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APPENDICES

9 SOILS AND TERRAIN

9.1 Introduction

The soils and terrain section provides information specified by clause 4.7.2 in the EIA TOR (AENV, 2007) for the Project. The topics addressed in this section include baseline soils and terrain conditions, interpretations of their characteristics with respect to environmental sensitivities, mitigative measures and potential environmental impacts. The Project soils and terrain section provides:

- Detailed baseline information on soils and terrain types, including their characteristics and distribution in the LSA and RSA;
- Interpretations of the soils and terrain characteristics for land capability for forest ecosystems, and reclamation suitability, as well as soil/terrain sensitivities to impacts (e.g., acid deposition, erosion, compaction, decreased soil quality/quantity, contamination, changes in terrain and land capability for forest ecosystems); and
- 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 impacts.

9.2 Issues and Assessment Criteria

Issues scoping for soils and terrain involved a review of previous EIAs for in situ oil sands projects including:

- OPTI Canada Inc. Long Lake Project (OPTI, 2000);
- Nexen/OPTI Long Lake South Project (Nexen/OPTI, 2006);
- Gulf Canada Resources Inc. Surmont In situ Oil Sands Project (Gulf, 2001);
- Petro-Canada Meadow Creek SAGD Project (Petro-Canada, 2001);
- Christina Lake Regional Project (MEG Energy Corp., 2005); and
- Jackfish Project (Devon Canada Corporation, 2003).

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

- Changes to land capability as a result of changes to soils and terrain;
- Potential soil acidification; and
- Loss of landforms.

The issues are also reflected in the Project's TOR (AENV, 2007), which provides the framework for this assessment.

9.3 Study Areas

The study areas for the assessment of the effects of the Project on the soils and terrain are described in terms of the spatial and temporal boundaries of the assessment.

9.3.1 Spatial Boundaries

Site selection for the Project footprint began in 2005 and has continued as the Project design has evolved. Soil and vegetation sampling were initiated in 2005 based on preliminary geological results and the North American land holdings at the time. Preliminary facility placements were based on:

- Maximizing resource recovery;
- Terrain (i.e., upland locations were preferred as were locations with minimal change in topography, thereby reducing need for cut and fill); and
- Avoiding open water bodies and defined watercourse channels (having defined bed and bank material).

The 2005 and 2006 soil survey design and the soils and terrain LSA boundaries were refined using initial geological resource constraints mapping prepared in 2006 for the Leismer Demonstration Project application. As the LSA was being defined, the development of the Project footprint was still in preliminary stages. Plans for utility ROWs connecting North American's leases were conceptual; the precise location of the ROWs was not defined. Therefore, soils on lands between the leases were also mapped.

The lease boundary and interconnecting lands encompasses almost 16 townships of land. Consideration was given to decreasing the LSA size to reduce the dilution effect on assessed impact of such a large LSA; however, insufficient engineering was available to eliminate any of these lands from potential development.

Since the initial selection of the soils and terrain LSA, North American has continued to refine the footprint layout based on a constraints mapping approach to avoid sensitive areas within the lease boundaries. North American made modifications to the footprint layout based on information acquired from the geological data collection, hydrogeological data, aquatics, and soils and vegetation surveys conducted in 2005 and 2006 combined with the AVI/ELC mapping and survey imagery (i.e., still photography images, aerial video, line scans and LiDAR, including topography).

As the Project footprint was further refined, several changes were made. North American examined each development area to determine the best SAGD well trajectories, giving consideration to variability in oil/water contact, reservoir quality, and character differences in the channels. Options for SAGD well pair placements in the channel trends considered non-reservoir shale plugs and various types of potential thief zones. Two SAGD pads were moved outside of the North American lease lands; however, well trajectories were designed to drain the resources from within the leases. The engineering and hydrogeologic assessments resulted in several source water and water disposal wells being located outside of the North American leases. In addition, the ROWs interconnecting the hubs were defined, some of which extended between North American leases. The refined Project footprint was used to assess impacts related to the Project.

The evolution of the Project footprint, following completion of the field programs, has resulted in small portions of the Project footprint occurring outside of the soils and terrain LSA boundary.

The initial developments of Leismer Commercial, Leismer Expansion and Corner hubs are entirely within the soils and terrain LSA. The small portions of infrastructure that are outside of the LSA are more conceptual in nature and are associated with future development. The implications of the small portions of the footprint being outside of the soils and terrain LSA were not considered to affect the overall evaluation of soils and terrain impacts. In addition, it is anticipated that the overall Project footprint will be further refined, based on additional geological, biophysical and construction/reclamation information. Prior to construction, pre-disturbance assessments (PDAs) will be conducted on the hub areas and SAGD pads to evaluate potential impacts and to develop C&R Plans for each site.

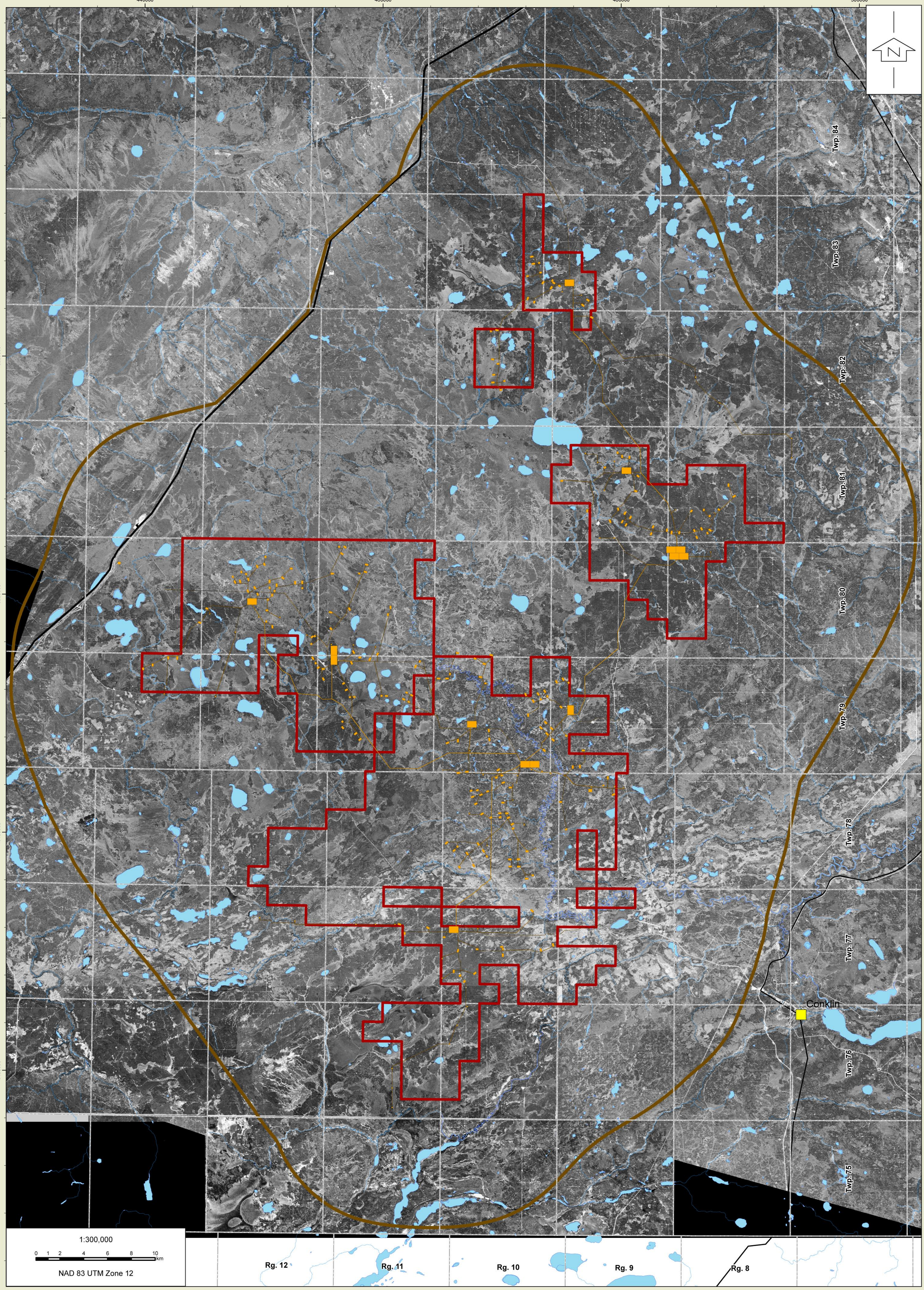
The surface disturbance footprint area (the footprint) includes all lands subject to potential direct surface disturbance (e.g., soil salvage) for the construction, operation or reclamation phases of the Project. These include the initial commercial phases at Leismer and Corner and the subsequent facilities at Hangingstone, Thornbury and South Leismer. Facilities include the CPFs at each hub, well sites, and associated infrastructure, including access roads and pipelines. The footprint covers approximately 3,032 ha (Figure 9.3-1).

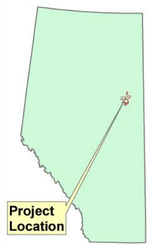
The soils and terrain LSA was selected to facilitate evaluation of all soils and terrain units within the lease area that could be potentially impacted by the Project. This LSA, presented in Figure 9.3-1, covers approximately 110,938 ha. The soils and terrain LSA falls within the vegetation and wildlife LSA, which covers approximately 145,349 ha. The smaller size of the soils and terrain LSA was defined so that it would be possible to conduct the soil survey at a level appropriate to describe the soil types. The RSA was selected to evaluate potential regional impacts related to air emission modelling for PAI and cumulative effects relating to physical disturbances associated with future announced projects. The RSA is the same for soils and terrain, vegetation and wildlife (Figure 9.3-1) and covers approximately 474,702 ha.

9.3.2 Temporal Boundaries

The temporal scope of the EIA reflects the timing and nature of the Project phases as well as information available on other proposed projects in the area. Project and cumulative Project effects are assessed for the construction, operations, decommissioning and reclamation, and closure phases of the Project. Each phase is assessed at the peak of Project activity. The timing of the phases for the Project is:

- Construction – 2008 through 2016;
- Operations – 2010 through 2050;
- Decommissioning and reclamation – progressive with final decommissioning in 2051 through 2053; and
- Closure – 2053.





Legend

- North American Soils RSA
- North American Soils LSA
- North American Footprint
- Rivers
- Lake
- Towns
- Major Road (Hwy. 63)
- Road (Hwy. 881)
- Alberta Twp. / Rg. Lines

Title:

TERRESTRIAL REGIONAL AND LOCAL STUDY AREAS WITH FOOTPRINT

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
CG/SC	June 12, 2007

File: Fig 9.3-1_Terrestrial_RSA_LSA_20070612

Drawn by:	Checked:	Fig. No.:
TR	LZ/JB	9.3-1

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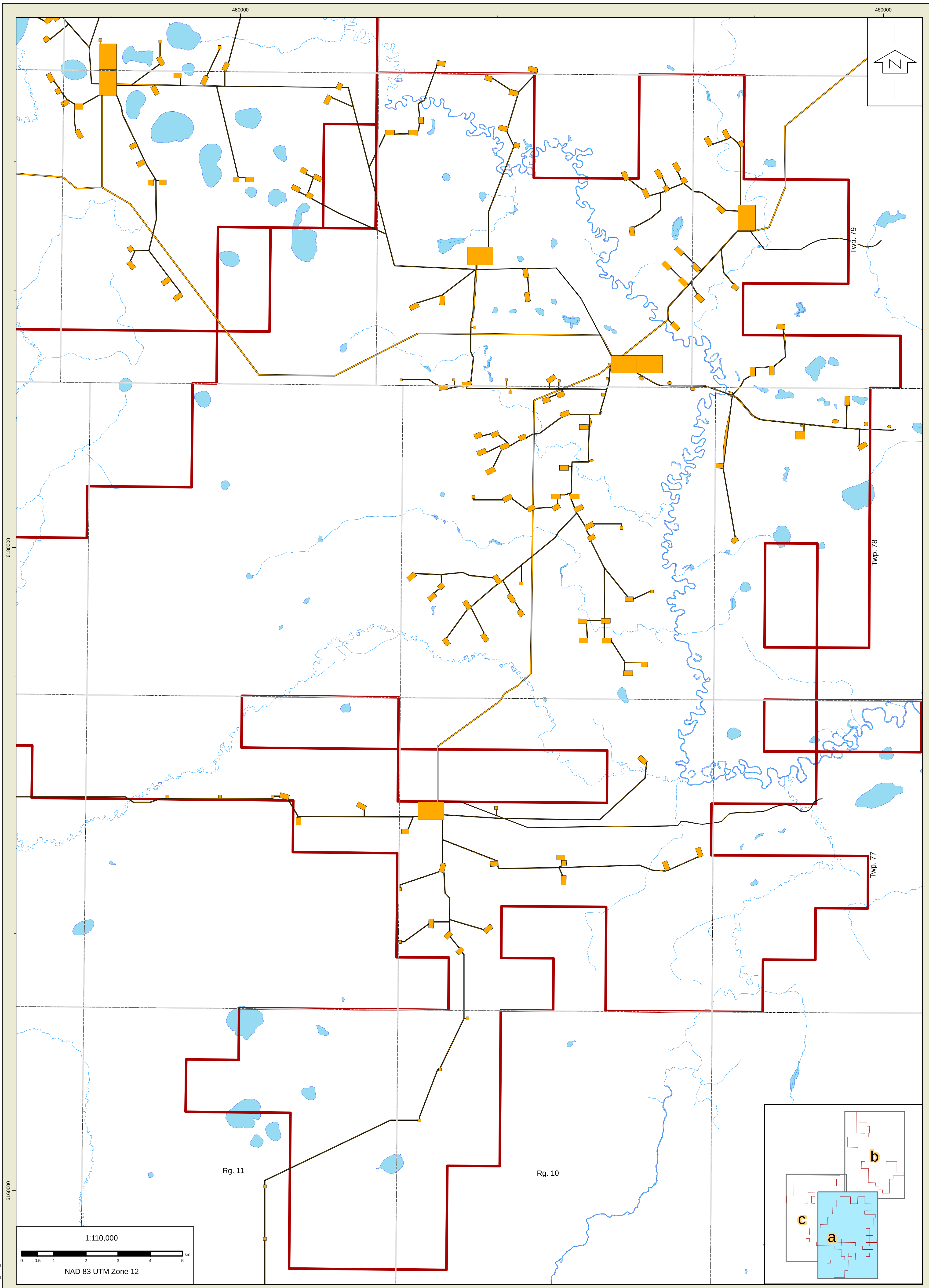

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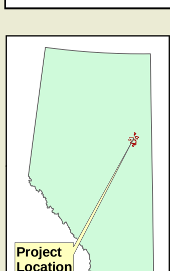


Legend

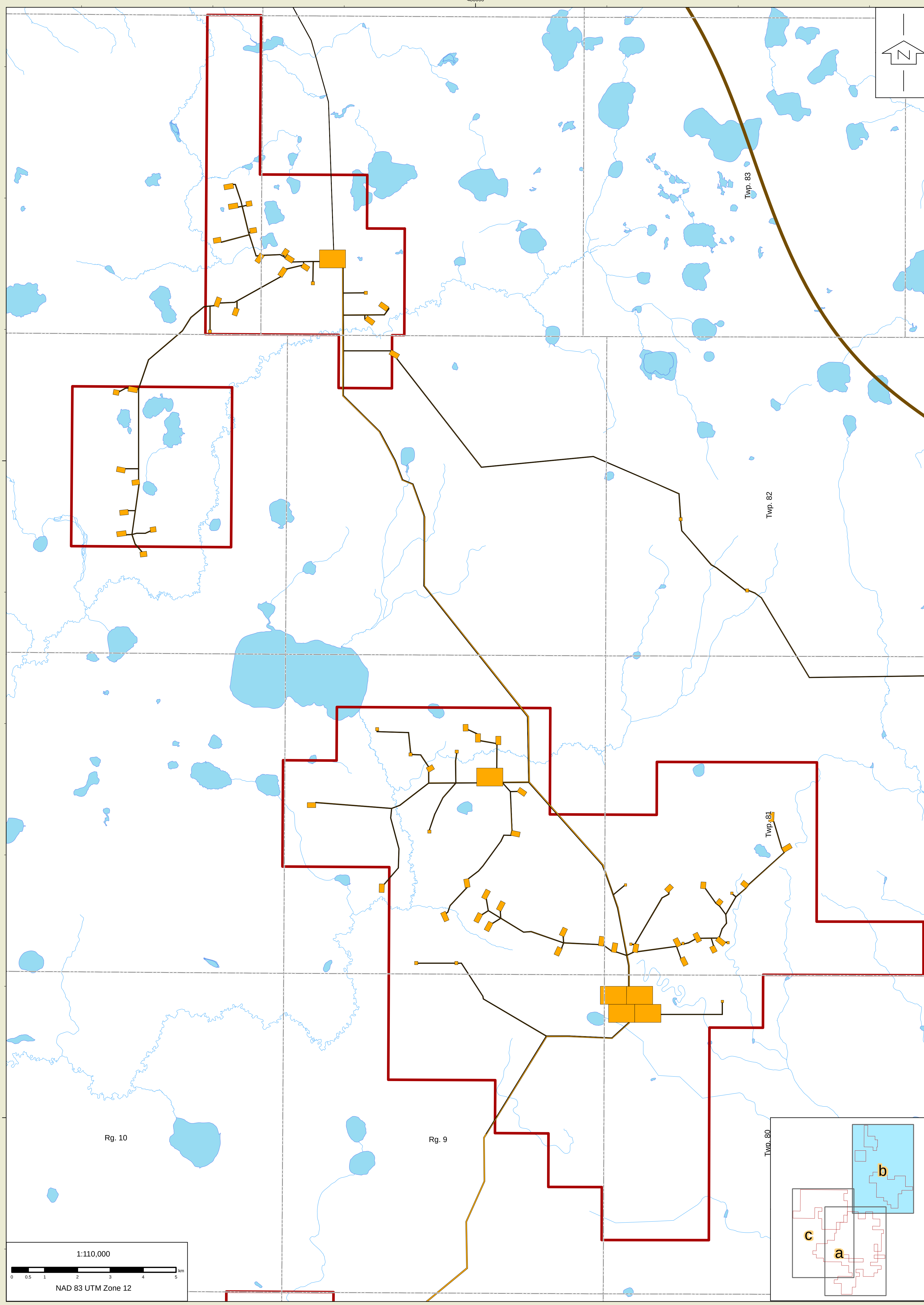
- North American Soils RSA
- North American Soils LSA
- North American Footprint
- Rivers
- Lake
- Towns
- Major Road (Hwy. 63)
- Road (Hwy. 881)
- Alberta Twp. / Rg. Lines

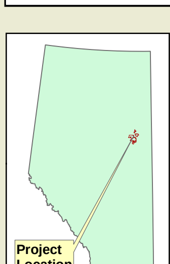
Title:

TERRESTRIAL REGIONAL AND LOCAL STUDY AREAS WITH FOOTPRINT

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/SC	Revision Date: June 12, 2007	
File: Fig 9.3-1a_Terestrial_RSA_LSA_20070612		
Drawn by: TR	Checked: LZ/JB	Fig. No.: **9.3-1a**





Legend

North American Soils RSA	Towns
North American Soils LSA	Major Road (Hwy. 63)
North American Footprint	Road (Hwy. 881)
Rivers	Alberta Twp. / Rg. Lines
Lake	

Title:

TERRESTRIAL REGIONAL AND LOCAL STUDY AREAS WITH FOOTPRINT

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/SC	Revision Date: June 12, 2007
File: Fig 9.3-1b_Terestrial_RSA_LSA_20070612	

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TR	LZ/JB	**9.3-1b**

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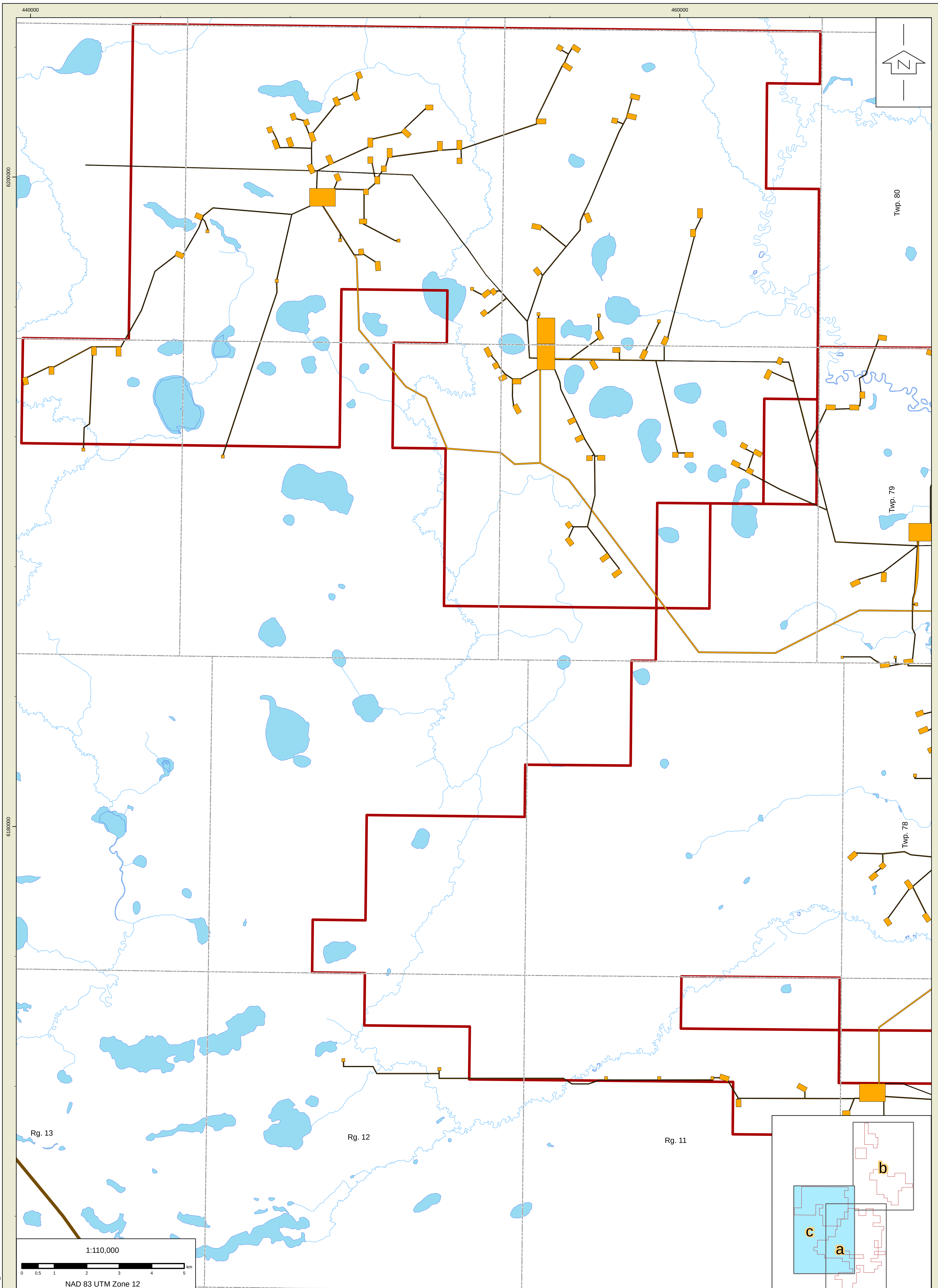

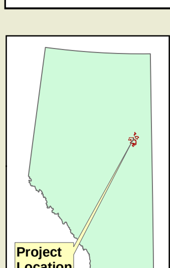

Legend

- North American Soils RSA
- North American Soils LSA
- North American Footprint
- Rivers
- Lake
- Towns
- Major Road (Hwy. 63)
- Road (Hwy. 881)
- Alberta Twp. / Rg. Lines

Title:

TERRESTRIAL REGIONAL AND LOCAL STUDY AREAS WITH FOOTPRINT

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/SC	Revision Date: June 12, 2007	
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9.4 Methods

9.4.1 Soil Mapping and Classification in the LSA

A total of 518 soil inspections were conducted in the LSA for an inspection density corresponding to SIL3 (1 inspection/214 ha). A total of 451 soil inspections were conducted on the footprint for an inspection density corresponding to SIL2 (approximately 1 inspection/6 ha). A focused survey was conducted on the Leismer Commercial and Corner Initial Development Areas:

- Leismer Commercial (54 inspections; 124 ha; SIL1); and
- Corner (25 inspections; 132 ha; SIL1).

Beyond initial developments at Leismer Commercial and Corner, the footprint extent and location cannot reasonably be predicted. Pre-disturbance site assessments (PDAs) at SIL1 (1 inspection/1-5 ha) will be conducted once the final layout is confirmed. Soil inspection sites are illustrated in Figure 9.4-1 and Figures 9.4.1a, 9.4.1b, and 9.4.1c.

Inspection sites were described to a maximum depth of 120 cm for mineral soils and to a maximum depth of 220 cm for Organic soils. Samples were analyzed from 21 inspection locations to provide representative samples from soil series encountered in the LSA. Landform, surficial materials, slope, texture, stoniness, topsoil thickness, drainage conditions and profile morphology were described at these inspection sites. Soils were described and classified 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).

The area was accessed both by motorized all-terrain vehicle and on foot. The inspections were conducted using a shovel and hand-held Dutch auger. A site inspection list is provided in Appendix 9A.

Previous to, and in conjunction with, the field program, a review of existing surficial geology and soil survey information for the LSA was conducted including:

- Surficial Geology Waterways 1:250,000 Map (NTS 74D) (Bayrock and Reimchen, 1973);
- Quaternary Geological Setting of the Athabasca Oil Sands (In Situ) Area, Northeast Alberta (Andriashak, 2003);
- Alberta Oil Sands Environmental Research Program (AOSERP; Turchenek and Lindsay, 1982);
- Soil Series Information for Reclamation Planning in Alberta (Volumes 1 and 2; Pedocan, 1993); and
- Soil surveys from EIAs previously conducted in the region including OPTI Canada Inc. Long Lake Project (OPTI, 2000), MEG Christina Lake Regional Project (MEG, 2005).

The soils identified in the LSA were correlated to current soil series names using the Alberta Soil Names File, Generation 3.0 (AGRASID; ASIC, 2001) as well as personal communications with the Soil Land Resources Information Specialist (Pers. Comm., T. Brierley, Agriculture and Agri-Food Canada). Where no soil series was established for a mapped soil, the closest soil series name corresponding to soil order and parent material in Soil Correlation Areas (SCA) 19 and 20 was used. Those were distinguished from the established soil series with the use of variant codes as adapted from ASIC (2001).

9.4.1.1 Soil Survey Map Units

Soil inspection information was extrapolated using published soils information available for the general area, aerial photograph interpretation, field observations, Alberta Vegetation Inventory and other indicators to develop a soil map for the LSA.

Soil map unit names were derived from the dominant soil series that occur within the soil map unit boundaries, as well as other significant soils that occurred within a soil map unit. For example, McLelland soil map units were named either MLD-1 or MLD-2. The three letter code (MLD) is the soil series short-hand notation for McLelland soils which are dominant in those map units. The number following the three letter code indicates MLD map units which have similar proportions of the dominant and significant soils that occur within a map unit with that label. All map units may have up to 20% soil inclusions; these are soils which occur within the map unit but are not extensive enough to be distinguished separately at the scale of mapping.

9.4.1.2 Analytical Program

To provide baseline soil chemistry data of the 71 sites sampled, 30 inspection sites were analyzed. Analytical tables and laboratory reports are provided in Appendix 9B and 9C, respectively. 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.

9.4.2 Soil Suitability and Sensitivity Assessment Criteria

The criteria used in assessing the soils and terrain information, including brief descriptions of the criteria, are presented in this section. Soil chemistry and physical properties data for the soil series were interpreted to determine land capability for forest ecosystems, soil suitability for reclamation, soil sensitivity to acid deposition, and erosion potential. Methods of interpretation were based on:

- Land Capability Classification System for Forest Ecosystems in the Oil Sands, 3rd Edition (AENV, 2006);
- 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);
- Critical Loads for Organic (Peat) Soils in Alberta (Turchenek et al., 1998);
- Soil Sensitivity to Acid Deposition (Holowaychuk and Fessenden, 1987);
- Critical Loads of Acid Deposition on soils in the Athabasca Oil Sands Region, Alberta (Abboud et al., 2002); and
- Application of Critical, Target, and Monitoring Loads for the Evaluation and Management of Acid Deposition (Clean Air Strategic Alliance [CASA], 1999).

9.4.2.1 Land Capability Classification for Forest Ecosystems

Baseline (pre-disturbance) land capability for forest ecosystems classes were developed for each soil series in the LSA. Soil capability ratings are based on soil physical and analytical information obtained through field site inspections and laboratory analysis of soil samples. The final land capability rating is obtained using a base rating, assessed on soil moisture and soil nutrient regimes, and deductions for the most limiting soil physical and chemical properties. 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 five land capability classifications are described in Table 9.4-1. Land capability subclasses are described in Table 9.4-2.

Table 9.4-1 Land Capability Classes for Forest Production

Land Class Capability		Land Capability
1	High capability (Final land rating 81 to 100)	Land having no significant limitations to supporting productive forestry, or only minor limitations that can be overcome with normal management practices.
2	Moderate capability (Final land rating 61 to 80)	Land having limitations which, in combination, are moderately limiting for forest production. The limitations will result in reduced productivity or benefits, or require increased inputs to the extent that the overall advantage to be gained from the use will still be attractive, but appreciably inferior to that expected on Class 1 land.
3	Low capability (Final land rating 41 to 60)	Land having limitations which, when combined, are moderately severe for forest production. The limitations will result in reduced productivity or benefits, or require increased inputs to the extent that the overall advantage to be gained from the use will be low.
4	Conditionally productive (Final land rating 21 to 40)	Land having severe limitations, some of which may be surmountable through management, but which cannot be feasibly corrected with existing practice.
5	Non-productive (Final land rating 0 to 20)	Land having limitations that appear so severe as to preclude any possibility of successful forest production.

Source: Land Capability Classification System for Forest Ecosystems in the Oil Sands, 3rd Edition (AENV, 2006)

Table 9.4-2 Land Capability Subclasses for Forest Production

Soil Moisture Regime Index & Subclasses		Limiting Factors Deductions
Soil Moisture	**Soil Nutrient Retention**	**Soil Physical & Chemical Properties**
Available water holding capacity (M)	Soil nutrient regime (F)	Structure/Consistence (D)
Organic Modifier (O)		Acidity/alkalinity (V)
Stoniness Modifier (P)		Salinity (N)
Impermeable Layer (Z)		Sodicity/saturation percentage (Y)
Landscape Modifier		

Source: Land Capability Classification System for Forest Ecosystems in the Oil Sands, 3rd Edition (AENV, 2006)

9.4.3 Soil Suitability for Reclamation

Reclamation suitability ratings were determined for the upper lift and lower lift for soils handling during salvage and stockpiling (Alberta Agriculture, 1987). The upper lift consists of the surface of the soil solum, including the organic surface material and mineral A horizons. Organic peat is not classified under this system. Criteria for evaluating the suitability of surface (upper lift) and subsurface (lower lift) soils for reclamation purposes in the Northern Forest Region are listed in Table 9.4-3 and Table 9.4-4.

Table 9.4-3 Reclamation Suitability Criteria for Surface Soil

Rating/Property	Good	Fair	Poor	Unsuitable
Reaction (pH)	5.0–6.5	4.0–5.0 6.5–7.5	3.5–4.0 7.5–9.0	<3.5 and >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 and >120
Stoniness (% Area)	<30	30–50	50–80	>80
Rockiness (% Area)	<20	20–40	40–70	>70
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
$CaCO_3$ Equivalent (%)	<2	2–20	20–70	>70

* Texture: fine sandy loam, very fine sandy loam, loam, silty loam, sandy loam, clay loam, sandy clay loam, silty clay loam, loamy sand, silty clay, clay, hard clay, sand

Source: Adapted from Alberta Agriculture (1987)

Table 9.4-4 Reclamation Suitability Criteria for Subsurface Soil

Rating/Property	Good	Fair	Poor	Unsuitable
Reaction (pH)	5.0–7.0	4.0–5.0 7.0–8.0	3.5–4.5 8.0–9.0	<3.5 and >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 and >120
Coarse Fragments (% Area)	<30 (<15)	30–50 (15–30)	50–70 (30–50)	<70 (<50)
Texture	FS, VFSL, L, SiL, SL	CL, SiC, SiCL	S, LS, C, HC	Bedrock
Moist Consistency	Very friable, friable, firm	Loose, very firm	Extremely firm	Hard rock
$CaCO_3$ Equivalent (%)	<5	5–20	20–70	>70

Source: Adapted from Alberta Agriculture (1987)

9.4.4 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 cation exchange capacity

[CEC]), texture, organic matter content, permeability, moisture holding capacity and drainage (Holowaychuk and Fessenden, 1987).

In 2002, Abboud et al conducted modelling of the soil acidification potential of soils found in the oil sands region of Alberta for the NO_x-SO_x Management Working Group of the Cumulative Environmental Management Association (CEMA). Most of the data used in the modelling came from the Alberta Oil Sands Environmental Research Program (AOSERP) soil survey for the northeast oil sands region. Therefore, the soils in northeast oil sands region are referred to as the AOSERP soil series. The critical load of potential acid input (PAI) was modelled for each soil series, based on critical chemical values (CV) for changes in pH, base saturation and exchangeable bases, to determine a loading value which is protective of the soil against acidification. The model used soil survey information on the mineral soil characteristics, as well as including the buffering capacity of the organic material layer. Organic soils were modelled based on the acid buffer capacity of peat and peat water.

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). Several different cases of critical loads for various chemical values were modelled by Abboud et al. (2002) as follows:

- The 75% and 85% Cases model the lowest critical load determined to be protective for 75% or 85%, respectively, of base saturation or base cation/aluminum ratio in mineral soils. For organic soils, the cases model 75% or 85% of base cation to hydrogen ratio;

- The Mid Chemical Value Case models the lowest critical load determined to be protective for 50% of the difference between the starting and literature-based values for a parameter. Literature based values were 0.1 for base saturation, 2 for base cation to aluminum ratio and 2 for base cation to hydrogen ratio; and

- The Fixed Case models the lowest critical load for literature based values. The literature based values were 0.1 for base saturation, 2 for base cation to aluminum ratio and 2 for base cation to hydrogen ratio.

The Acid Deposition Management Framework of CEMA recommended utilizing the Mid-CV Case critical loads over a typical life span of most oil sands developments, or 30 years (CEMA, 2004). The closest available modelled values are for the mid-case and 50 year time frame. Table 9.4-5 provides three cases of 50 year critical loads modelled for the soils found in the oil sands region of northeastern Alberta.

Table 9.4-5 50 Year Critical Loads for AOSERP Soil Series by Case

Soil Series	75% CV Case	Mid CV Case	Fixed CV Case
	(kmol/ha/y)		
Algar Lake	0.20	0.40	1.10*
Bayard	0.6	0.70	1.10
Bitumont	0.40	0.50	1.10
Buckton	1.10	1.10	1.10
Chipewyan	1.10	1.10	1.10
Conklin	1.10	1.10	1.10
Dalkin	1.10	1.10	1.10
Dover	1.10	1.10	1.10
Firebag	0.10	0.55	1.00
Fort	0.50	0.90	1.10
Gipsy	1.10	1.10	1.10
Gregoire	0.50	0.50	0.50

Soil Series	**75% CV Case**	**Mid CV Case**	**Fixed CV Case**
	(kmol/ha/y)		
Hartley	1.10	1.10	1.10
Horse River	1.10	1.10	1.10
Joslyn	1.10	1.10	1.10
Kearl	0.60	0.80	1.10
Kinosis	0.80	1.00	1.10
Legend	1.00	1.10	1.10
Livock	1.10	1.10	1.10
Mamawi	1.10	1.10	1.10
Marguerite	0.50	0.40	0.80
Mariana	0.50	1.10	1.10
McLelland	1.10	1.10	1.10
McMurray	1.10	1.10	1.10
Mikkwa	0.70	0.80	1.10
Mildred	0.09	0.40	1.10
Muskeg	0.60	0.65	1.10
Namur	1.10	1.10	1.10
Ruth Lake	0.90	1.10	1.10
Steepbank	0.20	0.40	1.10
Surmont	1.10	1.10	1.10
Wabasca	1.10	1.10	1.10

Source: Abboud et al. (2002)

* Values represented in Table 9.4-5 as 1.10 or as 0.09 were identified in the original source work as greater than 1.0 and less than 0.10, respectively. A specific value has been assigned in Table 9.4-5 to allow for assessment against PAI values.

The critical loads shown in Table 9.4-5 are not strictly aligned with estimations of high, medium and low sensitivity to acidification. However, soil sensitivity ratings of high, medium and low have been designated by Clean Air Strategic Alliance (CASA) for various generic critical loads, as shown in Table 9.4-6. These generic ratings of high, medium and low give an indication of the relative range of potential for acidification associated with different critical load values.

Table 9.4-6 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	0.25 - <0.50
Low	0.50 - <1.00

*From CASA, 1999.

9.4.5 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. In the forested setting, wind erosion risk is affected by tree cover, wind velocity and soil texture. Soils with a sandy texture are more susceptible to wind erosion than those with a clay texture. Organic soils have negligible risk to wind erosion unless they present an open face or are dry. For the purposes of this report, Table 9.4-7 was adapted from Coote and Pettapiece (1989), Pedocan

(1993), and Devon Canada Corporation (2003). The ratings identified in Table 9.4-7 were applied to the soil series based on the soil texture of the surface horizons (approximately 10 cm to 20 cm), with reference to the subsoil textures. Where the wind erosion susceptibility seemed to fall between two classes, the rating applied to the soil series in Pedocan (1993) was considered and used.

Table 9.4-7 Classes of Wind Erosion Susceptibility Based on Soil Texture

Wind Erosion Class	Soil Texture
High	Very fine sand, sand, coarse sand, loamy sand, gravely sand, dry humic organic materials
Moderate	Sandy loam, fine sandy loam, loam, silt loam, sandy clay loam, sandy clay, mesic organic soil
Low	Silt, silty clay loam, clay loam, silty clay, clay, heavy clay, fibric organic soil

Source: Adapted from Coote and Pettapiece (1989), Pedocan Land Evaluation Ltd. (1993), and Devon Canada Corporation (2003).

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 0.06 to 0.065. More sandy soils have a K factor of 0.031. The rating system used for soils in the LSA is shown in Table 9.4-8. Organic soils are considered to have negligible water erosion potential as they generally occur on level topography and are usually wet throughout some or all of the year. If Organic soils are disturbed or dry out, they can have high water erosion potential.

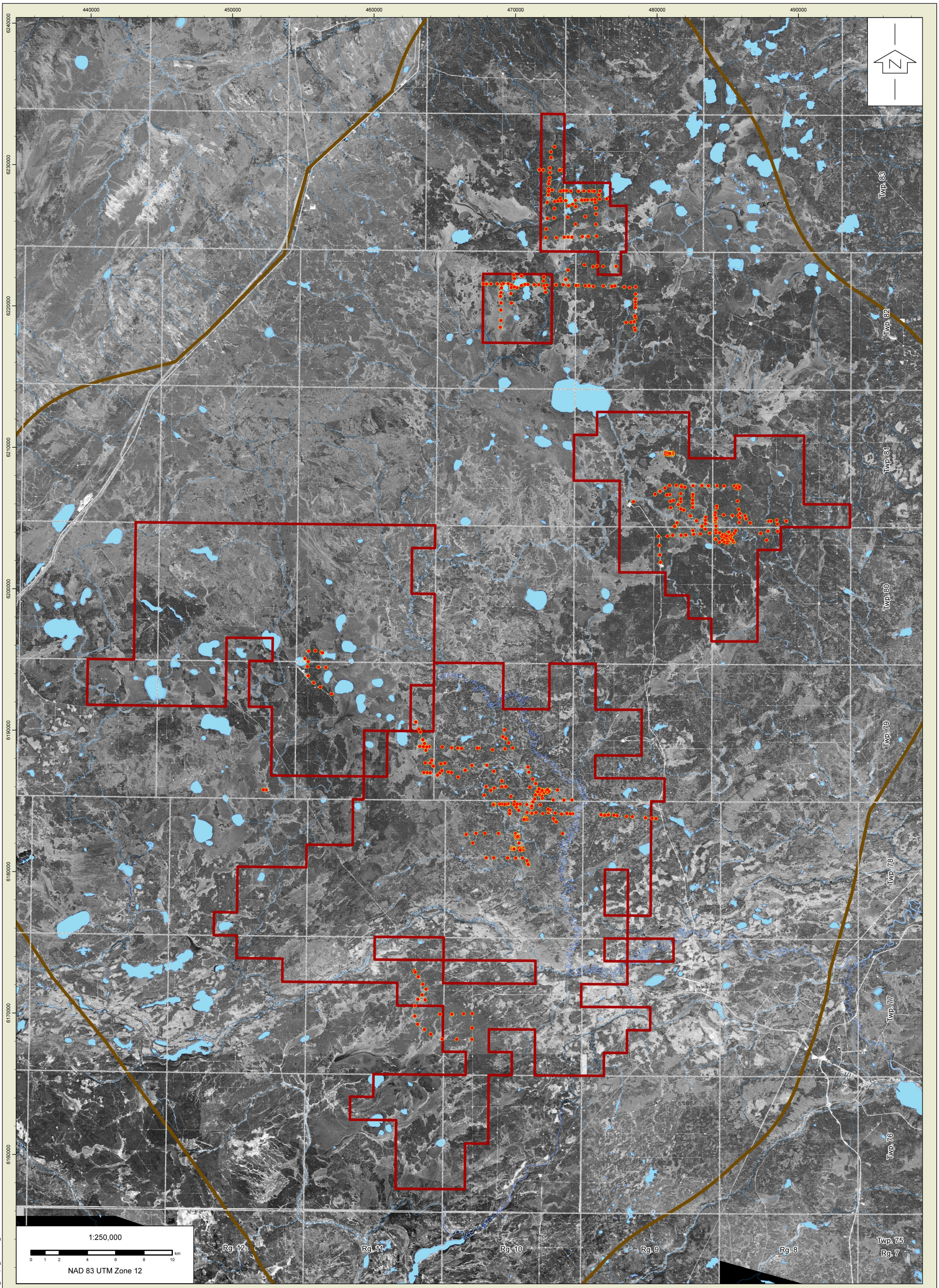
Table 9.4-8 Water Erosion Potential and Associated Potential Soil Losses for Soils in the LSA

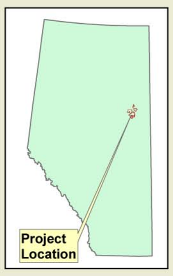
Water Erosion Potential	Slope Class	Slope Percentage	Slope Length (m)	LS Factor	K Factor
Low	1–3	<5	0–500	0.5–0.8	0.031–0.065
Moderate	4	5–9	50–500	0.8–2.2	0.031–0.065
High	5+	9+	50–500	2.2–3.5	0.040–0.065

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

9.4.6 Soil Mapping and Classification in the RSA

The RSA soil map and map units (soil series) were developed using surficial geology, AVI and aerial photograph information for both the LSA and RSA and referenced against the Christina Lake Regional Project (MEG Energy Corp., 2005) and the OPTI Canada Inc. Long Lake Project (OPTI, 2000). The RSA soils included additional soil types not occurring in the LSA; additional information on the RSA soils is presented in Section 9.5.9.





Legend

- Soil Inspection Locations
- North American Soils RSA
- North American Soils LSA
- Rivers
- Lake

Title:

SOIL INSPECTION AND SAMPLE LOCATIONS

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/SC	Revision Date: June 12, 2007

File: Fig 9.4-1_Soil_Inspection_Sample_Locations _20070612.mxd

Drawn by: TR	Checked: LZ/JB	Fig. No.: 9.4-1

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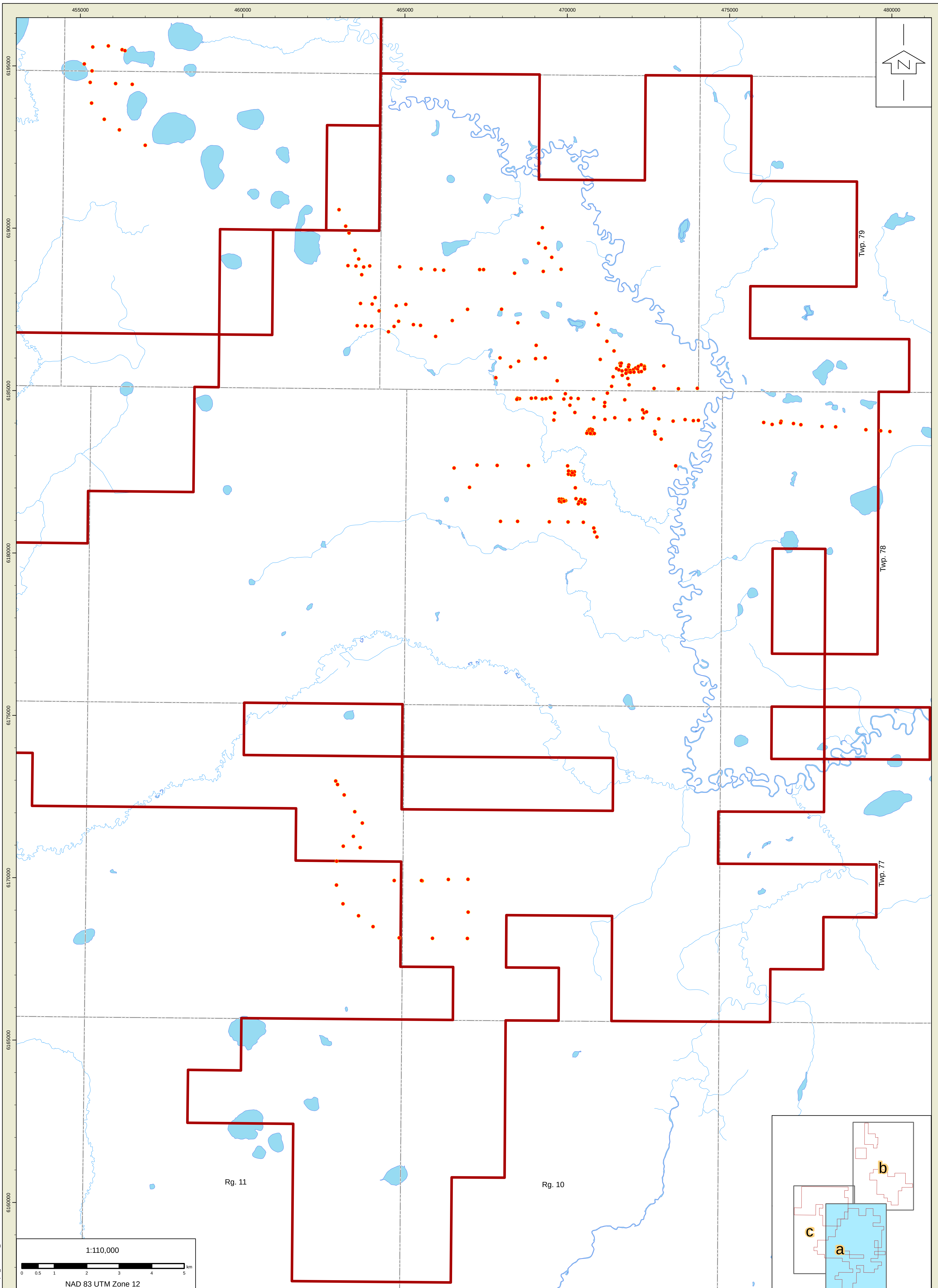

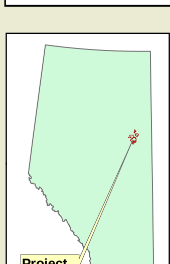

Legend

- Soil Inspection Locations
- North American Soils RSA
- North American Soils LSA
- Rivers
- Lake

Title:

SOIL INSPECTION AND SAMPLE LOCATIONS

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/SC	Revision Date: June 12, 2007
File: Fig 9.4-1a_Soil_Inspection_Sample_Locations_20070612	

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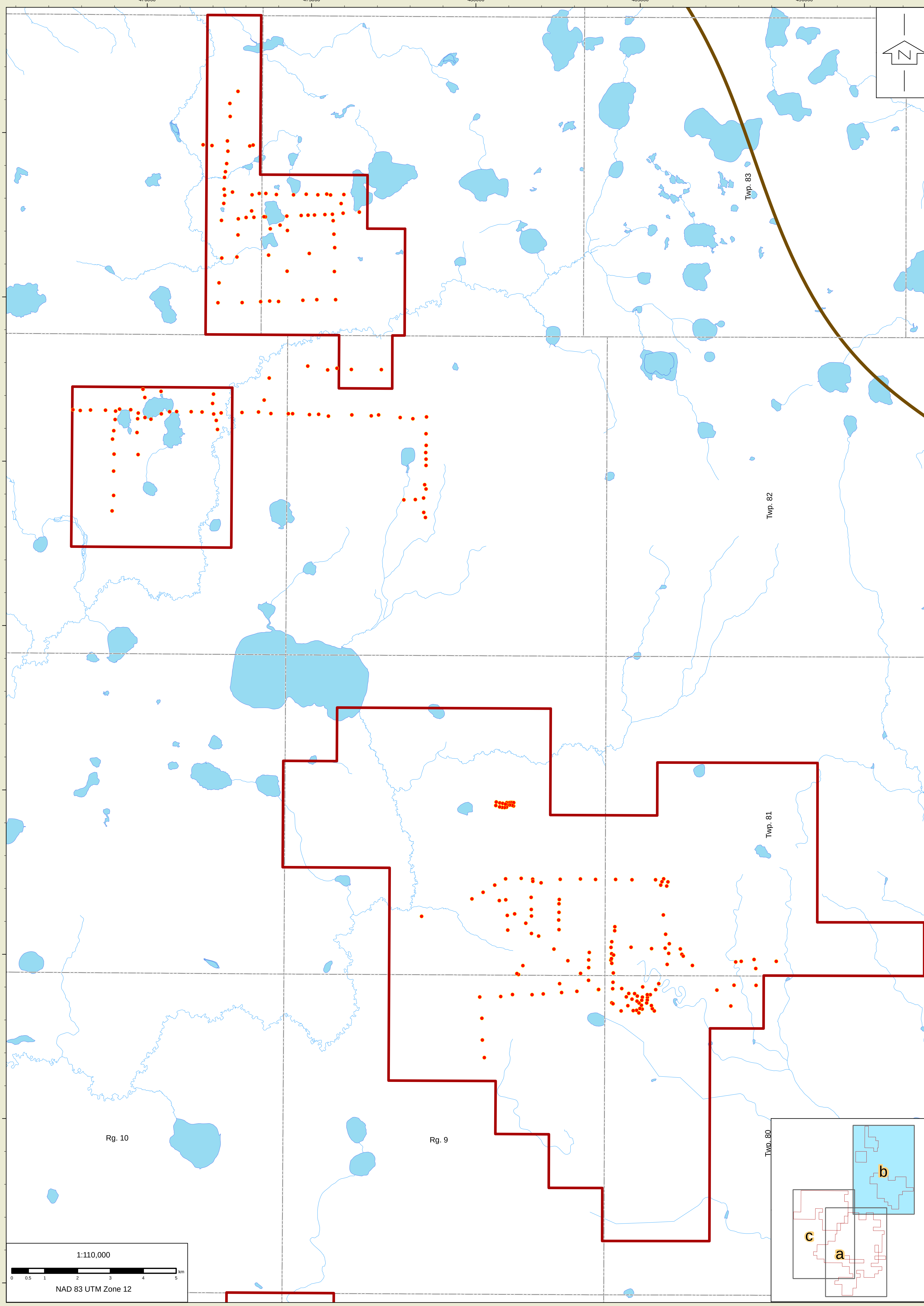

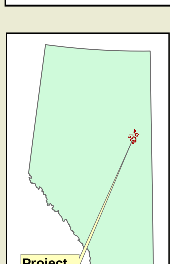

Legend

- Soil Inspection Locations
- North American Soils RSA
- North American Soils LSA
- Rivers
- Lake

Title:

SOIL INSPECTION AND SAMPLE LOCATIONS

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/SC	Revision Date: June 12, 2007

File: Fig 9.4-1b_Soil_Inspection_Sample_Locations_20070612

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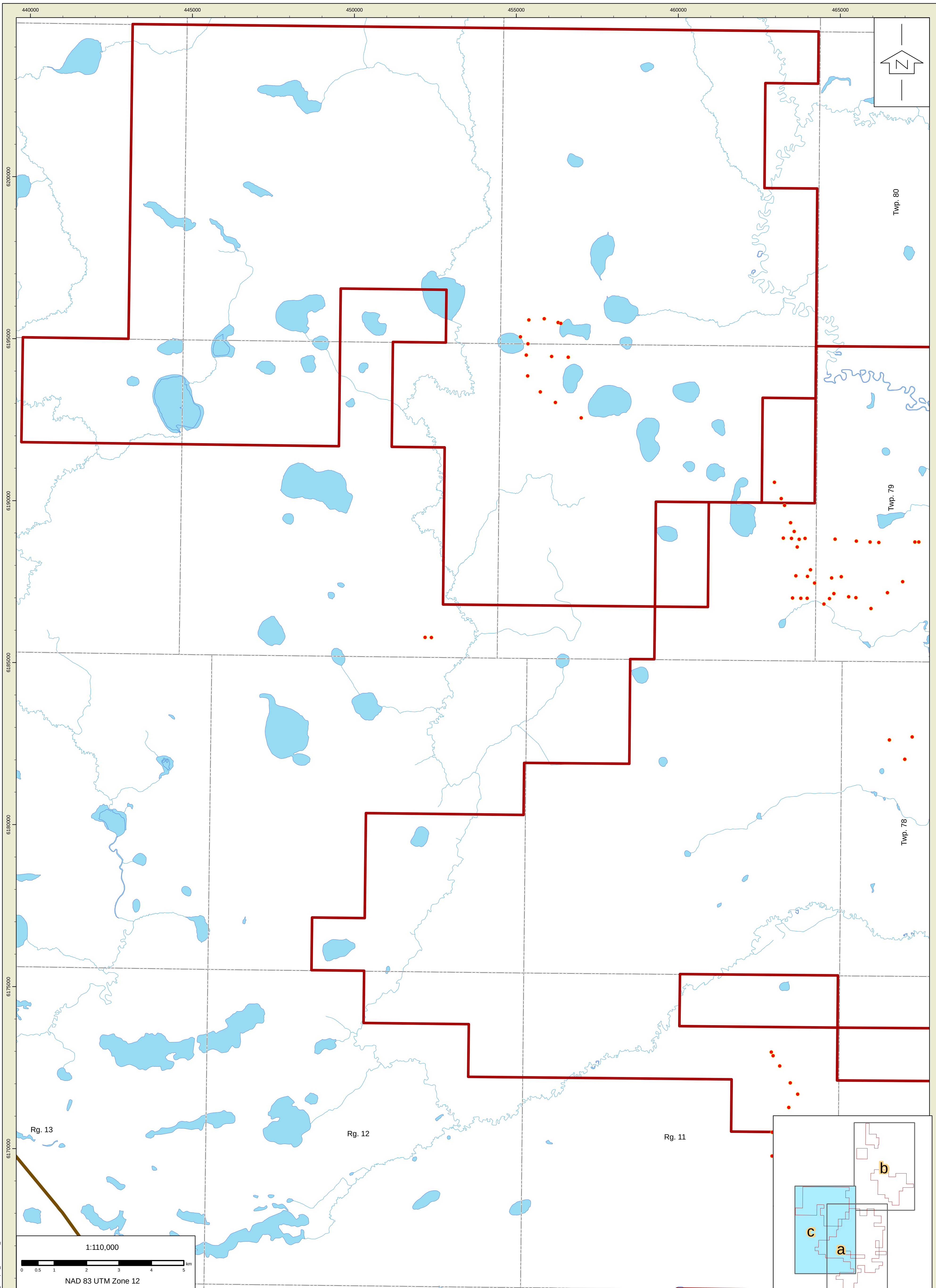
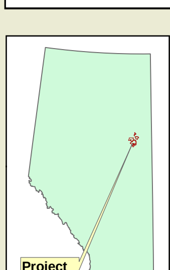




Legend

- Soil Inspection Locations
- North American Soils RSA
- North American Soils LSA
- Rivers
- Lake

Title:

SOIL INSPECTION AND SAMPLE LOCATIONS

Approved: CG/SC	Revision Date: June 12, 2007
File: Fig 9.4-1c_Soil_Inspection_Sample_Locations_20070612	
Drawn by: TR	Checked: LZ/JB
Fig. No.: **9.4-1c**	

9.5 Existing Conditions

The baseline biophysical environment is based on the Soils and Terrain LSA. The LSA covers approximately 110,938 ha. Land uses in the area include oil and gas production, forestry, traditional land use, and recreation.

Oil sands developments either existing or approved within the project study areas were assumed as part of the existing or baseline case. These projects include:

- OPTI Long Lake Project;
- Devon Jackfish SAGD Project;
- MEG Energy Christina Lake Regional Project;
- EnCana Christina Lake Pilot Project;
- ConocoPhillips Canada Resources Corp. Surmont Project;
- Petro-Canada Meadow Creek Project;
- Petrobank Whitesands Pilot;
- JACOS Hangingstone Project; and
- Connacher Great Divide Pilot.

Other existing developments in the study areas include various oil and gas industry facilities such as wells, buried pipelines and associated access roads. The other principal linear facilities in the RSA include Secondary Highways 881 and 63 and the Alberta Northern Railway traversing north to south within the RSA.

9.5.1 Geology and Physiography of the LSA

A detailed description of the physiography and geology is included in the groundwater quality sections 5.5.1 and 5.5.2 (Volume 3), respectively.

9.5.2 Soils in the LSA

A summary of soil properties and interpretations representative of the typical soil types is presented in the soil profile description tables in Appendix 9D.

Soils in the area were generally acidic, non-sodic and non-saline.

9.5.2.1 Organic Soils

Soils of the Organic Order are abundant in the lower elevation areas of the LSA. They are composed primarily of organic materials at various stages of decomposition, and include soils commonly known as peat or muskeg. Organic soils in the LSA have developed on poorly to very poorly drained depressional and level topography and are saturated with water for much of the year. A soil is classified as Organic if it has greater than 40 cm of partially (mesic) to highly (humic) decomposed organic material, or greater than 60 cm of weakly decomposed (fibric) organic material (Soil Classification Working Group, 1998).

Organic soil map units were mapped in approximately 51% of the LSA (56,253 ha). These soils have developed on fibric and mesic organic materials.

Organic soils associated with bog landforms were found in poorly to very poorly drained lower elevation areas on level to undulating terrain with level or nearly level slope gradients. These Organic soils are classified as Muskeg (MUS) series, which are characterized by greater than 160 cm peat, and Mariana (MRN) series, which have 40 cm to 160 cm of peat. The Mariana soils overlay till, glaciolacustrine or glaciofluvial materials. Both Muskeg and Mariana soils were common in the LSA. Muskeg soils covered 4,515 ha or 4% of the LSA, while Mariana soils covered 16,679 ha or 15% of the LSA. The Muskeg series were acidic with some samples having a pH below 4.

Organic soils associated with fen landforms were found on level terrain with very poor drainage. These Organic soils are classified as the McLelland (MLD) series (greater than 160 cm peat) and Hartley (HLY) series (40 cm to 160 cm peat). The Hartley soils overlay till, glaciolacustrine or glaciofluvial materials. Both McLelland and Hartley soils were common in the LSA. Hartley soils covered 6,674 ha or 6% of the LSA, and McClelland soils covered 28,306 ha or 26% of the LSA.

9.5.2.2 Luvisolic Soils

Luvisolic soils are found throughout the LSA and are the most common mineral soil type. The parent materials on which Luvisolic soils have developed include: till, colluviated till, glaciolacustrine, and glaciofluvial veneers over till. Luvisolic soils dominate the higher elevation areas. They also occur, to a lesser degree, in the lower elevation areas in association with other soil types. Luvisol soil map units were mapped over approximately 30% of the LSA (32,912 ha). Luvisols were differentiated from each other based on parent material origin as follows.

The dominant soils (Kinosis; KNS series) are moderately well drained Orthic Gray Luvisols developed on moderately fine- to fine-textured glacial till. These soils occur on undulating terrain with very gentle to undulating slope gradients. Gleyed Kinosis variants occur in lower slope, imperfectly drained areas. Surface soil textures are dominantly silt loam overlying a dominantly clay loam to sandy clay loam subsoil.

Moderately to well drained Orthic Gray Luvisols of the Surmont (SRT) series have developed on moderately fine- to fine-textured colluviated moraine (Lindsay and Turchenek, 1982). Surmont soils occur on stable slopes with variable slope gradients (generally gradients of 10% to 45% or more). Surface soil textures are dominantly silt loam overlying a dominantly clay loam to silty clay loam subsoil.

Orthic and Gleyed Gray Luvisols of the Dover (DOV) series have developed on moderately well to imperfectly drained, fine-textured glaciolacustrine materials. These soils occur predominantly on undulating terrain with nearly level to gently sloping gradients at lower elevations. Dover soils have dominantly silt loam surface textures underlain by textures ranging from clay loam to silty clay to clay.

Orthic and Brunisolic Gray Luvisols of the Fort (FRT) series have developed on well to moderately well drained, moderately coarse-textured glaciofluvial materials. These soils occur predominantly on undulating terrain with gentle to undulating slope gradients. At one location, a Fort soil was found on steeply sloping topography. Fort soils have dominantly sandy loam surface textures underlain by textures ranging from sandy loam to sandy clay loam, with one location having coarse sands at depth.

Orthic and Brunisolic Gray Luvisols of the Livock (LVK) series have developed on well to rapidly drained, moderately coarse- to coarse-textured glaciofluvial veneer materials overlying till parent materials. These soils occur predominantly on undulating terrain with gently sloping to undulating gradients; at one location this soil was found on a steeply sloping bank. Livock soils have moderately coarse-textured glaciofluvial materials underlain by textures ranging from moderately fine to fine.

9.5.2.3 Brunisolic Soils

Brunisols found in the LSA are coarse-textured soils with minimal soil profile development. Brunisol soil map units occur on approximately 3% of the LSA (3,795 ha). Soil analytical results indicated that the Brunisols in the region are of both the Dystric and Eutric Brunisol Great Groups.

Brunisolic soils developed on moderately coarse- to very coarse-textured glaciofluvial materials were designated as Mildred (MIL) series. These soils are well to rapidly drained and occur on undulating terrain with very gentle to moderate slope gradients. Surface soil and subsoil textures range from sandy loam to sand.

Brunisolic soils developed on gravelly, moderately coarse- to very coarse-textured glaciofluvial materials were designated as Firebag (FIR) series. These soils are well to rapidly drained and occur on undulating terrain with very gentle to moderate slope gradients. Gravels encountered within the soil profile can occur in ranges from 15% to 40% of the profile.

9.5.2.4 Gleysolic Soils

Gleysolic soils have developed in close association with areas of shallow organic soils mapped in the LSA. Peaty Gleysols characterized by a peaty (organic) surface layer ranging from 15 cm to 40 cm in thickness were common in the LSA. Gleysolic map units are dominantly in lower slope positions and cover approximately 6% of the LSA (6,900 ha). Gleysols are differentiated from one another largely by parent material origin.

Orthic Luvic Gleysols and subgroup variants that have developed mostly on level to nearly level topography, are poorly drained, with fine- to very fine-textured glaciolacustrine materials were designated as Algar Lake (ALG) soils series. Although Orthic Luvic Gleysol is the modal classification for these soils in SCA 20, the subgroup variants Orthic and Rego Gleysols developed on glaciolacustrine materials were more common. The variant soils have surface soil textures of silt loam to silty clay loam overlying subsoil textures of silty clay loam to silty clay.

Orthic Gleysols of the Steepbank (STP) series developed on till materials and terrain similar to the Algar Lake series. These soils have surface soil textures ranging from clay loam to silty clay loam, underlain by clay loam to sandy or silty clay loam textured subsoil.

9.5.2.5 Other Soils and Map Units

Stream Channel (SC) units were mapped in narrow zones along watercourses and comprised poorly developed mineral soils and organic soils. The mineral soils are dominantly Regosolic soils developed on fluvial parent material associated with active flood plains. Stream channel soil map units cover approximately 6% of the LSA (6,243 ha).

Rough Broken (RB) units are mapped in association with steeply sloping banks of stream channels.

Lakes are mapped as open waterbodies, and these map units cover approximately 2% of the LSA (2,136 ha).

9.5.3 Landforms in the LSA

Landform is the surface expression of surficial geological materials and the method of their deposition. The surficial materials and topography classes for the LSA are shown in Figure 9.5-1. Landform includes such factors as elevation, relief and slope. Landform information was collected during field soil inspections and was used when developing soil map units (Figure 9.5-2).

9.5.3.1 Organic Landforms (Nl, Nsl, Bsl and Bl Units)

Fens (Nl and Nsl units) are peat wetlands with water close to the surface. The water is usually nutrient rich and these units are groundwater fed. The peat is between 40 cm and 220 cm thick and these units are described using the N symbol. Those peatlands which are dominantly level are designated Nl. Nsl land form units describe fens that have shallow organic layers between 40 cm and 160 cm in depth, while Nl landform units describe fens which have greater than 160 cm of peat.

Bogs (Bl and Bsl units) are peat wetlands that are nutrient poor and that primarily receive their moisture through rainfall. The peat depth ranges between 40 cm and 220 cm thick, and they are distinguished using the B symbol. These peatlands have a dominantly level surface expression and are given the landform designation Bl. The Bl landform also includes the Mikkwa soil unit which contains frozen soil within the surface metre of the soil profile. Bsl land form units have shallow organic layers between 40 cm and 160 cm in depth, while Bl landform units describe bogs which have greater than 160 cm of peat.

9.5.3.2 Morainal Landforms (Ml, Mu, Mh, Mcu, Mch and Mu-Fgv Units)

Morainal material for this Project is designated as Kinosis (Ml, Mu, Mh) and Surmont (Mcu, Mch) soil units, and is a heterogeneous mix of sand, silt, clays, and pebbles and stones of varying sizes. Much of the morainal material is overlain by peat. Landforms for these morainal deposits are differentiated by type of morainal material (e.g., M for morainal and Mc for colluviated till material). Morainal landforms are further differentiated by relief. For example, Ml describes low relief, Mu or Mcu designates undulating landforms, and Mh or Mch describes high relief morainal landforms. The Livock soil unit has a veneer of sandy glaciofluvial outwash sands above the morainal material (Mu-Fgv).

9.5.3.3 Glaciofluvial Outwash Landforms (Fgu, Fgh, and Fgl Units)

Glaciofluvial deposits were moved by glaciers and deposited by streams from melting ice. The glaciofluvial deposits in the Project area are very coarse (loamy sands) and in some instances have gravel associated with them. The glaciofluvial outwash sands landform designations are different based on surface expression. Fgu units have gravel in their top 1 m and have an undulating surface expression, while Fgh units have strongly sloping surface expression. Fgl units are found to have level to nearly level topography.

9.5.3.4 Lacustrine Landforms (Lgl and Lgu Units)

Glaciolacustrine deposits are deposits moved by glaciers and then deposited by slow moving water and primarily consist of finer soil particles of silts and clays, resulting in finer textured soils. Glaciolacustrine landforms are primarily covered by surface peats and can occur in either low-lying areas (Lgl) or on better drained upland positions (Lgu) of the environment. Glaciolacustrine landforms are designated with the abbreviations Lgl and Lgu to indicate that there is some gravel associated with these landform units.

9.5.3.5 Channelled Landforms and Active Streams (C and Cs Units)

Channelled landforms are associated with actively flowing streams found in the LSA. These active stream channels are distinguished from each other as C units for those with low relief and Cs units which have steep slopes associated with the stream channel. Cs landform units are also described as being Rough Broken soil map units.

A summary of the main soil series and associated landforms identified in the LSA and their geographical extents is provided in Table 9.5-1.

Table 9.5-1 Extent of Main Soil Series and Landforms in the LSA

Soil Series	Code	Main Soil Subgroups	Parent Material	Landform Designation	Land Capability for Forestry	Area in LSA (ha)	Percent of LSA (%)
Organic Soils							
Hartley	HLY	Terric Fibrisol	Organic (fen)	Nsl	5	6,674	6.0
Marianna	MRN	Terric Mesisol	Organic (bog)	Bsl	5	16,679	15.0
McLelland	MLD	Typic and Terric Mesisols	Organic (fen)	Nl	5	28,306	25.5
Mikkwa	MKW	Fibric Organic Cryosol	Organic (fen)	Nl	5	79	0.1
Muskeg	MUS	Typic and Terric Mesisols	Organic (bog)	Bl	5	4,515	4.1
Luvisolic Soils							
Dover	DOV	Orthic Gray Luvisol	Glaciolacustrine	Lgl, Lgu	2	1,161	1.0
Fort	FRT	Orthic Gray Luvisol	Glaciofluvial	Fgu, Fgh	4	75	0.1
Kinosis	KNS	Orthic and Gleyed Gray Luvisols	Till	Ml, Mu, Mh	3	26,478	23.9
Livock	LVK	Orthic Gray Luvisol	Glaciofluvial/Till	Mu-Fg	3	635	0.6
Surmont	SRT	Orthic Gray Luvisol	Colluviated Till	Mcu, Mch	3	4,562	4.1
Brunisolic Soils							
Firebag	FIR	Eluviated Dystric Brunisols	Glaciofluvial	Fgu, Fgh	4	13	<0.1
Mildred	MIL:	Eluviated Dystric Brunisols	Glaciofluvial	Fgu, Fgl	4	3,783	3.4
Gleysolic Soils							
Algar Lake	ALG	Orthic and Rego Gleysols	Glaciolacustrine	Lgl	4	255	0.2
Steepbank	STP	Orthic Gleysols	Glaciolacustrine	Ml	5	6,645	6.0
Miscellaneous							
Non-soil Areas	Lakes SC RB	Lakes, Stream Channels and Rough Broken				8,455	7.6
Disturbed Land	DL					2,624	2.4
Total						**110,938**	**100.0**

9.5.4 Soil Map Units in the LSA

As described in Section 9.5.4, map units in the LSA comprise soils extensive enough to be distinguished separately at the scale of mapping and are based on published information and ground-truthing through soil inspections in the field. Soil interpretations were not done for stream channel map units due to the extreme variability of the soil in active fluvial environments.

The individual map units identified in the LSA are illustrated in Figure 9.5-3. The composition and series proportion for individual map units is summarized in Table 9.5-2. Stream channel, disturbed areas and open water map units were not further subdivided into smaller map units.

Each of the map units identified consists of a dominant soil series (50% or greater) with inclusions of significant series (additional series may have been encountered within the unit, but were not included if they represented less than 10% of the unit).

Table 9.5-2 Extent of Soil Map Units Identified in the LSA

Map Unit	Dominant Series		Significant Series		Land Capability for Forestry	Area (ha)	% of LSA
	Name	% of Unit	Name	% of Unit			
ALG-1	Algar Lake	60	Hartley	30	4	50	<0.1
ALG-2	Algar Lake	50	Marianna	30	4(5)	205	0.2
DOV-1	Dover	70	Algar Lake	30	2	1,140	1.0
DOV-2	gleyed Dover	60	Algar Lake	30	2	21	<0.1
FIR-1	Firebag	60	Livock Bitumont	20 20	4	13	<0.1
FRT-1	Fort	60	Livock	20	4	75	<0.1
HLY-1	Hartley	60	McClelland Steepbank	20 20	5	6,293	5.7
HLY-2	Hartley	60	Marianna Kinosis	20 20	5	381	0.3
KNS-1	Kinosis	60	Steepbank Peaty-Steepbank	20 20	3	6,279	6
KNS-2	Kinosis	60	Mildred Livock	20 20	3	14,282	12.9
KNS-3	Kinosis	60	Mildred Steepbank	20 20	3	2,229	2.0
KNS-4	Kinosis	70	Steepbank	30	3	3,688	3.3
LVK-1	Livock	60	Kinosis	20	3	635	0.6
MIL-1	Mildred	70	Marianna	30	4	278	0.3
MIL-2	Mildred	60	Kinosis	20	4	3,505	3.2
MKW-1	Mikkwa	60	Marianna Steepbank	20 20	5	79	0.1
MLD-1	McLelland	70	Hartley	30	5	27,668	24.9
MLD-2	McLelland	70	Muskeg	30	5	639	0.6
MRN-1	Marianna	70	Muskeg	30	5	6,811	6.1
MRN-2	Marianna	70	Steepbank	30	5	6,303	5.7
MRN-3	Marianna	70	Hartley	30	5	1,932	1.7
MRN-4	Marianna	60	Kinosis Steepbank	20 20	5	1,633	1.5
MUS-1	Muskeg	70	Marianna	30	5	4,296	3.9
MUS-2	Muskeg	50	McClelland Marianna	30 20	5	218	0.2
SRT-1	Surmont	70	Steepbank	30	3	3,961	3.6
SRT-2	Surmont	60	Mildred Steepbank	20 20	3	601	0.5

Map Unit	Dominant Series		Significant Series		Land Capability for Forestry	Area (ha)	% of LSA
	Name	% of Unit	Name	% of Unit			
STP-1	Steepbank	60	Kinosis	20	5	4,575	4.1
STP-2	Steepbank	60	Marianna	20	5	2,071	1.9
Sub-total						**99,859**	**90.0**
Non-soil units (RB, SC, Lake)					Unclassified	8,455	7.6
Disturbed Land (DL)						2,624	2.4
Total						**110,938**	**100.0**

Within the LSA, the Firebag soil series occupies the smallest area at 13 ha (less than 0.1% of the LSA). Organic soils cover the largest extent of the LSA at approximately 56,253 ha; McLelland soil series is the most prevalent covering approximately 28,306 ha (26% of the LSA). The majority of mineral soils are represented by Orthic Gray Luvisols, which cover an estimated 32,912 ha (30% of LSA), of which Kinosis soils account for 26,478 ha (24% of the LSA).

9.5.5 Land Capability Classification for Forest Ecosystems

Baseline land capability classes were developed for each soil series as described in Section 9.4.5.1. These classes were then applied to the soil map units for each soil series in the LSA (Table 9.5-2). In most cases, the dominant series accounted for 60% or greater of the map unit area, and the land capability for forest production was considered equivalent to that of the dominant series class. For example, map unit ALG-1 was evaluated and described as Class 4 (conditionally productive) and inclusions of Hartley soils (Class 5) were deemed insufficient to adjust the map unit capability. Map units in which dominant soils accounted for less than 60% were noted to have mixed capability, as shown for ALG-2. If the dominant series accounted for less than 50% of the map unit but the dominant and significant series had the same capability rating, no distinction was made.

A summary of the baseline land capability classes and the associated limitations to forest productivity is provided in Table 9.5-3. Land capability classes for the LSA are shown in Figure 9.5-4.

Table 9.5-3 Baseline Land Capability Classes and Sub-Class Limitations by Map Unit

Class	Sub-Class Limitations	Area (ha)	% of LSA
Class 1	***High capability***	0	0.0
Class 2	***Moderate capability***	**1,162**	**1**
DOV-1	Subsoil structure, subsoil acidity	1,141	1.0
DOV-2	Subsoil structure, subsoil acidity; areas of increased soil moisture (ALG)	21	<0.1
Class 3	***Low capability***	**3,1673**	**28.6**
KNS-1	Topsoil and subsoil acidity, subsoil structure; common depressional areas with increased soil moisture (STP)	6,279	5.7
KNS-2	Topsoil and Subsoil Acidity, Subsoil Structure	14,280	12.9
KNS-3	Topsoil and subsoil acidity, subsoil structure; interspersed with depressional areas with increased soil moisture (STP) and well drained areas with decreased soil moisture (MIL)	2,229	2.0
KNS-4	Topsoil and subsoil acidity, subsoil structure; some depressional areas with increased soil moisture (STP)	3,688	3.3
LVK-1	Topsoil and subsoil acidity, subsoil structure	635	0.6
SRT-1	Subsoil structure, nutrient regime, slope; some depressional areas with increased soil moisture (STP)	3,961	3.6

Class	Sub-Class Limitations	Area (ha)	% of LSA
SRT-2	Subsoil structure, nutrient regime, slope; interspersed with depressional areas with increased soil moisture (STP) and well drained areas with decreased soil moisture (MIL)	601	0.5
Class 4	***Conditionally productive***	**4,126**	**3.7**
ALG-1	Soil moisture (wet), subsoil structure	50	<0.1
ALG-2	Soil moisture (wet), subsoil structure; common areas of deeper peat (40-120 cm)	205	0.2
FIR-1	Soil moisture (dry), nutrient retention	13	<0.1
FRT-1	Subsoil structure, topsoil and subsoil acidity	75	0.1
MIL-1	Soil moisture (dry), nutrient retention, topsoil acidity; some areas of deeper peat (40-120 cm)	278	0.2
MIL-2	Soil moisture (dry), nutrient retention, topsoil acidity	3,505	3.2
Class 5	***Non-productive***	**62,898**	**56.7**
HLY-1	Organic (peat) surface	6,293	5.7
HLY-2	Organic (peat) surface; interspersed with bog areas (MRN) and some areas of isolated upland (KNS)	381	0.3
MKW-1	Soil moisture (wet), topsoil and subsoil acidity, subsoil structure	79	0.1
MLD-1	Organic (peat), nutrient retention	27,667	24.9
MLD-2	Organic (peat), nutrient retention; some areas of deep peat (120+ cm)	639	0.6
MRN-1	Organic (peat); some areas of deep peat (120+ cm)	6,811	6.1
MRN-2	Organic (peat); some areas of shallow peat surface (STP)	6,303	5.7
MRN-3	Organic (peat);	1,932	1.7
MRN-4	Organic (peat); interspersed with shallow peat surface (STP) and isolated upland areas (KNS)	1,633	1.5
MUS-1	Organic (peat), topsoil and subsoil acidity	4,296	3.9
MUS-2	Organic (peat), topsoil and subsoil acidity; some isolated areas of fen (MLD)	218	0.2
STP-1	Soil Moisture (wet), topsoil and subsoil structure, some isolated areas of upland (KNS)	4,575	4.1
STP-2	Soil Moisture (wet), topsoil and subsoil structure; some areas of deeper peat (MRN)	2,071	1.9
Subtotal		**99,859**	**90.0**
Non-Soil Units (RB, SC, Lake)		8,455	7.6
Disturbed Land		2,624	2.4
Total		**110,938**	**100.0**

No occurrences of Class 1 soils for forest production were encountered in the LSA. The moderately well drained, Class 2 Dover soils (1,162 ha; 1% of the LSA) have the highest capability for forest production and are limited only by subsoil structure (structure restricts root penetration).

Low productivity Class 3 soils, all represented by dominantly Orthic Gray Luvisolic soils, include Kinosis, Livock and Surmont. Limitations to forest productivity included subsoil structure and acidity (lower pH). Surmont soils, in addition to structure and nutrient limitations, are associated with colluvial deposits since these soils are situated on, and limited by, slope gradients ranging from 10% to 45%. Together, these soils account for approximately 29% of the area (31,675 ha) of the LSA.

Lower pH values throughout the soil profile of the Fort soil series, also an Orthic Gray Luvisol, resulted in a forest capability rating of Class 4.

The majority of Class 4 soils, however, are characterized by marginally productive soil series limited by extremes in moisture availability; dominantly coarse-textured Brunisolic units are typically too dry (FIR-1, MIL-1, and MIL-2), while water saturated Gleysolic units are too wet

(ALG-1, and ALG-2). Eluviated Dystric and Eutric Brunisols encountered in the LSA included Mildred and Firebag soils. Both Mildred and Firebag soil series were inspected in the field; however, only Mildred soils were sampled. The analytical data for a selection of the Mildred sites were evaluated for land capability; however, calculated capability classes for Mildred soils ranged from Class 2 to Class 5. Published data from other studies in the area were reviewed for historical ratings for Mildred soils; Mildred soils were typically ranked Class 4. This ranking was used in this report.

Both Brunisolic soils series were given a final rating of Class 4, with soil texture limitations. The total area of Class 4 soils is approximately 4% (4,126 ha) of the LSA.

Bog and fen areas, Class 5 (non-productive) soils, cover the greatest percentage of the LSA (57% or 62,899 ha). The Organic soils (Hartley, Marianna, McLelland and Muskeg soils) and the Cryosolic Mikkwa soils compose the majority of the Class 5 land area, representing approximately 51% (56,253 ha) of the LSA. Limitations to forest productivity are largely associated with deeper surficial organic horizons and high soil moisture; soil acidity and nutrient retention are also limitations characteristic of these soils. The remaining 6% (6,645 ha) of the Class 5 soils are attributed to the Gleysolic Steepbank map units (STP-1 and STP-2).

9.5.6 Soil Suitability for Reclamation

Reclamation suitability ratings for surface (upper lift) and subsurface (lower lift) soil materials were determined for each soil series in the LSA. Ratings are presented in Table 9.5-4. This rating system applies to mineral soil only and does not include Organic soils (Alberta Agriculture, 1987).

Table 9.5-4 Reclamation Suitability of Mineral Soils in the LSA

Soil Series	Surface Reclamation Suitability	Limitations	Subsurface Reclamation Suitability	Limitations
Algar Lake	---	Surface Peat	Fair	Consistence, texture
Dover	Good	---	Poor	Consistence, texture
Firebag	Poor	Texture	Poor	Texture
Fort	Fair	Reaction (pH)	Fair	Texture, pH
Kinosis	Good	---	Fair	Consistence, texture, pH
Livock	Fair	pH	Fair	Consistence, texture, pH
Mildred	Poor	Texture	Poor	Texture
Steepbank	---	Surface Peat	Fair	Consistence, texture
Surmont	Good	---	Fair	Texture

Algar Lake and Steepbank soils encountered during site inspections were often characterized by thicker surface peat layers and thin or absent A horizons. Therefore, no ranking was assigned to the upper lift for these soils and the limitation was noted as Surface Peat.

Mineral soils assigned the highest reclamation ratings (Dover, Kinosis, and Surmont series) cover approximately 29% (32,201 ha) of the LSA. The upper lift was rated good for all three series, and the lower lift was rated fair for Kinosis and Surmont soils. The lower lift of the Dover soils series, however, was rated poor due to increased clay content.

Dover, Fort and Livock soil series were assigned ratings of fair for both upper and lower lifts, indicating minor limitations to reclamation suitability that may be addressed through appropriate mitigation measures.

Reclamation suitability maps are presented in Figure 9.5-5 (Surface) and Figure 9.5-6 (Subsurface). Table 9.5-5 provides a summary of reclamation suitability ratings calculated for each mineral soil map unit in the LSA.

Table 9.5-5 Reclamation Suitability Ratings for Mineral Soil Map Units in the LSA

Map Unit	Surface Reclamation Suitability	Limitations	Subsurface Reclamation Suitability	Limitations	Area (ha)	% of LSA
ALG-1	---	Surface Peat	Fair	Consistence, Texture	50	<0.1
ALG-2	---	Surface Peat	Fair - Unsuitable	Consistence, Texture, Deeper Peat	205	0.2
DOV-1	Good	---	Poor	Texture	1,140	1.0
DOV-2	Good	---	Poor	Texture	21	<0.1
FIR-1	Poor	Texture	Poor	Texture	13	<0.1
FRT-1	Fair	Reaction (pH)	Fair	Texture, pH	75	0.1
KNS-1	Good	---	Fair	Consistence, Texture, pH	6,279	5.7
KNS-2	Good	---	Fair	Consistence, Texture, pH	14,282	12.9
KNS-3	Good	---	Fair	Consistence, Texture, pH	2,229	2.0
KNS-4	Good	---	Fair	Consistence, Texture, pH	3,688	3.3
LVK-1	Fair	pH	Fair	Consistence, Texture, pH	635	0.6
MIL-1	Poor	Texture	Poor	Texture	278	0.2
MIL-2	Poor	Texture	Poor	Texture	3,505	3.2
SRT-1	Good	---	Fair	Texture	3,961	3.6
SRT-2	Good	---	Fair	Texture	601	0.5
STP-1	---	Surface Peat	Fair	Consistence, texture	4,575	4.1
STP-2	---	Surface Peat	Fair	Consistence, texture	2,071	1.9
Organic Soil					56,253	50.7
Non-Soil Units (RB, SC, Lakes)					8,455	7.6
Disturbed Land					2,624	2.4
Total	---	---	---	---	**110,938**	**100.0**

Table 9.5-6 provides a summary of the extent of each of the reclamation suitability classes within the LSA.

Table 9.5-6 Areas of Reclamation Suitability Classes of Mineral Soils in the LSA

Reclamation Suitability Rating	Upper Lift		Lower Lift	
	Area (ha)	%LSA	Area (ha)	%LSA
Good	32,201	29.0	0	---
Fair	711	0.6	38,650	34.8
Poor	3,795	3.4	4,957	4.5
Surface Peat	6,900	6.2	0	---
Organics	56,253	50.7	56,253	50.7
Non-Soil Units (RB, SC, Lakes)	8,455	7.6	8,455	7.6
Disturbed Lands	2,624	2.4	2,624	2.4
Total	**110,938**	**100.0**	**110,938**	**100.0**

Upper lift ratings were not assigned to Algar Lake or Steepbank map units due to thicker organic surface layers, and often absent A horizons.

9.5.7 Soil Sensitivity to Acid Deposition

Sensitivity to acidification ratings were assigned to map units based on the rating assigned to the dominant soil series. The sensitivity of each soil series to acid deposition is presented in Table 9.5-7.

Historical forest fires have occurred over much of the LSA. Site inspections conducted in the burned areas and analytical results show the organic and mineral soils are comparable to non-burned soils with respect to LFH depths, organic layer depths and CEC. As the fires did not appear to have a residual effect on the top 20 cm of soil, the 50 year Mid-CV Case critical load model was used for all soils.

Using the Mid-CV Case critical loads, there are no soils in the LSA considered to have a high sensitivity to acidification in a 50 year time frame.

Table 9.5-7 Sensitivity of Soils in the LSA to Acid Deposition by Series

Soils Series	50 Year Mid-CV Case Critical Load (kmol H^+/ha/y)	Estimated Sensitivity to Acidification	
		Rating	Critical Load Range (kmol H^+/ha/y)
Algar Lake	0.40	Medium	0.25 – 0.5
Dover	1.10	Low	0.5 +
Firebag	0.55	Low	0.5 +
Fort	0.90	Low	0.5 +
Hartley	1.10	Low	0.5 +
Kinosis	1.00	Low	0.5 +
Livock	1.10	Low	0.5 +
Mikkwa	0.80	Low	0.5 +
Mildred	0.40	Medium	0.25 – 0.5
Mariana	1.10	Low	0.5 +
McLelland	1.10	Low	0.5 +
Muskeg	0.65	Low	0.5 +
Steepbank	0.40	Medium	0.25 – 0.5
Surmont	1.10	Low	0.5 +

Table 9.5-8 provides a summary of sensitivity ratings for each map unit in the LSA. Sensitivity ratings were assigned to map units based on the rating assigned to the dominant soil series in the

map unit. Both ratings were presented where the map units had co-dominant soil series, using brackets for the co-dominant soil series. Figure 9.5-7 illustrates the extent of soils rated low, medium and high sensitivity, as defined by the individual soil critical chemical value.

Table 9.5-8 Acidification Sensitivity of Soil Map Units in the LSA

Map Unit	Dominant Series	Significant Series	Acidification Sensitivity	Area (ha)	% of LSA
ALG-1	Algar Lake	Hartley	Medium	50	<0.1
ALG-2	Algar Lake	Marianna	Medium (Low)	205	0.2
DOV-1	Dover	Algar Lake	Low	1,140	1.0
DOV-2	Gleyed Dover	Algar Lake	Low	21	<0.1
FIR-1	Firebag	Livock Bitumont	Low	13	<0.1
FRT-1	Fort	Livock	Low	75	0.1
HLY-1	Hartley	McClelland Steepbank	Low	6,293	5.7
HLY-2	Hartley	Marianna Kinosis	Low	381	0.3
KNS-1	Kinosis	Steepbank	Low	6,279	5.7
KNS-2	Kinosis	Mildred Livock	Low	14,282	12.9
KNS-3	Kinosis	Mildred Steepbank	Low	2,229	2.0
KNS-4	Kinosis	Steepbank	Low	3,688	3.3
LVK-1	Livock	Kinosis	Low	635	0.6
MIL-1	Mildred	Marianna	Medium	278	0.2
MIL-2	Mildred	Kinosis	Medium	3,505	3.2
MKW-1	Mikkawa	Marianna Steepbank	Low	79	0.1
MLD-1	McLelland	Hartley	Low	27,668	24.9
MLD-2	McLelland	Muskeg	Low	639	0.6
MRN-1	Marianna	Muskeg	Low	6,811	6.1
MRN-2	Marianna	Steepbank	Low	6,303	5.7
MRN-3	Marianna	Hartley	Low	1,932	1.7
MRN-4	Marianna	Kinosis Steepbank	Low	1,633	1.5
MUS-1	Muskeg	Marianna	Low	4,296	3.9
MUS-2	Muskeg	McClelland Marianna	Low (Low)	218	0.2
SRT-1	Surmont	Steepbank	Low	3,961	3.6
SRT-2	Surmont	Mildred Steepbank	Low	601	0.5
STP-1	Steepbank	Kinosis	Low	4,575	4.1
STP-2	Steepbank	Marianna	Low	2,071	1.9
Unclassified (Lakes, SC, RB)				8,455	7.6
Disturbed Land				2,624	2.4
Total				**110,938**	**100.0**

Ratings in brackets are that of the co-dominant soil series.

Table 9.5-9 summarizes the area and percentage of the LSA occupied by soils of various acidification sensitivity ratings. Using the modelled critical loads for the Mid-CV Case, no highly sensitive soils are located in the LSA.

Table 9.5-9 Extent of Acidification Sensitivity of Soils in the LSA

Acidification Sensitivity Rating	Critical Load Range (keq H^+/ha/y)	Area (ha)	Proportion of LSA (%)
Low	0.5 +	89,179	80.4
Medium	0.25 – 0.5	10,680	9.6
High	0-<0.25	0	0
Unclassified (RB, SC, Lakes)	No range	8,455	7.6
Disturbed Land	No range	2,624	2.4
Total	Not applicable	**110,938**	**100.0**

9.5.8 Soil 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 presented in Table 9.5-10. The risk of erosion is interpreted to increase with increasing slope (water) and exposure of soil faces (wind and water).

As mentioned in Section 9.5.7, LFH and organic layer depths in the burned areas were comparable to non-burned areas. Therefore, burned areas were rated in the same manner as the non-burned areas.

Table 9.5-10 Risk of Soils to Wind and Water Erosion in the LSA

Soil Series	Risk to Wind Erosion	Risk to Water Erosion
Algar Lake	Low	Low
Dover	Low	Low, increasing with slope steepness to high at slopes greater than 9%
Firebag	High	Low, increasing with slope steepness to high at slopes greater than 9%
Fort	Moderate	Low, increasing with slope steepness to high at slopes greater than 9%
Hartley	Negligible	Negligible
Kinosis	Low	Low, increasing with slope steepness to high at slopes greater than 9%
Livock	Moderate	Low, increasing with slope steepness to high at slopes greater than 9%
Mariana	Negligible	Negligible
Mikkwa	Negligible	Negligible
Mildred	High	Low, increasing with slope steepness to high at slopes greater than 9%
McLelland	Negligible	Negligible
Muskeg	Negligible	Negligible
Steepbank	Low	Low
Surmont	Low	Low, increasing with slope steepness to high at slopes greater than 9%

Erosion potential ratings were assigned to map units based on the rating assigned to the dominant soil series in the map unit. Both ratings were presented where the map units had co-dominant soil series, using brackets for the co-dominant soil series. A wind erosion potential map is presented in Figure 9.5-8, and a water erosion potential map is presented in Figure 9.5-9. Table 9.5-11 and Table 9.5-12 provide summaries of wind and water erosion risk ratings calculated for each map unit in the LSA, respectively.

Table 9.5-11 Risk of Wind Erosion of Soil Map Units in the LSA

Map Unit	Wind Erosion Risk	Area (ha)	% of LSA
ALG-1	Low	50	<0.1
ALG-2	Low (Low)	205	0.2
DOV-1	Low	1,140	1.0
DOV-2	Low	21	<0.1
FIR-1	High	13	<0.1
FRT-1	Moderate	75	0.1
HLY-1	Negligible	6,293	5.7
HLY-2	Negligible	381	0.3
KNS-1	Low	6,279	5.7
KNS-2	Low	14,282	12.9
KNS-3	Low	2,229	2.0
KNS-4	Low	3,687	3.3
LVK-1	Moderate	635	0.6
MIL-1	High	278	0.2
MIL-2	High	3,505	3.2
MKW-1	Negligible	79	0.1
MLD-1	Negligible	27,668	24.9
MLD-2	Negligible	639	0.6
MRN-1	Negligible	6,811	6.1
MRN-2	Negligible	6,303	5.7
MRN-3	Negligible	1,932	1.7
MRN-4	Negligible	1,633	1.5
MUS-1	Negligible	4,296	3.9
MUS-2	Negligible	218	0.2
SRT-1	Low	3,961	3.6
SRT-2	Low	601	0.5
STP-1	Low	4,575	4.1
STP-2	Low	2,071	1.9
Non-Soil Units (RB, SC, Lakes)		8,455	7.6
Disturbed Land		2,624	2.4
Total		**110,938**	**100.0**

Ratings in brackets are that of the co-dominant soil series.

Table 9.5-12 Risk of Water Erosion of Soil Map Units and Topographical Relief in the LSA

Map Unit	Topographical Class	Water Erosion Risk	Area (ha)	% of LSA
ALG-1	1-3	Low	50	<0.1
ALG-2	1-3	Low (Low)	205	0.2
DOV-1	1-3	Low	1,140	1.0
DOV-2	1-3	Low	21	<0.1

Map Unit	Topographical Class	Water Erosion Risk	Area (ha)	% of LSA
FIR-1	1-3	Low	5	<0.1
FIR-1	4	Moderate	8	<0.1
FRT-1	4	Moderate	75	0.1
HLY-1	1-3	Negligible	6,293	5.7
HLY-2	1-3	Negligible	381	0.3
KNS-1	1-3	Low	3,777	3.4
KNS-1	4	Moderate	1,991	1.8
KNS-1	5+	High	511	0.5
KNS-2	1-3	Low	9,561	8.6
KNS-2	4	Moderate	4,549	4.1
KNS-2	5+	High	172	0.2
KNS-3	1-3	Low	1,899	1.7
KNS-3	4	Moderate	320	0.3
KNS-3	5+	High	10	<0.1
KNS-4	1-3	Low	458	0.4
KNS-4	4	Moderate	3,230	2.9
LVK-1	1-3	Low	513	0.5
LVK-1	4	Moderate	105	0.1
LVK-1	5	High	17	<0.1
MIL-1	1-3	Low	202	0.2
MIL-1	4	Moderate	76	0.1
MIL-2	1-3	Low	2,882	2.6
MIL-2	4	Moderate	570	0.5
MIL-2	5+	High	53	<0.1
MKW-1	1-3	Negligible	79	0.1
MLD-1	1-3	Negligible	27,650	24.9
MLD-1	5+	Negligible	18	<0.1
MLD-2	1-3	Negligible	639	0.6
MRN-1	1-3	Negligible	6,811	6.1
MRN-2	1-3	Negligible	6,302	5.7
MRN-3	1-3	Negligible	1,932	1.7
MRN-4	1-3	Negligible	1,633	1.5
MUS-1	1-3	Negligible	4,296	3.9
MUS-2	1-3	Negligible	218	0.2
SRT-1	1-3	Low	497	0.4
SRT-1	4	Moderate	2,218	2.0
SRT-1	5+	High	1,246	1.1
SRT-2	1-3	Low	3	<0.1
SRT-2	4	Moderate	598	0.5
STP-1	1-3	Low	4,565	4.1
STP-1	4	Moderate	10	<0.1
STP-2	1-3	Low	2,071	1.9
Non-Soil Units (RB, SC, Lakes)			8,455	7.6
Disturbed Land			2,624	2.4
Total			**110,938**	**100.0**

Ratings in brackets are that of the co-dominant soil series.

Generally, the loamy to clay soil textures present in the mineral soils contribute to an estimation of relatively low wind erosion potential. The Mildred and Firebag soils have high sand content and are subject to high wind erosion risk.

Organic soils generally are rated as having negligible wind and water erosion risk due to their level topography and moist condition, unless the soil face (at an excavation) is exposed or dried.

Similarly, the Algar Lake and Steepbank soils are rated as having low risk to erosion due to their organic surface layer, level topography, and clay subsoil.

In all cases, slope gradient affects the potential for water erosion. Many of the mineral soils are found on level to undulating terrain with gentle slopes; fewer areas are mapped with steep slopes and high water erosion potential.

Table 9.5-13 summarizes the area and percentage of the LSA and the associated risk to wind and water erosion.

Table 9.5-13 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	27,849	25.1	Low	39,101	35.3
Moderate	13,748	12.4	Moderate	710	0.6
High	2,009	1.8	High	3796	3.4
Negligible	56,253	50.7	Negligible	56,253	50.7
Non-Soil Units (RB, SC, Lakes)	8,455	7.6	Non-Soil Units (RB, SC, Lakes)	8,455	7.6
Disturbed Land	2,624	2.4	Disturbed Land	2,624	2.4
Total	**110,938**	**100.0**		**110,938**	**100.0**

9.5.9 Soil Series in the RSA

Figure 9.5-10 shows the soils mapped in the RSA, and Table 9.5-14 lists total area and percent area of each series in the RSA. The Horse River soil series was the only series encountered in the RSA that was not present in the LSA. As in the LSA, rough broken, stream channels, lakes, and disturbed lands are mapped in the RSA as separate non-soils units.

Table 9.5-14 Areas of Soil Series in the RSA[1]

Soil Series	Area (ha)	%RSA
Algar Lake	273	0.1
Dover	9,306	2.0
Firebag	4,514	1.0
Fort	86	<0.1
Hartley	12,171	2.6
Horse River	8,950	1.9
Kinosis	154,843	32.6
Livock	2,785	0.6
Mariana	28,468	6.0
Mikkwa	83	<0.1
Mildred	8,968	1.9
McLelland	174,089	36.7
Muskeg	9,472	2.0
Steepbank	6,777	1.4
Surmont	16,703	3.5
Non-Soil Units (RB, SC, Lakes)	27,963	5.9
Disturbed Land	9,251	1.9
Total	**474,702**	**100.0**

1 Adapted from the Long Lake Project Environmental Impact Report regional soil map (OPTI, 2000)

As indicated in Table 9.5-14, Organic soils (Hartley, Mikkwa, Mariana, McClelland and Muskeg soil series) dominate the RSA occupying approximately 47% of the RSA. The dominant mineral soils are Kinosis soils occupying approximately 33% of the RSA. Some general soil characteristics of the additional soils in the RSA (ASIC, 2001) are described below.

9.5.9.1 Horse River

Horse River (HRR) soils are Orthic Gray Luvisols developed on moderately fine till parent material. These soils are well drained, upland soils and generally occur in undulating to rolling terrain with slopes ranging from 2% to 15% or more.

9.5.10 Acidification Potential of Soils in the RSA

The soils of the RSA were rated for sensitivity to acidification using the criteria set out in Section 9.4.6. This results in the ratings for RSA soils shown in Table 9.5-15.

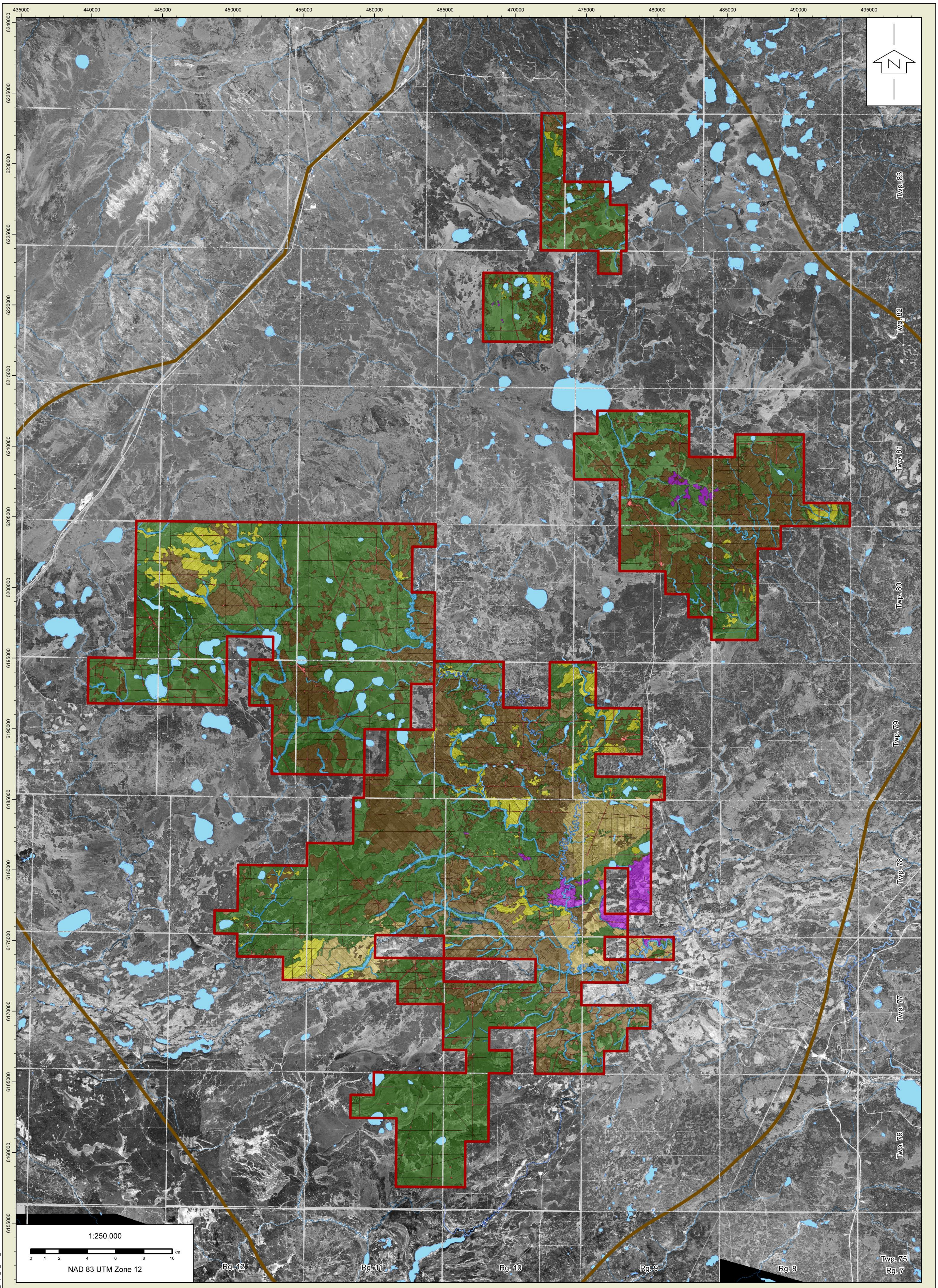
Table 9.5-15 Sensitivity of Soils in the RSA to Acid Deposition by Series

Soils Series	50 Year Mid CV Case Critical Load (kmol H^+/ha/y)	Sensitivity to Acidification	Critical Load Range (kmol H^+/ha/y)
Algar	0.40	Medium	0.25 – 0.5
Dover	1.10	Low	0.5 +
Firebag	0.55	Low	0.5 +
Fort	0.90	Low	0.5 +
Hartley	1.10	Low	0.5 +
Horse River	1.10	Low	0.5 +
Kinosis	1.00	Low	0.5 +
Livock	1.10	Low	0.5 +
Mariana	1.10	Low	0.5 +
McLelland	1.10	Low	0.5 +
Mildred	0.40	Medium	0.25 – 0.5
Mikkwa	0.80	Low	0.5 +
Muskeg	0.65	Low	0.5 +
Steepbank	0.40	Medium	0.25 – 0.5
Surmont	1.10	Low	0.5 +

A summary of areas in the RSA rated high, medium and low for sensitivity to acidification is presented in Table 9.5-16.

Table 9.5-16 Extent of Acidification Sensitivity of Soils in the RSA

Acidification Sensitivity Rating (Critical Load Ranges)	Area (ha)	Proportion of RSA (%)
Low (0.5+ keq H^+/ha/y)	421,691	88.83
Medium (0.25 keq H^+/ha/y to 0.5 keq H^+/ha/y)	15,774	3.32
Unclassified (RB, SC Lakes, Disturbed)	37,237	7.85
Total	**474,702**	**100.00**



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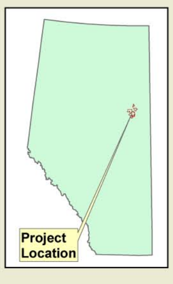


Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Topographic Classes

Level to nearly level	1; 1-2; 2;
Gently undulating	(2-3; 3)
Undulating	(3-4; 4)
Moderate to strong slopes	(4-5; 5; 5-6; 6)
Very strong slopes	(7; RB)

Surficial Materials

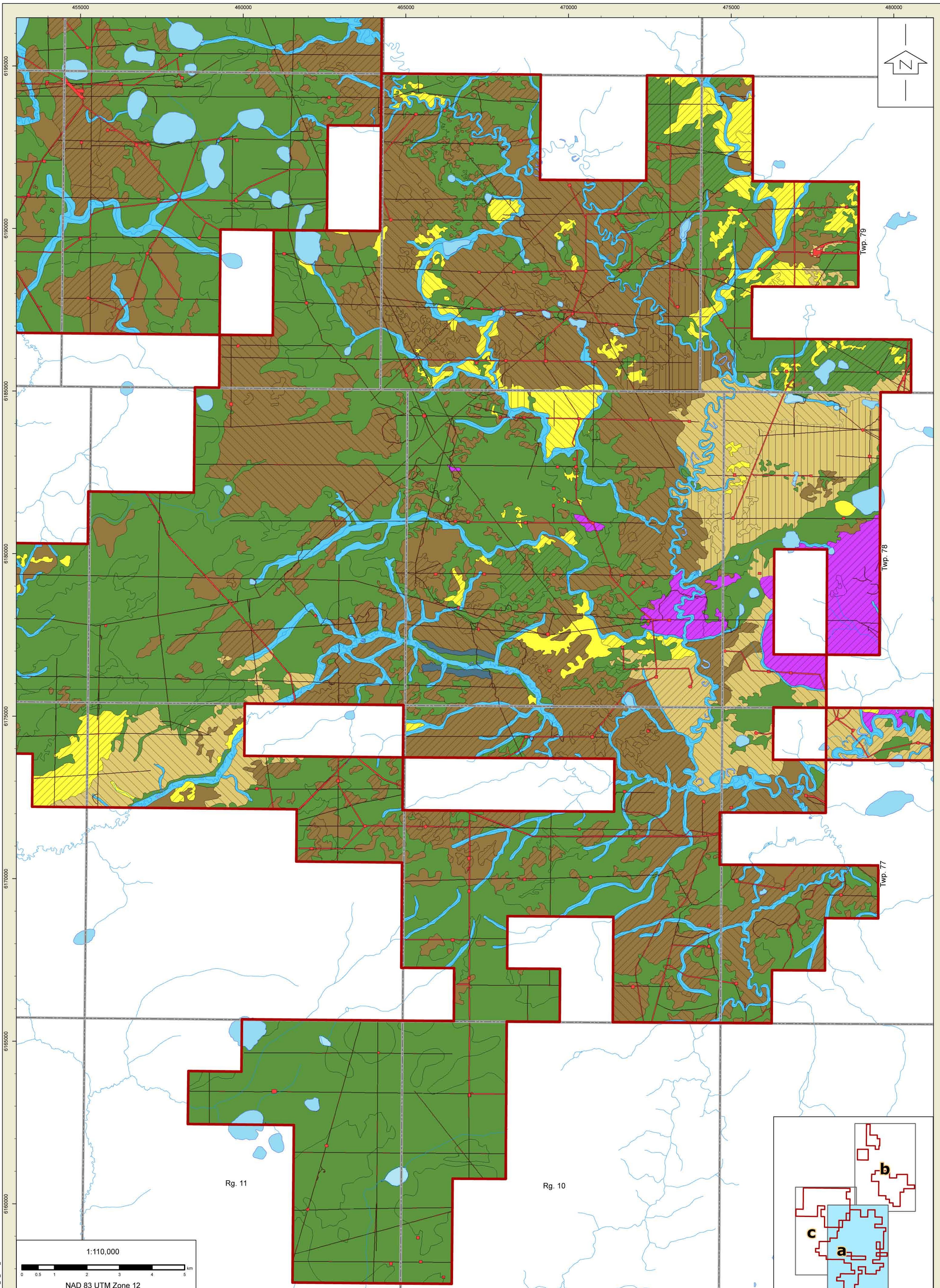
- Colluviated till
- Glaciolacustrine
- Glaciofluvial
- Organic
- Till
- SC
- RB
- Water
- NA

Title:

SURFICIAL MATERIALS & TOPOGRAPHIC CLASSES IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:	
CG/SC	June 14, 2007	
File: Fig 9.5-1_Surficial_Mat_Topo_in_LSA_20070614.mxd		
Drawn by: TR	Checked: LZ/JB	Fig. No.: **9.5-1**



I:\4455-514_NAOS\FINAL_MAPS\SOILS\Fig 9.5-1a_Surficial_Mat_Topo_in_LSA_20070615.mxd

Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Topographic Classes

Level to nearly level	(1; 1-2; 2)
Gently undulating	(2-3; 3)
Undulating	(3-4; 4)
Moderate to strong slopes	(4-5; 5; 5-6; 6)
Very strong slopes	(7; RB)

Surficial Materials

Colluviated till	SC
Glaciolacustrine	RB
Glaciofluvial	Water
Organic	NA
Till	

Title:

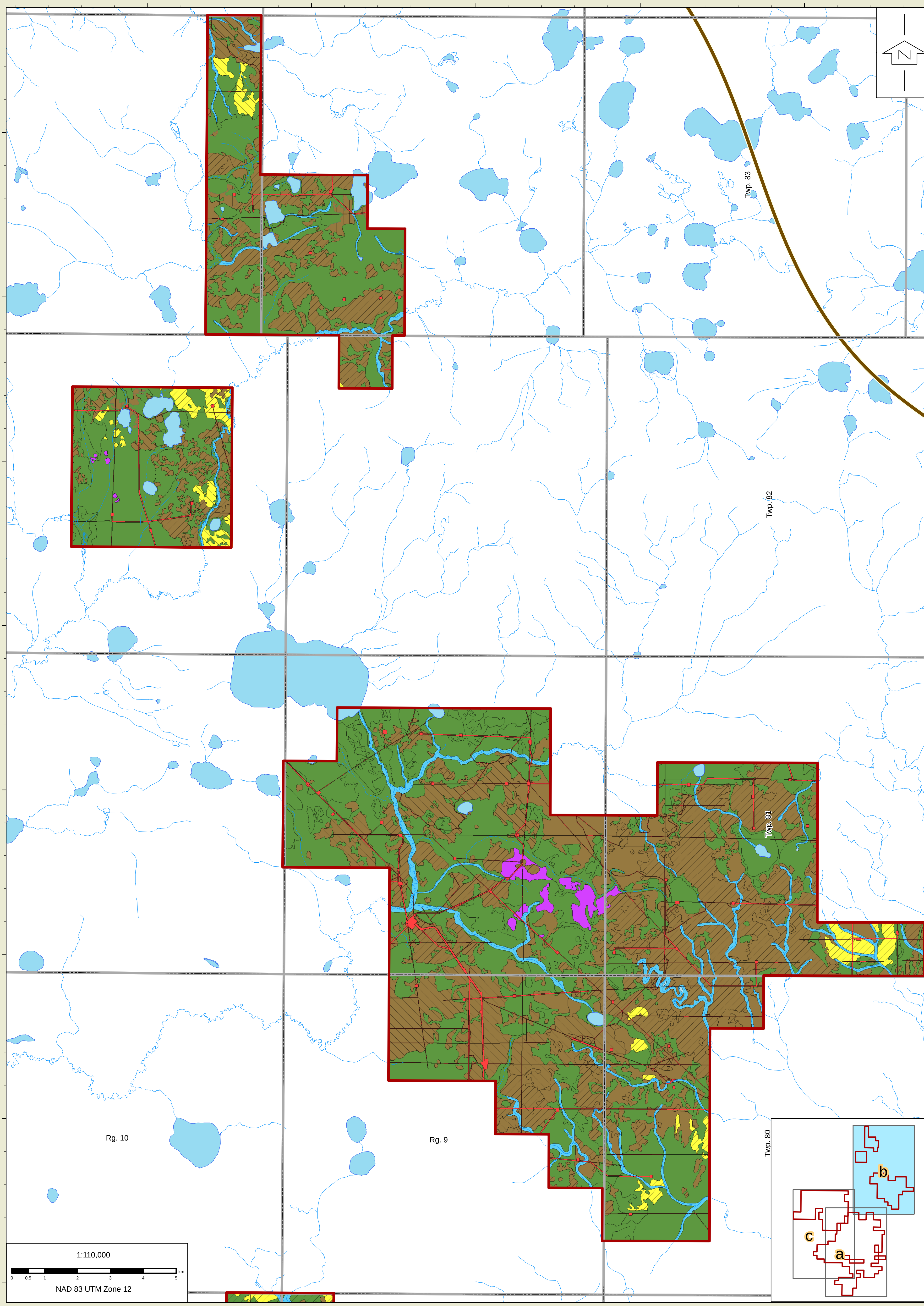
SURFICIAL MATERIALS
& TOPOGRAPHIC CLASSES
IN THE LSA

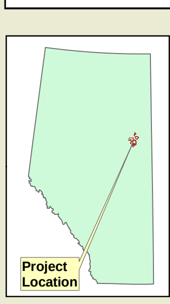
NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
CG/SC	June 15, 2007

File: Fig 9.5-1a_Surficial_Mat_Topo_in_LSA_20070615

Drawn by:	Checked:	Fig. No.:
TR	LZ/JB	9.5-1a





Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Topographic Classes

Level to nearly level	(1; 1-2; 2)
Gently undulating	(2-3; 3)
Undulating	(3-4; 4)
Moderate to strong slopes	(4-5; 5; 5-6; 6)
Very strong slopes	(7; RB)

Surficial Materials

Colluviated till	SC
Glaciolacustrine	RB
Glaciofluvial	Water
Organic	NA
Till	

Title:

SURFICIAL MATERIALS
& TOPOGRAPHIC CLASSES
IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/SC	Revision Date: June 15, 2007	
File: Fig 9.5-1b_Surficial_Mat_Topo_in_LSA_20070615		
Drawn by: TR	Checked: LZ/JB	Fig. No.: **9.5-1b**

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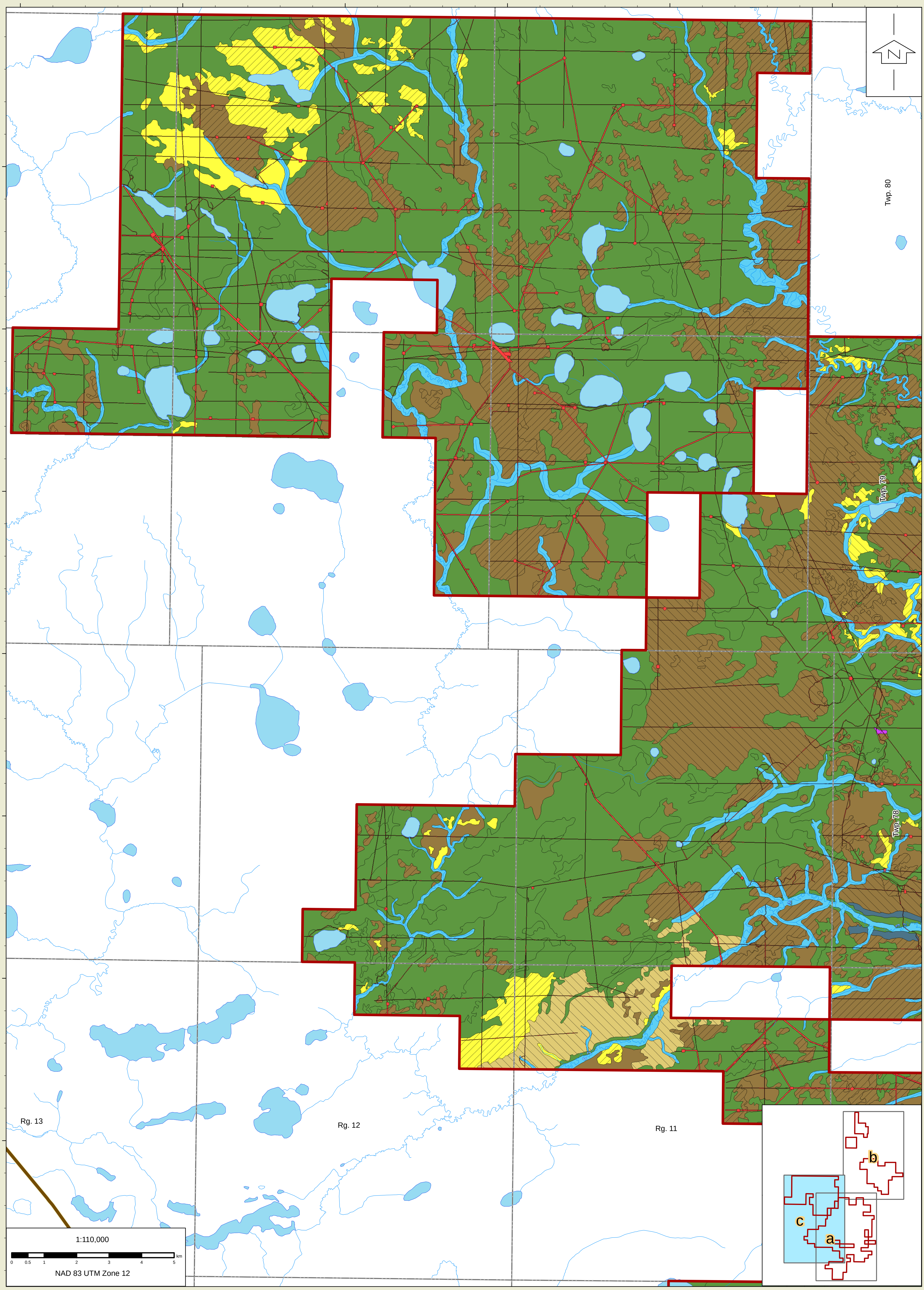

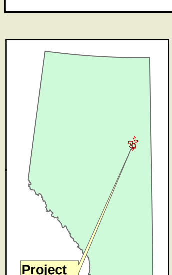

Legend

North American Soils RSA
North American Soils LSA
Lake
River / Stream

Topographic Classes

Level to nearly level	(1; 1-2; 2)
Gently undulating	(2-3; 3)
Undulating	(3-4; 4)
Moderate to strong slopes	(4-5; 5; 5-6; 6)
Very strong slopes	(7; RB)

Surficial Materials

Colluviated till	SC
Glaciolacustrine	RB
Glaciofluvial	Water
Organic	NA
Till	

Title:

SURFICIAL MATERIALS & TOPOGRAPHIC CLASSES IN THE LSA

Approved: CG/SC	Revision Date: June 15, 2007
File: Fig 9.5-1c_Surficial_Mat_Topo_in_LSA_20070615	
Drawn by: TR	Checked: LZ/JB
Fig. No.: 9.5-1c	

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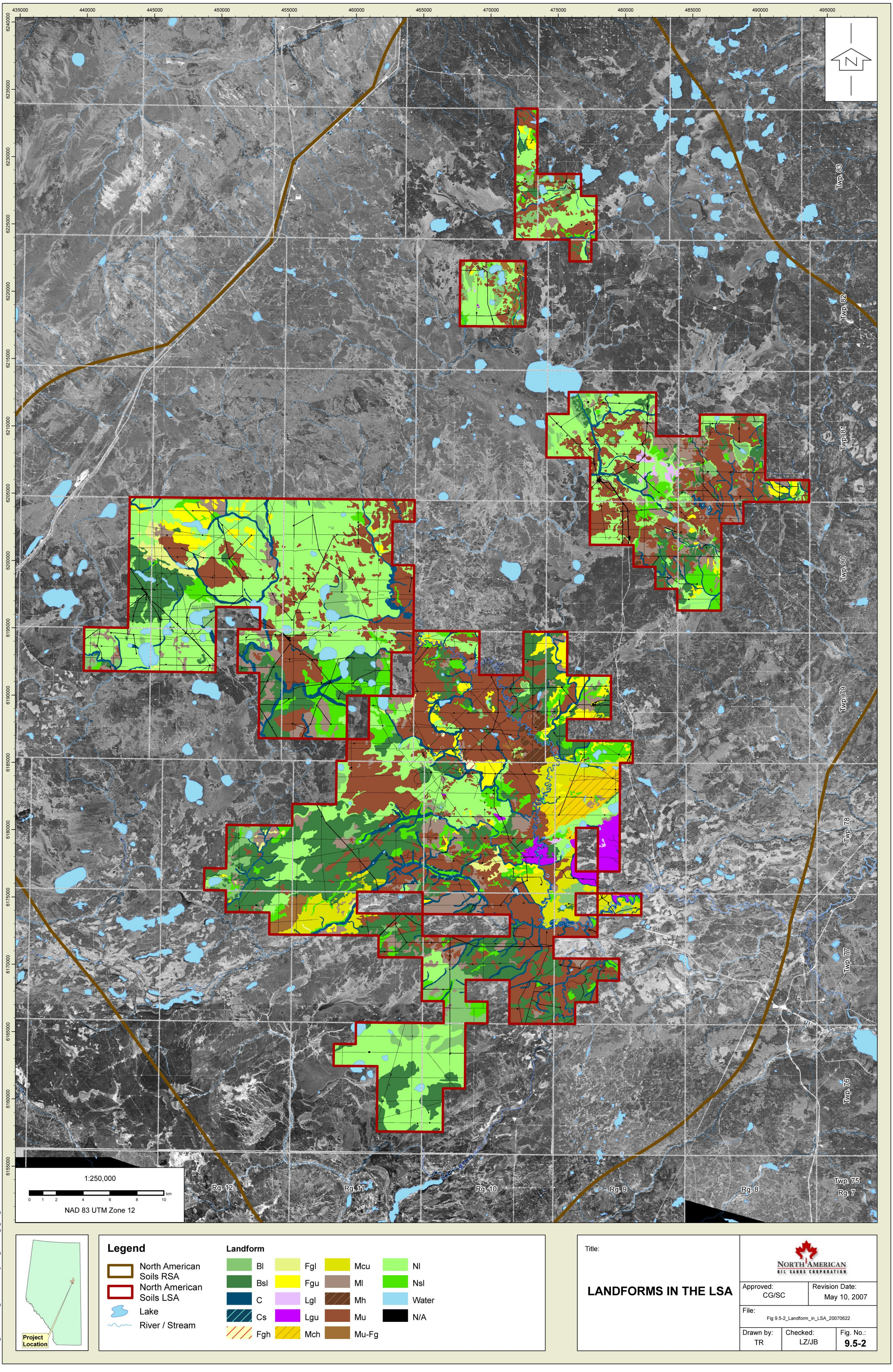

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Twp. 83
Twp. 82
Twp. 81
Twp. 80
Twp. 79
Twp. 78
Twp. 77
Twp. 76
Twp. 75
Rg. 12
Rg. 11
Rg. 10
Rg. 9
Rg. 8
Rg. 7
1:250,000
0 1 2 4 6 8 10
km
NAD 83 UTM Zone 12
Project Location
Legend
North American Soils RSA
North American Soils LSA
Lake
River / Stream
Landform
Bl
Bsl
C
Cs
Fgh
Fgl
Fgu
Lgl
Lgu
Mch
Mcu
Ml
Mh
Mu
Mu-Fg
Nl
Nsl
Water
N/A
Title:
LANDFORMS IN THE LSA
NORTH AMERICAN OIL SANDS CORPORATION
Approved:
CG/SC
Revision Date:
May 10, 2007
File:
Fig 9.5-2_Landform_in_LSA_20070622
Drawn by:
TR
Checked:
LZ/JB
Fig. No.:
9.5-2
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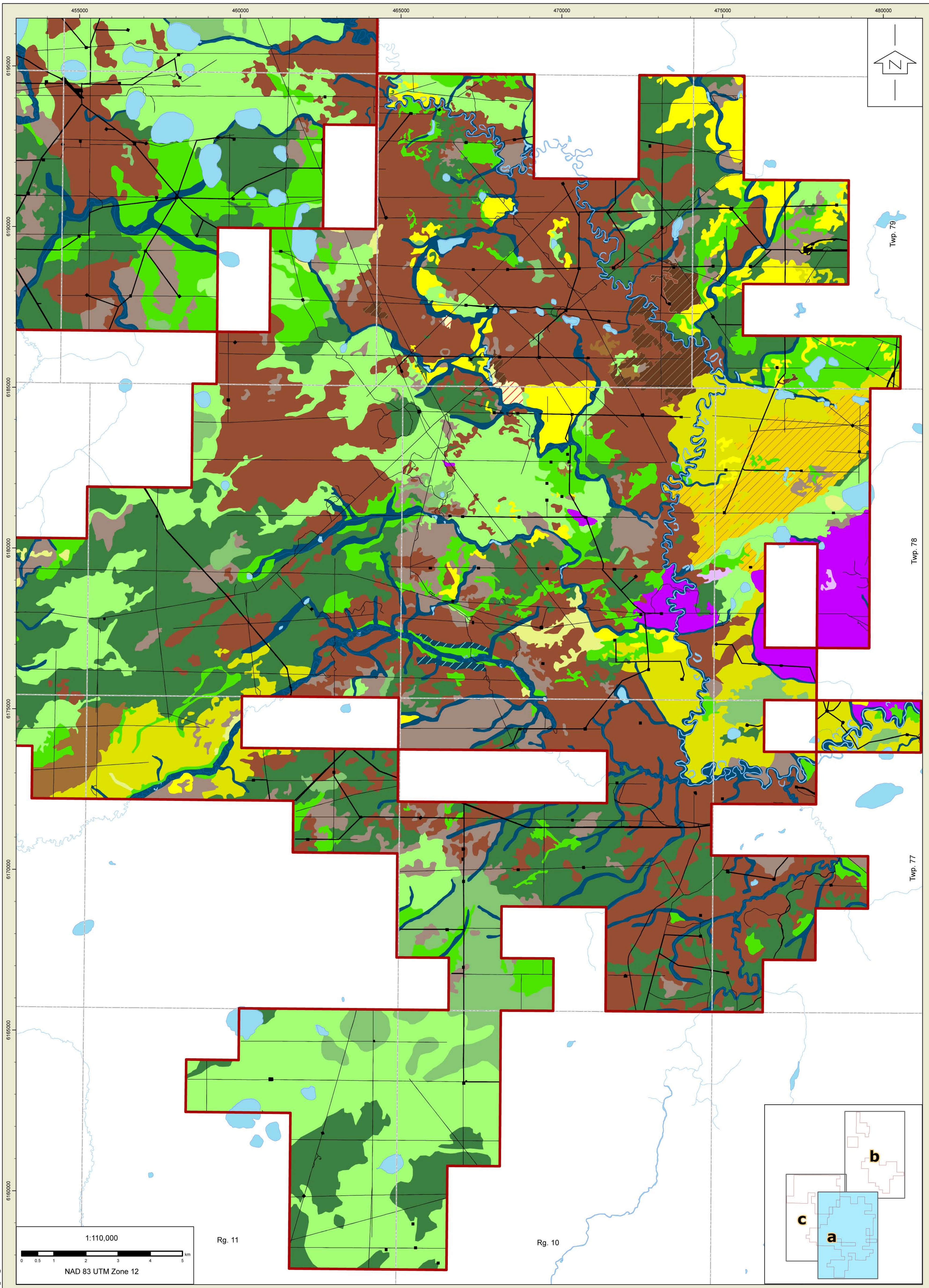

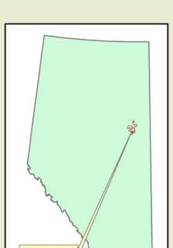

Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Landform

Bl	Fgl	Mcu	Nl
Bsl	Fgu	Ml	Nsl
C	Lgl	Mh	Water
Cs	Lgu	Mu	N/A
Fgh	Mch	Mu-Fg	

Title:

LANDFORMS IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/SC	Revision Date: June 22, 2007

File: Fig 9.5-2a_Landform_in_LSA_20070622

Drawn by:	Checked:	Fig. No.:
TR	LZ/JB	9.5-2a

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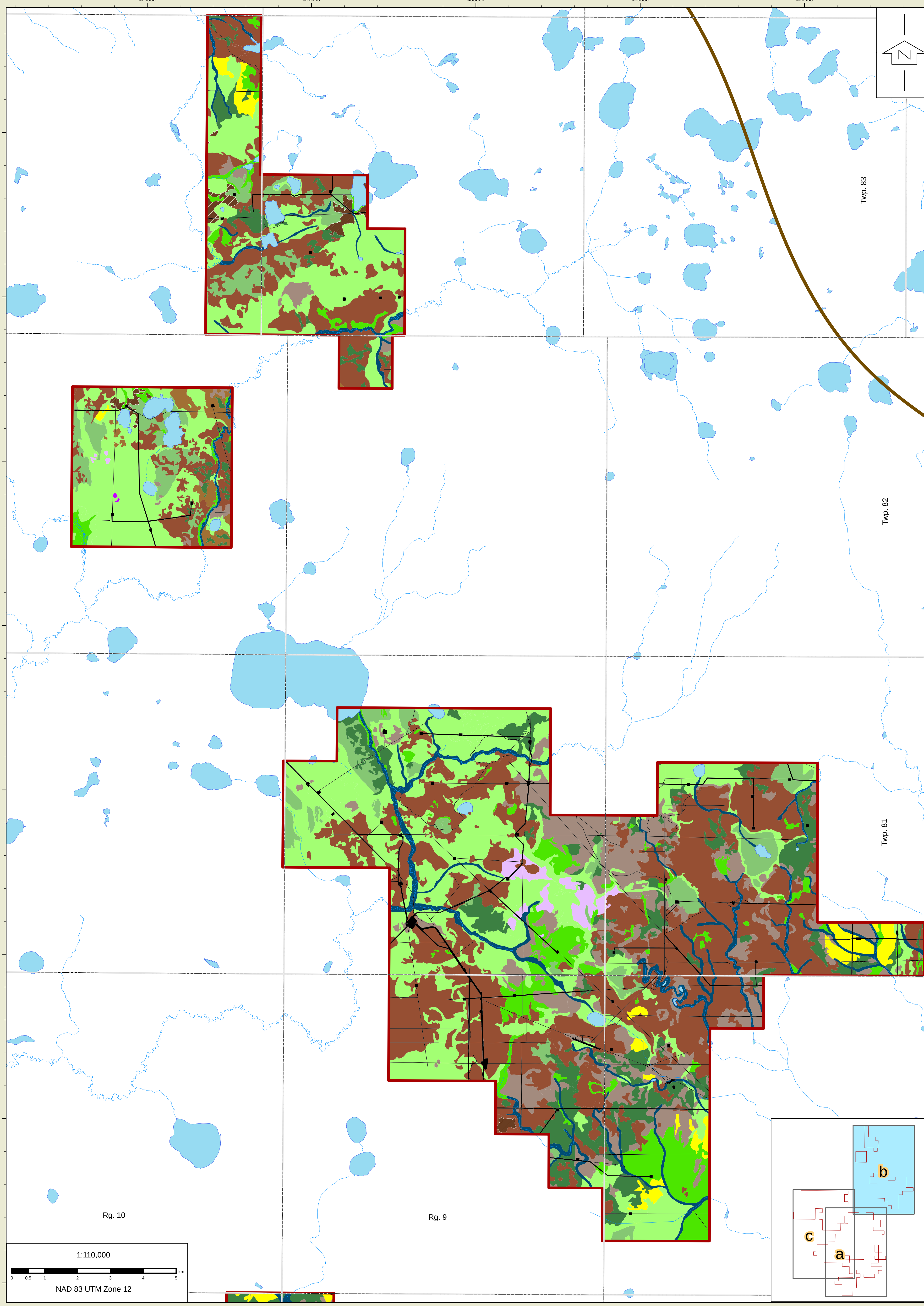

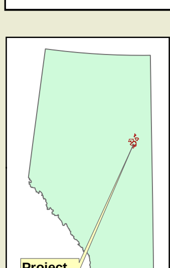

Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Landform

Bl	Fgl	Mcu	Nl	
Bsl	Fgu	Ml	Nsl	
C	Lgl	Mh	Water	
Cs	Lgu	Mu	N/A	
Fgh	Mch	Mu-Fg		

Title:

LANDFORMS IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/SC	Revision Date: May 10, 2007	
File: Fig 9.5-2b_Landform_in_LSA_20070622		
Drawn by: TR	Checked: LZ/JB	Fig. No.: **9.5-2b**

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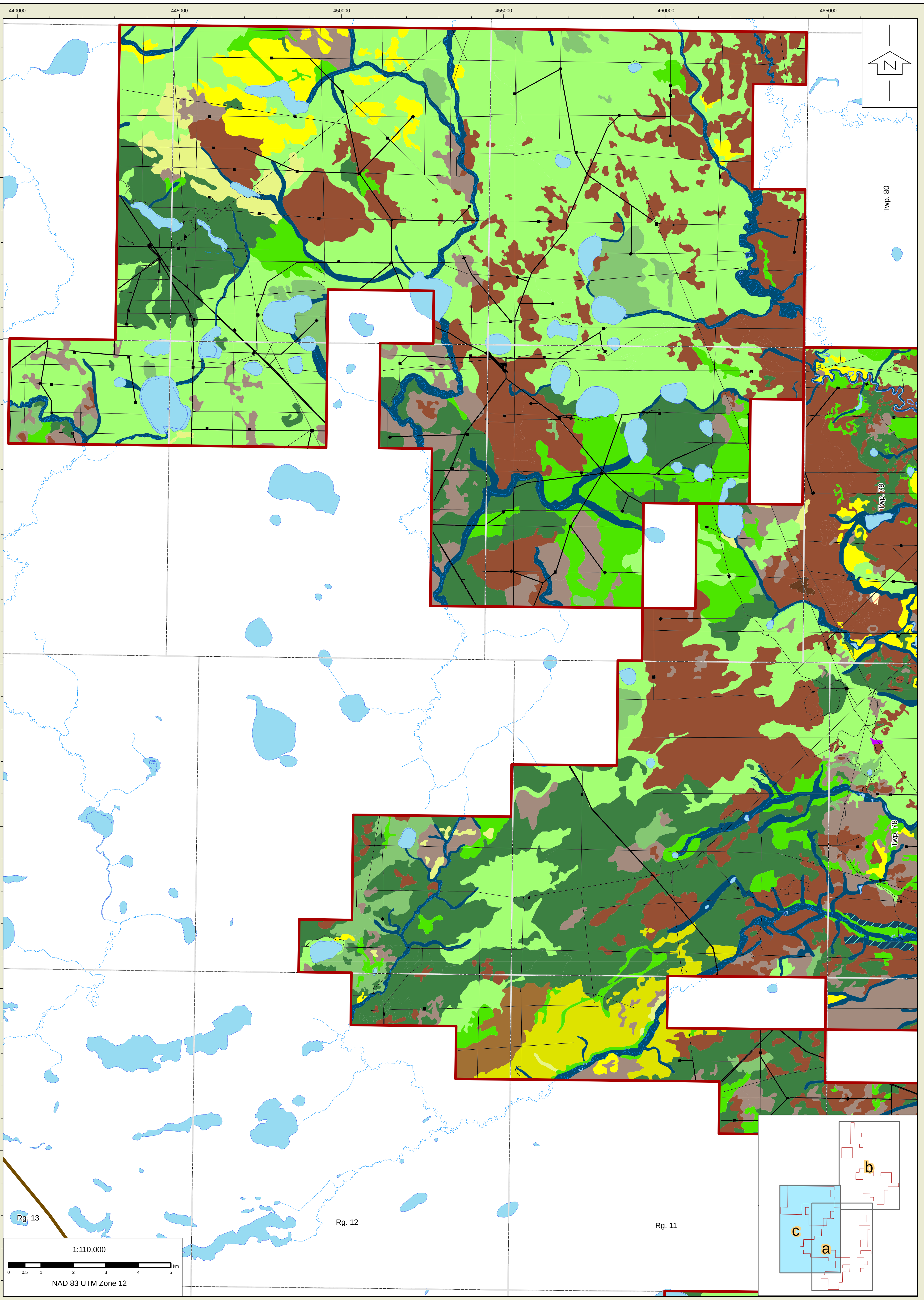

Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Landform

Bl	Fgl	Mcu	Nl
Bsl	Fgu	Ml	Nsl
C	Lgl	Mh	Water
Cs	Lgu	Mu	NA
Fgh	Mch	Mu-Fg	

Title:

LANDFORMS IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
CG/SC	May 10, 2007

File: Fig 9.5-2c_Landform_in_LSA_20070622

Drawn by:	Checked:	Fig. No.:
TR	LZ/JB	9.5-2c

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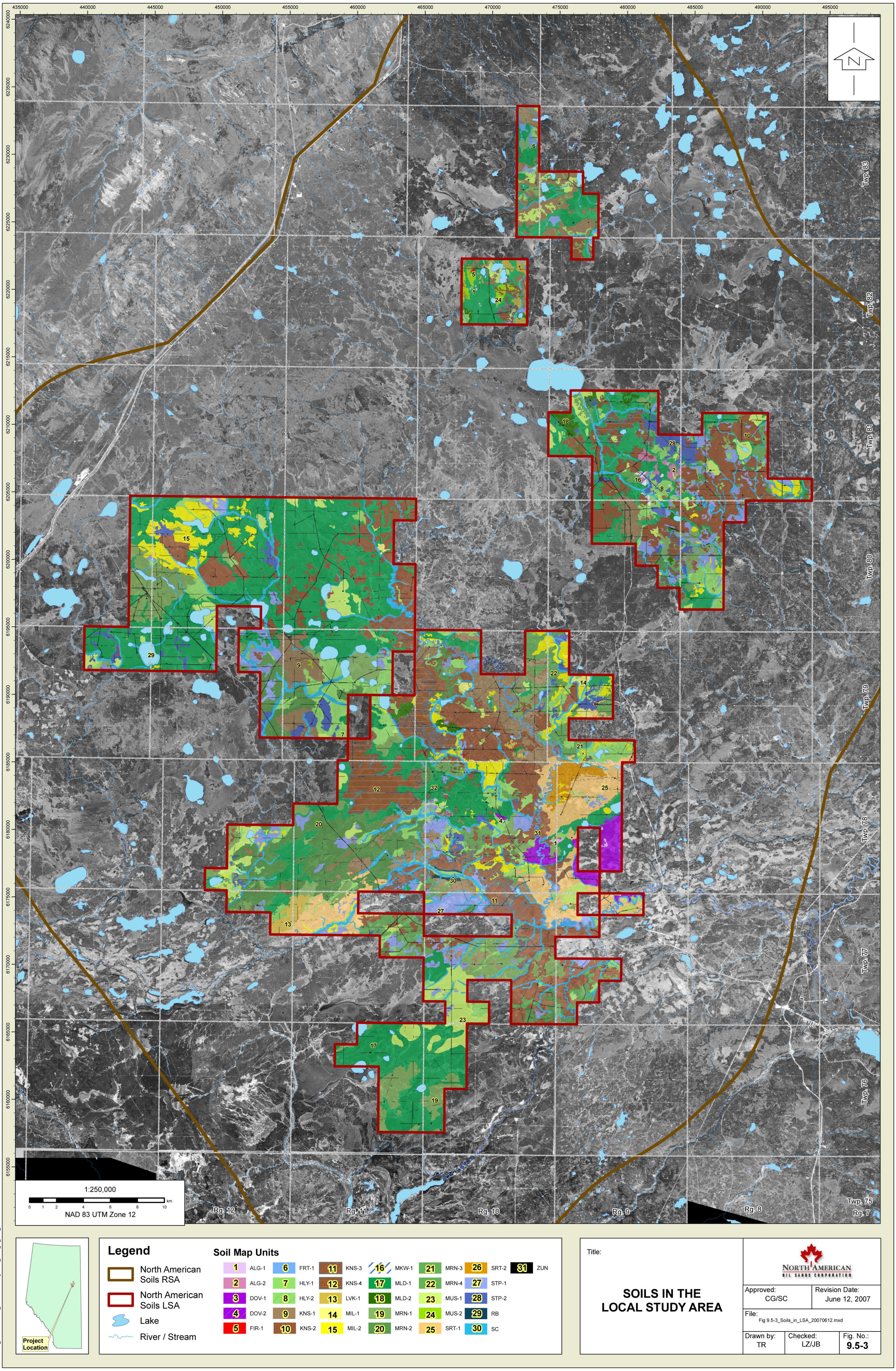

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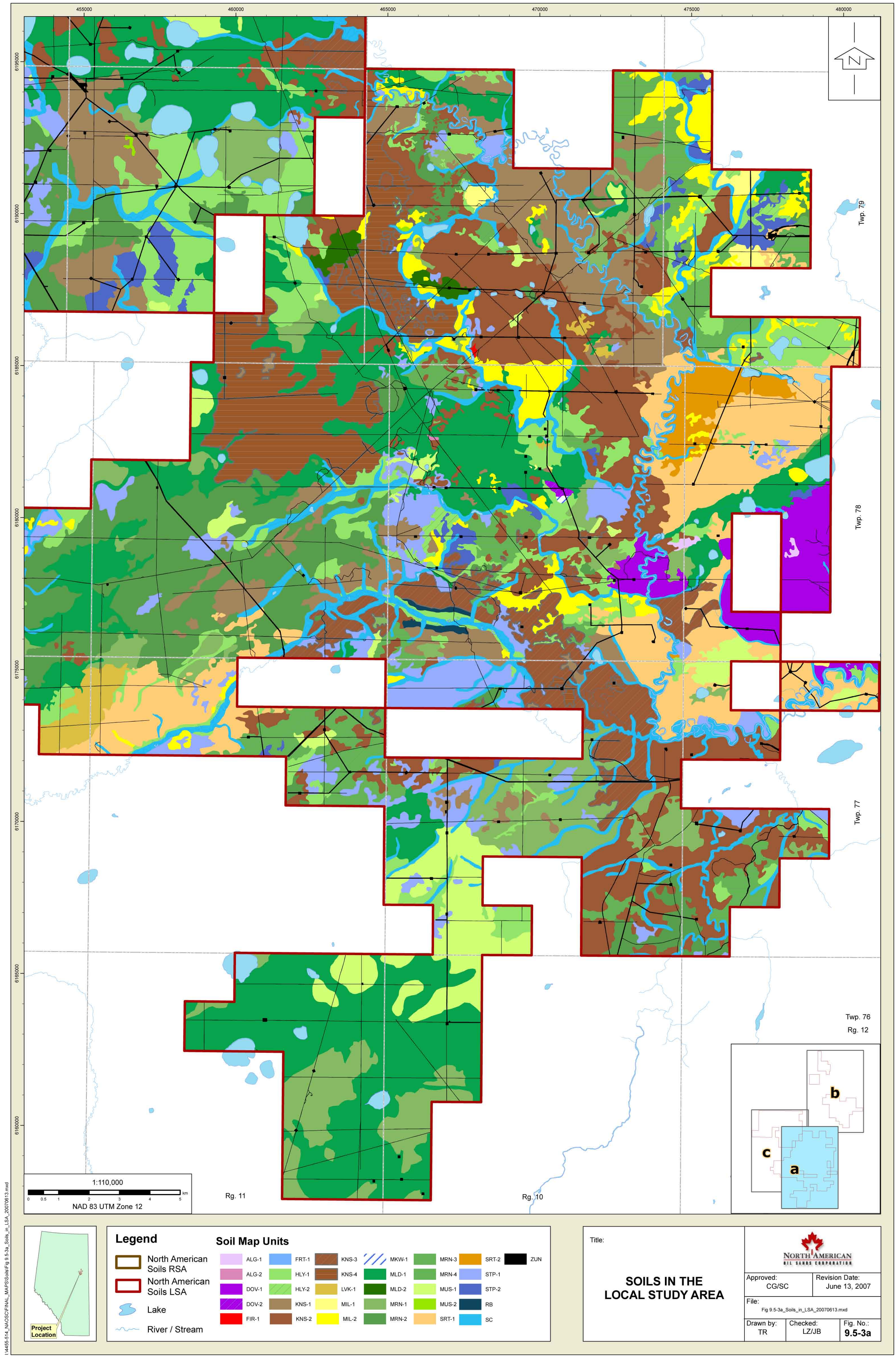
km
NAD 83 UTM Zone 12
Twp. 83
Twp. 82
Twp. 81
Twp. 80
Twp. 79
Twp. 78
Twp. 77
Twp. 76
Twp. 75
Rg. 12
Rg. 11
Rg. 10
Rg. 9
Rg. 8
Rg. 7
Project Location
Legend
North American Soils RSA
North American Soils LSA
Lake
River / Stream
Soil Map Units
1 ALG-1
2 ALG-2
3 DOV-1
4 DOV-2
5 FIR-1
6 FRT-1
7 HLY-1
8 HLY-2
9 KNS-1
10 KNS-2
11 KNS-3
12 KNS-4
13 LVK-1
14 MIL-1
15 MIL-2
16 MKW-1
17 MLD-1
18 MLD-2
19 MRN-1
20 MRN-2
21 MRN-3
22 MRN-4
23 MUS-1
24 MUS-2
25 SRT-1
26 SRT-2
27 STP-1
28 STP-2
29 RB
30 SC
31 ZUN
Title:
SOILS IN THE LOCAL STUDY AREA
NORTH AMERICAN OIL SANDS CORPORATION
Approved: CG/SC
Revision Date: June 12, 2007
File: Fig 9.5-3_Soils_in_LSA_20070612.mxd
Drawn by: TR
Checked: LZ/JB
Fig. No.: 9.5-3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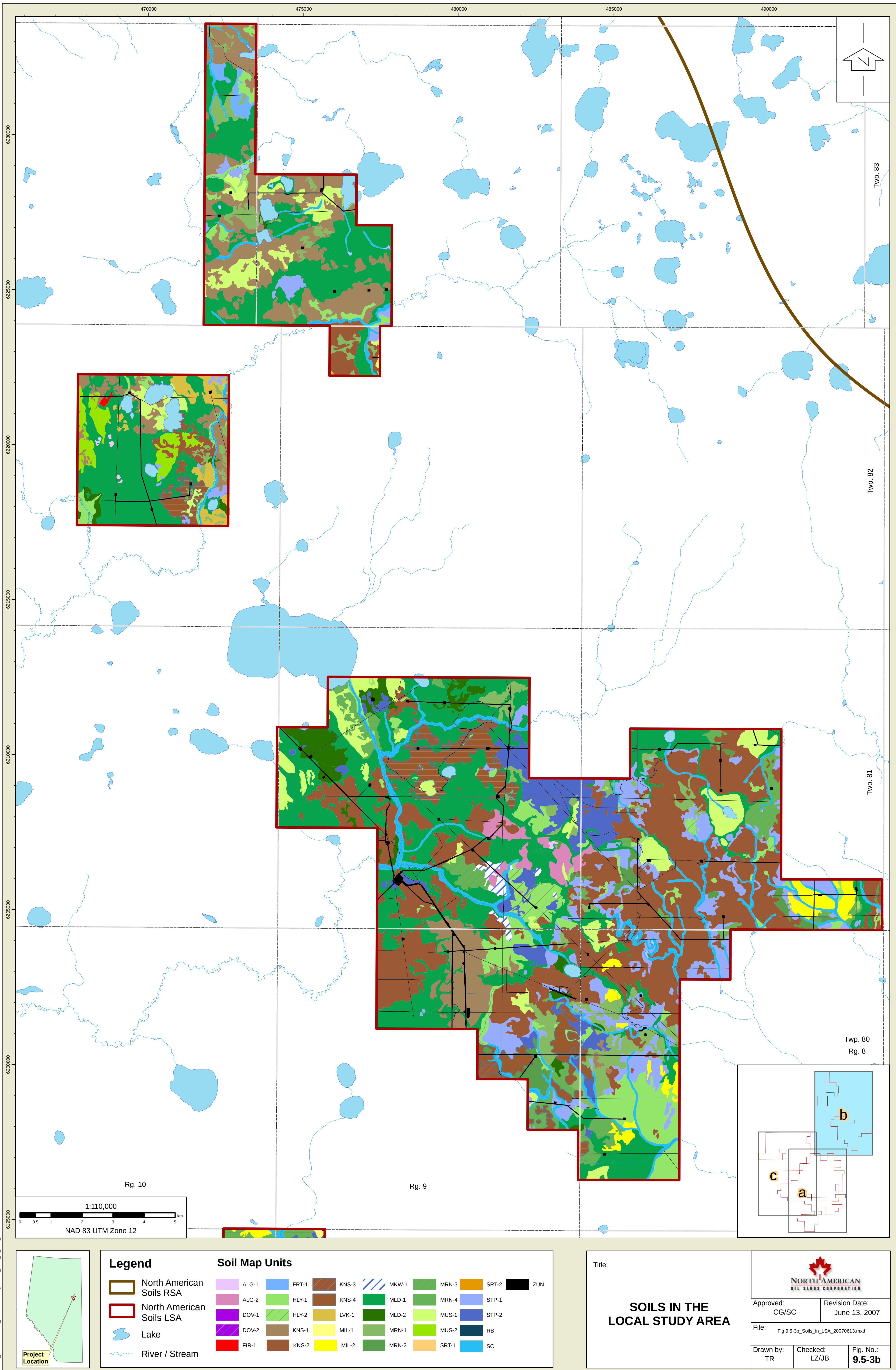
Twp. 79
Twp. 78
Twp. 77
Twp. 76
Rg. 12
Rg. 11
Rg. 10
b
c
a
1:110,000
0 0.5 1 2 3 4 5 km
NAD 83 UTM Zone 12
Project Location
Legend
North American Soils RSA
North American Soils LSA
Lake
River / Stream
Soil Map Units
ALG-1
ALG-2
DOV-1
DOV-2
FIR-1
FRT-1
HLY-1
HLY-2
KNS-1
KNS-2
KNS-3
KNS-4
LVK-1
MIL-1
MIL-2
MKW-1
MLD-1
MLD-2
MRN-1
MRN-2
MRN-3
MRN-4
MUS-1
MUS-2
SRT-1
SRT-2
STP-1
STP-2
RB
SC
ZUN
Title:
SOILS IN THE LOCAL STUDY AREA
NORTH AMERICAN OIL SANDS CORPORATION
Approved: CG/SC
Revision Date: June 13, 2007
File: Fig 9.5-3a_Soils_in_LSA_20070613.mxd
Drawn by: TR
Checked: LZ/JB
Fig. No.: 9.5-3a
14455-514_NAOSC\FINAL_MAPS\Soils\Fig 9.5-3a_Soils_in_LSA_20070613.mxd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Twp. 83
Twp. 82
Twp. 81
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Rg. 8
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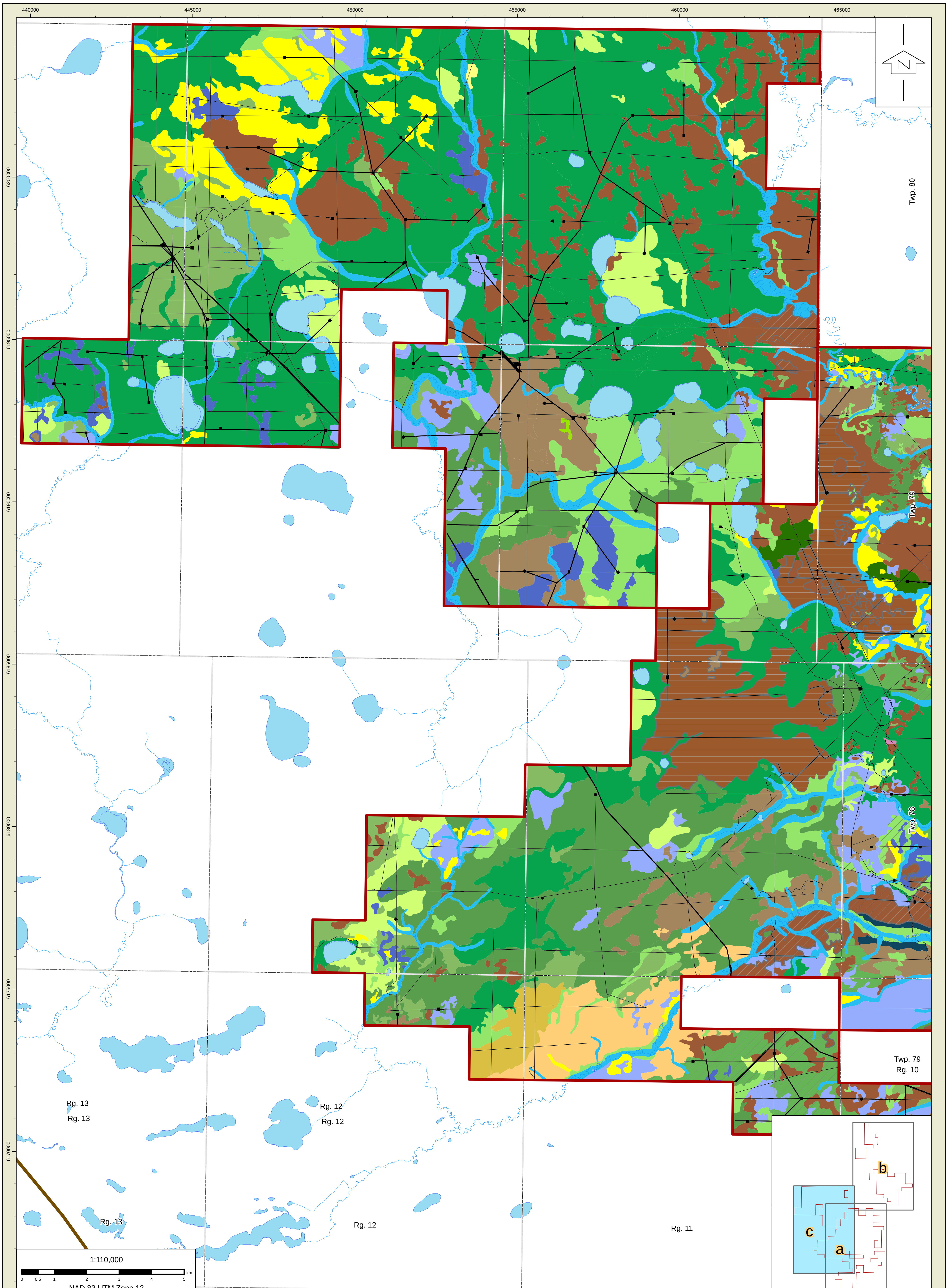
1:110,000
0 0.5 1 2 3 4 5 km
NAD 83 UTM Zone 12
I:\4455-514_NAOSC\FINAL_MAPS\Soils\Fig 9.5-3b_Soils_in_LSA_20070613.mxd
Project Location
Legend
North American Soils RSA
North American Soils LSA
Lake
River / Stream
Soil Map Units
ALG-1
ALG-2
DOV-1
DOV-2
FIR-1
FRT-1
HLY-1
HLY-2
KNS-1
KNS-2
KNS-3
KNS-4
LVK-1
MIL-1
MIL-2
MKW-1
MLD-1
MLD-2
MRN-1
MRN-2
MRN-3
MRN-4
MUS-1
MUS-2
SRT-1
SRT-2
STP-1
STP-2
RB
SC
ZUN
Title:
SOILS IN THE LOCAL STUDY AREA
NORTH AMERICAN OIL SANDS CORPORATION
Approved: CG/SC
Revision Date: June 13, 2007
File: Fig 9.5-3b_Soils_in_LSA_20070613.mxd
Drawn by: TR
Checked: LZ/JB
Fig. No.: 9.5-3b



Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Soil Map Units

ALG-1	FRT-1	KNS-3	MKW-1	MRN-3	SRT-2	ZUN
ALG-2	HLY-1	KNS-4	MLD-1	MRN-4	STP-1	
DOV-1	HLY-2	LVK-1	MLD-2	MUS-1	STP-2	
DOV-2	KNS-1	MIL-1	MRN-1	MUS-2	RB	
FIR-1	KNS-2	MIL-2	MRN-2	SRT-1	SC	

Title:

SOILS IN THE LOCAL STUDY AREA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/SC	Revision Date: June 13, 2007
File: Fig 9.5-3c_Soils_in_LSA_20070613.mxd	
Drawn by: TR	Checked: LZ/JB
Fig. No.: 9.5-3c	

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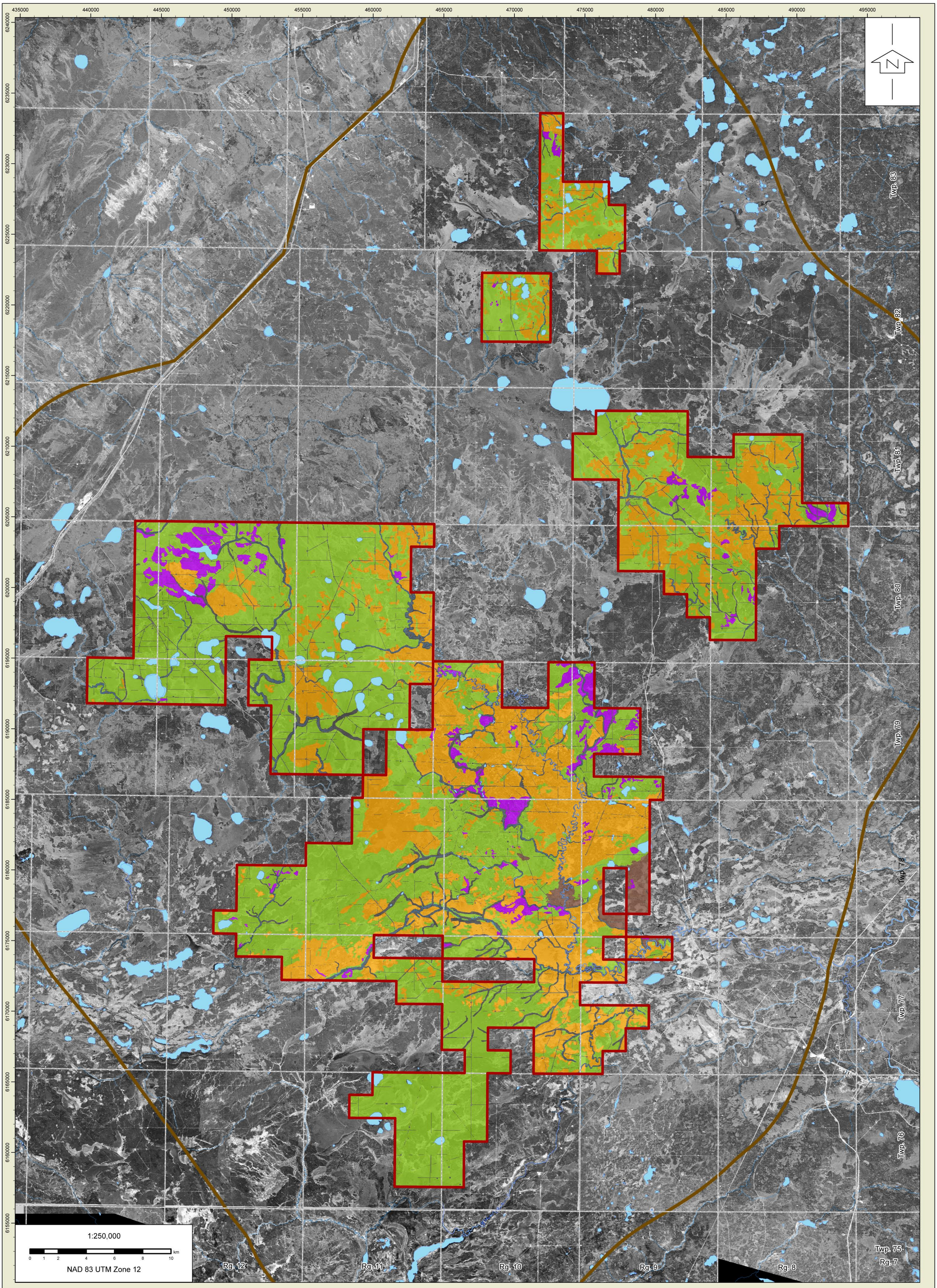

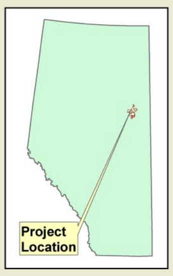

Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Land Capability for Forest Production

- Unclassified (Baseline Disturbances, Lakes, Stream Channels, Rough Broken)
- Class 2 (Moderate Capability)
- Class 3 (Low Capability)
- Class 4 (Conditionally Productive)
- Class 5 (Non-Productive)

Title:

LAND CAPABILITY FOR FOREST PRODUCTION IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:	
CG/SC	June 15, 2007	
File: Fig 9.5-4_Land_Cap_Forest_Production_in_LSA_20070615		
Drawn by: TR	Checked: LZ/JB	Fig. No.: 9.5-4

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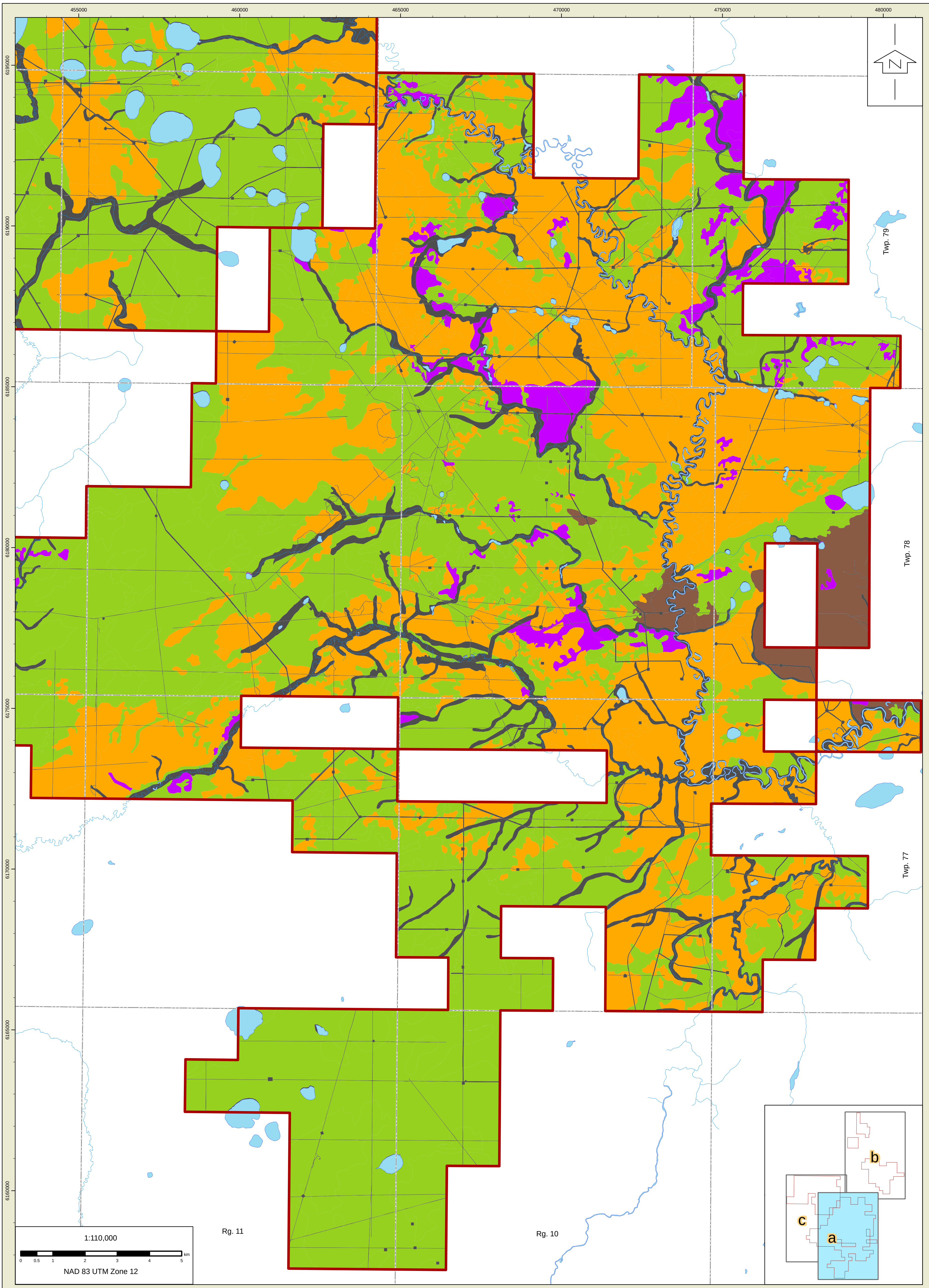

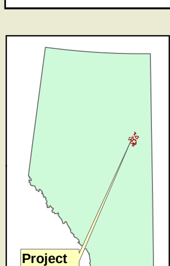

Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Land Capability for Forest Production

- Unclassified (Baseline Disturbances, Lakes, Stream Channels, Rough Broken)
- Class 2 (Moderate Capability)
- Class 3 (Low Capability)
- Class 4 (Conditionally Productive)
- Class 5 (Non-Productive)

Title:

LAND CAPABILITY FOR FOREST PRODUCTION IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:	
CG/SC	June 13, 2007	
File: Fig 9.5-4a_Land_Cap_Forest_Production_in_LSA_20070613		
Drawn by: TR	Checked: LZ/JB	Fig. No.: **9.5-4a**

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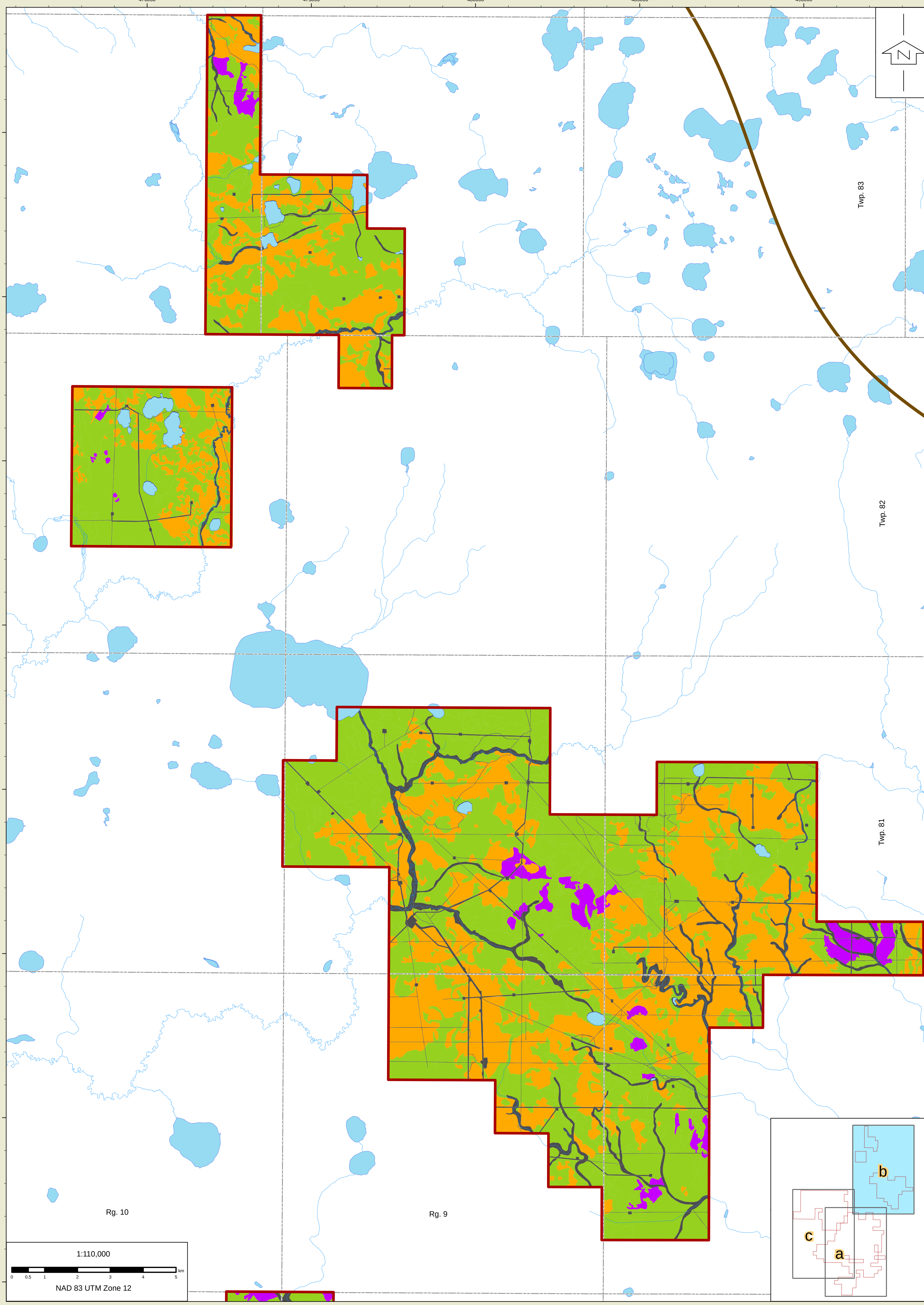

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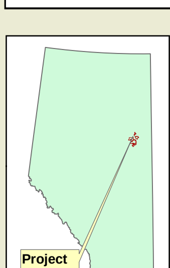

Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Land Capability for Forest Production

- Unclassified (Baseline Disturbances, Lakes, Stream Channels, Rough Broken)
- Class 2 (Moderate Capability)
- Class 3 (Low Capability)
- Class 4 (Conditionally Productive)
- Class 5 (Non-Productive)

Title:

LAND CAPABILITY FOR FOREST PRODUCTION IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/SC	Revision Date: June 13, 2007	
File: Fig 9.5-4b_Land_Cap_Forest_Production_in_LSA_20070613		
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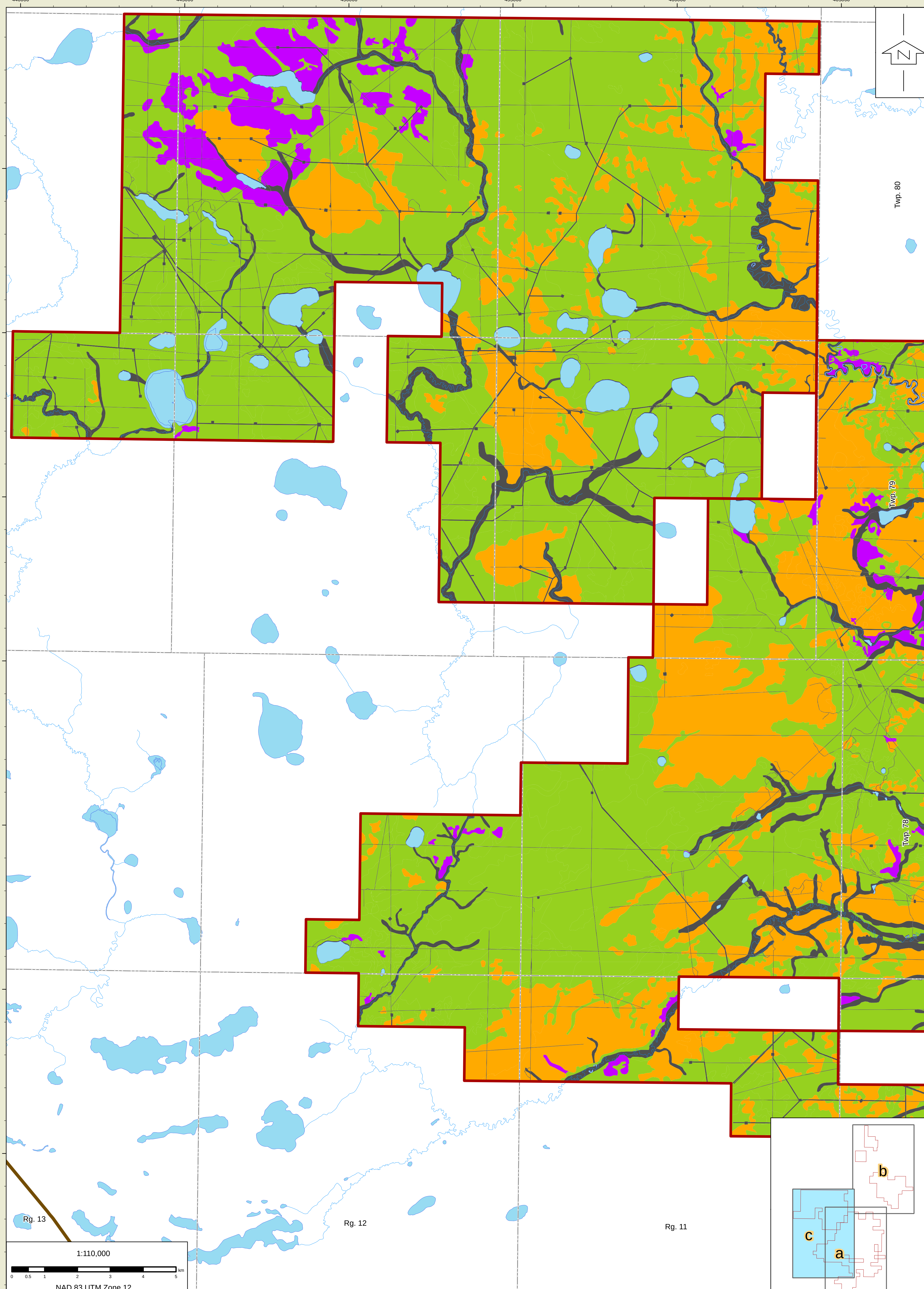

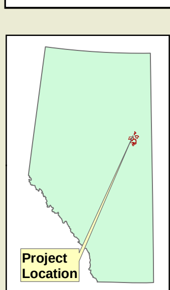

Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Land Capability for Forest Production

- Unclassified (Baseline Disturbances, Lakes, Stream Channels, Rough Broken)
- Class 2 (Moderate Capability)
- Class 3 (Low Capability)
- Class 4 (Conditionally Productive)
- Class 5 (Non-Productive)

Title:

LAND CAPABILITY FOR FOREST PRODUCTION IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:	
CG/SC	June 13, 2007	
File: Fig 9.5-4c_Land_Cap_Forest_Production_in_LSA_20070613		
Drawn by: TR	Checked: LZ/JB	Fig. No.: 9.5-4c

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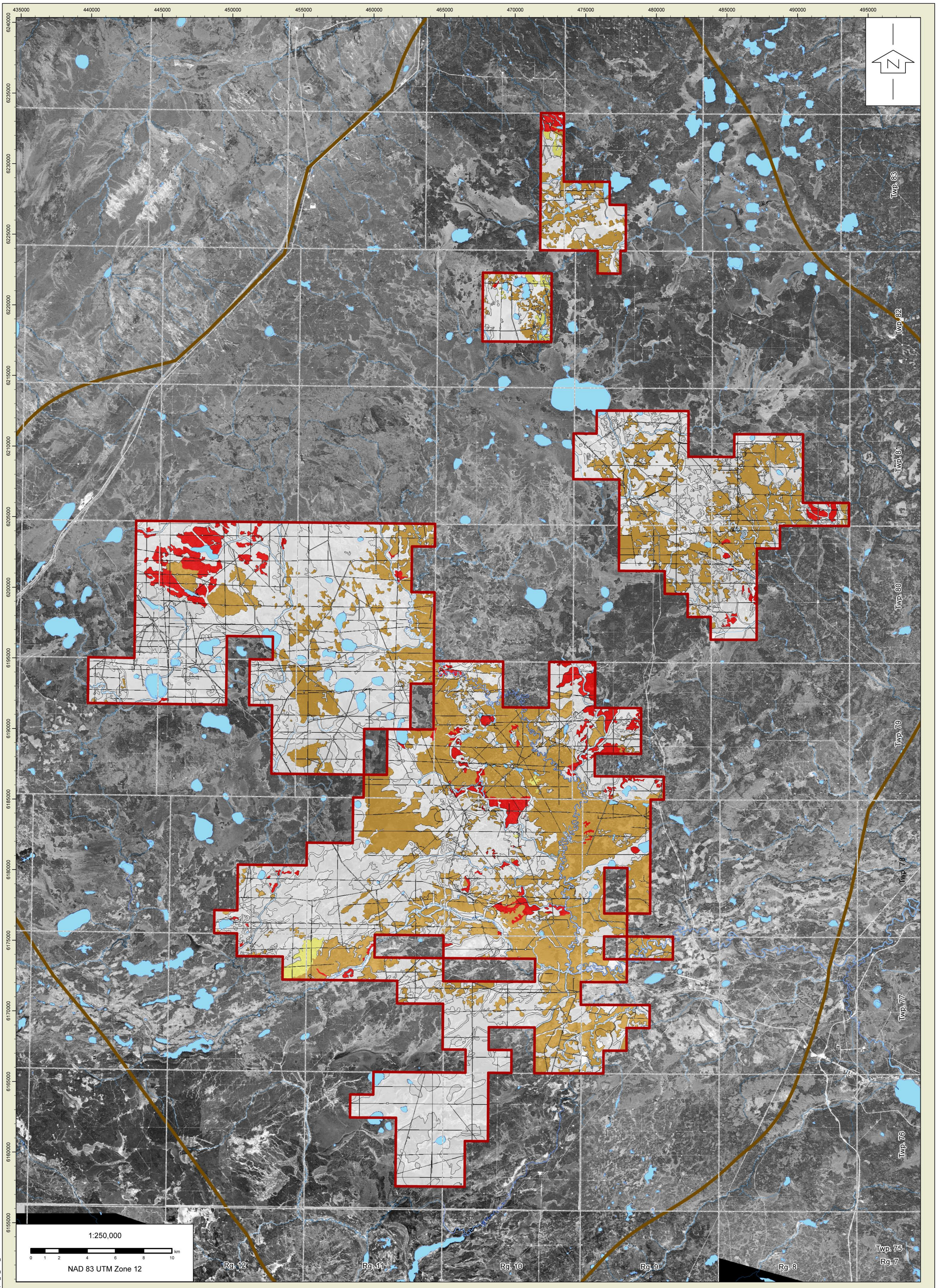

Project Location

Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Reclamation Suitability- Upper Lift

- Good
- Fair
- Poor
- Organic; Surface Peat; Lake; SC; RB

Title:

SOIL SUITABILITY FOR RECLAMATION - UPPER LIFT IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/SC	Revision Date: June 15, 2007
File: Fig 9.5-5_Soils_Suit_Upper_in_LSA_20070615	

Drawn by:	Checked:	Fig. No.:
TR	LZ/JB	9.5-5

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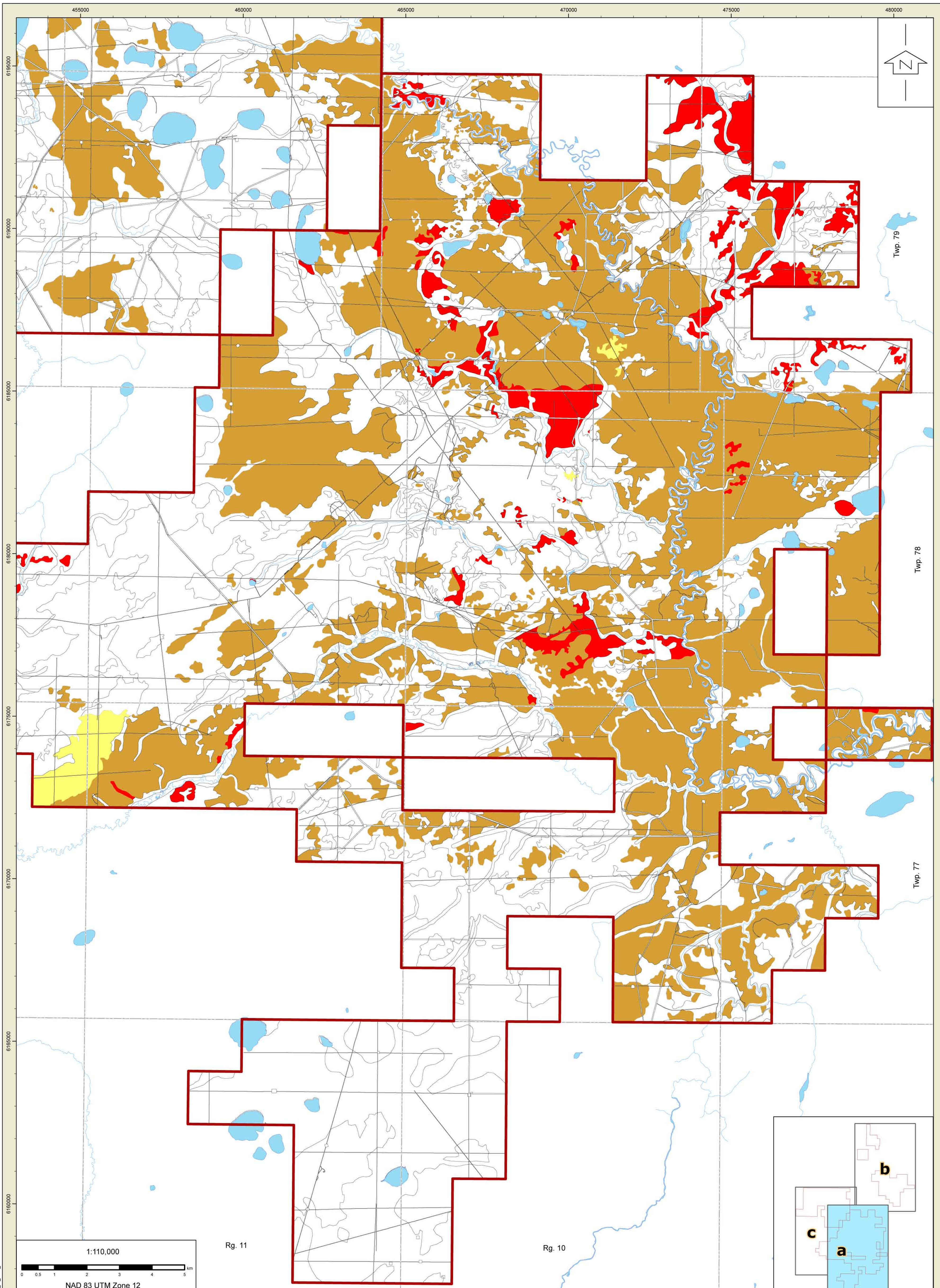
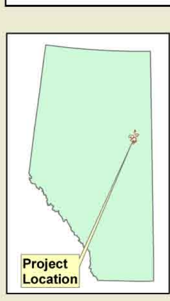




Legend

North American Soils RSA

North American Soils LSA

Lake

River / Stream

Reclamation Suitability - Upper Lift

Good

Fair

Poor

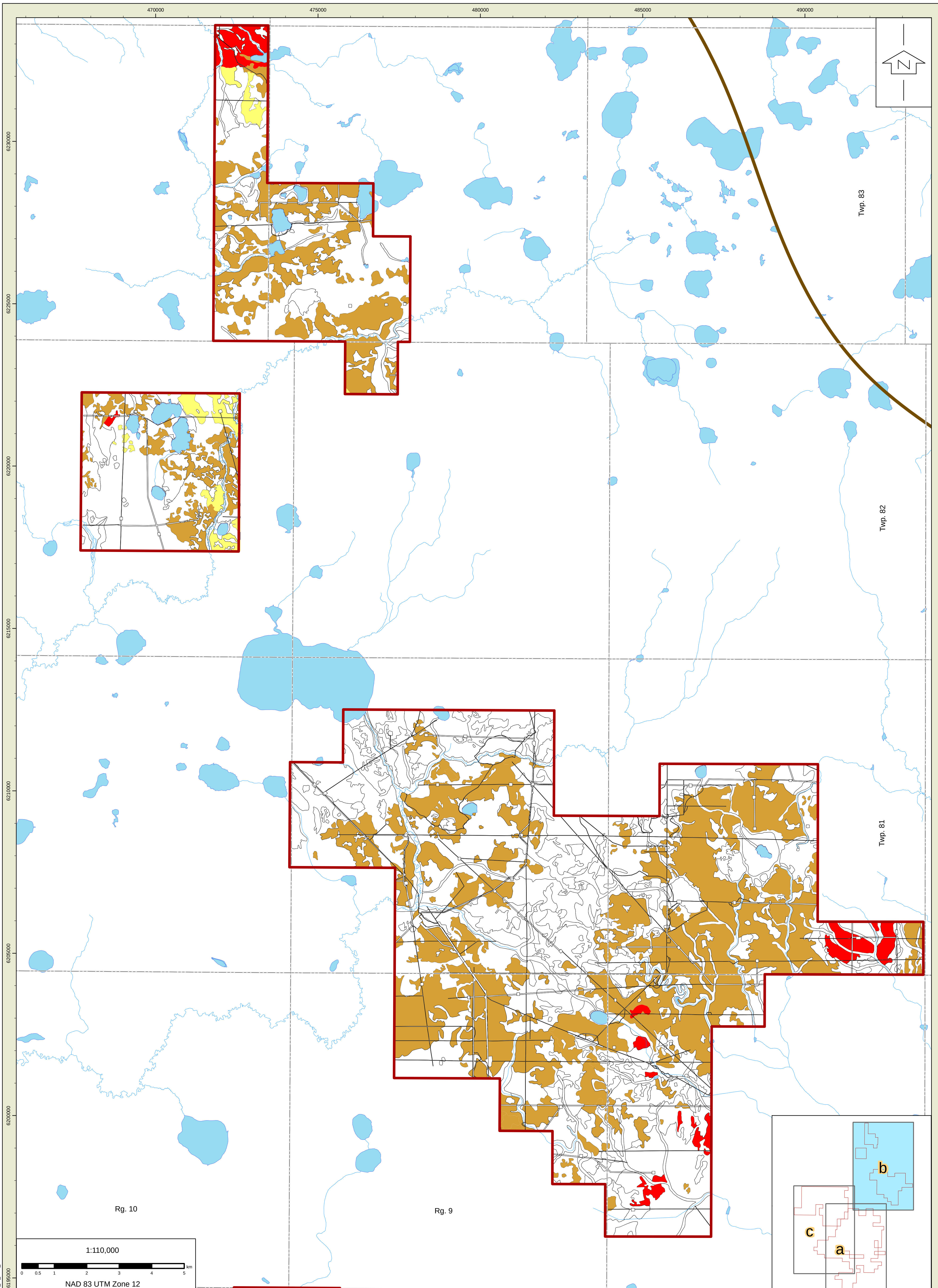
Organic; Surface Peat; Lake; SC; RB

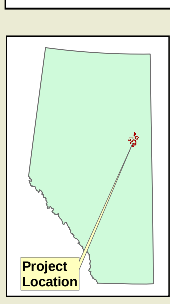
Title:

SOIL SUITABILITY FOR RECLAMATION - UPPER LIFT IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/SC	Revision Date: June 15, 2007	
File: Fig 9.5-5a_Soils_Suit_Upper_in_LSA_20070615		
Drawn by: TR	Checked: LZ/JB	Fig. No.: **9.5-5a**





Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Reclamation Suitability - Upper Lift

- Good
- Fair
- Poor
- Organic; Surface Peat; Lake; SC; RB

Title:

SOIL SUITABILITY FOR RECLAMATION - UPPER LIFT IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/SC	Revision Date: June 15, 2007
File: Fig 9.5-5b_Soils_Suit_Upper_in_LSA_20070615	

Drawn by:	Checked:	Fig. No.:
TR	LZ/JB	9.5-5b

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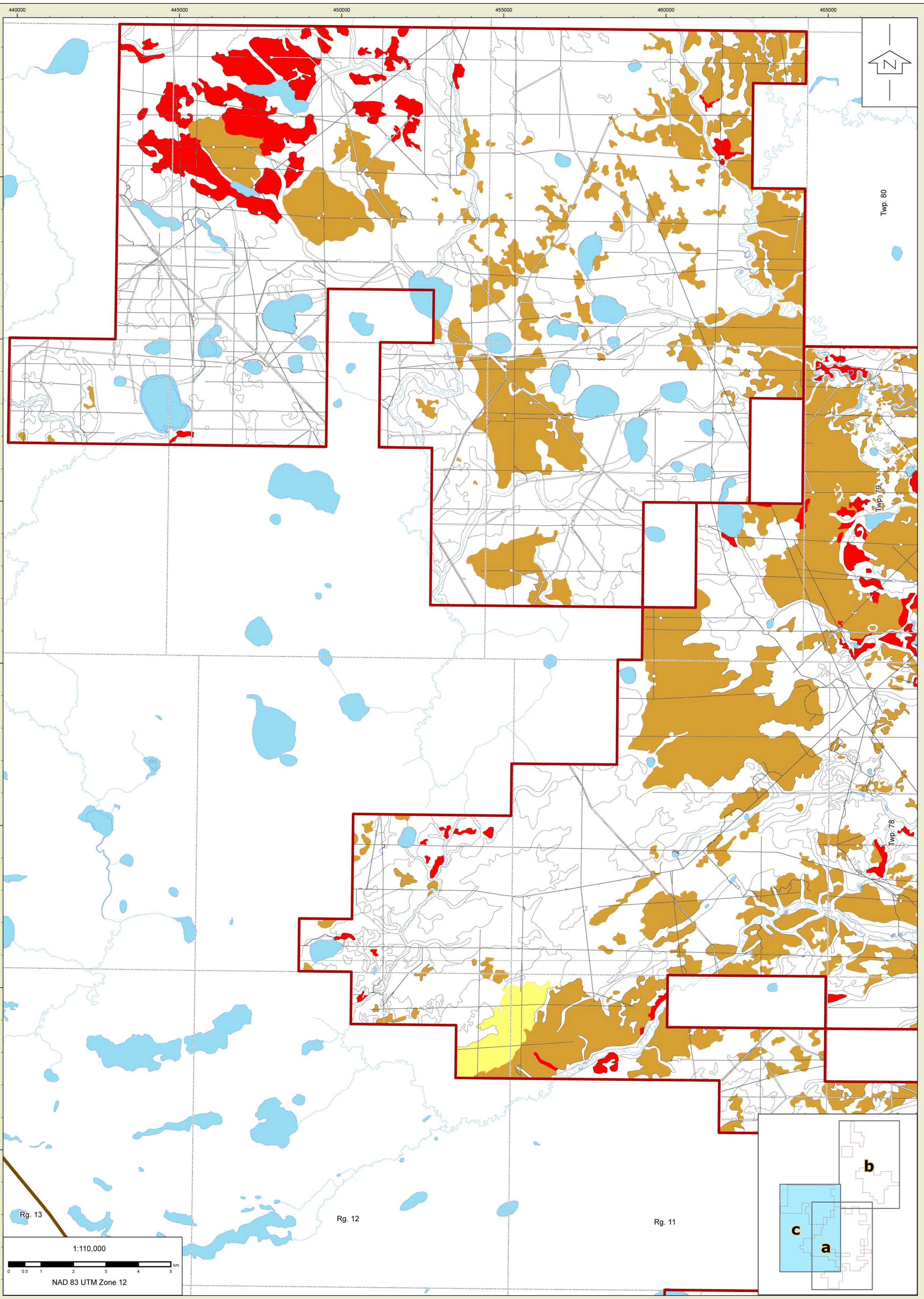
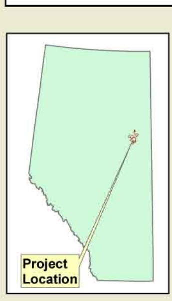




Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Reclamation Suitability - Upper Lift

- Good
- Fair
- Poor
- Organic; Surface Peat; Lake; SC; RB

Title:

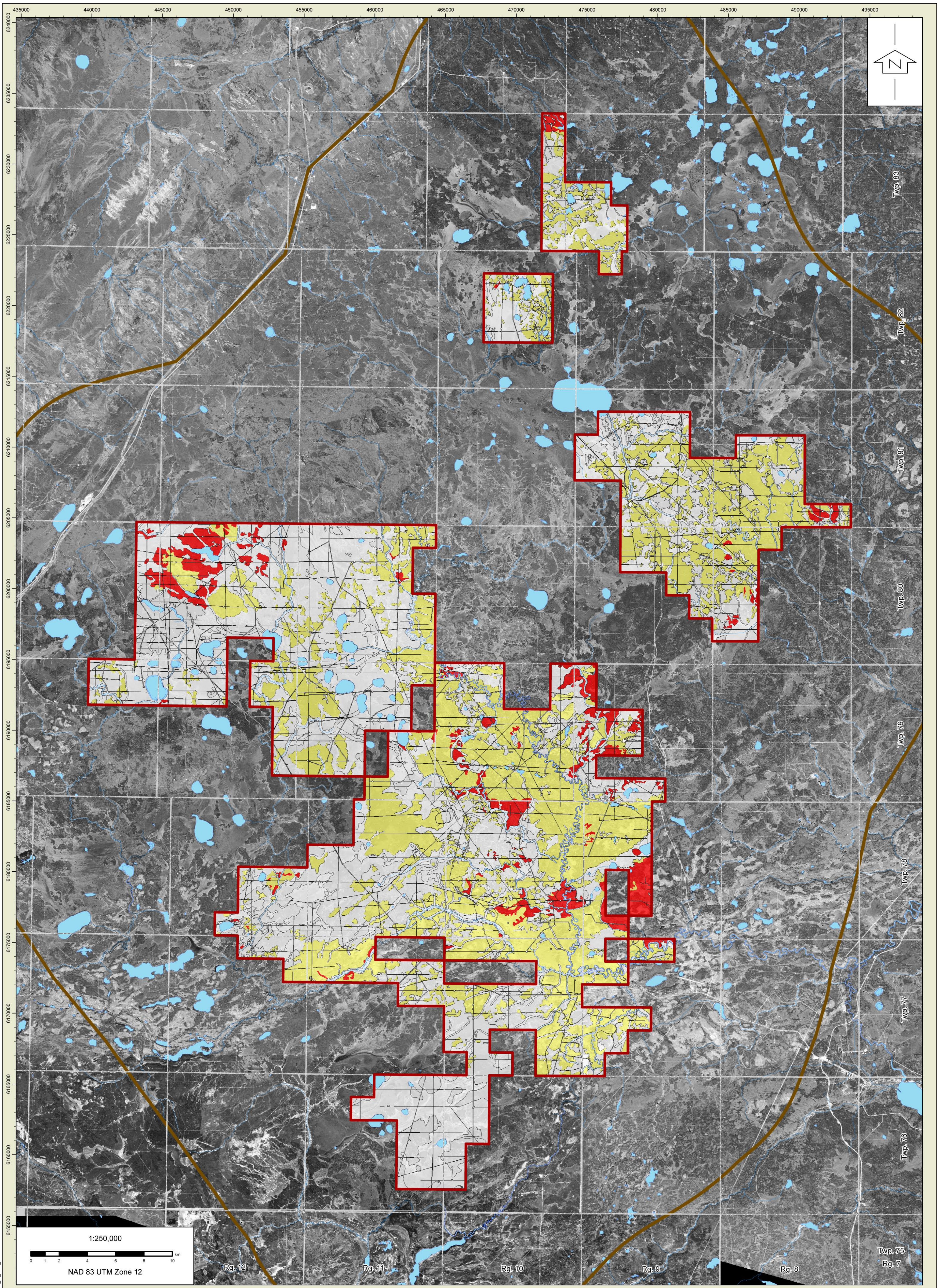
SOIL SUITABILITY FOR RECLAMATION - UPPER LIFT IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

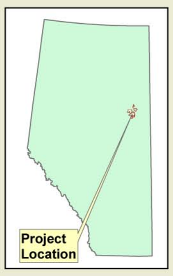
Approved: CG/SC	Revision Date: June 15, 2007
File: Fig 9.5-5c_Soils_Suit_Upper_in_LSA_20070615	

Drawn by:	Checked:	Fig. No.:
TR	LZ/JB	9.5-5c

14455-514_NAOSC\FINAL_MAPS\SOILS\Fig 9.5-5c_Soils_Suit_Upper_in_LSA_20070615.mxd



14455-514_NAOSC/FINAL_MAPS/Soils/Fig 9.5-6_Soil_Suit_Lower_in_LSA_20070614.mxd



Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Reclamation Suitability- Lower Lift

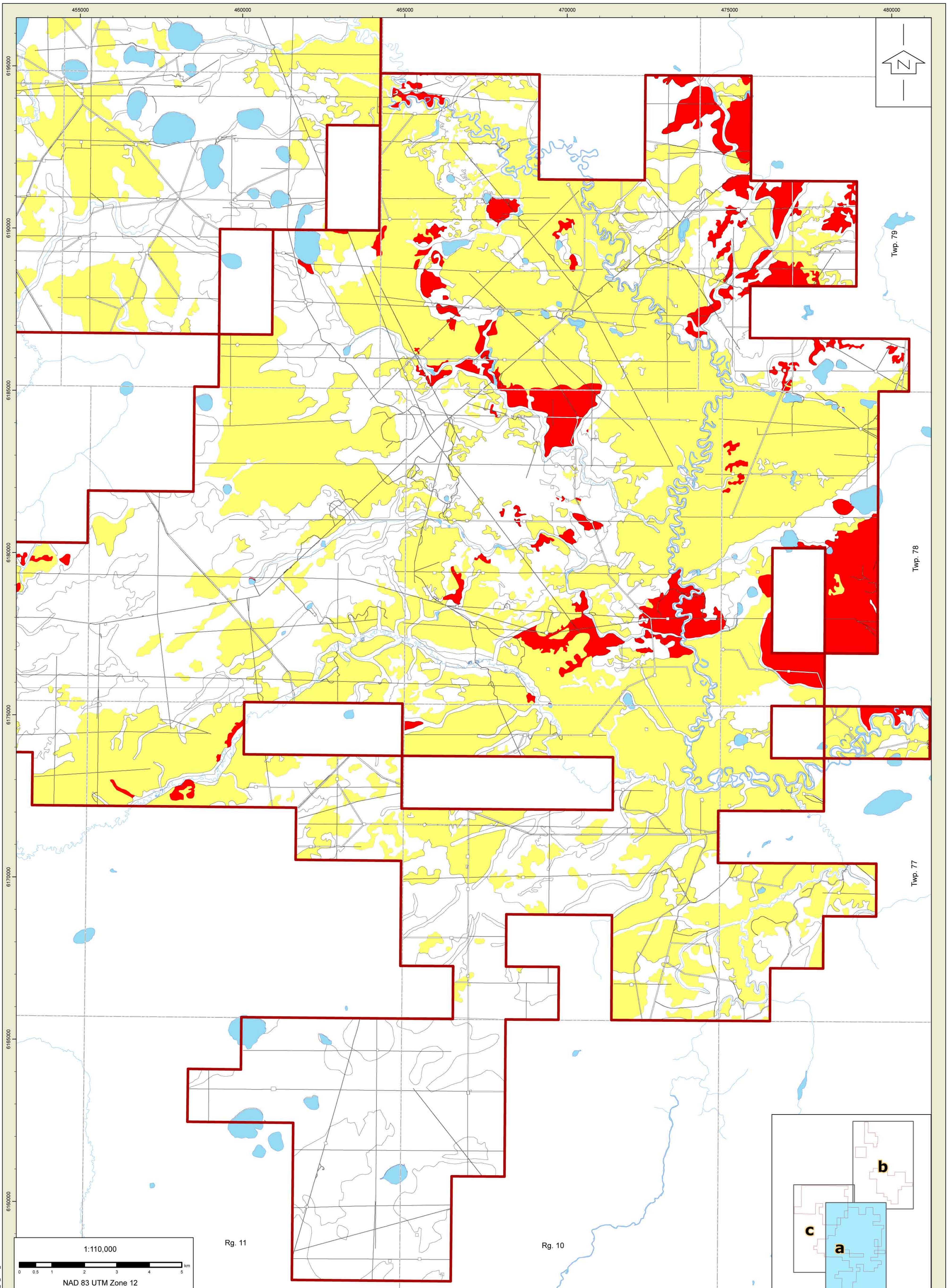
- Good
- Fair
- Poor
- Organic; Surface Peat; Lake; SC; RB

Title:

SOIL SUITABILITY FOR RECLAMATION - LOWER LIFT IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:	
CG/SC	June 14, 2007	
File: Fig 9.5-6_Soil_Suit_Lower_in_LSA_20070614.mxd		
Drawn by: TR	Checked: LZ/JB	Fig. No.: 9.5-6



Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Reclamation Suitability - Lower Lift

- Good
- Fair
- Poor
- Organic; Surface Peat; Lake; SC; RB

Title:

SOIL SUITABILITY FOR RECLAMATION - LOWER LIFT IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/SC	Revision Date: June 15, 2007

File: Fig 9.5-6a_Soil_Suit_Lower_in_LSA_20070615

Drawn by:	Checked:	Fig. No.:
TR	LZ/JB	9.5-6a

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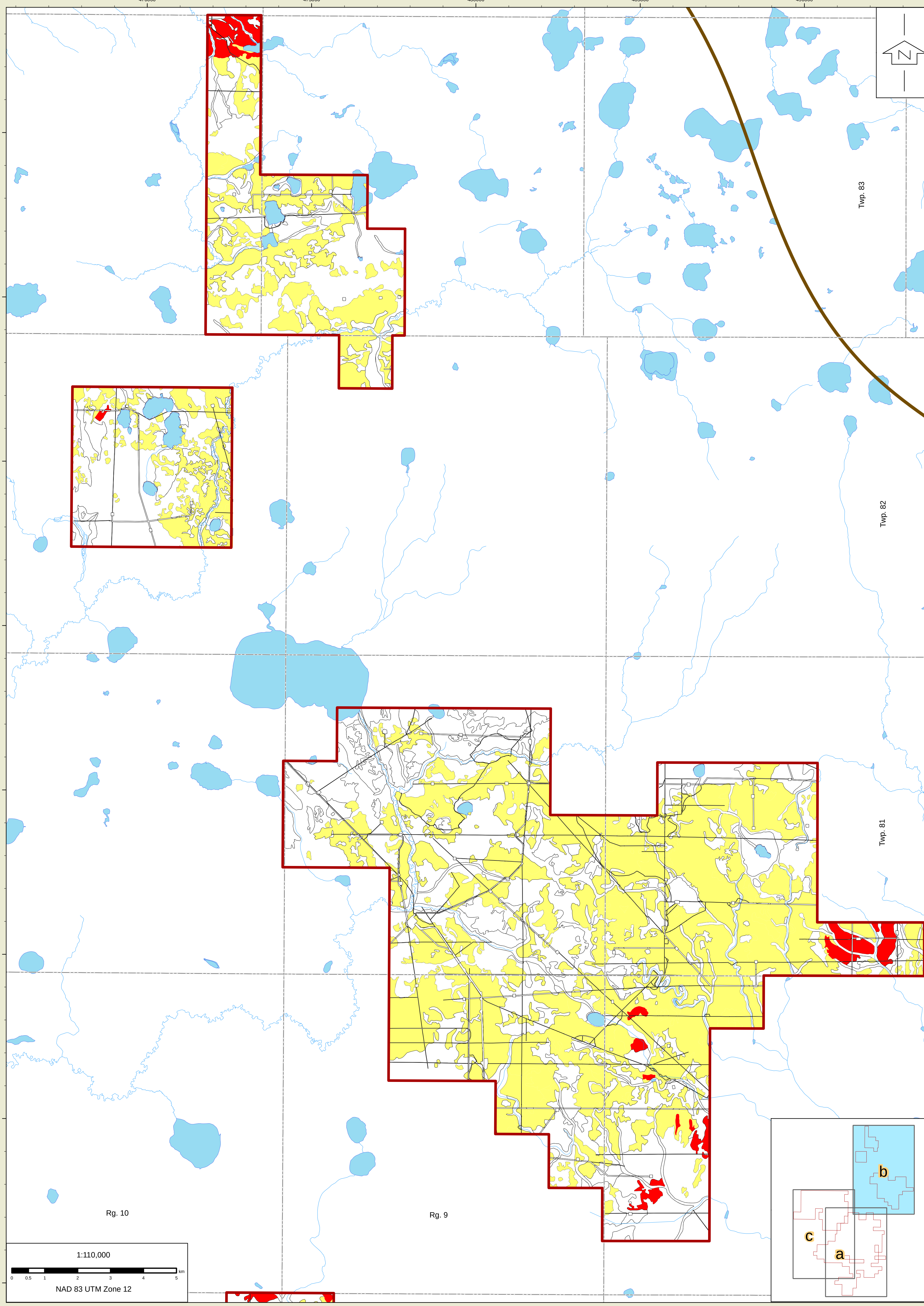

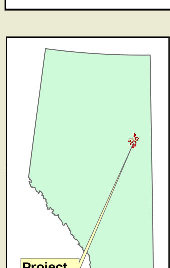

Legend

North American Soils RSA

North American Soils LSA

Lake

River / Stream

Reclamation Suitability - Lower Lift

Good

Fair

Poor

Organic; Surface Peat; Lake; SC; RB

Title:

SOIL SUITABILITY FOR RECLAMATION - LOWER LIFT IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/SC	Revision Date: June 15, 2007

File: Fig 9.5-6b_Soil_Suit_Lower_in_LSA_20070615

Drawn by:	Checked:	Fig. No.:
TR	LZ/JB	**9.5-6b**

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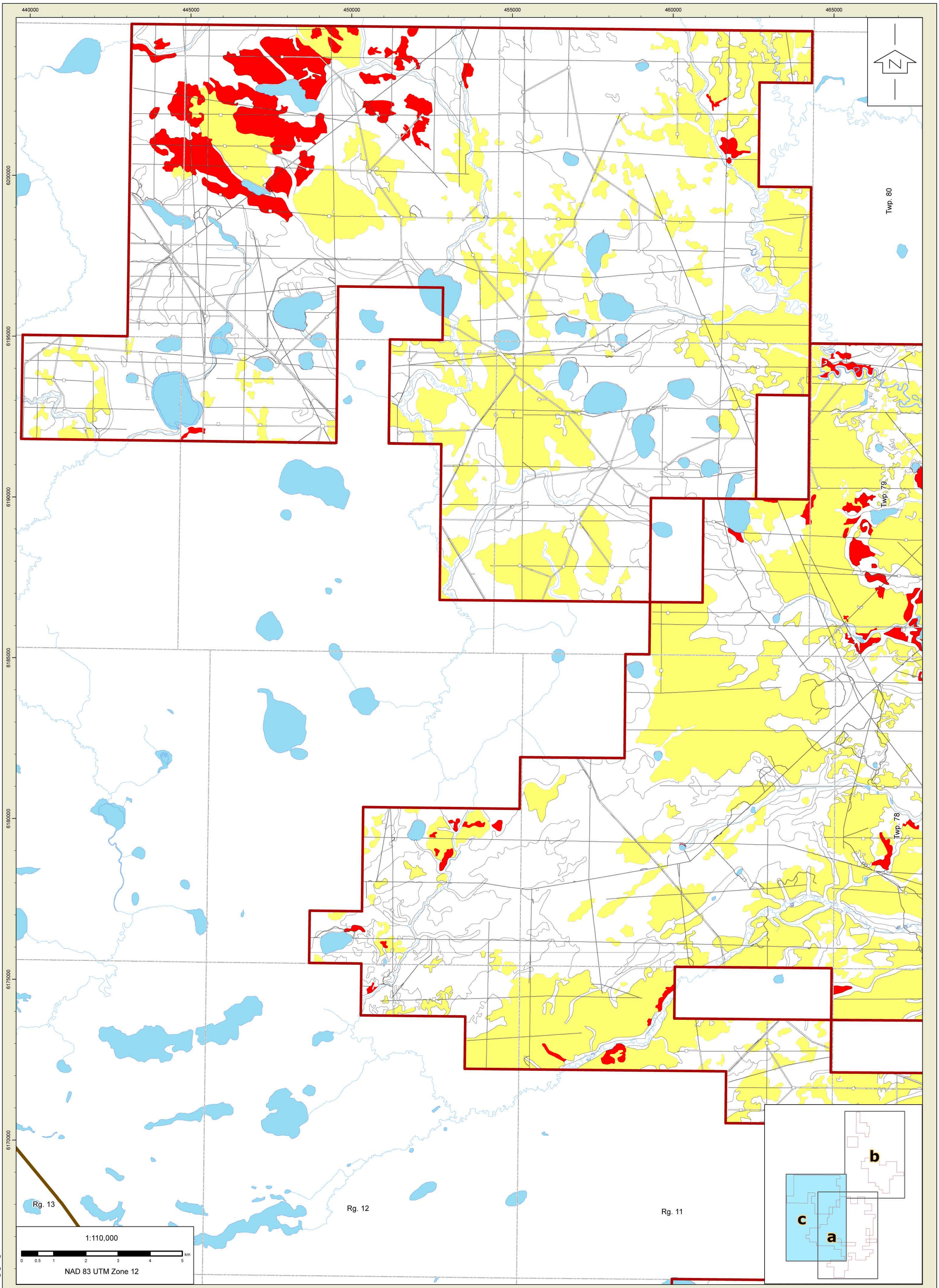

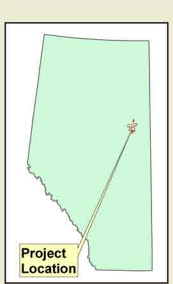

Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Reclamation Suitability - Lower Lift

- Good
- Fair
- Poor
- Organic; Surface Peat; Lake; SC; RB

Title:

SOIL SUITABILITY FOR RECLAMATION - LOWER LIFT IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/SC	Revision Date: June 15, 2007	
File: Fig 9.5-6c_Soil_Suit_Lower_in_LSA_20070615		
Drawn by: TR	Checked: LZ/JB	Fig. No.: 9.5-6c

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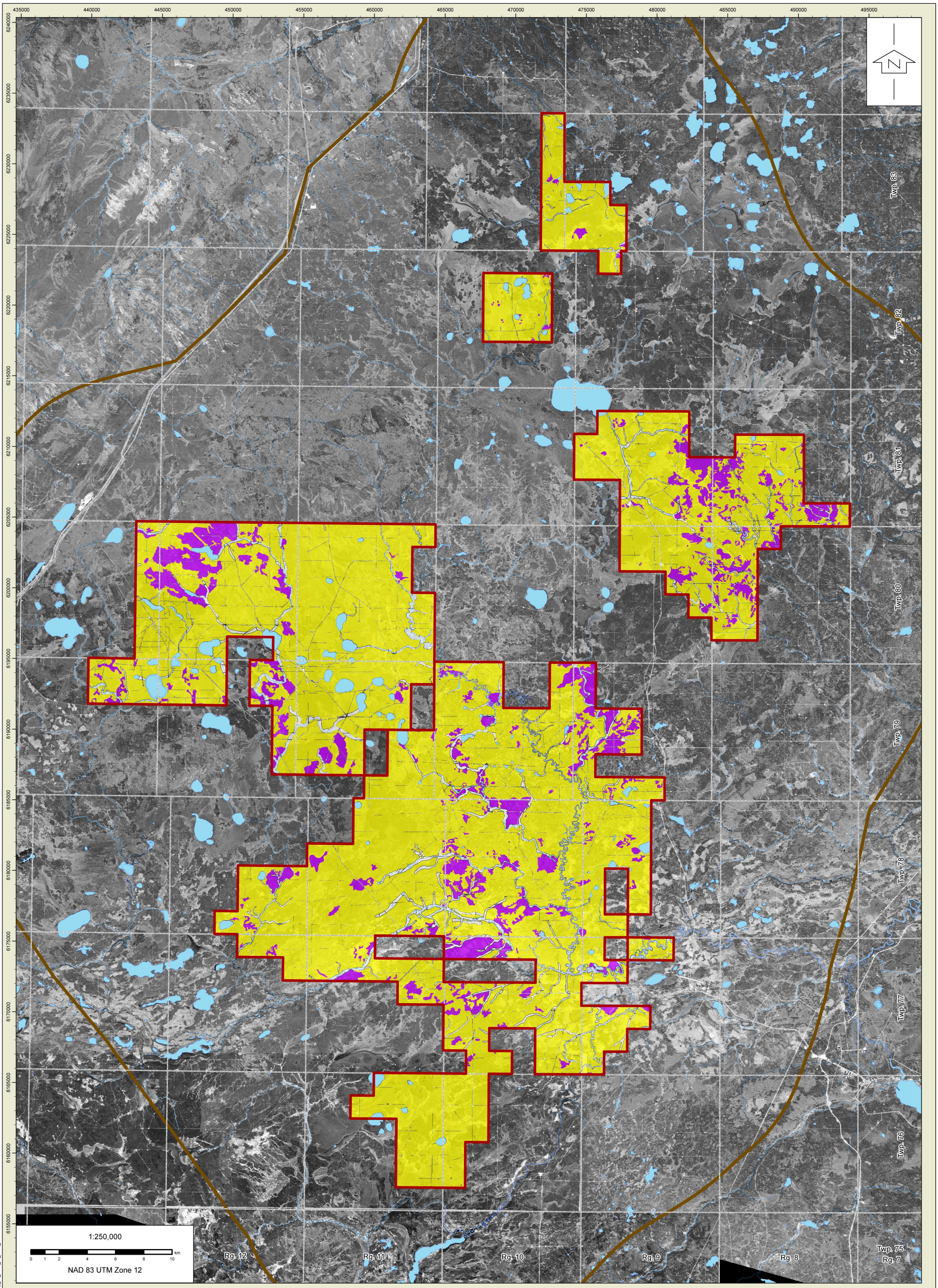
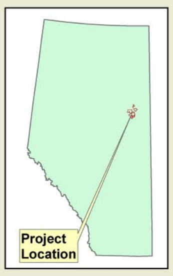


I:\455-514_NAOSC\FINAL_MAPS\Soils\Fig 9.5-7_Soil_Sensitivity_to_Acid_in_LSA_20070614.mxd



Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Acidification Potential:

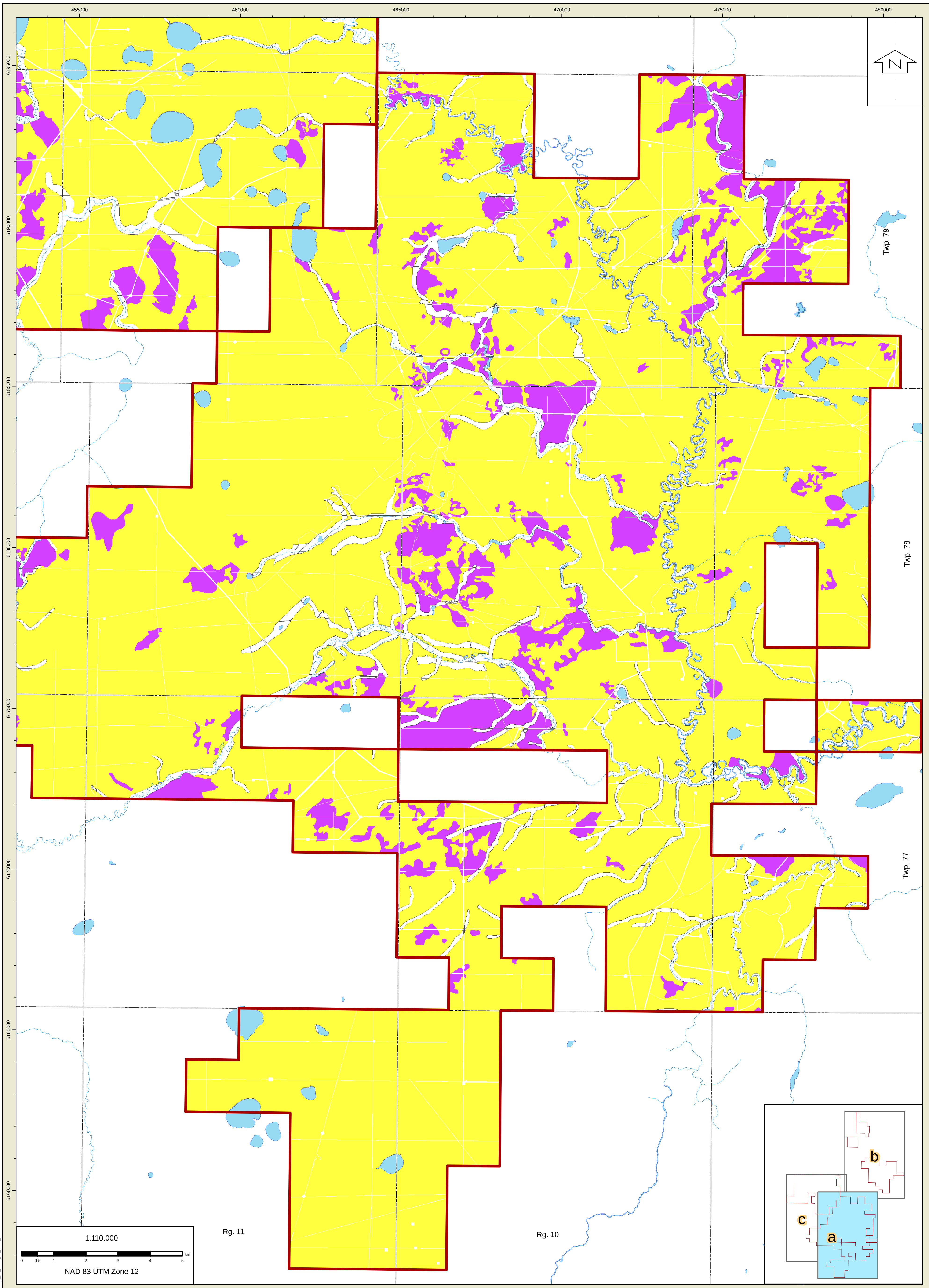
- Low
- Moderate
- Unclassified (Water, Disturbed, Stream Channel)

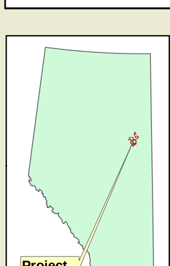
Title:

SOIL SENSITIVITY TO ACIDIC INPUTS IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/SC	Revision Date: June 14, 2007	
File: Fig 9.5-7_Soil_Sensitivity_to_Acid_in_LSA_20070614.mxd		
Drawn by: TR	Checked: LZ/JB	Fig. No.: 9.5-7





Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Acidification Potential:

- Low
- Moderate
- Unclassified (Water, Disturbed, Stream Channel)

Title:

SOIL SENSITIVITY TO ACIDIC INPUTS IN THE LSA

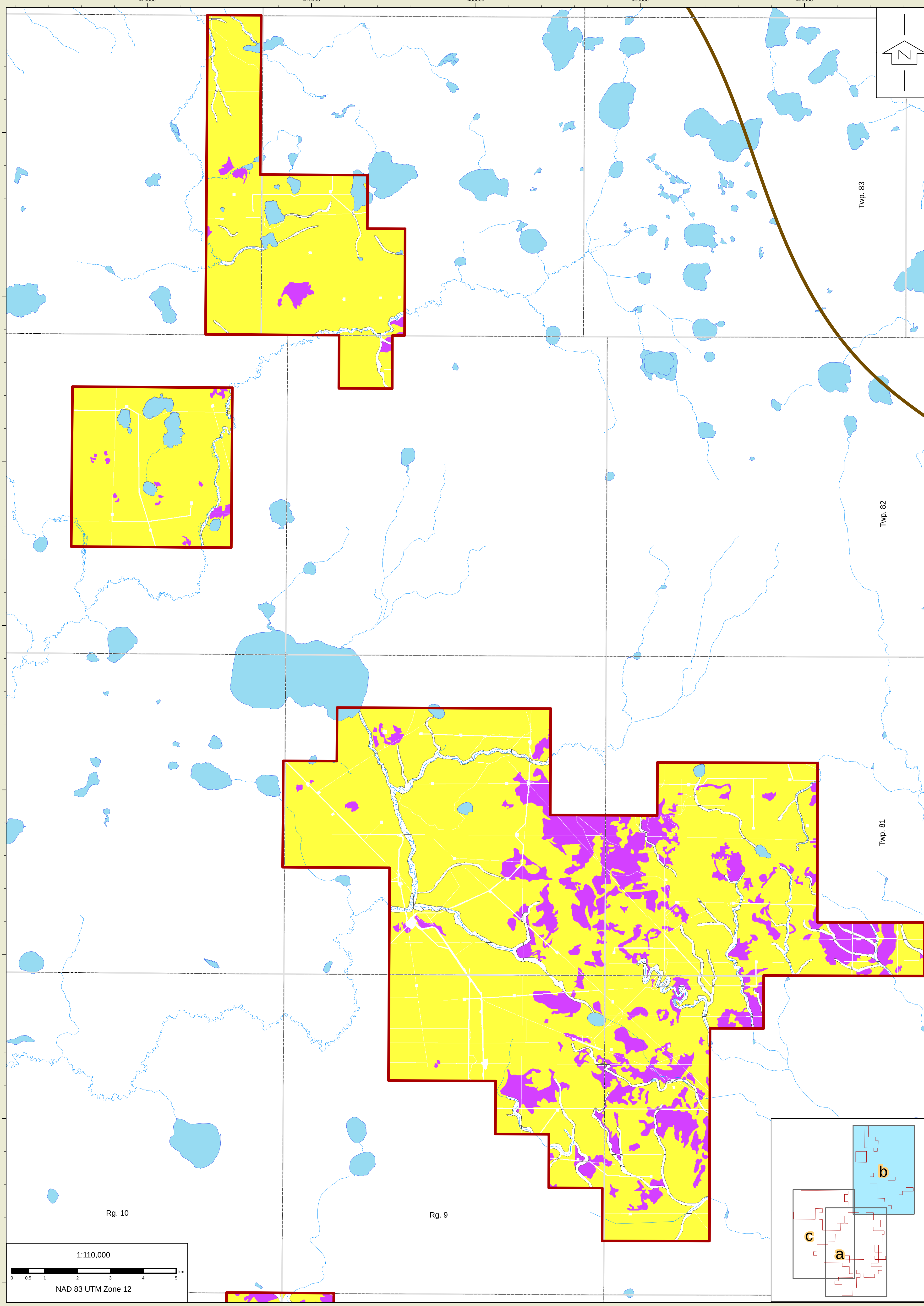
NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
CG/SC	June 13, 2007

File: Fig 9.5-7a_Soil_Sensitivity_to_Acid_in_LSA_20070613

Drawn by:	Checked:	Fig. No.:
TR	LZ/JB	9.5-7a

I:\4455-514_NAOSC\FINAL_MAPS\SOILS\Fig 9.5-7a_Soil_Sensitivity_to_Acid_in_LSA_20070613.mxd



Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Acidification Potential:

- Low
- Moderate
- Unclassified (Water, Disturbed, Stream Channel)

Title:

SOIL SENSITIVITY TO ACIDIC INPUTS IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
CG/SC	May 10, 2007

File: Fig 9.5-7b_Soil_Sensitivity_to_Acid_in_LSA_20070613

Drawn by:	Checked:	Fig. No.:
TR	LZ/JB	9.5-7b

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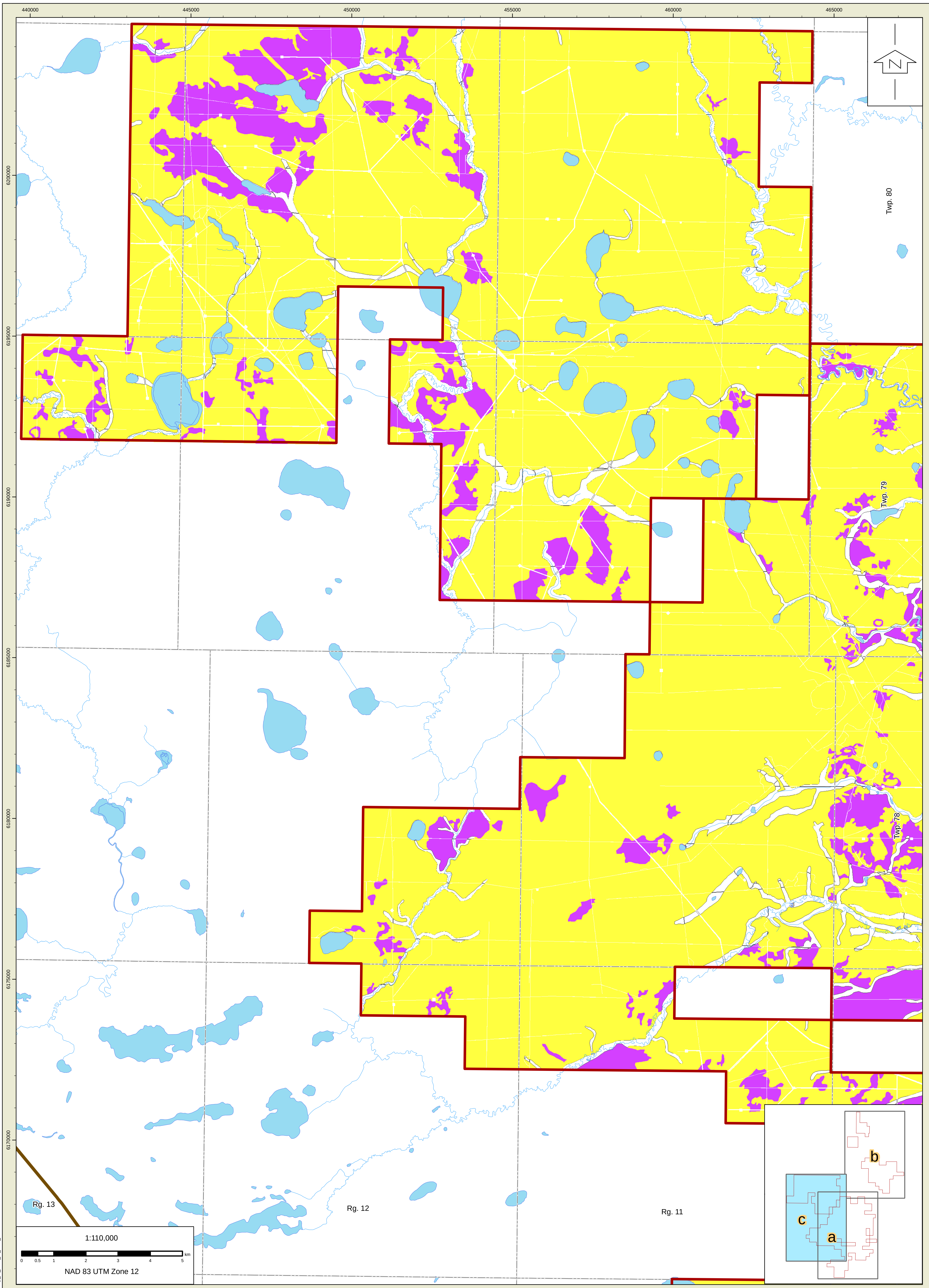

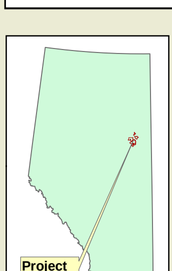

Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Acidification Potential:

- Low
- Moderate
- Unclassified (Water, Disturbed, Stream Channel)

Title:

SOIL SENSITIVITY TO ACIDIC INPUTS IN THE LSA

Approved:	Revision Date:
CG/SC	June 13, 2007

File: Fig 9.5-7c_Soil_Sensitivity_to_Acid_in_LSA_20070613

Drawn by:	Checked:	Fig. No.:
TR	LZ/JB	**9.5-7c**

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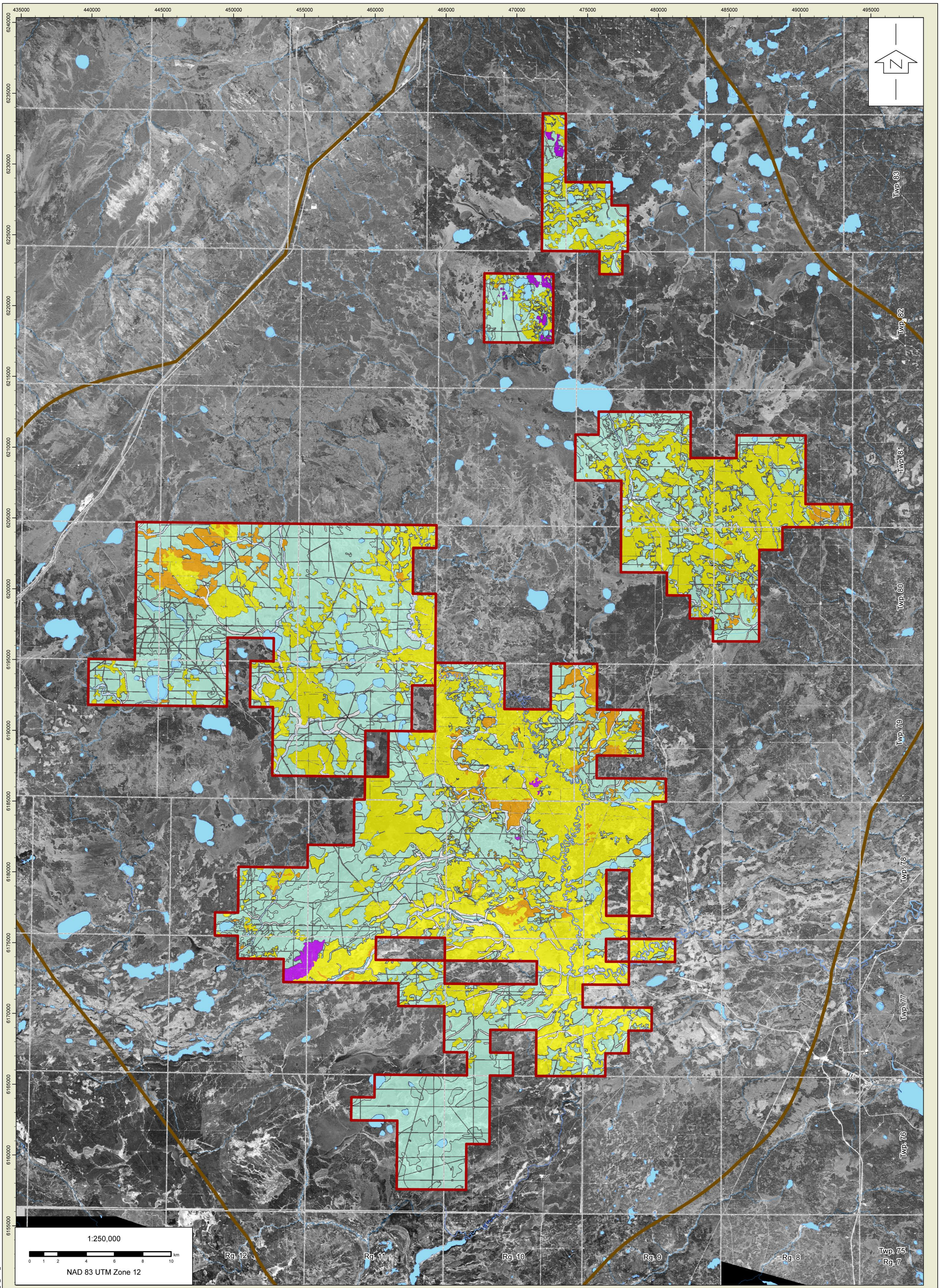
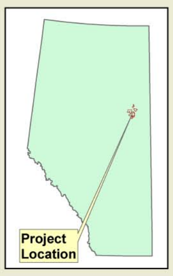


I:\4455-514_NAOSC\FINAL_MAPS\Soils\Fig 9.5-8_Wind_Erosion_in_LSA_20070614.mxd



Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Risk of Wind Erosion

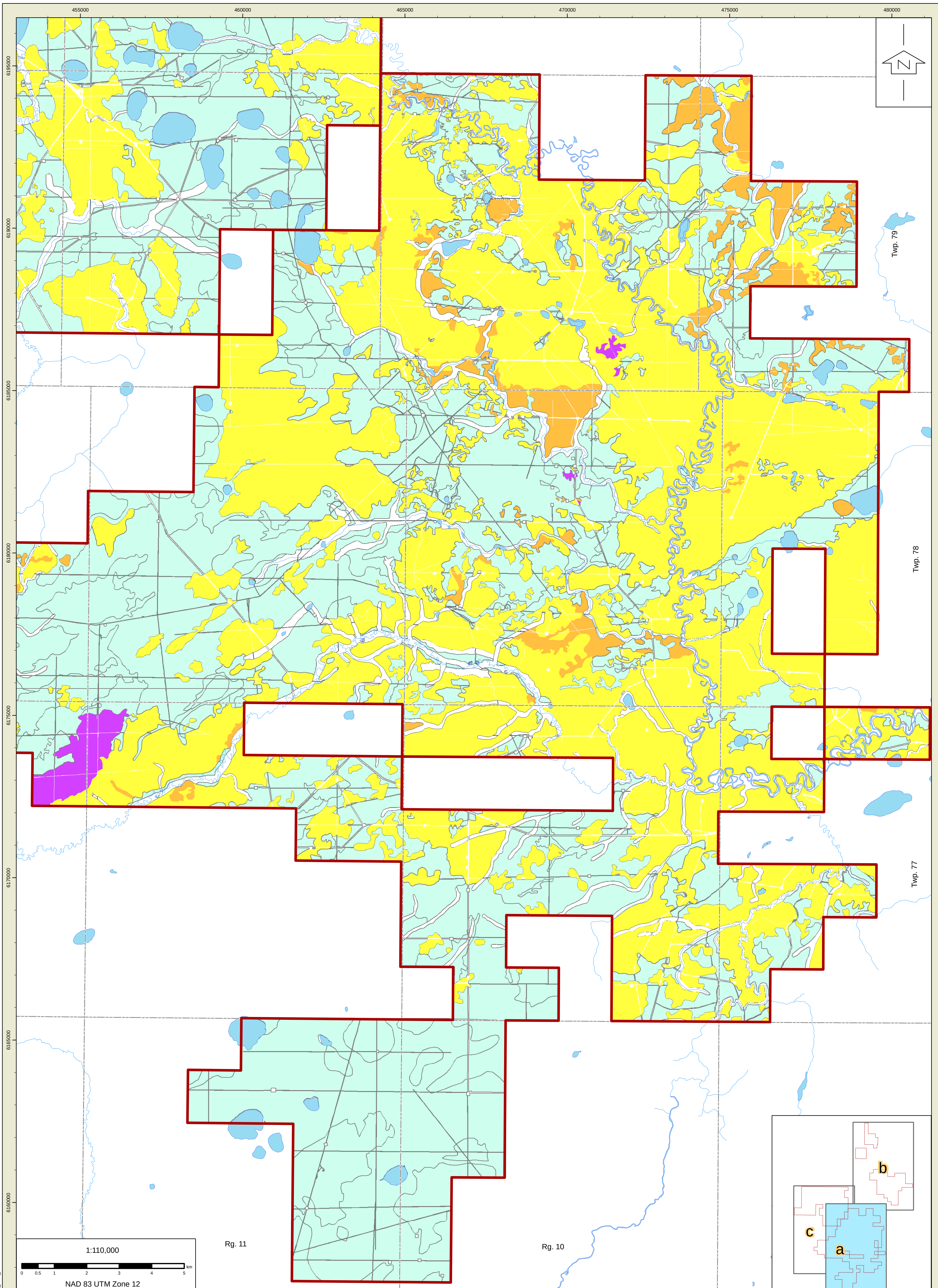
- Low
- Moderate
- High
- Negligible (Organic Soils)
- Unclassified (Water, Stream Channel, Disturbed)

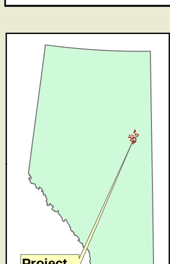
Title:

WIND EROSION IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:	
CG/SC	June 14, 2007	
File: Fig 9.5-8_Wind_Erosion_in_LSA_20070614.mxd		
Drawn by: TR	Checked: LZ/JB	Fig. No.: **9.5-8**





Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Risk of Wind Erosion

- Low
- Moderate
- High
- Negligible (Organic Soils)
- Unclassified (Water, Stream Channel, Disturbed)

Title:

WIND EROSION IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/SC	Revision Date: June 15, 2007	
File: Fig 9.5-8a_Wind_Erosion_in_LSA_20070615		
Drawn by: TR	Checked: LZ/JB	Fig. No.: **9.5-8a**

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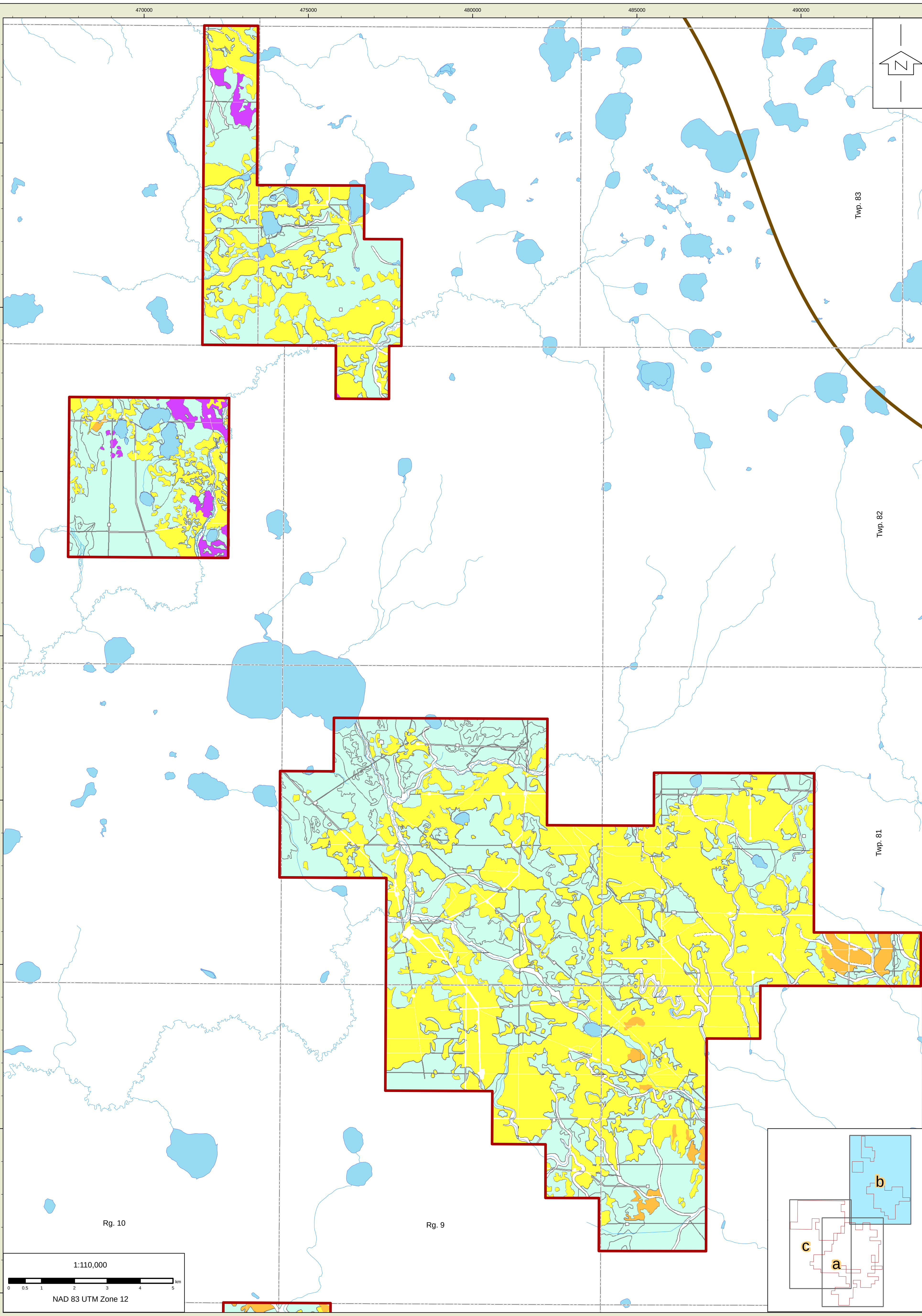
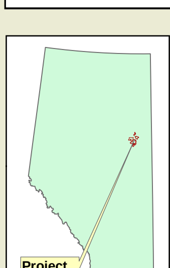




Legend

North American Soils RSA	
North American Soils LSA	
Lake	
River / Stream	

Risk of Wind Erosion

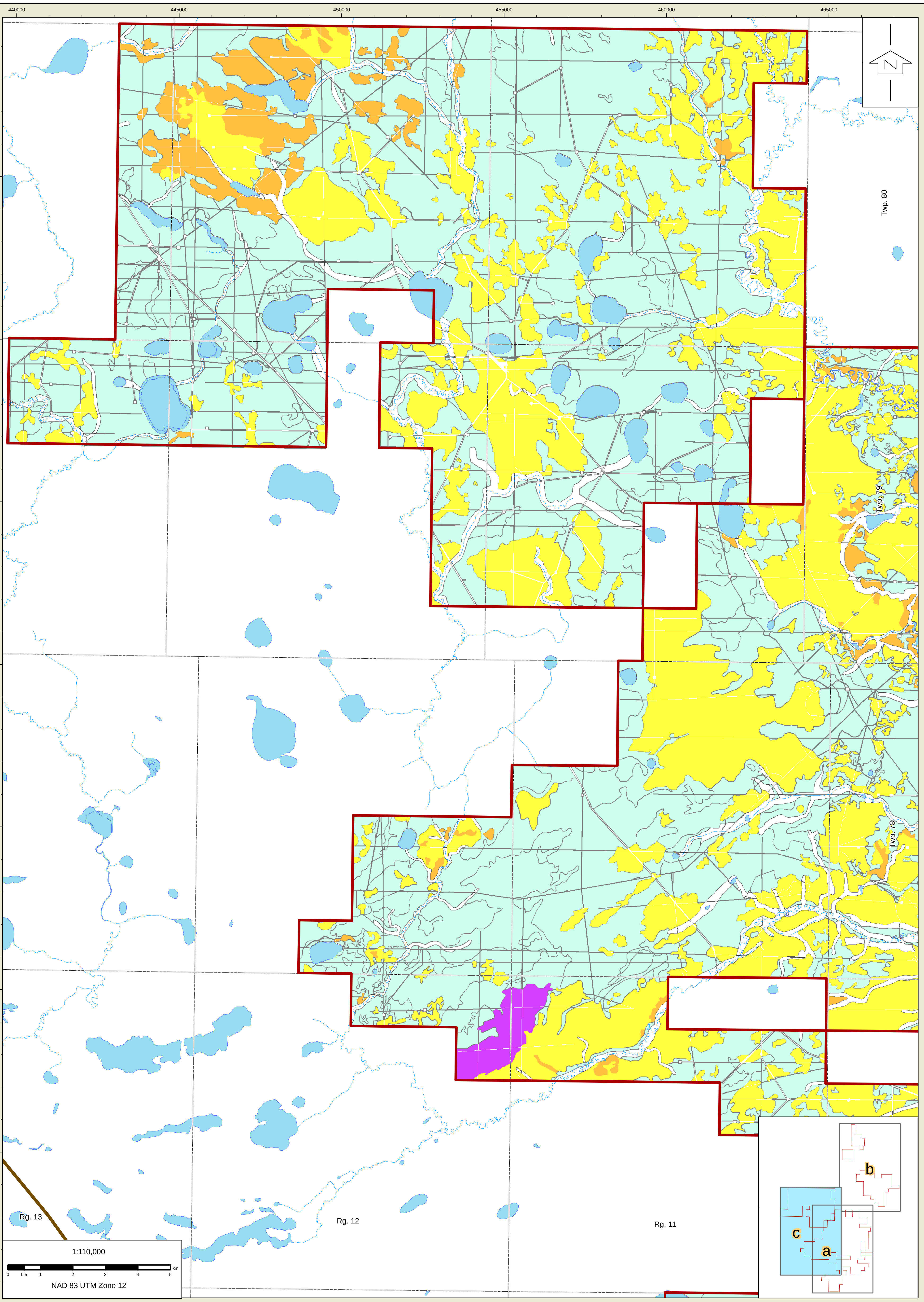
- Low
- Moderate
- High
- Negligible (Organic Soils)
- Unclassified (Water, Stream Channel, Disturbed)

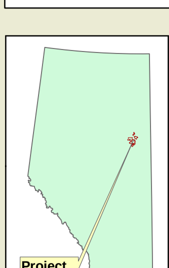
Title:

WIND EROSION IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/SC	Revision Date: June 15, 2007	
File: Fig 9.5-8b_Wind_Erosion_in_LSA_20070615		
Drawn by: TR	Checked: LZ/JB	Fig. No.: **9.5-8b**





Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Risk of Wind Erosion

- Low
- Moderate
- High
- Negligible (Organic Soils)
- Unclassified (Water, Stream Channel, Disturbed)

Title:

WIND EROSION IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/SC	Revision Date: June 15, 2007	
File: Fig 9.5-8c_Wind_Erosion_in_LSA_20070615		
Drawn by: TR	Checked: LZ/JB	Fig. No.: **9.5-8c**

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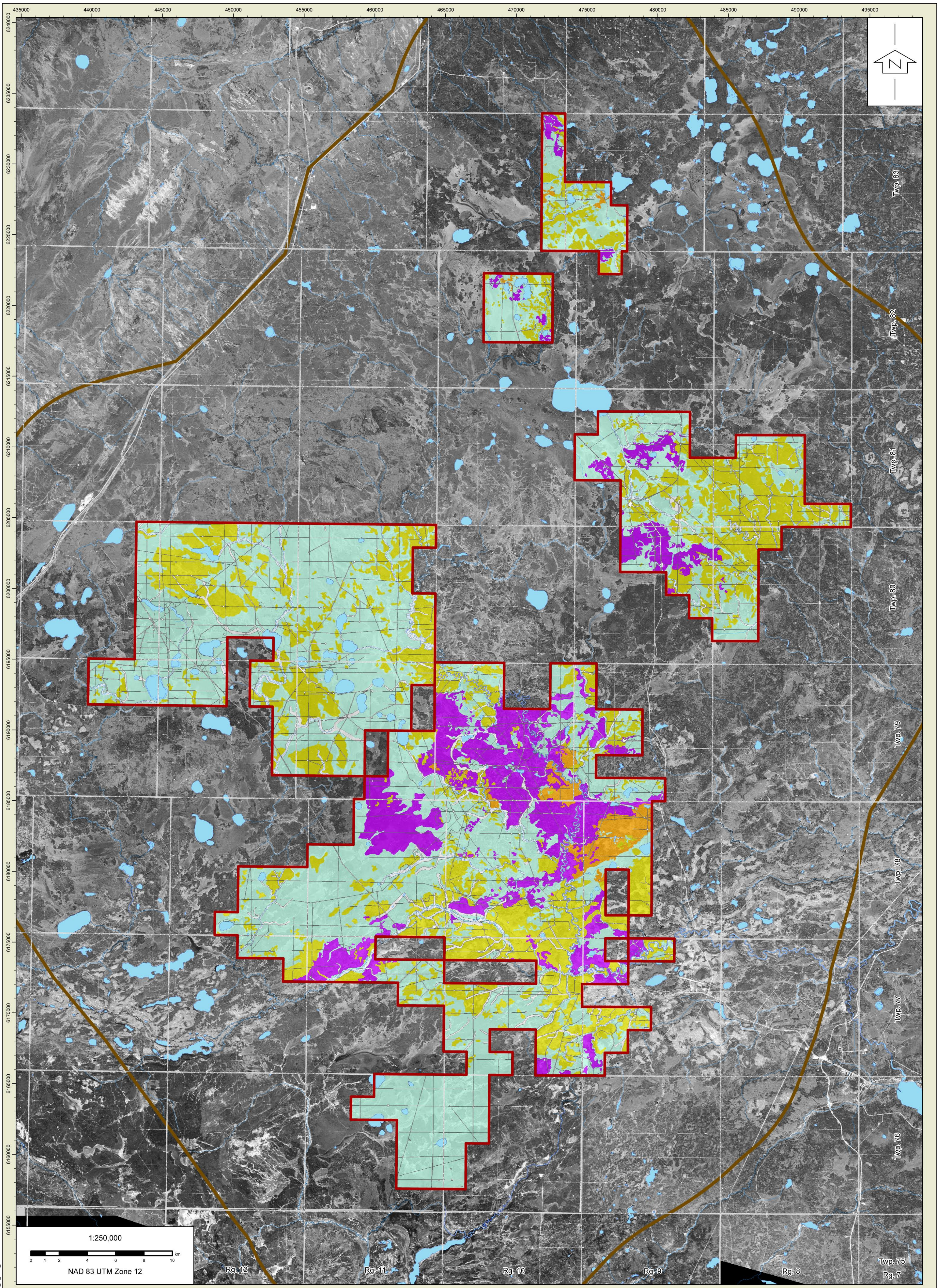


I:\4455-514_NAOSC\FINAL_MAPS\Soils\Fig 9.5-9_Water_Erosion_in_LSA_20070614.mxd

Project Location

Legend

North American Soils RSA

North American Soils LSA

Lake

River / Stream

Risk of Water Erosion

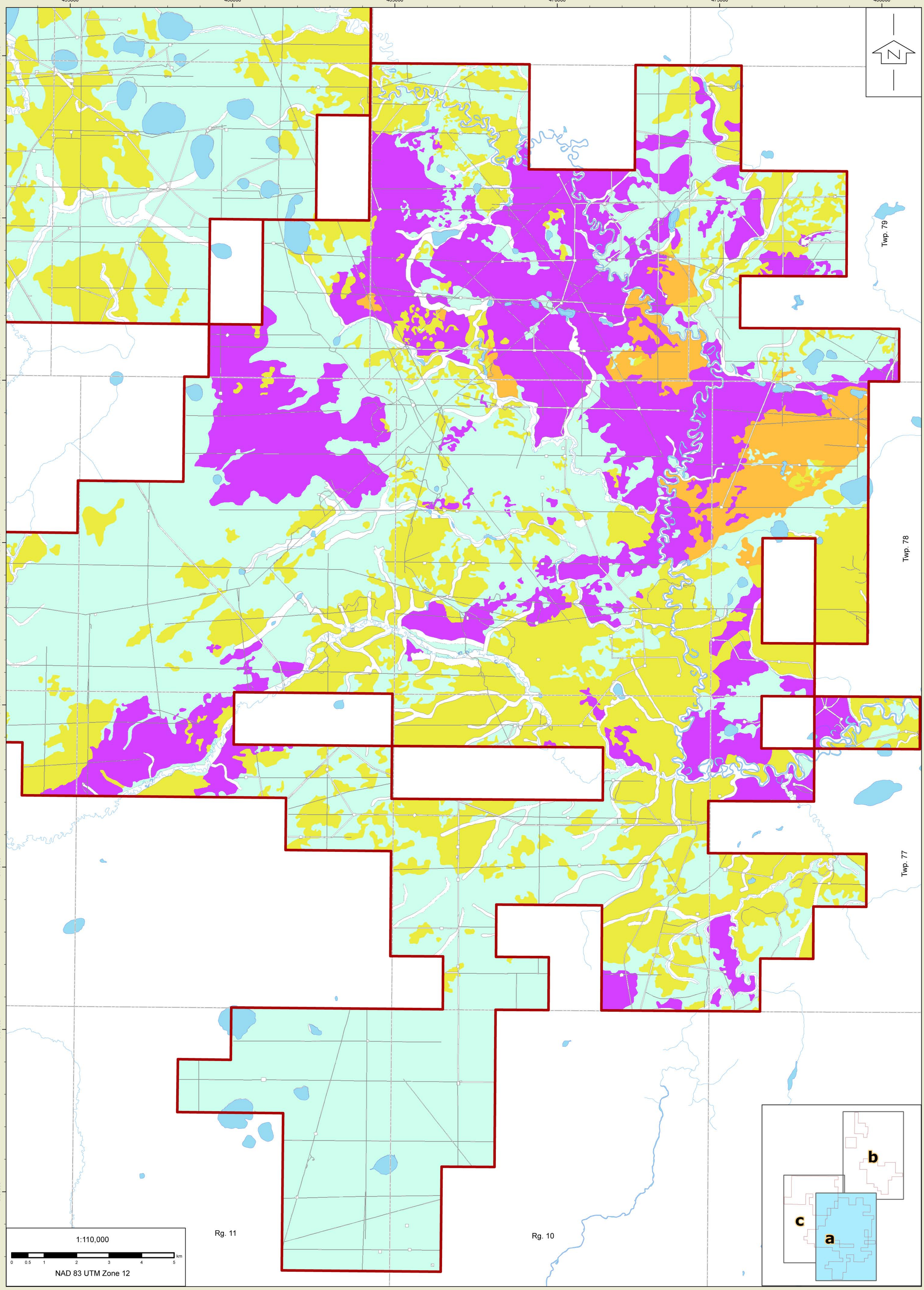
- Low
- Moderate
- High
- Negligible (Organic Soils)
- Unclassified (Water, Stream Channel, Disturbed)

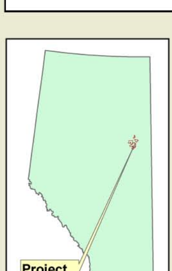
Title:

WATER EROSION IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/SC	Revision Date: June 14, 2007	
File: Fig 9.5-9_Water_Erosion_in_LSA_20070614.mxd		
Drawn by: TR	Checked: LZ/JB	Fig. No.: 9.5-9





Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Risk of Water Erosion

- Low
- Moderate
- High
- Negligible (Organic Soils)
- Unclassified (Water, Stream Channel, Disturbed)

Title:

WATER EROSION IN THE LSA

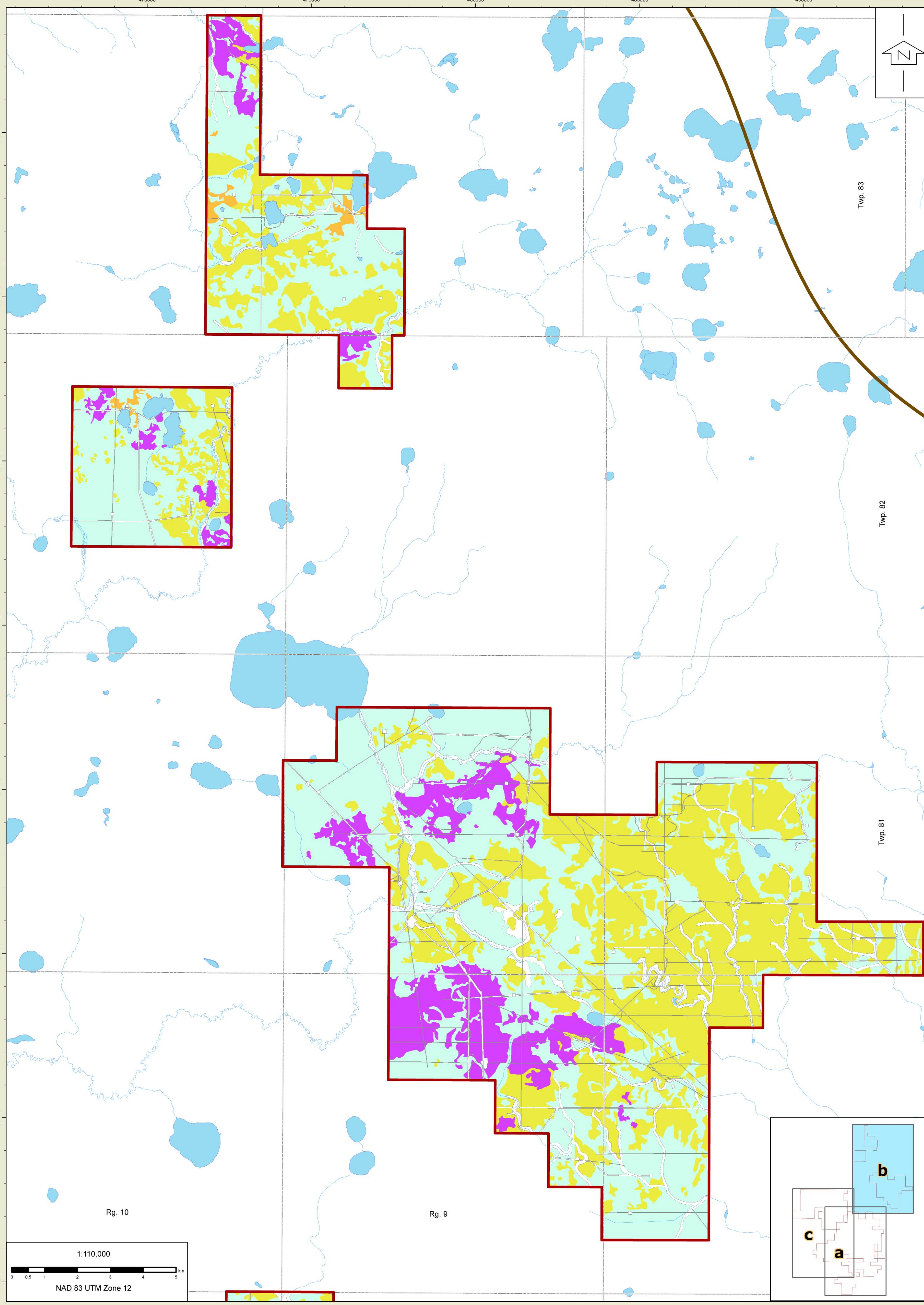
NORTH AMERICAN OIL SANDS CORPORATION

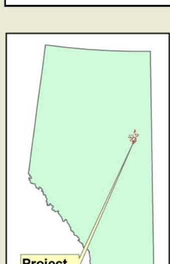
Approved:	Revision Date:
CG/SC	June 13, 2007

File: Fig 9.5-9a_Water_Erosion_in_LSA_20070613

Drawn by:	Checked:	Fig. No.:
TR	LZ/JB	9.5-9a

14455-514_NAOSC\FINAL_MAPS\SOILS\Fig 9.5-9a_Water_Erosion_in_LSA_20070613.mxd





Legend

North American Soils RSA	
North American Soils LSA	
Lake	
River / Stream	

Risk of Water Erosion

- Low
- Moderate
- High
- Negligible (Organic Soils)
- Unclassified (Water, Stream Channel, Disturbed)

Title:

WATER EROSION IN THE LSA

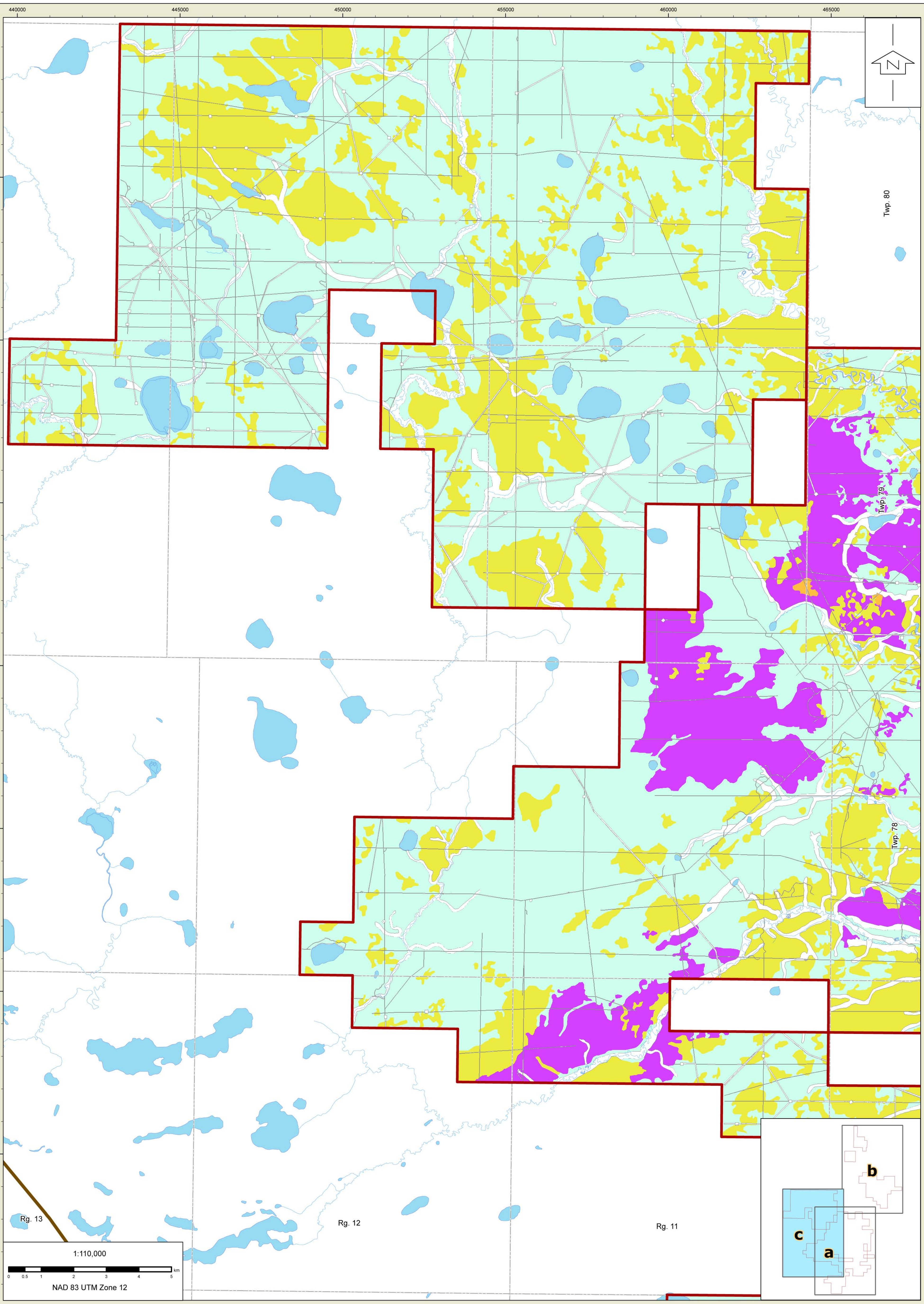
NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
CG/SC	June 13, 2007

File: Fig 9.5-9b_Water_Erosion_in_LSA_20070613

Drawn by:	Checked:	Fig. No.:
TR	LZ/JB	9.5-9b

14455-514_NAOSC\FINAL_MAPS\SOILS\Fig 9.5-9b_Water_Erosion_in_LSA_20070613.mxd



I:\4455-314_NAOS\FINAL_MAPS\SOILS\Fig 9.5-9c_Water_Erosion_in_LSA_20070613.mxd

Project Location

Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Risk of Water Erosion

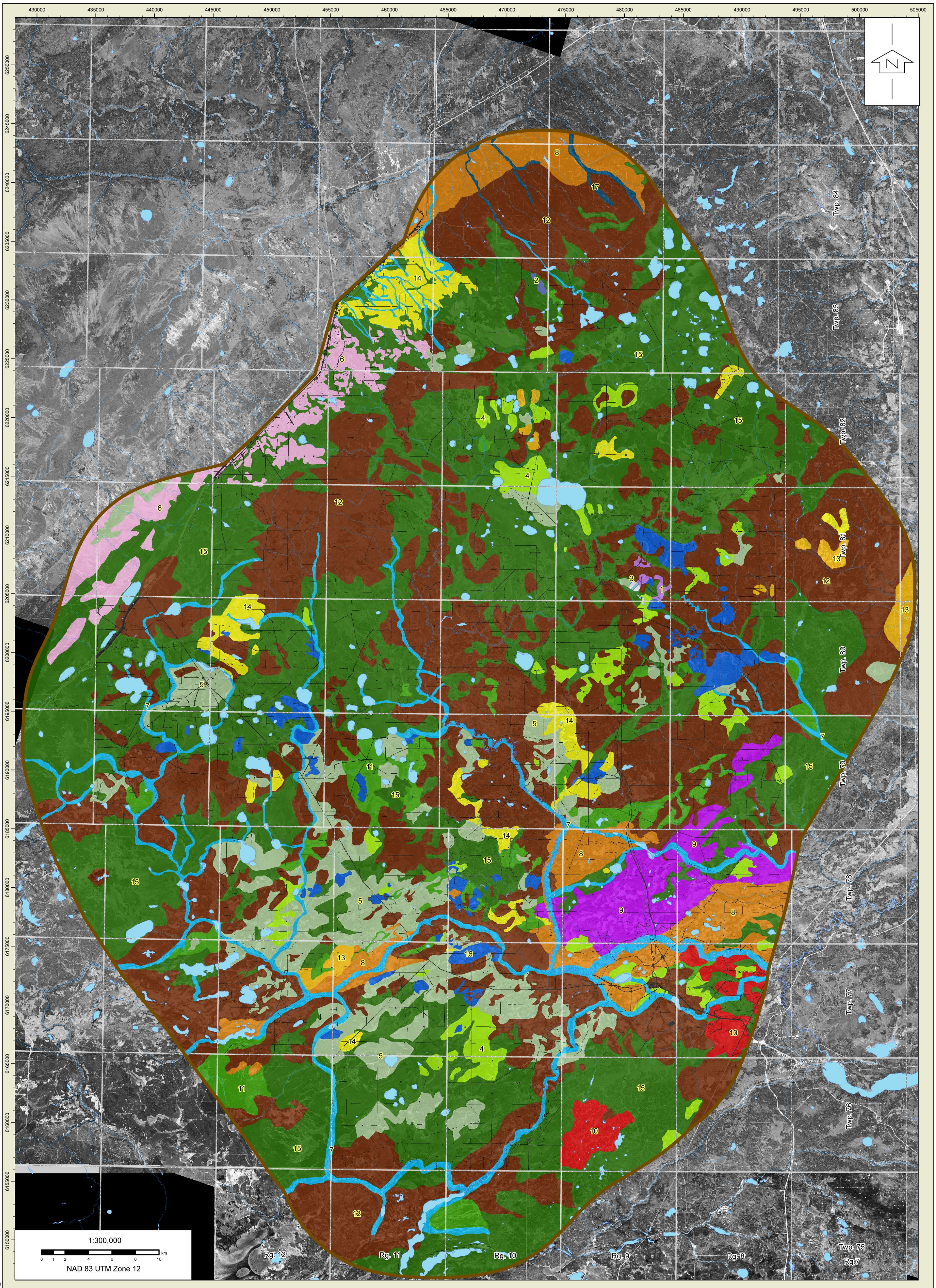
- Low
- Moderate
- High
- Negligible (Organic Soils)
- Unclassified (Water, Stream Channel, Disturbed)

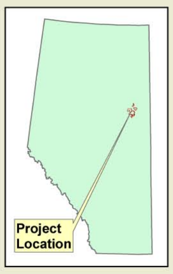
Title:

WATER EROSION IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/SC	Revision Date: June 13, 2007	
File: Fig 9.5-9c_Water_Erosion_in_LSA_20070613		
Drawn by: TR	Checked: LZ/JB	Fig. No.: 9.5-9c





Legend

- North American Soils RSA
- Rivers
- Lake

Soil Map Units:

Algar Lake (ALG)	Stream Channel (SC)	Livock (LVK)
Fort (FRT)	Surmont (SRT)	Mildred (MIL)
Mikkwa (MKW)	Dover (DOV)	McLelland (MLD)
Muskeg (MUS)	Firebag (FIR)	Steep Bank (STP)
Mariana (MRN)	Harley (HLY)	Rough Broken (RB)
Horse River (HRR)	Kinosis (KNS)	Disturbed (ZUN)

Title:

SOILS IN THE REGIONAL STUDY AREA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/SC	Revision Date: June 12, 2007	
File: Fig 9.5-10 Soils in RSA_20070612.mxd		
Drawn by: TR	Checked: LZ/JB	Fig. No.: 9.5-10

I:\4455-514_NAOSC\FINAL_MAPS\Soils\Fig 9.5-10 Soils in RSA_20070612.mxd

9.6 Summary of Baseline Conditions in the LSA and RSA

The soils and terrain LSA is approximately 110,938 ha in size. Landforms in the LSA include organic, morainal, glaciofluvial, lacustrine, channelled and active streams (Rough Broken).

Approximately 30% (32,912 ha) of the LSA is mapped as Luvisols, dominantly the Orthic and Gleyed Gray Luvisols of the Kinosis series. Organic soils of the McLelland, Muskeg, Mariana and Hartley series occupy approximately 51% of the LSA or 56,174 ha. Brunisolic and Gleysolic soils cover approximately 3% (3,795 ha) and 6% (6,900 ha), respectively.

The Land Capability for Forest Ecosystems classes for soils occurring on the LSA ranged from Class 2 to Class 5. Soil series within the Luvisol order were rated Class 2 to Class 3, the Brunisols were rated Class 4 and the Organic soils were rated Class 5. Gleysols were rated Class 4 and Class 5 for different soil series. Class 3 (low capability) was the dominant rating for mineral soil, which was made up of Kinosis and Surmont soils. These soils account for approximately 28% of the LSA or 31,039 ha.

Mineral soils assigned the highest reclamation ratings (Dover, Kinosis and Surmont series) cover approximately 29% (32,201 ha) of the LSA. The upper lift was rated good for all three series, and the lower lift was rated fair for Kinosis and Surmont soils. The lower lift of the Dover soils series, however, was rated poor due to increased clay content. The rest of the mineral soils were rated as fair or poor with texture or reaction limitations, or there was a significant surface peat layer present.

No soils in the LSA were rated high for sensitivity to acid deposition. Soils having medium sensitivity to acid deposition cover approximately 10,680 ha (10% of the LSA), while low sensitivity soils cover approximately 80% of the LSA (89,179 ha).

As organics cover approximately 51% of the LSA, wind and water erosion were rated as negligible for just over half of the LSA. Approximately one quarter of the soils in the LSA (25% or 27,849 ha) exhibit a low potential for water erosion. A further 13,748 ha or 12% of the soils in the LSA have a moderate rating for water erosion, largely due to the prevalence of Kinosis soils on slopes between 5% and 9%. Almost 2% of the LSA is rated high for water erosion due largely to steeper slope gradients (2,027 ha).

Approximately 35% of soils within the LSA or 39,118 ha were rated as having low risk to wind erosion. The rating was consistent with the occurrence of Gleysolic soils and soils with relatively high clay content in the LSA. Mineral soils of the Mildred series account for approximately 3.4% of the LSA (3,795 ha) and were rated as highly sensitive to wind erosion due to the sandy soil texture.

Landforms and soils found in the RSA are very similar to what was found in the LSA. Horse River was the only soil series found in the RSA but not the LSA. Organic soils dominate the RSA occupying approximately 47% of the RSA (224,504 ha). The dominant mineral soils are Kinosis soils occupying approximately 33% of the RSA covering 154,843 ha.

9.7 Impact Assessment and Mitigative Measures

The Project footprint requires 3,032 ha for facility development. An estimated 2,721 ha occurs within the soils and terrain LSA. An additional 311 ha of Project footprint exist outside the soils and terrain LSA (refer to Section 9.3.1). Distribution of soil types on the footprint in the LSA include 221 ha (0.2% of LSA) of existing disturbance, 1,064 ha (1.0% of the LSA) of organic soils and 1,436 ha (1.3% of the LSA) of mineral soils.

Potential impacts over the proposed 45 year lifespan of the Project relate to changes to soil and landform resources from the construction, operations, and decommissioning and reclamation phases of the Project development. Impacts may include:

- Change in soil moisture;
- Change or loss of landforms;
- Changes to land capability for forest production; and
- Potential soil acidification.

Activities such as site clearing, facility and road construction and muskeg removal during the construction phase will have adverse effects as soils will be susceptible to compaction, erosion and elimination as a result of physical disturbances. Clearing and grading will result in changes to landforms. Physical disturbances and potential 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 the construction, operation and reclamation phases of the development. Additional details are provided in the Conservation and Reclamation Plan (Volume 1, Section 8). AENV and ASRD 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 (AEP, 1995);
- A Guide to Reclamation Criteria for Wellsites and Associated Facilities – 2007 Forested Lands in the Green Area Update (ASRD, 2007);
- Environmental Protection Guidelines for Oil Production Sites (AENV, 2002);
- Code of Practice for Oil Production Sites (AEP, 1997);
- 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, 2000).

The main potential impacts to soils and landforms and general mitigation methods are discussed in the following sections. Mitigation strategies are also described in the Conservation and Reclamation (C&R) section (Volume 1, Section 8).

9.7.1 Change in Soil Moisture

Changes to the soil moisture regime can occur as a result of the development of pads, roads and other 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 and 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 can 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 8).

Changes in local hydrology or surface topography (i.e., creation of depressions) may lead to intermittent or permanently waterlogged conditions in normally well drained mineral soils, particularly in drainage draws, lower slope positions, or locations that are transitional to wetter areas. Creation of depressions can be prevented by ensuring operational (ditches, culverts, etc.) and post reclamation drainage design is adequate and compatible with the surrounding landscape.

Construction on Organic soils has potential to impede drainage and affect the local wetland environment. Mitigative measures include placing culverts on access roads where required and drainage ditches around well pads.

The residual impact to soil moisture following the completion of reclamation will be neutral to negative in direction, subregional in extent, and low in magnitude resulting in a final impact rating of low impact to soil moisture regime in the LSA.

9.7.2 Change or Loss of Landforms

Project activities during the construction, operations, and reclamation phases will have adverse effects on existing landforms within the LSA. Terrain alterations will occur as a result of activities such as:

- Removal of muskeg;
- Drainage diversions;
- Grading affecting landscape and land capability; and
- Reclamation of wetlands, Organic soils, and depressional soils to upland soils.

The surface disturbance of well pads and other facilities of similar size are small relative to the abundance of these landforms in the LSA, and impacts to landforms will be localized and will not impact overall landform diversity. Upland sites will be reclaimed to landforms consistent with pre-disturbance conditions (Volume 1, Section 8).

Landscape borrows will be required to supply fill material for the construction of the Project facilities. All landscape borrow areas will be located on upland sites. To ensure sufficient fill material will be available for the construction of the Project, the area of potential landscape borrow locations within the LSA was evaluated. Potential locations were defined as upland areas with mineral soils that had developed on clay textured parent material. Based on these criteria, approximately 14,309 ha of potential landscape borrow locations was identified, indicating that there will be sufficient fill material available for construction of the Project. The locations of the landscape borrows, and therefore the actual volume of available fill, will be determined based on geotechnical surveys.

It is anticipated that approximately 1,064 ha (1.0% of the LSA) of organic landforms will be disturbed by Project activities. Of the total area within the LSA affected by the Project footprint, approximately 780 ha of fens and 284 ha of bogs will be converted to either upland soils (where Organic soils underlie roads) or upland/transitional peat complexes (where Organic soils underlie well pads) during the reclamation phase (Volume 1, Section 8). Reclamation will involve excavation of the pad material from the target transition zone onto areas to be reclaimed as upland. The edges of the upland area will be re-contoured to a stable slope. Salvaged peat will be replaced in the transition zone to form a poorly drained peat surface, similar to the adjacent undisturbed peatland area. The goal is to construct the transitional zone such that a similar amount of peat is replaced as was salvaged (Volume 1, Section 8). The target ecosite phase at reclamation for facilities sited on organic landforms, including areas with deep peat (>40 cm), is the upland g1 Labrador tea – subhygric Black spruce-Jack Pine vegetation community.

Mitigation for change in landforms will include the use of transitional areas between the reclaimed upland area of the pad and the existing wetland and the removal of portions of the pad surface to reduce the height of the reclaimed landform compared to the surrounding area. Mitigative measures to reduce the effects of physical disturbance may include minimizing disturbance to only those areas underlying the Project footprint during construction and operations, and monitoring during reclamation to reduce effects to adjacent undisturbed areas.

The residual impact to landforms following the completion of reclamation will be negative in direction, subregional in extent, and low in magnitude resulting in a final impact rating of low impact to landforms in the LSA.

The anticipated changes in landforms are presented in Table 9.7-1.

Table 9.7-1 Summary of Changes to Landforms in the LSA

Landform	**Baseline**		**Post Reclamation**		**Change at Closure**	
	ha	**% of LSA**	**ha**	**% of LSA**	**ha**	**% of LSA**
Upland (mineral) and depressional	43,606	39.3	44,343	40.0	+737	+0.7
Organic	56,253	50.7	55,696	50.2	-557	-0.5
Unclassified	11,079	10.0	10,899	9.8	-180	-0.2
Total	**110,938**	**100.0**	**110,938**	**100.0**	**0**	**0.0**

9.7.3 Land Capability Classification for Forest Production

The goal of reclamation activities is to achieve land capability equivalent to pre-disturbance conditions. End land use objectives for facilities constructed on upland mineral soils will be the same as those that existed prior to the disturbance thereby maintaining the same land capability class for forest production as the pre-disturbance land capability. At present, approximately 1,436 ha (1.3% of the footprint) of mineral soils are expected to be disturbed by the Project. Mineral soils underlying the proposed Project footprint are rated Class 3 (low capability), Class 4 (currently non-productive) and Class 5 (permanently non-productive).

There will be an alteration in land capability class for forest production on those sites developed on Organic soils; Organic soils account for approximately 1,064 ha or 1.0% of the footprint. The proposed closure strategy for Organic soils will result in an increase of Class 3 soils and a reduction of Class 5 soils. Some sites developed on Organic soils (e.g., well pads) will be reclaimed to a combination/complex of Class 3 and Class 5 post reclamation. The final composition of the reclaimed landscape for each area will be determined on a site specific basis.

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. 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, in particular when working on Luvisolic soils;
- 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 to positive in direction, subregional in extent, and low in magnitude resulting in a final impact rating of low impact to land capability for forest production in the LSA.

The reclaimed land capability class developed for each of the soil series is based on the soil and landform information collected for the baseline report, the reclamation plan, and expectations of how construction, operation and reclamation activities would change various soil and landscape conditions. The anticipated changes in the land capability for forest production classes are presented in Table 9.7-2. Post-reclamation land capability for forest production is illustrated in Figure 9.7-2.

Table 9.7-2 Summary of Changes to Land Capability Classification for Forest Production in the LSA

Forest Capability Class[1]	Baseline		Post Reclamation		Change at Closure	
	ha	% of LSA	ha	% of LSA	ha	% of LSA
Class 1 High Capability	0	0.0	0	0.0	0	0.0
Class 2 Moderate Capability	1,162	1.0	1,162	1.0	0	0.0
Class 3 Low Capability	31,673	28.6	31,916	28.8	243	0.2
Class 3/5 Low Capability	0	0.0	608	0.5	608	0.5
Class 4 Currently Non-Productive	4,126	3.7	4,134	3.7	8	<0.1
Class 5 Permanently Non-Productive	62,898	56.7	62,219	56.1	-679	-0.6
Unclassified	11,079	10.0	10,899	9.8	-180	-0.2
Total	**110,938**	**100.0**	**110,938**	**100.0**	**0**	**0.0**

9.7.4 Impact to Soils from Potentially Acidifying Inputs

The future emissions are predicted for the application case, which includes existing and approved developments in the RSA plus the Project. The air section (Volume 2, Section 2) provides the methodology and results of the air emission modelling.

The baseline and application case PAI isopleths have been overlain on the critical load ranges of soils in the LSA and RSA (Figure 9.7-2 and Figure 9.7-3, respectively). No soils within the LSA or RSA were considered at risk for exceeding the critical load range.

The residual impact from potentially acidifying emissions following the completion of reclamation will be neutral in direction, regional in extent, and low in magnitude resulting in a final impact rating of low impact to soils from PAI in the LSA or RSA.

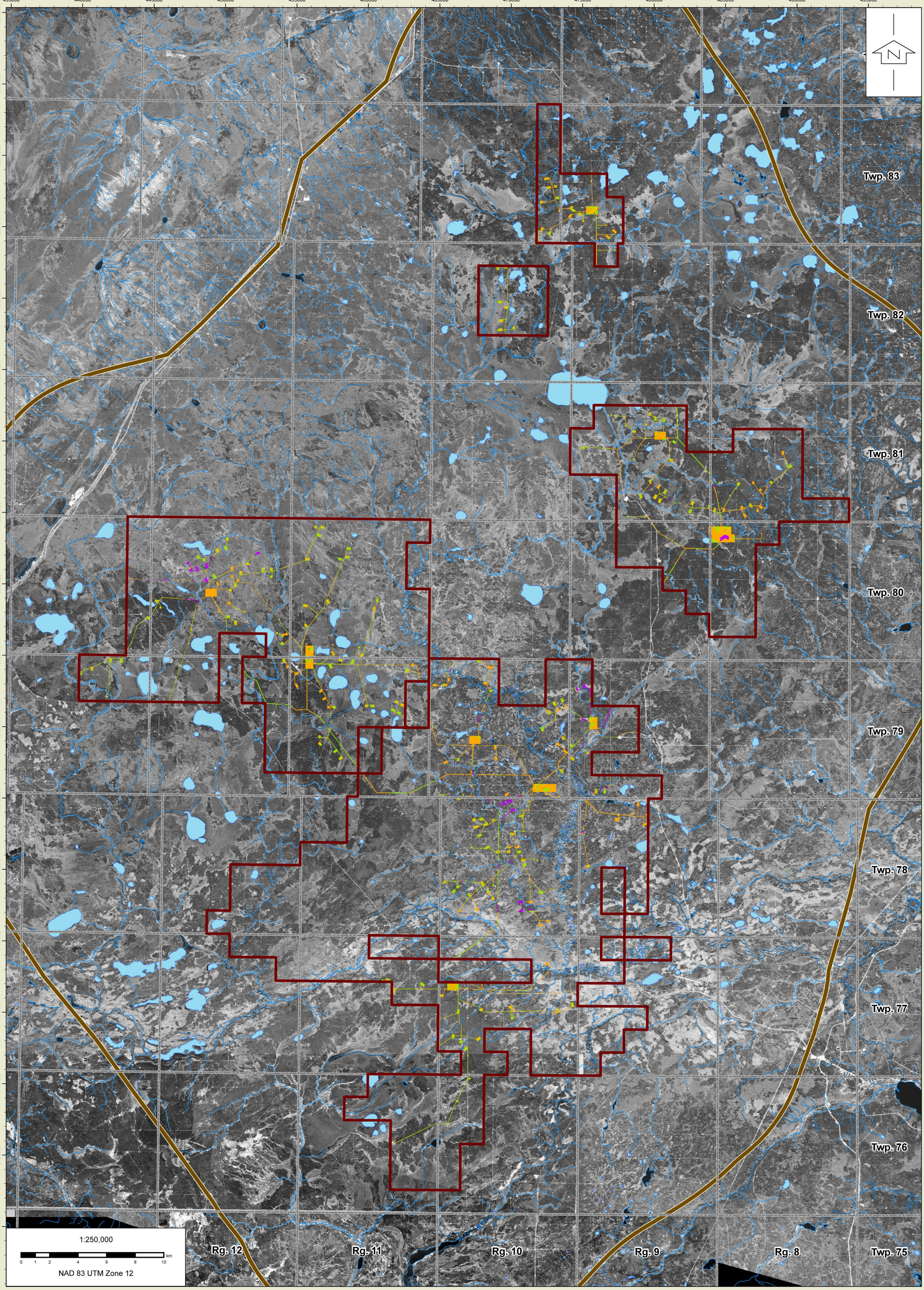
9.7.5 Impact Classification

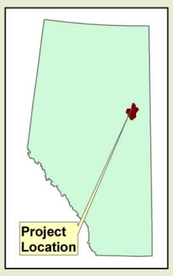
A summary and classification of impacts for the application case are presented in Table 9.7-3, which follows the guidelines described in Volume 2, Section 1.

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

Parameter	Direction	Extent	Magnitude	Duration	Frequency of Occurrence	Permanence	Confidence	Final Impact Rating
Change in Soil Moisture	Neutral to Negative	Subregional	Low	Long-term	Occasional	Reversible in medium to long-term	Medium	Low
Loss or Change of Landforms	Negative	Subregional	Low	Long-term	Occasional	Irreversible	Low to Medium	Low
Changes to Land Capability for Production	Neutral to Positive	Subregional	Low	Long-term	Occasional	Reversible in medium to long-term	Medium	Low
Potential Acidification	Neutral	Regional	Low	Long-term	Continuous	Reversible in long-term	Medium	Low

The residual impact to the key parameters, soil moisture, landforms, land capability and acidification, is low for soils and terrain in the application case. Overall, no single parameter is predicted to affect more than 5% of the soils in the LSA.





Legend

- North American Siols RSA
- North American Soils LSA
- Lake
- River / Stream

Land Capability for Forest Production

- Unclassified (Baseline Disturbances, Lakes, Stream Channels, Rough Broken)
- Class 2 (Moderate Capability)
- Class 3 (Low Capability)
- Class 4 (Conditionally Productive)
- Class 5 (Non-Productive)
- Class 3/5 Complex (Low Capability, Non-Productive)

Title:

POST RECLAMATION LAND CAPABILITY CLASSIFICATION FOR FOREST PRODUCTION IN THE APPLICATION CASE

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/SC	Revision Date: June 15, 2007	
File: Fig 9.7-1_Post_Land_Cap_Forest_Production_in_Application_Case_20070611		
Drawn by: TR	Checked: LZ/JB	Fig. No.: 9.7-1

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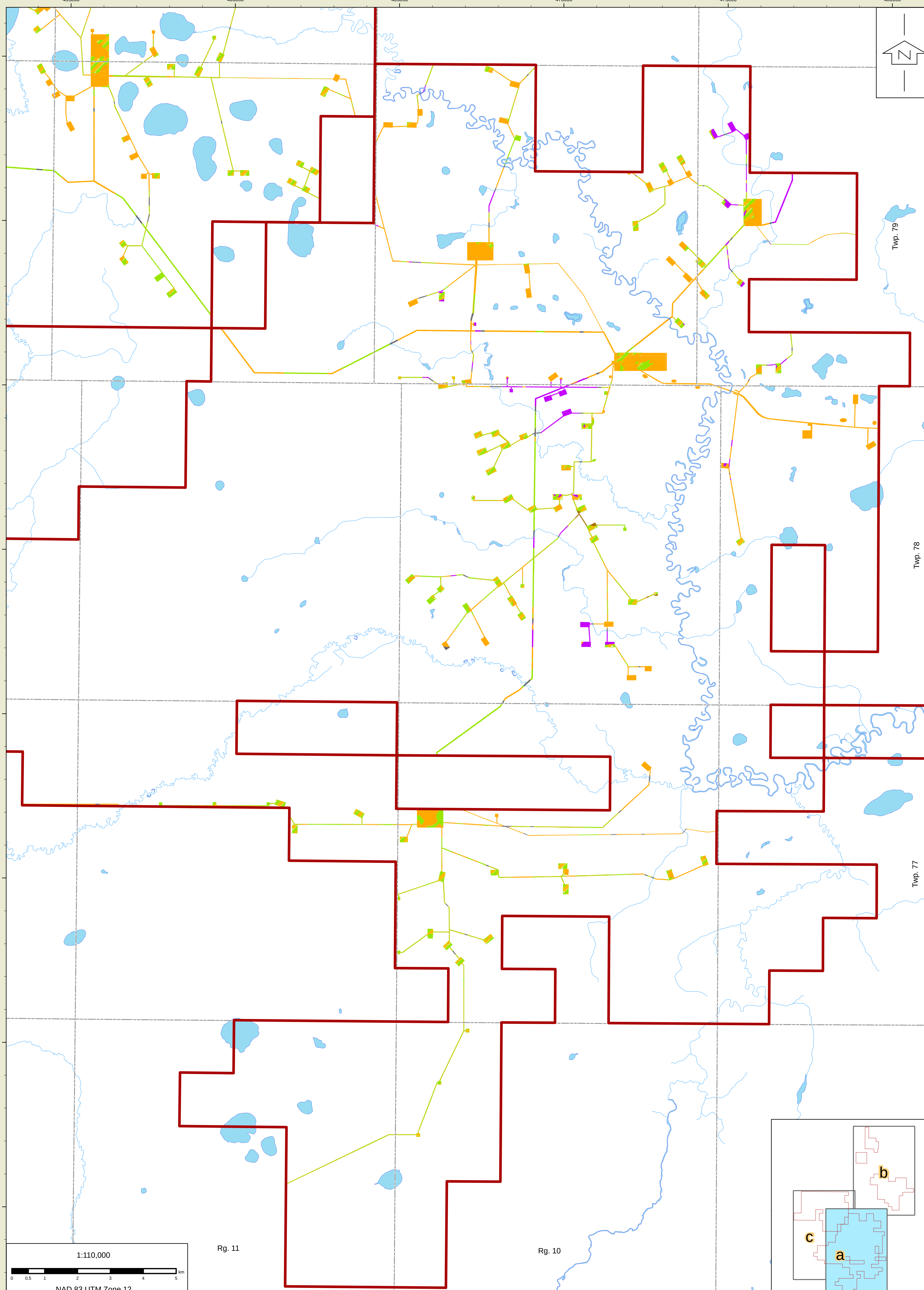

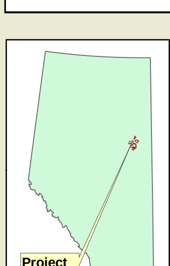

Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

Land Capability for Forest Production

- Unclassified (Baseline Disturbances, Lakes, Stream Channels, Rough Broken)
- Class 2 (Moderate Capability)
- Class 3 (Low Capability)
- Class 4 (Conditionally Productive)
- Class 5 (Non-Productive)
- Class 3/5 Complex (Low Capability, Non-Productive)

Title:

POST RECLAMATION LAND CAPABILITY CLASSIFICATION FOR FOREST PRODUCTION IN THE APPLICATION CASE

Approved: CG/SC	Revision Date: June 13, 2007
File: Fig 9.7-1a_Post_Land_Cap_Forest_Production_in_Application_Case_20070611	

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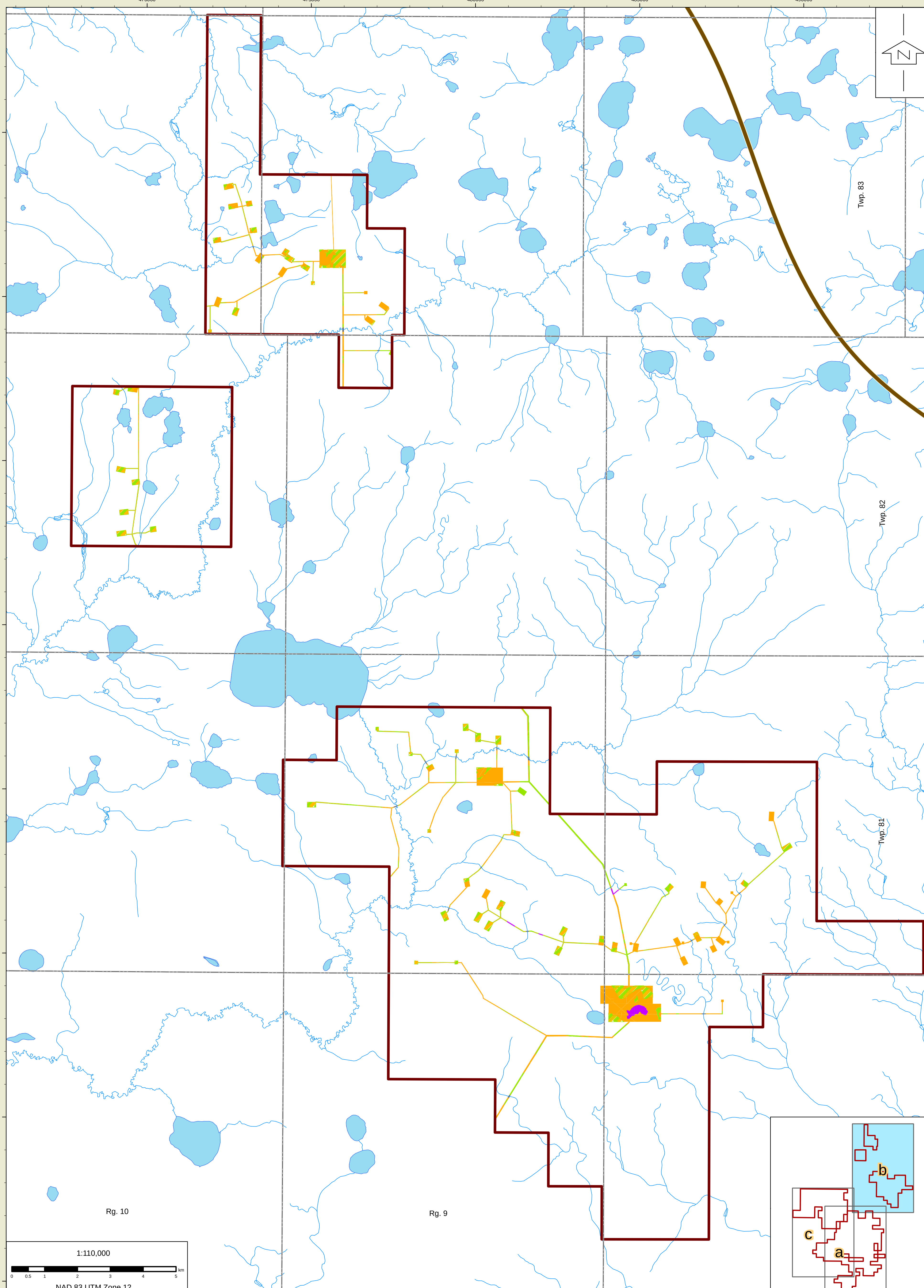

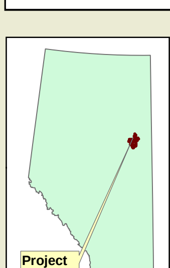

Legend

- North American Siols RSA
- North American Soils LSA
- Lake
- River / Stream

Land Capability for Forest Production

- Unclassified (Baseline Disturbances, Lakes, Stream Channels, Rough Broken)
- Class 2 (Moderate Capability)
- Class 3 (Low Capability)
- Class 4 (Conditionally Productive)
- Class 5 (Non-Productive)
- Class 3/5 Complex (Low Capability, Non-Productive)

Title:

POST RECLAMATION LAND CAPABILITY CLASSIFICATION FOR FOREST PRODUCTION IN THE APPLICATION CASE

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
CG/SC	June 11, 2007

File: Fig 9.7-1b_Post_Land_Cap_Forest_Production_in_Application_Case_20070611

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TR	LZ/JB	9.7-1b

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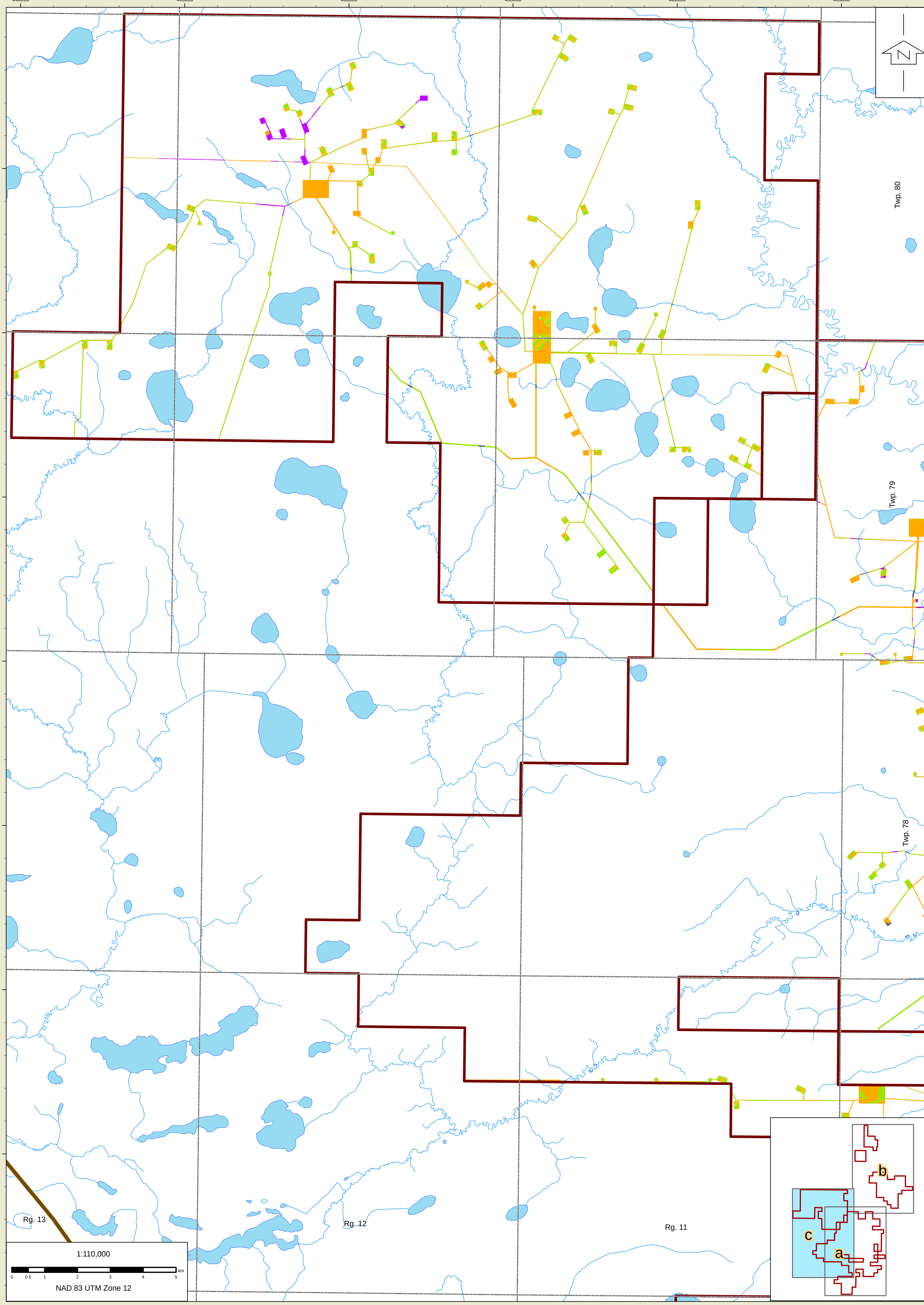

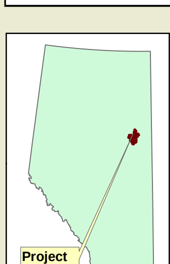

Legend

- North American Siols RSA
- North American Soils LSA
- Lake
- River / Stream

Land Capability for Forest Production

- Unclassified (Baseline Disturbances, Lakes, Stream Channels, Rough Broken)
- Class 2 (Moderate Capability)
- Class 3 (Low Capability)
- Class 4 (Conditionally Productive)
- Class 5 (Non-Productive)
- Class 3/5 Complex (Low Capability, Non-Productive)

Title:

POST RECLAMATION LAND CAPABILITY CLASSIFICATION FOR FOREST PRODUCTION IN THE APPLICATION CASE

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:	
CG/SC	May 10, 2007	
File: Fig 9.7-1c_Post_Land_Cap_Forest_Production_in_Application_Case_20070611		
Drawn by: TR	Checked: LZ/JB	Fig. No.: 9.7-1c

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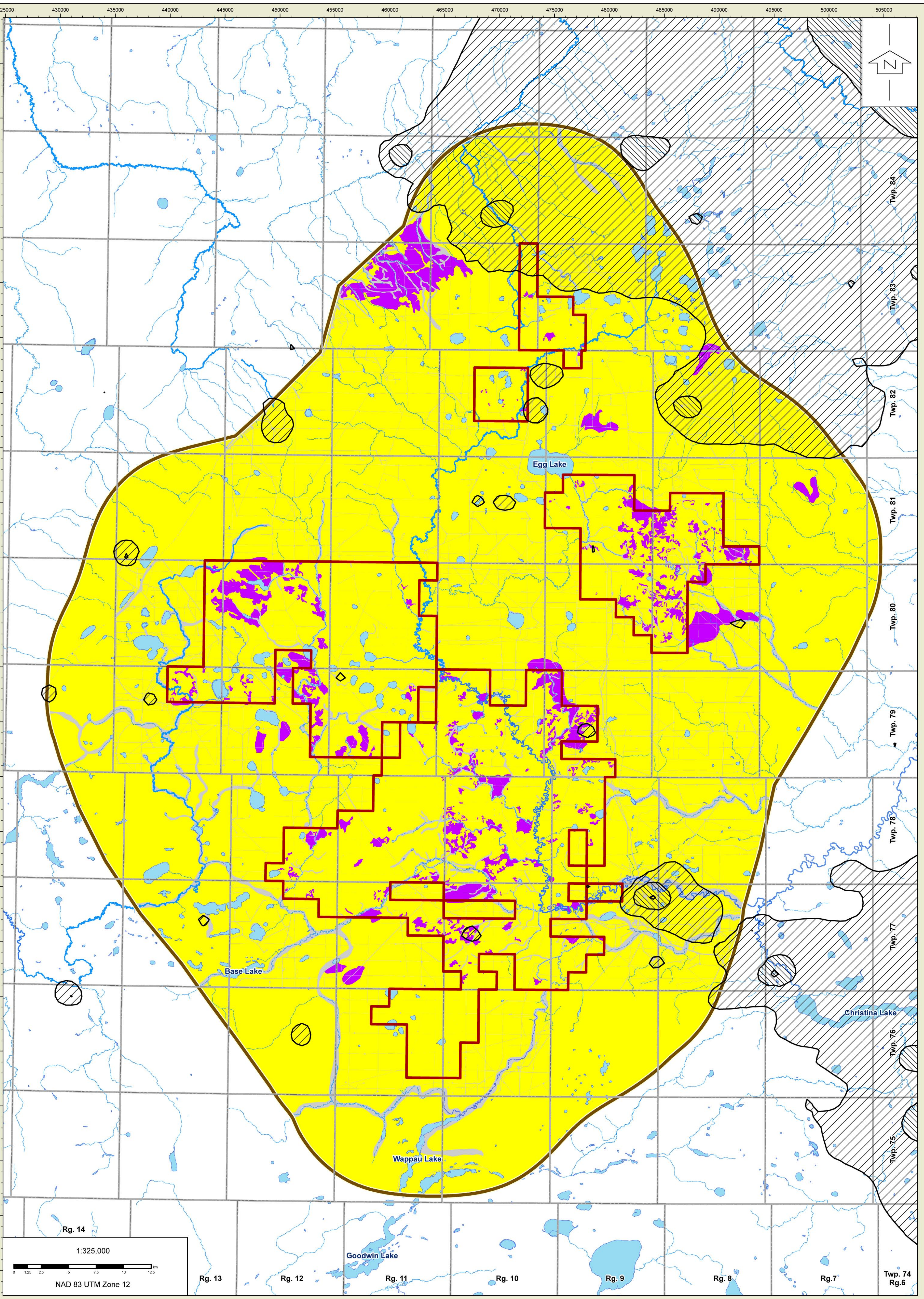

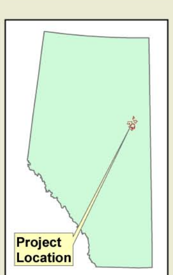

Legend

North American Soils RSA	
North American Soils LSA	
Lake	
River / Stream	

PAI (keqH⁺/ha/y)

- 0.17 to <0.25
- 0.25 to <0.5
- 0.5+

Soil Critical Load (keqH⁺/ha/y)

- 0.5 + (Low Acidification Potential)
- 0.25 to <0.5 (Moderate Acidification Potential)
- Unclassified

Title:

PAI AND SOIL CRITICAL LOAD LIMITS IN THE BASELINE CASE

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
CG/SC	May 10, 2007

File: Fig 9.7-2_PAI_in_the_Baseline_Case_20070612

Drawn by:	Checked:	Fig. No.:
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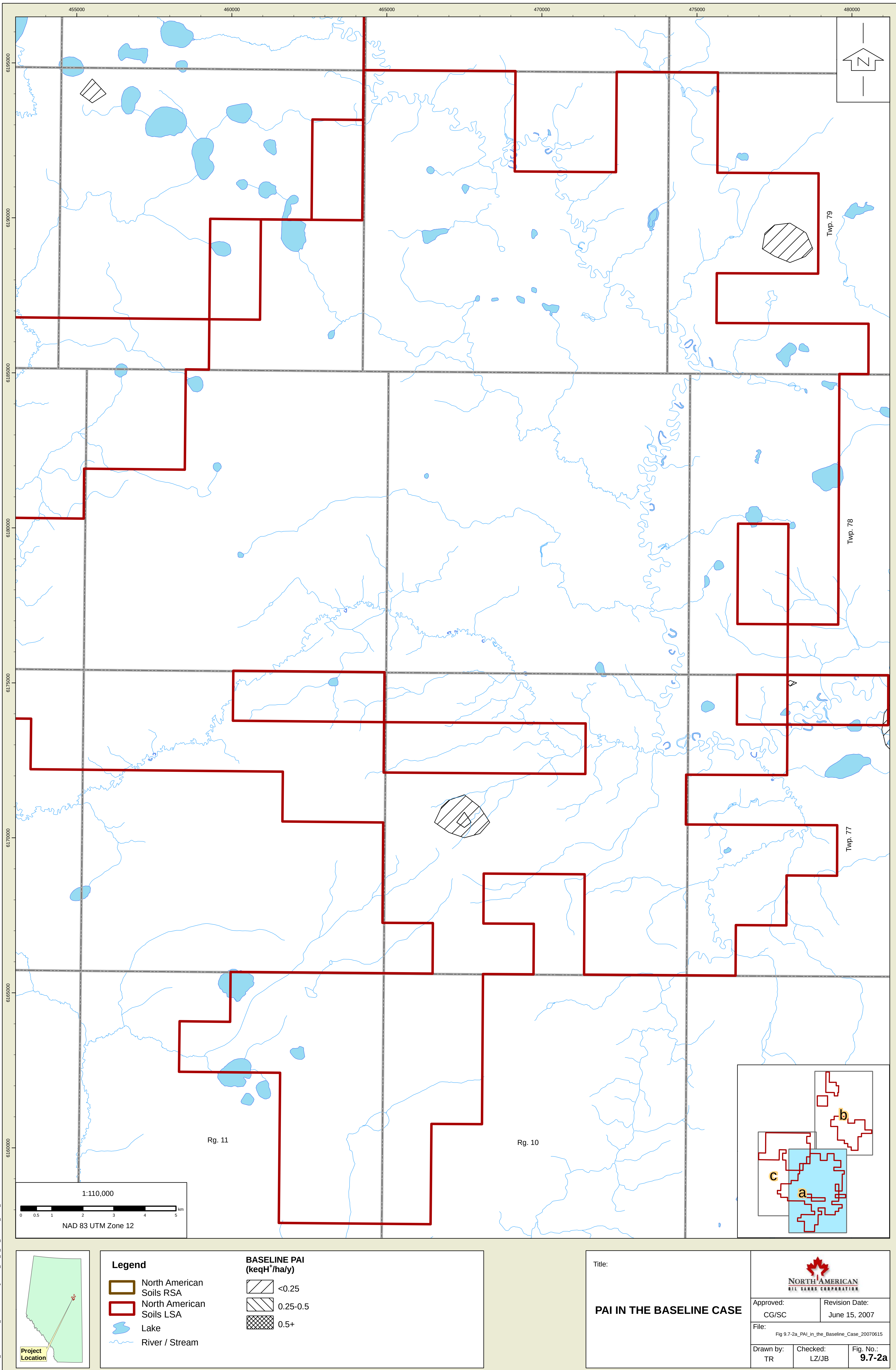

Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

BASELINE PAI
(keqH$^+$/ha/y)

- <0.25
- 0.25-0.5
- 0.5+

Title:

PAI IN THE BASELINE CASE

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
CG/SC	June 15, 2007

File: Fig 9.7-2a_PAI_in_the_Baseline_Case_20070615

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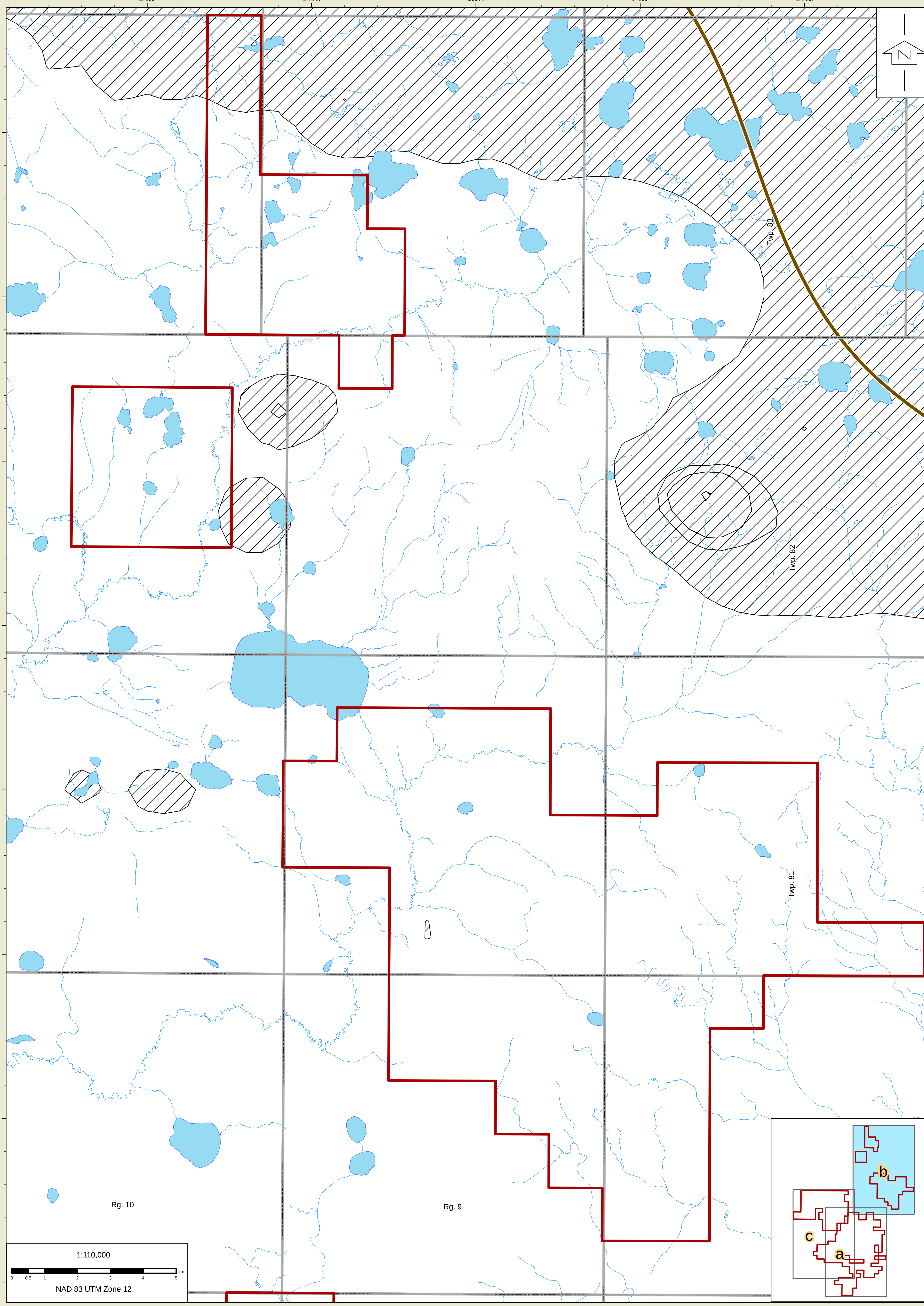

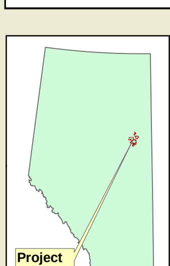

Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

BASELINE PAI (keqH^{+}/ha/y)

- <0.25
- 0.25-0.5
- 0.5+

Title:	NORTH AMERICAN OIL SANDS CORPORATION
PAI IN THE BASELINE CASE	Approved: CG/LP/JB/SC
	Revision Date: June 15, 2007
	File: Fig 9.7-2b_PAI_in_the_Baseline_Case_20070615
	Drawn by: TR
	Checked: LZ/JB
	Fig. No.: **9.7-2b**

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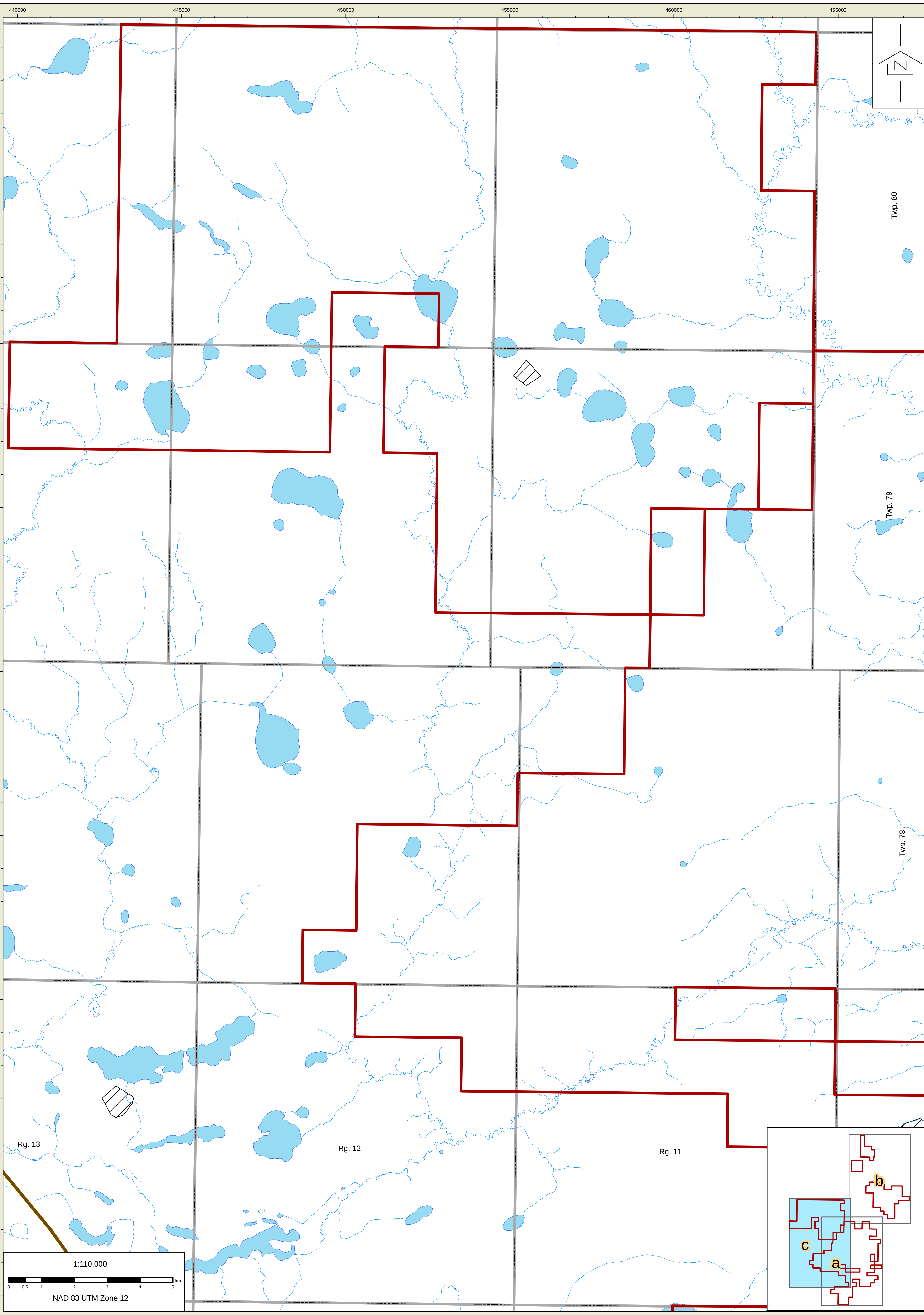

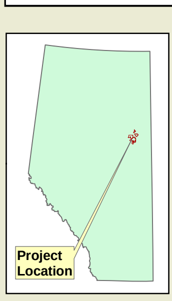

Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

BASELINE PAI (keqH$^+$/ha/y)

- <0.25
- 0.25-0.5
- 0.5+

Title:

PAI IN THE BASELINE CASE

NORTH AMERICAN OIL SANDS CORPORATION

Approved: CG/LP/JB/SC	Revision Date: June 15, 2007	
File: Fig 9.7-2c_PAI_in_the_Baseline_Case_20070615		
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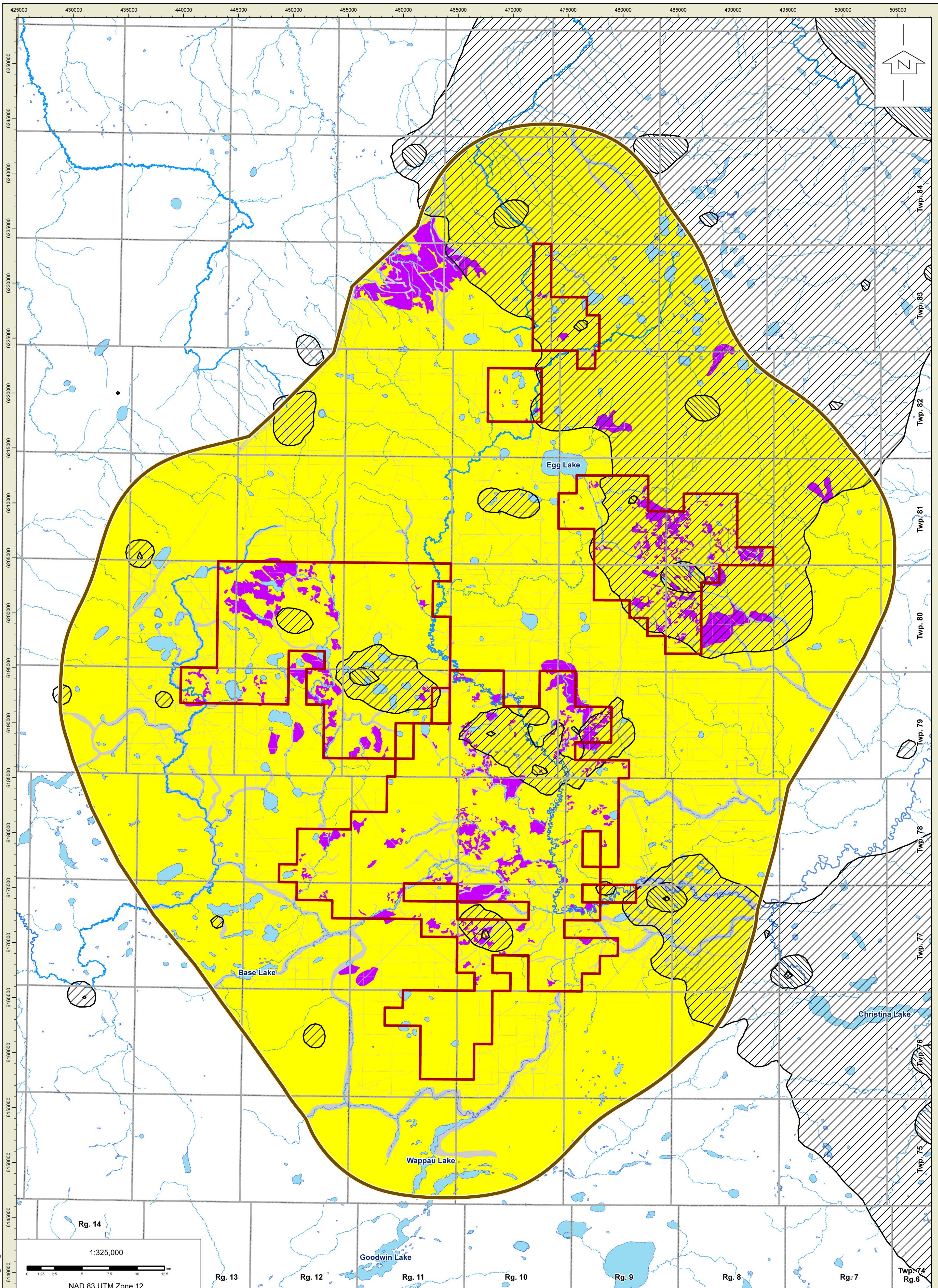

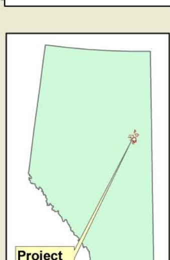

Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

PAI (keqH$^+$/ha/y)

- 0.17 to <0.25
- 0.25 to <0.5
- 0.5+

Soil Critical Load (keqH$^+$/ha/y)

- 0.5 + (Low Acidification Potential)
- 0.25 to <0.5 (Moderate Acidification Potential)
- Unclassified

Title:

PAI AND SOIL CRITICAL LOAD LIMITS IN THE APPLICATION CASE

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
CG/SC	June 15, 2007

File: Fig 9.7-3_PAI_in_the_Application_Case_20070615.mxd

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TR	LZ/JB	9.7-3

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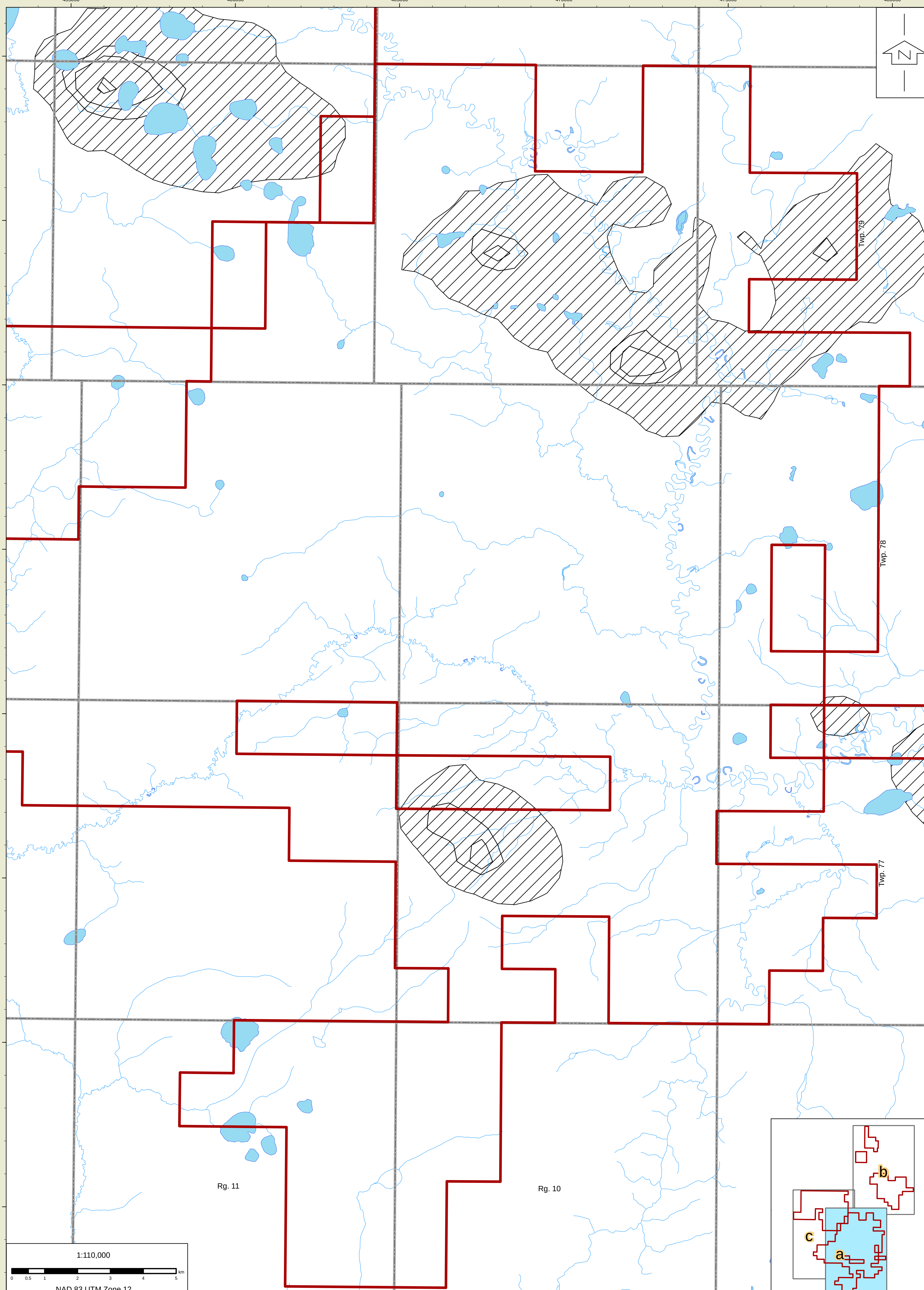

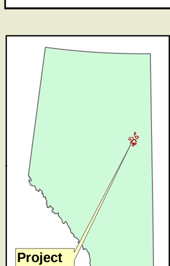

Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

APPLICATION PAI (keqH⁺/ha/y)

- <0.25
- 0.25- 0.5
- 0.5+

Title:

PAI IN THE APPLICATION CASE

Approved: CG/LP/JB/SC	Revision Date: June 15, 2007
File: Fig 9.7-3a_PAI_in_the_Application_Case_20070615	

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TR	LZ/JB	**9.7-3a**

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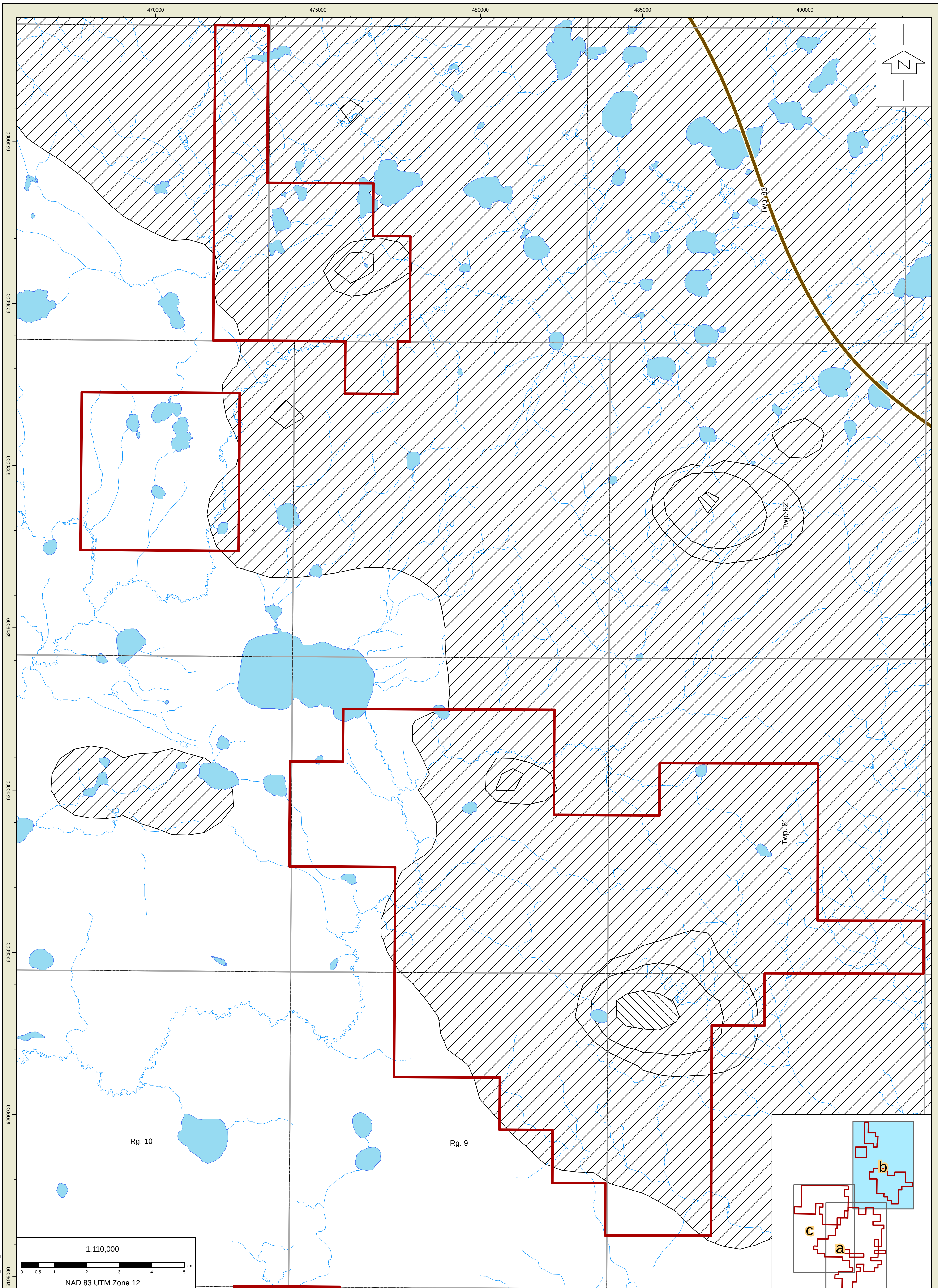

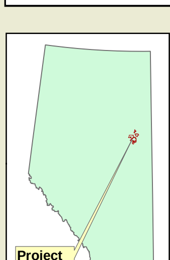

Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

APPLICATION PAI (keqH^+/ha/y)

- <0.25
- 0.25- 0.5
- 0.5+

Title:

PAI IN THE APPLICATION CASE

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:	
CG/LP/JB/SC	June 15, 2007	
File: Fig 9.7-3b_PAI_in_the_Application_Case_20070615		
Drawn by: TR	Checked: LZ/JB	Fig. No.: **9.7-3b**

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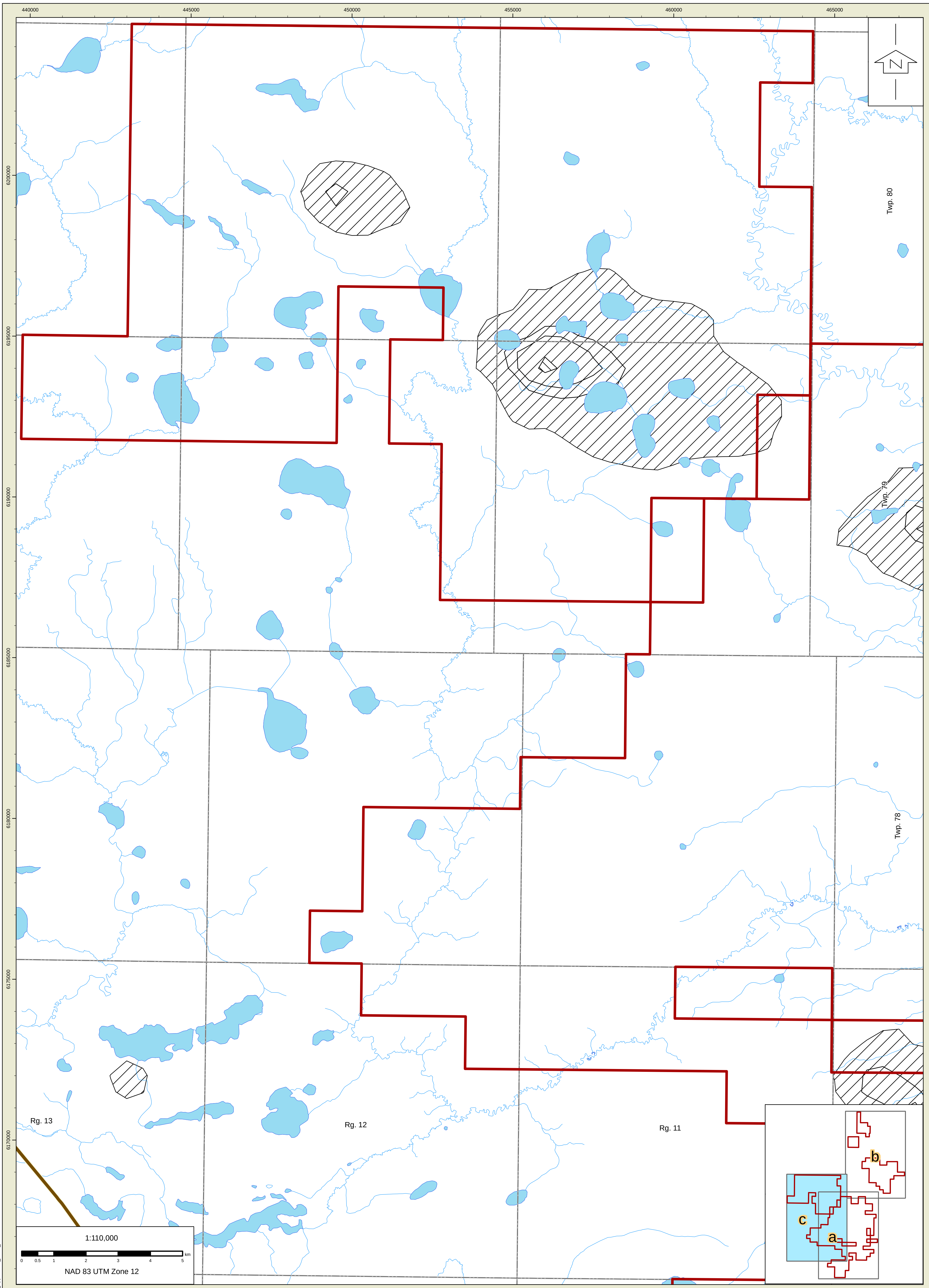

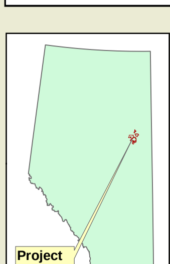

Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

APPLICATION PAI (KeqH+/ha/yr)

- <0.25
- 0.25- 0.5
- 0.5+

Title:

PAI IN THE APPLICATION CASE

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:	
CG/LP/JB/SC	May 10, 2007	
File: Fig 9.7-3c_PAI_in_the_Application_Case_20070615		
Drawn by: TR	Checked: LZ/JB	Fig. No.: 9.7-3c

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9.8 Cumulative Effects Assessment

The potential soils and terrain cumulative impacts in the RSA associated with the Project are loss of organic soil landforms soil and acidification. Additional future activities in the RSA include proposed highway and road developments and future SAGD oil sands operations.

9.8.1 Loss of Organic Soil Landforms

A cumulative effects assessment (CEA) considers the impacts of the Project with other existing, approved, planned and potential projects in the region that overlap temporally and spatially. These projects are listed in Volume 2, Section 1, Table 1.5-1 and include other planned, existing or approved oil and gas facilities, forest harvesting, recreational activity and road construction (possible connector highway and bypass between Highway 63 and Highway 881).

At the time of this assessment, there were no publicly announced future oil sands developments identified in the RSA. Future industrial activities within the RSA are predicted to include exploration for oil and gas, seismic activity and forest harvesting however quantitative details (or footprints) of these future activities and associated developments are not available to North American. As such a qualitative CEA was conducted for soils and landforms.

For the purposes of the cumulative effects assessment, the following assumptions have been made:

- Soils handling, mitigation, and reclamation methods will be similar to those identified by North American, as future projects will also be required to achieve equivalent land capability and to obtain reclamation certification prior to site closure;
- End land use targets for the planned and proposed projects will be similar to North American's; and
- Demonstrated methods to reclaim sites developed in Organic soil landforms to equivalent landforms are not currently developed.

Based on these assumptions, potential impacts and mitigation measures in the cumulative case are anticipated to be similar to those discussed in the application case. Therefore, the residual cumulative impact rating to Organic soil landforms is predicted to be low as in the application case. The confidence of the CEA predictions is lowered by the uncertainty of future project timing and details.

The cumulative case assessment is considered to be conservative as:

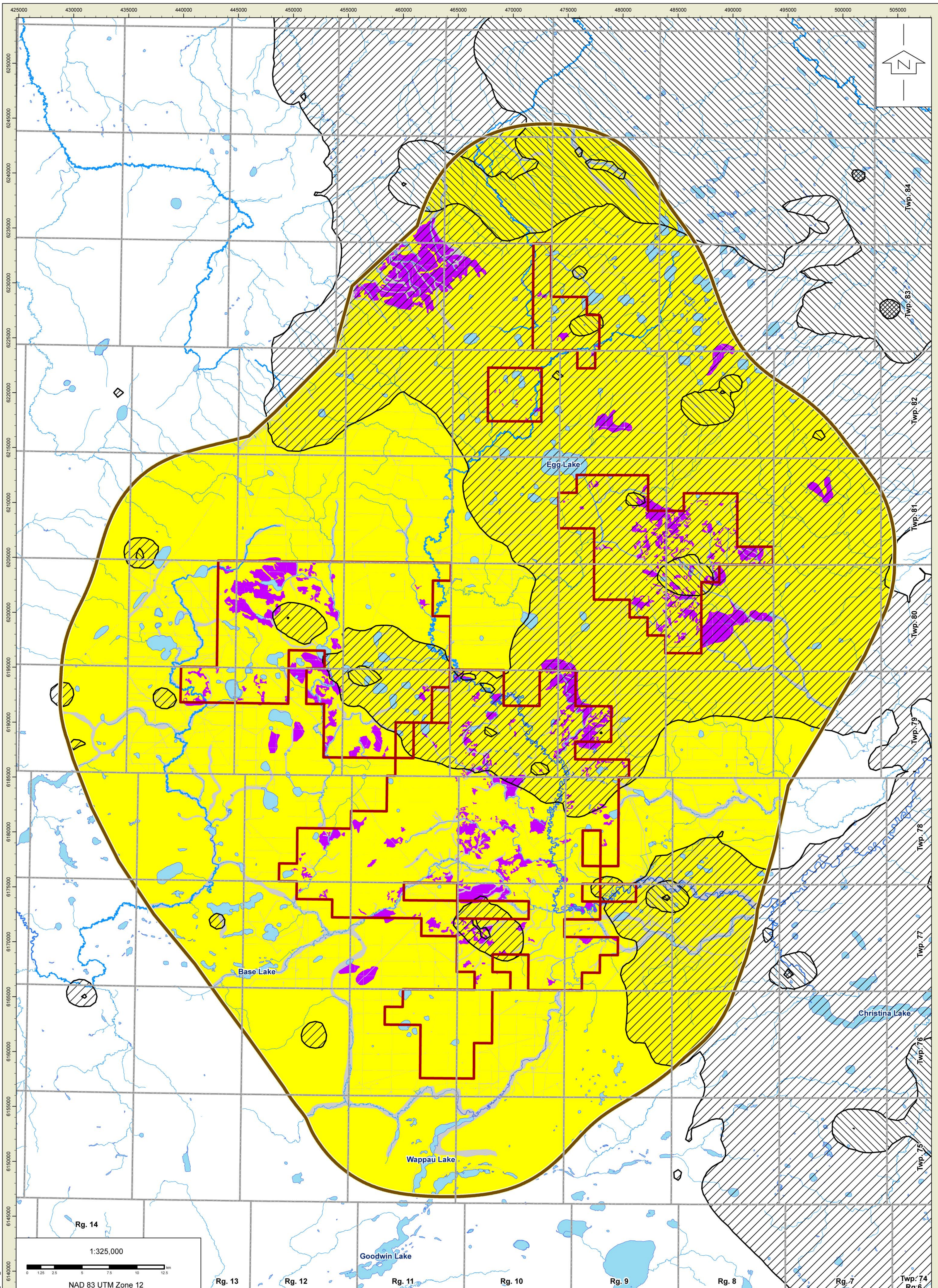
- Proponents of the planned and proposed projects, like North American, will utilize landscape borrows, rather than borrow pits, to source fill material, thereby minimizing the potential impact to Organic soil landforms;
- Project proponents are guided by best practices and requirements under AEPEA;
- New approaches to reclaiming sites developed in Organic soil landforms are being explored; and
- Adaptive management strategies will be used by all SAGD operators to update reclamation procedures throughout the life of the projects.

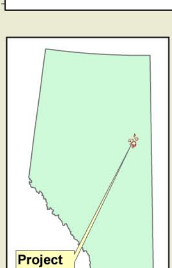
9.8.2 Impact to Soils from Potentially Acidifying Inputs

The future emissions are predicted for the cumulative case, which includes projects north of Fort McMurray. Figure 9.8-1 shows the cumulative case PAI isopleths overlain on the critical load ranges of soils in the RSA.

Under the cumulative case, 34 ha (<0.1% of the RSA) fall under PAI isopleths greater than the 50 year Mid-CV case critical loads identified for various soil types in the RSA. The 34 ha of soils at risk of exceeding the soils critical load are located in Corner and on/adjacent to the CPF (approximately 19 ha occur under the Project footprint).

The baseline, application and cumulative cases all result in less than <0.1% of the RSA soils at risk of having critical load exceeded by PAI.





Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

PAI (keqH+/ha/y)

- 0.17 to <0.25
- 0.25 to <0.5
- 0.5+

Soil Critical Load (keqH+/ha/y)

- 0.5 + (Low Acidification Potential)
- 0.25 to <0.5 (Moderate Acidification Potential)
- Unclassified

Title:

PAI AND SOIL CRITICAL LOAD LIMITS IN THE CUMULATIVE CASE

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
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File: + Fig 9.8-1_PAI_in_the_CEA_Case_20070615.mxd

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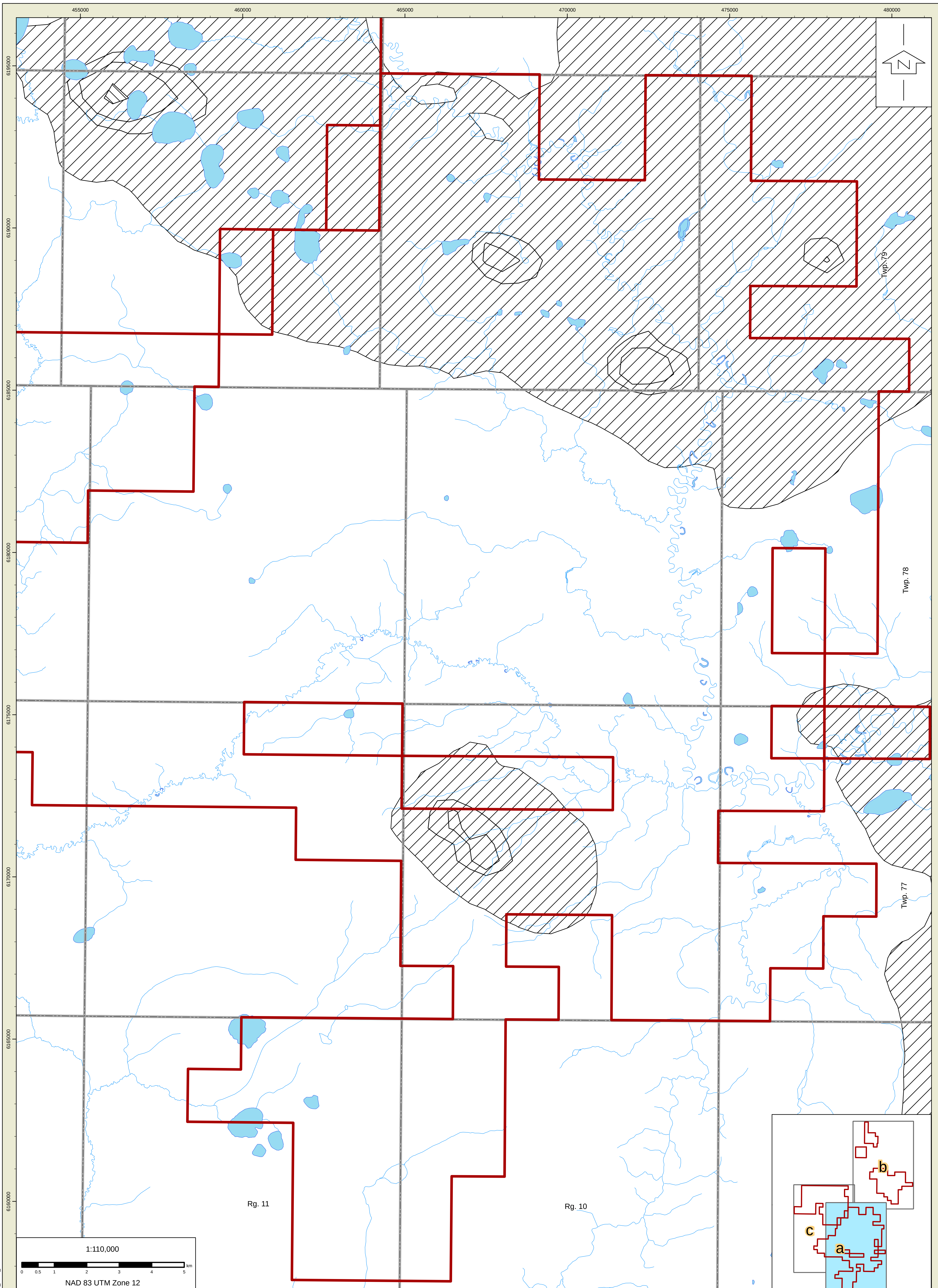

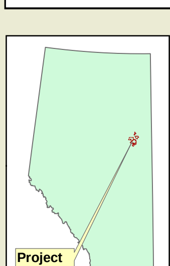

Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

CEA PAI (keqH^{+}/ha/y)

- <0.25;
- 0.25- 0.5
- 0.5+

Title: **PAI IN THE CEA CASE**

NORTH AMERICAN OIL SANDS CORPORATION

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File: Fig 9.8-1a_PAI_in_the_CEA_Case_20070615

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TR	LZ/JB	9.8-1a

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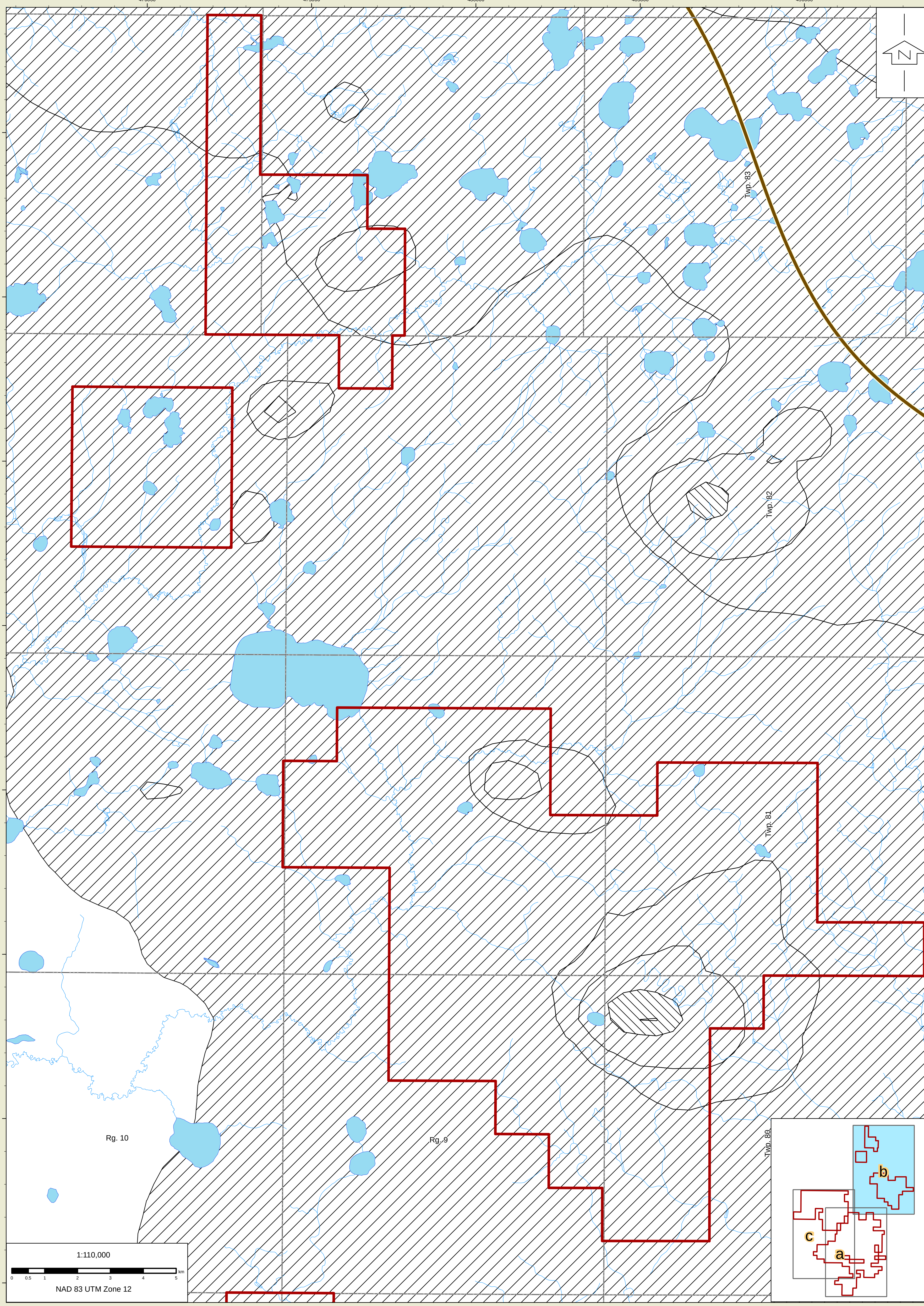

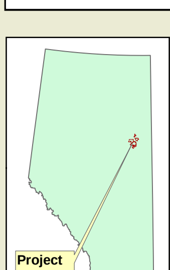

Legend

- North American Soils RSA
- North American Soils LSA
- Lake
- River / Stream

CEA PAI
(keqH$^+$/ha/y)

- <0.25;
- 0.25- 0.5
- 0.5+

Title:

PAI IN THE CEA CASE

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:	
CG/SC	June 15, 2007	
File: Fig 9.8-1b_PAI_in_the_CEA_Case_20070615		
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TR	LZ/JB	**9.8-1b**

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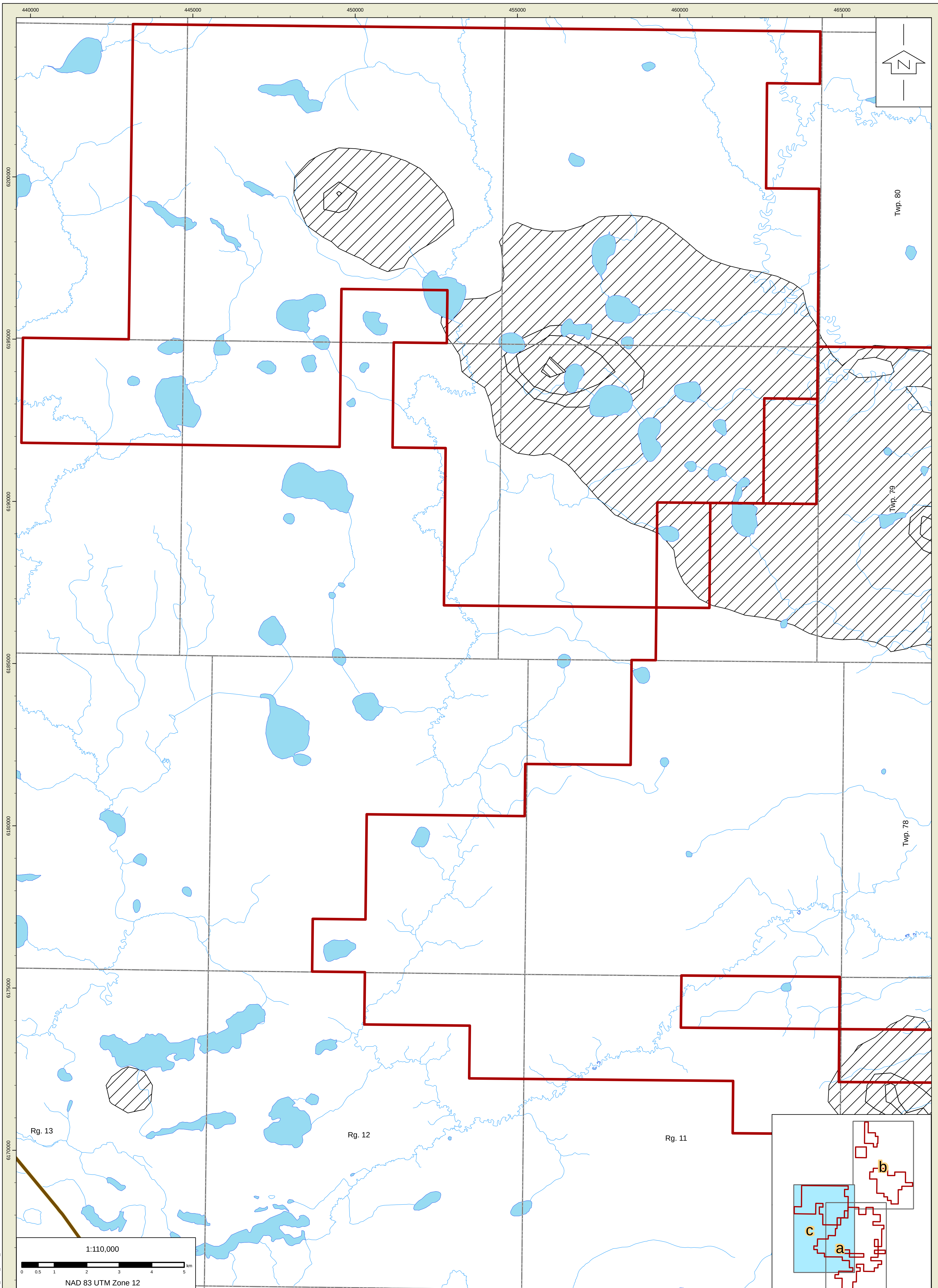

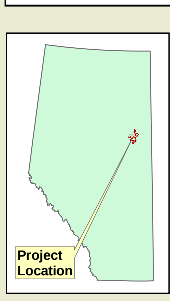

Legend

North American Soils RSA

North American Soils LSA

Lake

River / Stream

CEA PAI (keqH$^+$/ha/y)

<0.25;

0.25- 0.5

0.5+

Title:

PAI IN THE CEA CASE

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
CG/SC	June 15, 2007

File: Fig 9.8-1c_PAI_in_the_CEA_Case_20070615

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TR	LZ/JB	**9.8-1c**

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9.9 Follow-up and Monitoring

9.9.1 Land Capability for Forest Ecosystems

Monitoring for impacts that could affect land capability for forest ecosystems will be conducted during the life of the Project, as well as during the reclamation phase, until a Reclamation Certificate is obtained. Reclamation monitoring programs will be developed in consultation with AENV and ASRD. 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 monitoring in the southern oil sands area.

9.10 Summary

The predicted residual impacts to the key parameters of soil moisture, landforms, land capability and acidification potential are low for soils and terrain in the application case. Overall, no single parameter is predicted to affect more than 5% of the soils in the LSA. The Project is anticipated to have a negligible to low effect in the cumulative case for loss of organic landforms and impacts to soils from potentially acidifying emissions.

9.11 Literature Cited

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