acidification) is low for the Application Case. Modelled PAI changes on RSA soils in the Application Case affects 0.2% of the undisturbed soils of the RSA.



Project Location

Legend

- NORTH AMERICAN UPGRADER RSA
- NORTH AMERICAN UPGRADER LSA
- ELK ISLAND NATIONAL PARK
- ALBERTA TOWNSHIP/RANGE
- DISTURBED LAND
- WATERBODY
- RIVER/STREAM
- PAI EXCEEDS CRITICAL LOAD
- PAI ISOPLETH LINE (keqH+/ha/year)

SOIL SENSITIVITY TO ACIDIFICATION

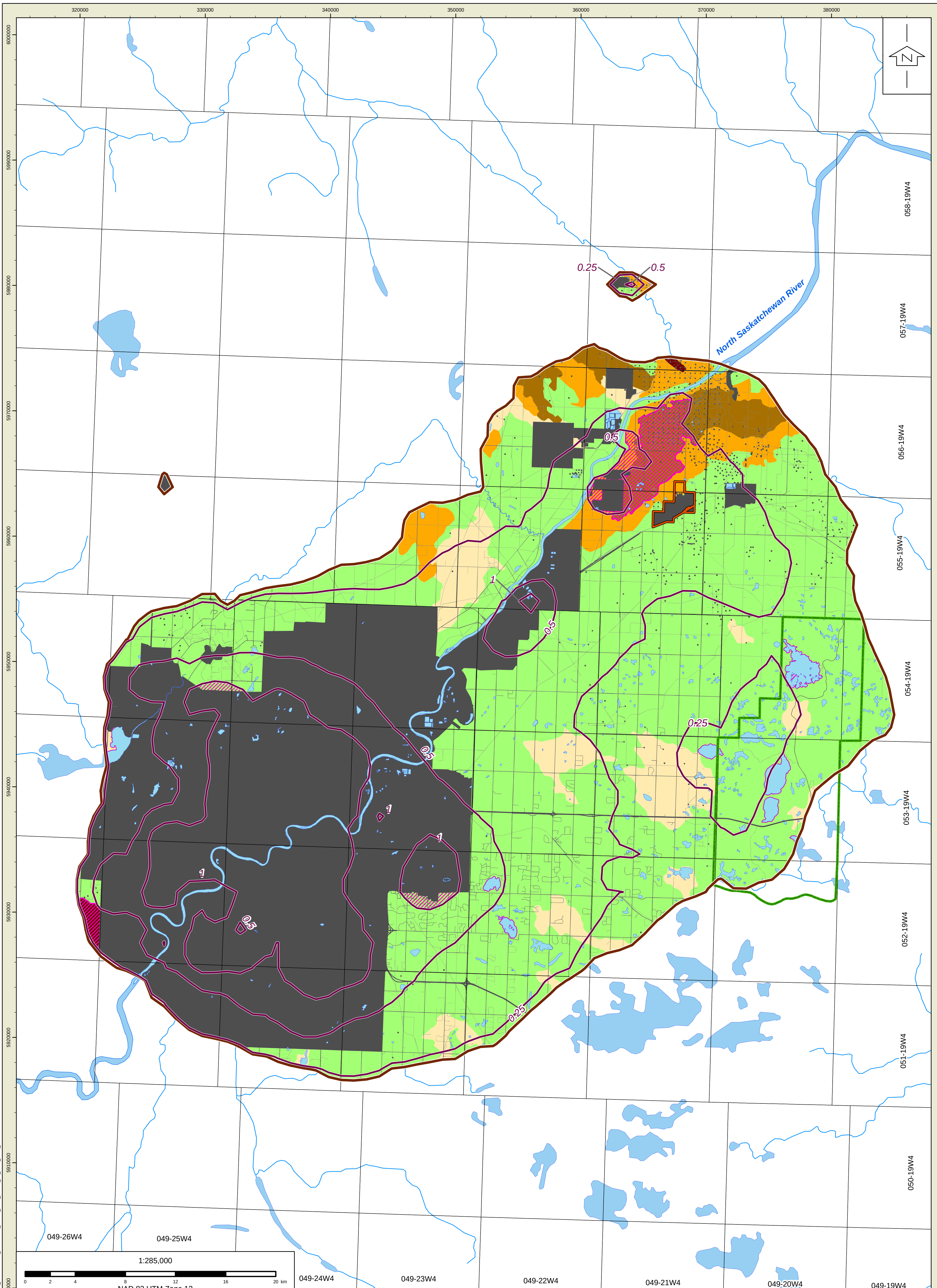
- HIGH
- MEDIUM-HIGH
- LOW-HIGH
- MEDIUM
- LOW-MEDIUM
- LOW

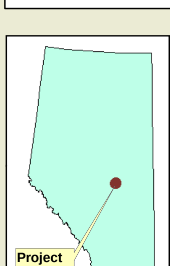
Title:

SOILS IN RSA WITH PAI EXCEEDING CRITICAL LOADS IN BASELINE CASE

NORTH AMERICAN OIL SANDS CORPORATION

Approved: BE	Revision Date: Oct.15, 2007	
File: FIGURE_9.7_1_SOILS_WITH_EXCEEDED_CRITICAL_LOAD_BASELINE_IN_THE_RSA_TABLOID.mxd		
Drawn by: JC	Checked: BM	Fig. No.: 9.7-1





Legend

- NORTH AMERICAN UPGRADER RSA
- NORTH AMERICAN UPGRADER LSA
- ELK ISLAND NATIONAL PARK
- DISTURBED LAND
- ALBERTA TOWNSHIP/RANGE
- WATERBODY
- RIVER/STREAM
- PAI EXCEEDS CRITICAL LOAD
- PAI ISOPLETH LINE (keqH^+/ha/year)

SOIL SENSITIVITY TO ACIDIFICATION

- HIGH
- MEDIUM-HIGH
- LOW-HIGH
- MEDIUM
- LOW-MEDIUM
- LOW

Title:

SOILS IN RSA WITH PAI EXCEEDING CRITICAL LOADS IN APPLICATION CASE

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
BE	Oct.15, 2007

File: FIGURE_9.7_2_SOILS_WITH_EXCEEDED_CRITICAL_LOAD_APP_CASE_IN_THE_RSA_TABLOID.mxd

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JC	BM	9.7-2

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9.8 Cumulative Effects Assessment

Low residual effects are predicted in the Application Case for the key indicators of land suitability for crop production, soil moisture and soil acidification. Project effects in the Application Case with a predicted magnitude of low or higher which could act cumulatively with other environmental pressures, have been included in the Cumulative Case for soils. Low residual effects were predicted in the Application Case for the key indicator parameters identified. Additional future activities in the RSA include proposed road developments and upgraders. Similar closure scenarios are predicted for all proposed projects within the soils RSA.

9.8.1 Change in Soil Moisture

Soils within 100 m of the ponds will experience reduced soil moisture as a result of dewatering during the construction and operations phases of the Project. Cessation of dewatering activities is estimated to return groundwater levels to pre-disturbance conditions within 50 years. A review of other EIAs in the RSA suggests that dewatering will only occur during the construction phase for those projects. Dewatering effects related to the Project are predicted on a local scale, and effects will be restricted to less than 200 m around the ponds. Sensitive receptors within the LSA (wetland and sandy soils) are outside the radius of influence of the dewatering. No mitigation is proposed for these areas. No cumulative effect is predicted as a result of dewatering around the Project ponds.

The residual impact to soil moisture following the completion of reclamation will be neutral to negative in direction, subregional in geographic extent, low in magnitude, of long-term duration and continuous, but reversible in the medium-term. Therefore, a final impact rating of low has been assigned to changes in soil moisture within the LSA.

9.8.2 Changes to Land Suitability for Agricultural Crops

The goal at closure of all proposed and existing projects within the soils RSA is equivalent land capability. As such, no cumulative adverse effects are predicted with respect to the capacity of lands to sustain crops at site closure, provided proper soil handling and mitigation strategies are followed during all the phases of the Project.

The residual impact to land capability following the completion of reclamation will be neutral in direction, subregional in geographic extent, of low magnitude, long-term in duration and will occur regularly throughout the life of the Project. A final impact rating of low has been assigned to the key indicator of land suitability for agricultural crops in the LSA.

9.8.3 Impact to Soils from Potential Acid Inputs

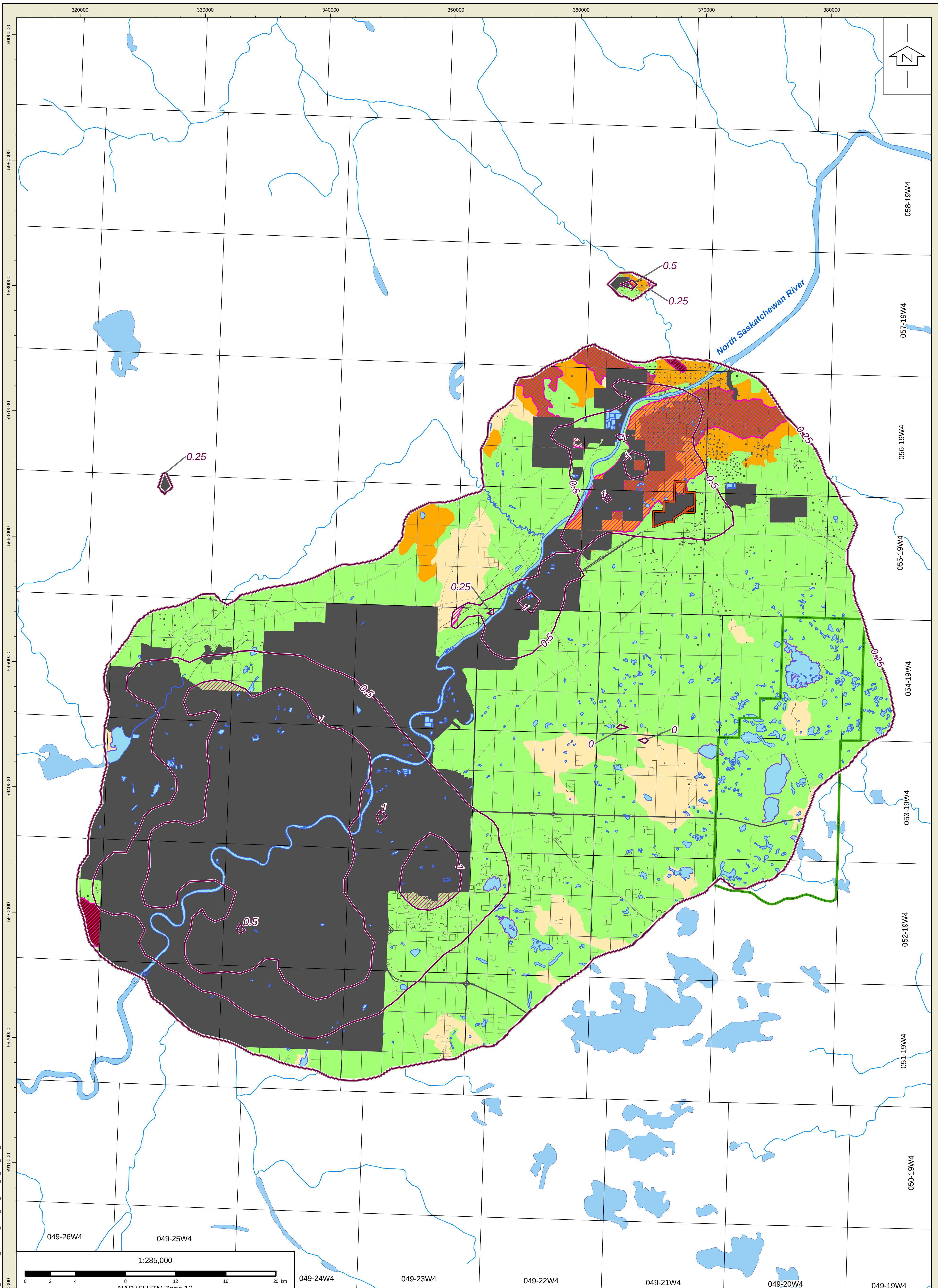
Figure 9.8-1 shows the Cumulative Case of predicted PAI in the RSA. Projected disturbance increases as footprints for future developments will remove soil from potential deposition. Sensitivity ratings or critical loads have not been developed for disturbed soils. Table 9.8.1 indicates the soils where PAI may exceed the generic critical load for soils in the Cumulative Case.

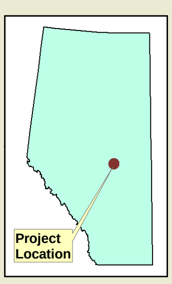
Table 9.8-1 Soils Where PAI May Exceed Critical Load in the Cumulative Case

Soil Series At Risk	Soil Map Units	Area Where PAI Exceeds Critical Load (ha)	Proportion of Undisturbed Soils in RSA (%)	Change from Baseline Case (ha; %)
Primula	PRM1	421	0.3	51 (0.0)
	PRM2	102	0.1	102 (0.1)
	PRZO	3,948	2.7	1,503 (1.0)
	MNaaPR	1,360	1.0	1,360 (1.0)
	PHPR	17	0.0	17 (0.0)
Mundare	MDR1	418	0.3	309 (0.2)
	MDR2	814	0.6	814 (0.6)
	MDR4	479	0.3	348 (0.2)
	MDPH	38	0.0	38 (0.0)
Kavanagh	KVPH	58	0.0	58 (0.0)
Malmo	MMO1	227	0.2	46 (0.1)
Uncas	UCS1	324	0.2	29 (0.0)
Miscellaneous Undifferentiated	ZUN1	22	0.0	1 (0.0)
Miscellaneous Water and Undifferentiated	ZUZW	8	0.0	8 (0.0)
Total	Not Applicable	8,236	5.7%	4,684 ha (3.2%)

The Cumulative Case results in an additional 4,684 ha of soil where the critical load may be exceeded by PAI. This change, based on 144,537 of undisturbed soils in the Baseline Case, represents an increase of 3.2% of the undisturbed RSA at risk from PAI exceeding critical load. Approximately 5,427 ha (71%) of the soils at risk of PAI exceeding critical load in the Cumulative Case are mapped as either dominantly or co-dominantly Primula, with high sensitivity to acidification. The hectares of Primula soil where PAI exceeds critical load are 80% of the total Primula soils mapped in the RSA.

On the basis of the RSA, the change in soils at risk of having critical load exceeded by PAI is negative in direction, regional in geographic extent and low in magnitude, resulting in a final impact rating of low impact to soils from changes in PAI in the RSA for the Cumulative Case. High-sensitivity soils constitute 71% of the soils where PAI may exceed critical load of soils.





Legend

- NORTH AMERICAN UPGRADER RSA
- NORTH AMERICAN UPGRADER LSA
- ELK ISLAND NATIONAL PARK
- DISTURBED LAND
- ALBERTA TOWNSHIP/RANGE
- WATERBODY
- RIVER/STREAM
- PAI EXCEEDS CRITICAL LOAD
- PAI ISOPLETH LINE (keqH$^+$/ha/year)

SOIL SENSITIVITY TO ACIDIFICATION

- HIGH
- MEDIUM-HIGH
- LOW-HIGH
- MEDIUM
- LOW-MEDIUM
- LOW

Title:

SOILS IN RSA WITH PAI EXCEEDING CRITICAL LOADS IN CUMULATIVE CASE

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:	
BE	Oct.15, 2007	
File: FIGURE_9.8-1_SOILS_WITH_EXCEEDED_CRITICAL_LOAD_CEA_CASE_IN_THE_RSA_TABLOID.mxd		
Drawn by: JC	Checked: BM	Fig. No.: **9.8-1**

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9.9 Follow-up and Monitoring

9.9.1 Land Suitability for Agricultural Crops

Monitoring for impacts that could affect land suitability for agricultural crops will be conducted during the life of the Project and the reclamation phase until a Reclamation Certificate is obtained. Reclamation monitoring will comply with the AENV Approval to Operate, and reclamation activities will be reported annually.

9.9.2 Soil Acidification Monitoring

North American will participate in regional soil-monitoring programs existing in the RSA.

9.10 Summary

The predicted residual impacts to the key parameters of soil moisture, land capability and acidification potential are low for soils and terrain in the Application Case. The Project is anticipated to have a low impact to soils and terrain in the Cumulative Case.

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