have low to moderate magnitude impacts in the LSA and negligible to low magnitude impacts at the regional scale during construction and operations.

Of particular conservation concern in the area is caribou. A moderate magnitude Project impact was assessed for caribou in the area. However, there remains a high level of uncertainty in this assessment due to uncertainty among regional mitigation measures and in estimates of regional caribou abundance. As such, North American intends to proactively continue a long-term wildlife monitoring program for detecting impacts on caribou, moose and wolf and to assess mitigation successes for these species. This wildlife monitoring program is intended as an adaptive framework for monitoring future planned projects in the RSA, which may include exploration for oil and gas, seismic activity and forest harvesting.

## 7.12 Biodiversity

Project construction will result in loss of habitat area, which impacts the potential for the landscape to sustain current levels of biodiversity. The biodiversity assessment considered impacts on indicators of habitat richness, species biodiversity potential and habitat fragmentation.

No impact to habitat richness is predicted. Construction will lead to reductions in the total area of several ecosite phases and other habitat types. However, the Project impact on species richness is predicted to be low. Project construction will reduce the mean patch size and increase the number of patches of some habitats in the LSA, thereby increasing fragmentation, however, the overall impact on habitat fragmentation is expected to be low.

## 7.13 Land and Resource Use

The development of oil sands resources is in keeping with the provincial planning for the area. The Project footprint does not impact any provincially or federally protected environmental areas, but does fall in the Egg Lake – Algar Diversity Area, which formally recognizes the biodiversity of the area but does not have specific management objectives.

The footprint of the Project will result in an increase in roads and linear disturbances equal to 3% of the LSA. Increased access has both positive and negative effects. As a result of the Project, recreational users will be positively affected as they will have greater access into previously remote areas, and potentially negative through increased pressures on wildlife and vegetation use. Traditional users may also benefit from increased access as they can travel more easily, but the loss of wildlife habitat and increased competition for hunted species may make it more difficult for traditional users. Traplines may be disrupted by infrastructure, and compensation will be managed according to the provincial framework. The impact from increased access is considered neutral as it has both positive and negative effects.

North American will work with Al-Pac, the main timber license holder in the area, and any other local industries, to integrate clearing and road building wherever possible. The depletion of granular resources has a negative, long-term, irreversible medium impact as the Project requires more granular resources than are currently known to be available in the area south of Fort McMurray. As there are other oil sands developments that may be constructed in the area, there will be a shortage of local aggregate and industry will be forced to ship aggregate in from other locations.

Cumulatively, the impacts do not differ from the application case, as the other future projects do not contribute to the footprint and access within the land and resource use RSA. The cumulative case is negative for granular resources for the same reasons as mentioned previously.

## 7.14 Socio-Economic Impact Assessment

The Project will generate substantial economic benefits in Alberta, including almost 15,000 person-years (P-Y) of construction employment, 3,200 P-Y of employment per year once the Project is operating at capacity, GDP of $630 million annually, and fiscal revenues of $11 billion over the Project's 42-year life. Many of these impacts will remain within the local area.

The Project will result in an increase in the permanent population of the local area of about 1,150 people over 10 years. About 350 new dwellings will be required to house the new population, primarily in Lac La Biche and Lakeland County. Demand here can be readily accommodated; however, increased demand will add to current pressures on the cost of housing, especially affordable housing.

In Conklin and Janvier, accommodation of new population will be hindered by the need to upgrade municipal infrastructure and the lack of a house builder in the communities.

Increases in permanent population and in the number of workers living in camps will create demands on local medical, emergency response and social services, not all of which will be included in the provincial funding formulae for these services. In the rural communities, where services are provided by the RMWB, increased demand will further strain fiscal and staffing resources. Traffic in all communities will increase although, with staging of construction related traffic, conflict during high volume times will be reduced. Truck traffic related to production will decline after the first four years of the Project.

## 7.15 Historical

Historical resources studies were conducted for the Project. The studies conducted provided baseline data relative to historical resources to support the EIA application. The historical resources studies conducted consisted of a site file search and literature review, development of a model of archaeological potential for use in project planning and management, and field evaluation of the model in pay zones and additional moderate to high potential areas. Ground truthing resulted in some modification of the model. No archaeological, historical or palaeontological sites were identified or revisited.

## 7.16 Traditional Use and Traditional Ecological Knowledge

North American is conducting separate Traditional Environmental Knowledge (TEK) and Traditional Use (TU) Studies with the communities which are in closest physical proximity to the Kai Kos Dehseh Project: Conklin Métis Local 193, Chipewyan Prairie Dené First Nation, Chard Métis Local 214, and Fort McMurray No. 468 First Nation. The TEK and TU studies are intended to support North American's application to the Alberta Energy and Utilities Board and Alberta Environment, with a specific focus on the initial developments to take place within Leismer and Corner hubs. Work plans are being developed in collaboration with each Aboriginal group to allow for an individualized approach and tailored for each community. The TEK and TU study reports will be submitted to the regulatory authorities upon completion.

# 8 CONSERVATION AND RECLAMATION

## 8.1 Introduction

The C&R plan describes the Project-specific conservation, mitigation and reclamation measures to be implemented throughout the development of the Project to minimize the potential environmental impacts identified in the EIA, and to achieve equivalent land capability after reclamation. The TOR for the EIA requires provision of a Conservation and Reclamation (C&R) plan for the Project and specifies items that must be considered in the plan. The TOR, included in Appendix D, specifies information required in the reclamation plan as part of the Application.

The C&R plan focuses on land and soil conservation, surface disturbance, and reclamation concepts, as well as reclamation options (Alberta Land Conservation and Reclamation Council [ALCRC], 1991) throughout the life of the Project. Future pre-disturbance site assessment (PDA) reports will provide additional site-specific information, including detailed C&R plans, on finalized facility locations.

Information sources consulted and considered in the C&R plan design include:

- The Project EIA Terms of Reference;
- Project design;
- North American's policies/programs;
- Regional initiatives;
- Pre-existing biophysical information for the area;
- Biophysical information (including soils and terrain, ecological land classification, vegetation, and wildlife) collected for the Project, and interpretations for potential impacts and mitigative measures;
- Other SAGD EIAs and their respective C&R plans (e.g., OPTI Canada Inc. Long Lake Project EIA [2000], Nexen/OPTI Long Lake South Project EIA [Nexen/OPTI, 2006]);
- Oil and gas facilities reclamation experience; and
- Existing AENV Approvals for other related projects, and regulator input regarding the Leismer Demonstration Project.

## 8.2 Project Overview

### 8.2.1 Facilities and Footprint

The Project lease areas are located within Townships 76 to 83 and Ranges 8 to 13 W4M as illustrated in Figure 8.2-1. The footprint of the Project covers approximately 3,032 ha. The facilities include field facilities (production pads and access roads, steam distribution and production flowlines, power lines, observation wells, and water source and disposal wells), hub central plant facilities (production treatment and associated facilities) and satellite facilities (steam generation and gas separation facilities, electrical, air and water utility systems, tankage and buildings, and oil emulsion and treated water flowlines). Temporary drilling and construction, and permanent operations camps will also be constructed. The Project footprint is illustrated in Figure 8.2-2. Initial borrow excavations for the Leismer Demonstration Project are included; additional borrow excavations will be needed, but locations have not been finalized. Additional information on Project facilities is provided in Sections 2 and 5 of the Application.

Table 8.2-1 lists the facility areas on the Project footprint.

**Table 8.2-1 Facility Areas on the Project Footprint**

| Project Facility | Area on Footprint (ha) |
|---|---|
| Central Plant Facilities | 616 |
| Production Well Sites (SAGD Pads) | 877 |
| Groundwater (including source & disposal) Well Sites | 51 |
| Production Well Site ROWs | 477 |
| Sales & Diluent Pipeline ROWs | 380 |
| Groundwater Well Site ROWs | 169 |
| Access Roads | 439 |
| Work Camps | 12 |
| Borrow Excavations (North American & Al-Pac) | 12 |
| Total | 3,032 |

### 8.2.2 Development and Reclamation Phasing

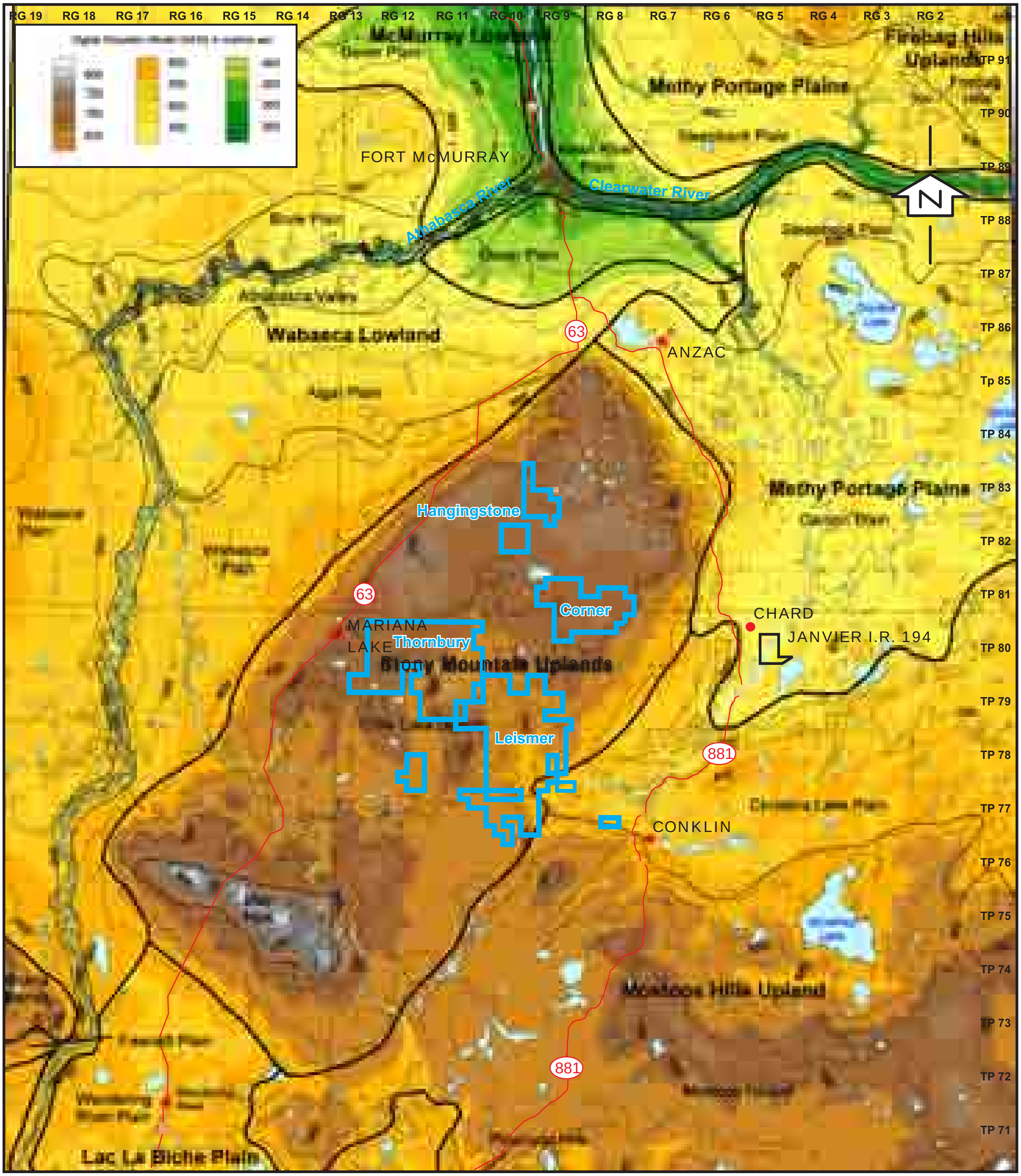
The Project involves development of approximately 158 well sites from 4 development areas (Leismer, Corner, Thornbury, Hangingstone) over a 30 year time frame and phasing out with decreased production over an additional 10 years. Development will occur in approximately ten phases.

The first phase of the initial development includes the Leismer Demonstration Project. This phase will be followed by the Leismer Commercial development (2010) and the Leismer Expansion (2011), and then the initial Corner development (2012). Consecutive development of the remaining phases is to occur between 2013 and 2034. Well pads are expected to have an operational lifespan of 10 to 15 years.

Progressive reclamation will be undertaken on facilities as they are decommissioned and abandoned throughout the life of the Project; examples are temporary camps, production pads and associated facilities that have finished production and are no longer needed. Monitoring will commence after reclamation of a site. Further reclamation measures as needed will be on-going until pertinent criteria are met. Information gathered during the initial reclamation and subsequent reclamation monitoring will be used in the adaptive management to improve future reclamation design, principles and monitoring. Adaptive management will also take advantage of knowledge gained from reclamation on other SAGD projects as it becomes available.

Partial or interim reclamation for facilities will be undertaken during the Project life as practicable including, but not limited to: soil replacement at underground pipelines as the final step in pipeline construction, soil replacement and re-vegetation at facility edge areas not needed for operations, and re-vegetation/erosion control of salvaged soil stockpiles.

Final reclamation of all remaining un-reclaimed facilities will be completed when the Project is decommissioned, abandoned and any contamination remaining has been addressed.




*Scale*

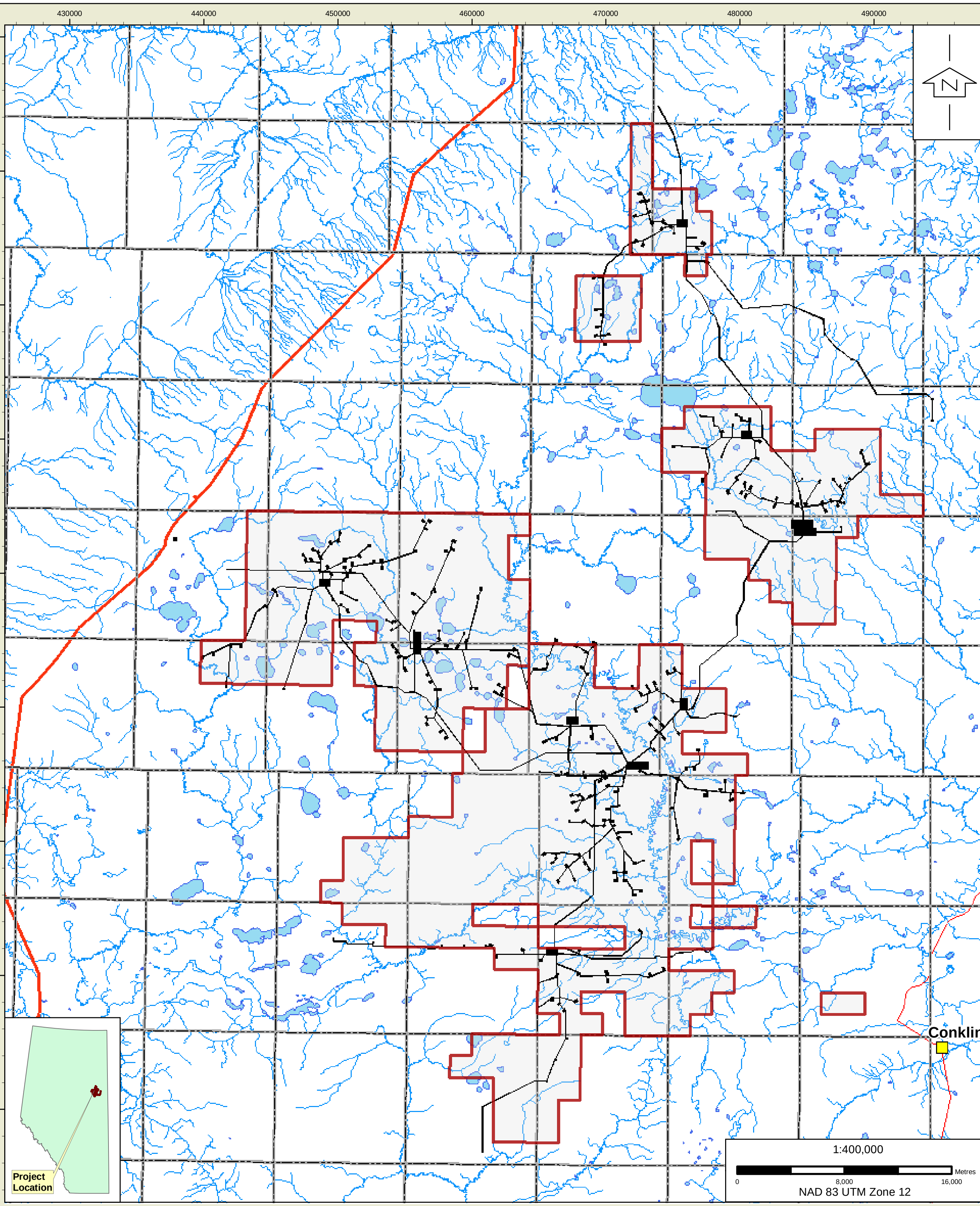
1:1 000 000 10 0 10 20 30 40 km

LEGEND

Lease boundaries

REFERENCE
FIGURE FROM ANDRIASHEK, L.D., 2003. "QUATERNARY GEOLOGICAL SETTING OF THE ATHABASCA OIL SANDS (IN SITU) AREA, NORTHEAST ALBERTA." ALBERTA ENERGY AND UTILITIES BOARD, ALBERTA GEOLOGICAL SURVEY. EDMONTON, ALBERTA, APRIL 2003.

| Title: | | |
|---|---|---|
| KAI KOS DEHSEH PROJECT - LEASE BOUNDARIES WITH SURFACE TOPOGRAPHY AND PHYSIOGRAPHY | Approved: | Revision Date: 07/06/21 |
| | File: 4455-projectarea-07.cdr | |
| | Drawn by: ADF | Checked: SC | Fig. No.: 8.2-1 |




I:\4455-514_NAOSC\NAOSC_Maps\Maps_Soils\RECLAMATION\Fig 8.2-2 Project Footprint 200700723.mxd

**Legend**

- Proposed Project Footprint
- NAOSC Lease Boundary
- Lake
- Stream
- Towns
- Major Road (Hwy. 63)
- Road (881)
- Twp. / Rg. Lines

Title:

# Project Footprint

NORTH AMERICAN OIL SANDS CORPORATION

| Approved: SC/DH | Revision Date: May 02, 2007 |
|---|---|

File: Fig 8.2-2 Project Footprint 200700723.mxd

| Drawn by: LZ/JC | Checked: LZ/SC | Fig. No.: 8.2-2 |
|---|---|---|

## 8.3 Reclamation Planning Concepts

### 8.3.1 General Conservation and Reclamation (C&R) Plan Objectives

The objective of reclamation defined by the EPEA Conservation and Reclamation Regulation (AEP, 1996a) is to return areas disturbed for industrial development to equivalent land capability. This means that the ability of the land to support various land uses after conservation and reclamation should be similar to the ability that existed prior to disturbance. However, the end land use for a specific site will not necessarily be identical to what previously existed.

In general, objectives of C&R planning to achieve the desired environmental outcome include:

- Conserving existing resources as much as possible;
- Adopting measures to mitigate, minimize or prevent environmental impact; and
- Undertaking appropriate reclamation or other ameliorative measures.

Reclamation objectives for the Project include the following:

- The Project will be reclaimed to provide equivalent to pre-disturbance land capability.
- Reclaimed areas will be compatible with the surrounding area and land use, including forested areas, wetlands and streams.
- Reclaimed lands will provide for maintenance free, self-sustaining ecosystems with a similar range of potential end uses, including wildlife habitat and traditional use, compared to pre-disturbance conditions.

The C&R plan provides a general guideline for reclamation throughout the Project life. Adjustments to the general guidelines will be provided in PDA reports prepared for individual sites due to site specific differences in topography, soils, vegetation and drainage.

Land disturbance associated with water source and disposal wells will be addressed as part of the ASRD Environmental Field Report process.

### 8.3.2 Reclamation Closure and End Land Use Objectives

The goal of reclamation is restoration to equivalent land capability. North American will liaise with AENV and ASRD (as well as Al-Pac) for the duration of the Project regarding closure reclamation objectives and the target end land uses for disturbed sites.

The reclamation plan aims to return pre-disturbance forested upland areas to reclaimed upland areas with end ecosite phases and land use (dominantly timber production, habitat and traditional use) that will be the same as, or similar to, the pre-disturbance conditions. To achieve this, the reclamation objectives for upland areas include achieving soils, landforms/drainage, vegetation and habitat that are similar to pre-disturbance conditions and compatible with the surrounding undisturbed areas.

North American recognizes the challenges to reclaiming sites developed on peatland to wetland ecosites. North American will incorporate wetland reclamation principles (OSWWG, 2000) and design, where practicable, into its reclamation plans. This will form part of North American's adaptive management strategy. The central area of well pads on peatland will be reclaimed to upland areas, while the outer portions of the pads will be reclaimed to a poorly to very poorly drained surface peat area, which is transitional to the undisturbed peatland. It is anticipated that this transition zone would support a similar range of land use to the pre-disturbance peatland area. Specific methodology pertaining to this reclamation strategy is provided in section 8.6.5.

### 8.3.3 Reclamation Guidelines

North American intends to meet all applicable regulatory reclamation guidelines (as amended) for the Project including, but not limited to, those listed in Table 8.3-1.

**Table 8.3-1 Applicable Reclamation Guideline Documents**

| | |
|---|---|
| A Guide to the Preparation of Applications and Reports for Coal and Oil Sands Operations | ALCRC, 1991 |
| Storage Requirements for the Upstream Petroleum Industry (Directive 055) | EUB, 1995 |
| Drilling Waste Management (Directive 050) | EUB, 1996a |
| Oilfield Waste Management Requirements for the Upstream Petroleum Industry (Directive 058) | EUB, 1996b |
| Well Abandonment Guide (Directive 020) | EUB, 1996c |
| Guide for Pipelines Pursuant to the Environmental Protection and Enhancement Act and Regulations | AEP, 1994a |
| Guide for Oil Production Sites: Pursuant to the Environmental Protection and Enhancement Act and Regulations | AEP, 1994b |
| Environmental Protection Guidelines for Electric Transmission Lines (C&R/IL/95-2) | AEP, 1995b |
| Reclamation Criteria for Wellsites and Associated Facilities – 1995 Update (C&R/IL/95-3) | AEP, 1995c |
| Environmental Protection and Enhancement Act Conservation and Reclamation Regulation (AR 115/93, as amended) | AEP, 1996a |
| Guideline for Monitoring and Management of Soil Contamination Under Environmental Protection and Enhancement Act Approvals | AENV, 1996 |
| Reclamation Certificates for Overlapping Activities (C&R/IL/97-6) | AENV, 1997 |
| Code of Practice for Watercourse Crossings | AENV, 2000a |
| Environmental Protection Guidelines for Roadways | AENV, 2000b |
| Environmental Protection Guidelines for Oil Production Sites (C&R/IL/02-1) | AENV, 2002 |
| Sites Reclaimed Using Natural Recovery Methods | AENV, 2003 |
| Code of Practice for Pipelines and Telecommunication Lines Crossing a Water Body | AENV, 2000c |
| Code of Practice For Pits | AENV, 2004 |
| Weed Management in Forestry Operations (Directive 2001-06) | ASRD, 2001a |
| Alberta Operational Statement, Habitat Management Program | DFO, 2006 |
| Land Capability Classification for Forest Ecosystems in the Oil Sands Region, 3rd Edition | CEMA, 2006 |
| Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region (consulted, but does not directly apply) | OSVRC, 1998 |
| Guideline for Wetland Establishment on Reclaimed Oil Sands Leases | OSWWG, 2000 |

### 8.3.4 Project Area Regional Initiatives

As the Project develops, North American will participate in regional groups and integrated land management initiatives including: Chipewyan Prairie Dené First Nation Industry Relations Corp., McMurray No. 468 First Nation Industry Relations Corp., Métis Industry Consultation Program, Al-Pac and representatives of industry stakeholders in the region, and other groups with interest and responsibility in oil sands development in the area (e.g., trappers). North American is participating in the integrated land management activities of the Chamber of Resources, Al-Pac and other oil and gas operators in the region.

North American participates in the Southern SAGD Working Group to share information and coordinate the companies' activities in the area of the SAGD projects, and in the Lac La Biche region Industry Consultation Committee to pursue matters of common interest. Other initiatives include participation in an informal group of SAGD operators in the Conklin area to cooperate on infrastructure, coordinating drilling programs with MEG Energy Corp. (MEG), collaboration with MEG and OPTI Canada Inc./Nexen Inc. (OPTI/Nexen) on a wildlife (wolf, caribou, moose) scat survey, and integrating road access and construction plans with Al-Pac. North American maintains on-going contact and coordination of activities with Al-Pac.

### 8.3.5 Stakeholder Consultation

North American's stakeholder group and individual consultations have included federal, provincial, regional and municipal governments, Aboriginal stakeholders, regional service providers, special interest groups and stakeholders with an interest in the land on or near the Project (e.g., trappers, Al-Pac and the public). Communities' concerns included the status of wildlife (e.g., health and populations), minimizing land impact and the quality and quantity of water. North American will conduct business in a manner that benefits and engages local and Aboriginal communities, and consultation will continue throughout the life of the Project.

North American has provided information to stakeholders through its first Report to the Community (North American, 2006a) and Environmental Report to the Communities (North American, 2006b). Local community members assisted in collection of environmental data and contributed local knowledge on the environment. North American is committed to publishing a report to the communities each year. Additional information on participation in regional initiatives and stakeholder consultation is presented in Section 6 of the Application.

## 8.4 Existing Conditions

### 8.4.1 Biophysical Setting

The lease areas are predominantly located in the Stony Mountain Uplands physiographic area with a small lease area located in the Christina Lake Plain. Elevations in the Uplands range from about 600 masl to 700 masl, and surface water drains radially from the Uplands into the surrounding river basins. Stagnant, dead-ice collapse features are the dominant morainal landforms on the Uplands. Organic deposits (e.g., fens and bogs) are an integral part of the hummocky morainal landscapes filling in the depressions within the hummocks and between the till landforms (Andriashak, 2003).

The lease areas are predominantly in the Lower Boreal Highland Natural Subregion, which has moister and cooler climatic conditions than the bordering Central Mixedwood Natural Subregion. Land uses in the area include oil and gas production, forestry, traditional land use, trapping and recreation (Natural Regions Committee, 2006). The Egg Lake–Algar Lake Diversity Area, noted for the presence of patterned fens, caribou habitat and vegetation diversity, covers parts of the lease area. The Stony Mountain Wildland is adjacent to the Hangingstone lease area.

The soil and terrain LSA covers approximately 110,938 ha. Portions of the LSA have undergone previous disturbance including:

- Oil and gas production with well sites, pipelines, seismic lines and access roads; and
- Forestry with logging and associated access roads.

Detailed information on the existing terrestrial and aquatic environments, potential environmental impacts and mitigative measures associated with the Project is provided in the sections of the EIA listed in Table 8.4-1.

**Table 8.4-1 Environmental Impact Assessment Components**

| **Component** | **Volume** | **Section** |
|---|---|---|
| Introduction and EIA Methodology | Volume 2 | Section 1 |
| Air | | Section 2 |
| Noise | | Section 3 |
| Health | | Section 4 |
| Hydrogeology | Volume 3 | Section 5 |
| Hydrology | | Section 6 |
| Surface Water Quality | | Section 7 |
| Fish and Fish Habitat | | Section 8 |
| Soils and Terrain | Volume 4 | Section 9 |
| Vegetation and Wetlands | | Section 10 |
| Wildlife | | Section 11 |
| Biodiversity | | Section 12 |
| Land and Resource Use | Volume 5 | Section 13 |
| Socio-Economic Impact Assessment | | Section 14 |
| Historical Resources | | Section 15 |
| Traditional Ecological Knowledge / Traditional Use | | Section 16 |

### 8.4.2 Soils and Terrain

A brief summary of the soils and terrain baseline information and potential impacts is presented below. More detailed information can be found in the Soils and Terrain section of the EIA (Volume 4, Section 9).

The terrain in the LSA consists of morainal (till), glaciofluvial and glaciolacustrine deposits of Quaternary age, and recent deposits of organic (peat) materials. A summary of the soil series is presented in Table 8.4-2. The soil and terrain LSA is dominated by glacial till (including colluviated till) mapped over approximately 34% of the LSA, and Organic soil mapped over approximately 51% of the LSA. The dominant soil Great Group is Organic soil mapped over approximately 51% of the Soil and Terrain LSA, and Luvisolic soil mapped over approximately 30% of the LSA (Table 8.4-3).

Distribution and areas of soil types are described in the soils and terrain baseline section and illustrated in the soils and terrain LSA soil map (Volume 4, Section 9; Figure 9.5-3).

### Table 8.4-2 Main Soil Series Identified in the LSA

| Soil Series | Code | Main Soil Subgroups | Parent Material |
|---|---|---|---|
| **Organic Soils** | | | |
| Hartley | HLY | Terric Fibrisol | Organic (fen) |
| Mariana | MRN | Terric Mesisol | Organic (bog) |
| McLelland | MLD | Typic and Terric Mesisols | Organic (fen) |
| Mikkwa | MKW | Fibric Organic Cryosol | Organic (fen) |
| Muskeg | MUS | Typic and Terric Mesisols | Organic (bog) |
| **Luvisolic Soils** | | | |
| Dover | DOV | Orthic Gray Luvisol | Glaciolacustrine |
| Fort | FRT | Orthic Gray Luvisol | Glaciofluvial |
| Kinosis | KNS | Orthic and Gleyed Gray Luvisols | Till |
| Livock | LVK | Orthic Gray Luvisol | Glaciofluvial/Till |
| Surmont | SRT | Orthic Gray Luvisol | Colluviated Till |
| **Brunisols** | | | |
| Firebag | FIR | Eluviated Dystric Brunisols | Glaciofluvial |
| Mildred | MIL: | Eluviated Dystric Brunisols | Glaciofluvial |
| **Gleysolic Soils** | | | |
| Algar Lake | ALG | Orthic and Rego Gleysols | Glaciolacustrine |
| Steepbank | STP | Orthic Gleysols | Glaciolacustrine |

Table 8.4-3 lists the areas of the soil series on the footprint.

**Table 8.4-3 Main Soil Series Identified on the Footprint**

| Soil Series | Code | Footprint Area (ha) | % of Footprint |
|---|---|---|---|
| **Organic Soils** | | | |
| Hartley | HLY | 170 | 5.6 |
| Mariana | MRN | 228 | 7.5 |
| McLelland | MLD | 704 | 23.2 |
| Mikkwa | MKW | 7 | 0.2 |
| Muskeg | MUS | 70 | 2.3 |
| **Luvisolic Soils** | | | |
| Dover | DOV | 4 | 0.1 |
| Fort | FRT | 0 | 0 |
| Kinosis | KNS | 1,134 | 37.4 |
| Livock | LVK | 23 | 0.8 |
| Surmont | SRT | 86 | 2.8 |
| **Brunisols** | | | |
| Firebag | FIR | 0 | 0 |
| Mildred | MIL: | 147 | 4.8 |
| **Gleysolic Soils** | | | |
| Algar Lake | ALG | 3 | 0.1 |
| Steepbank | STP | 173 | 5.7 |
| **Other** | | | |
| Disturbed, Stream Channel, Rough Broken | | 283 | 9.3 |
| Total | | 3,032 | 100 |

## 8.4.3 Baseline Land Capability, Sensitivity, and Suitability for Reclamation

Baseline land capability for forest ecosystems was rated using the system outlined in the Land Capability Classification System for Forest Ecosystems (CEMA, 2006). Details of the rating system and its application are presented in detail in EIA Volume 4, Section 9. Table 8.4-4 summarizes the baseline land capability ratings for forest ecosystems and associated limitations for each soil series in the Soil and Terrain LSA. Table 8.4-5 defines the land capability classes for forest ecosystems.

**Table 8.4-4 Baseline Forest Ecosystem Land Capability and Limitations**

| Soil Series | Baseline Land Capability Class and Limitations | |
|---|---|---|
| | Class | Sub-Class Limitations |
| Algar Lake | 4 | Soil Moisture (Wet), Subsoil Structure |
| Dover | 2 | Subsoil Structure, Subsoil Acidity |
| Firebag | 4 | Soil Moisture (Dry), Nutrient Retention |
| Fort | 4 | Subsoil Structure, Topsoil and Subsoil Acidity |
| Hartley | 5 | Organic (Peat) Surface |
| Kinosis | 3 | Topsoil and Subsoil Acidity, Subsoil Structure |
| Livock | 3 | Topsoil and Subsoil Acidity, Subsoil Structure |
| Mariana | 5 | Organic (Peat) |
| McLelland | 5 | Organic (Peat), Nutrient Retention |
| Mikkwa | 5 | Soil Moisture (Wet), Topsoil and Subsoil Acidity, Subsoil Structure |
| Mildred | 4 | Soil Moisture (Dry), Nutrient Retention, Topsoil Acidity |
| Muskeg | 5 | Organic (Peat), Topsoil and Subsoil Acidity |
| Steepbank | 5 | Soil Moisture (Wet), Topsoil and Subsoil Structure |
| Surmont | 3 | Subsoil Structure, Nutrient Regime, Slope |

**Table 8.4-5 Descriptions of Land Capability Classes for Forest Production in the Soils and Terrain LSA**

| Capability Class | Capability Class Definition |
|---|---|
| 1 (High capability) | Land having no significant limitations to supporting productive forestry, or only minor limitations that will be overcome with normal management practices. |
| 2 (Moderate capability) | Land having limitations which in aggregate are moderately limiting for forest production. The limitations will reduce productivity or benefits, or increase inputs to the extent that the overall advantage to be gained for the use will still be attractive but appreciably inferior to that expected on Class 1 land. |
| 3 (Low capability) | Land having limitations which in aggregate are moderately severe for forest production. The limitations will reduce productivity or benefits, or increase inputs to the extent that the overall advantage to be gained from the use will be low. |
| 4 (Conditionally productive) | Land having severe limitations, some of which may be surmountable through management, but which cannot be corrected with existing knowledge. |
| 5 (Non-productive) | Land having limitations which appear severe enough as to preclude any possibility of successful forest production. |

Soils and terrain interpretations for sensitivity to erosion and soil suitability for reclamation are described in detail, including interpretive maps, in the Volume 4, Section 9. Table 8.4-6 and Table 8.4-7 summarize some of this information.

**Table 8.4-6 Sensitivity of Soil Series to Acidification and Erosion**

| Soils Series | Sensitivity to Acidification | Sensitivity to Water Erosion | Sensitivity to Wind Erosion |
|---|---|---|---|
| Algar | Medium | Low | Low |
| Dover | Low | Low, increasing with slope steepness to high at slopes greater than 9% | Low |
| Firebag | Low | Low, increasing with slope steepness to high at slopes greater than 9% | High |
| Fort | Low | Low, increasing with slope steepness to high at slopes greater than 9% | Medium |
| Hartley | Low | Negligible | Negligible |
| Kinosis | Low | Low, increasing with slope steepness to high at slopes greater than 9% | Low |
| Livock | Low | Low, increasing with slope steepness to high at slopes greater than 9% | Medium |
| Mikkwa | Low | Negligible | Negligible |
| Mildred | Medium | Low, increasing with slope steepness to high at slopes greater than 9% | High |
| Mariana | Low | Negligible | Negligible |
| McLelland | Low | Negligible | Negligible |
| Muskeg | Low | Negligible | Negligible |
| Steepbank | Medium | Low | Low |
| Surmont | Low | Low, increasing with slope steepness to high at slopes greater than 9% | Low |

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 (Volume 4, Section 9).

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; few areas are mapped with steep slopes and high water erosion potential. The dominant slope class mapped was Class 1-2 (level to nearly level) over approximately 49% of the LSA.

The Mildred and Firebag soils have high sand content and are subject to high wind erosion risk; however, the area rated high for wind erosion risk is relatively small in the Project area (approximately 3.4% of the Soil and Terrain LSA).

### Table 8.4-7 Soil Series Suitability for Reclamation

| Soil Series | Surface Reclamation Suitability | Limitations | Subsurface Reclamation Suitability | Limitations |
|---|---|---|---|---|
| **Algar Lake** | --- | Surface Peat | Fair | Consistence, Texture |
| **Dover** | Good | Consistence, Texture | Poor | Consistence, Texture |
| **Firebag** | Poor | Texture | Poor | Texture |
| **Fort** | Fair | Reaction (pH) | Fair | Texture, pH |
| **Hartley** | --- | Organic | --- | Organic |
| **Kinosis** | Good | --- | Fair | Consistence, Texture, pH |
| **Livock** | Fair | pH | Fair | Consistence, Texture, pH |
| **Mariana** | --- | Organic | --- | Organic |
| **Mildred** | Poor | Texture | Poor | Texture |
| **Mikkwa** | --- | Organic | --- | Organic |
| **McLelland** | --- | Organic | --- | Organic |
| **Mariana** | --- | Organic | --- | Organic |
| **Muskeg** | --- | Organic | --- | Organic |
| **Steepbank** | --- | Surface Peat | Fair | Consistence, Texture |
| **Surmont** | Good | --- | Fair | Texture |

The Luvisolic soils dominate the mineral soils present and have dominantly good surface reclamation suitability and fair subsurface reclamation suitability.

## 8.5 Potential Impacts on Land Capability

Potential impacts to the soils and terrain (Volume 4, Section 9), if sufficiently severe, could lower the baseline land capability for forest ecosystems of an area.

The following points highlight potential impacts to land capability resulting from impacts to the soils and terrain resources in the LSA:

- Water erosion can be significant in areas where surface topography results in concentrated flow on long slopes, and where surface soils lack adequate vegetative or other protective cover, resulting in soil loss and degradation.
- Wind erosion resulting in soil loss or degradation could be significant for surface soils where lack of surrounding tree/bush cover allows a significant level of wind exposure and wind velocity.
- Compaction and loss of structure of mineral soils is a significant potential impact particularly with the finer textured subsoils in higher soil moisture locations.
- Loss of soil, or salvaged soil degradation, (e.g., decrease in organic carbon or adverse change in soil texture and consistence) can result from mixing subsoil into topsoil (admixing), particularly in soil salvage operations.

- Drainage problems resulting in excess moisture may occur, particularly in the lower lying and level areas.
- Contamination from operations may impact soil, groundwater and surface water.
- Potential adverse effect of soil acidification due to acid deposition may occur.
- Potential for loss of, or changes to, landforms (e.g., bog/fen) and associated biophysical resources may occur.
- Terrain instability (e.g., slumping), particularly from cut and fill on steep slope gradients, may occur.

## 8.6 Conservation and Reclamation Plan

### 8.6.1 Introduction

The C&R plan provides measures to prevent, mitigate, or ameliorate impacts, and to return land disturbed by the Project to equivalent, pre-disturbance land capability. Mitigative measures are also presented in the EIA (Table 8.4-1 shows locations in the EIA). Creation and implementation of this C&R plan is a part of the pre-construction planning, which ensures consideration of conservation and reclamation procedures in all phases of the Project including construction, operations and closure. Integration of conservation and reclamation measures with the Project includes such considerations as facility siting and design, and operational measures such as soil salvage, weed control, surface water management, sediment and erosion control, waste management and reclamation, re-vegetation and monitoring.

### 8.6.2 General Project Conservation and Mitigation Measures – All Phases of Project

#### 8.6.2.1 Facility Siting and Disturbance Minimization

Environmental considerations (constraints) have been included from the beginning of Project planning and design. This section includes examples of environmental mitigation measures considered in the Project design. Facilities were sited to avoid water courses and designed to minimize surface disturbance where practical.

Environmental considerations in facility planning included:

- Siting facilities with consideration of:
  - **Topography** - preference given to higher, drier, stable ground with lower gradient slopes.
  - **Soils** - preference given to mineral soils.
  - **Vegetation** - avoidance of rare plants where practical.
  - **Surface water** - North American identified a 100 m buffer around open waterbodies and defined watercourse channels (i.e., having defined bed and bank material) and observed these buffers where practical. However, based on the location of the bitumen resource and the extent of wetlands in the area, pads and infrastructure will need to be constructed in some wetlands. North American is committed to berming

pads and will meet the requirements of Directive 055 (EUB, 1995) with regard to acceptable measures for onsite containment to prevent release of contaminants.

- o **Site-specific biophysical conditions** - generally will be used to adjust locations where feasible to reduce impact.

- Minimizing surface disturbance to increase conservation of biophysical resources (e.g., soils, biodiversity) by:
  - o Coordinating with other industry on infrastructure and utilizing existing disturbances (e.g., ROWs, cutlines) where practicable. For example:
    - ▪ The main access for the Leismer lease will be via a forestry road, the industry shared Wadell road, and an Al-Pac road and bridge.
    - ▪ Road and infrastructure coordination has been undertaken with Whitesands Insitu Ltd. and Paramount Resources.
    - ▪ North American is evaluating pipeline transportation with other bitumen shippers and pipeline companies to maximize use of existing and planned routings (e.g., potential use of existing sales and diluent pipelines to Cheecham Terminal).
  - o Using common access roads for several well pads;
  - o Combining access and utilities (pipelines, power lines) into a common ROW;
  - o Minimizing the number of pads by locating multiple well pairs on each pad;
  - o Minimizing production pad size to the extent allowed by surface infrastructure and salvaged soil storage; and
  - o Restricting traffic and other activities off of facility areas.

#### 8.6.2.2 Surface Water Management

North American's water management plan focuses on produced water reuse, water supply management and surface water protection. Measures to control site runoff and maintain adequate surface water flow that is compatible with the surroundings both in upland areas and wetland areas will be undertaken. Examples of mitigation measures include:

- Watercourse crossings will meet applicable legislative requirements for minimal impact engineering and regulatory requirements such as Alberta's *Water Act* (RSA 2000, W-3) and *Fisheries Act* (RSA 2000, F-16), Department of Fisheries and Oceans Operational Statements (DFO, 2006), *Code of Practice for Pipelines and Telecommunications Lines Crossing a Water Body* (AENV, 2000c), *Code of Practice for Watercourse Crossings* (AENV, 2000a), and *Public Lands Act* requirements (RSA 2000, cP-40), as well as additional requirements, if any, in the AENV Approval.
- Production well pads will have a perimeter ditch/berm system to prevent flow onsite, and contain runoff in a graded lower corner with clay used as a liner. To contain surface water runoff, CPF design will include grading, berms, ditching and lined storm water ponds.

- Accumulated facility runoff water will be tested to determine whether release to the environment is appropriate as per the relevant surface water quality guidelines (e.g., AENV Approval conditions, or *Surface Water Quality Guidelines for Use in Alberta* [AENV, 1999]). Water will be released in a manner preventing erosion or drainage impacts. Water not meeting the appropriate guidelines will be sent for treatment or appropriate disposal.

- Disturbed surfaces will be contoured to prevent unintended depressional areas that would accumulate water.

- Where practical, facilities will be located to minimize watercourse crossings and interference with natural drainage.

- Culverts and ditches will be placed as topography dictates to prevent blockage of surface water flow, to avoid accumulation and formation of unwanted wet areas (ponded water), as well as to prevent flow onto disturbed areas.

- Culverts and/or buried rock drains will be used where needed on padded well sites and access on deep peat areas (e.g., fens) to maintain water flow. North American will monitor conditions around roads and pads to evaluate any additional measures (e.g., clear blocked culverts) needed to maintain water flow and the ecological integrity of the wetland.

Detailed mitigation measures for potential hydrological impacts are provided in the Hydrology (Volume 3, Section 6) and Fish and Fish Habitat (Volume 3, Section 8) sections.

#### 8.6.2.3 Mitigation of Erosion Impacts

Where necessary, erosion control measures will be implemented; examples may include:

- Silt fencing or settling ponds will be used during construction where needed to contain sediment in surface runoff;

- Disturbed surfaces will be contoured to avoid concentrated surface flow and formation of rills/gullies down long slopes;

- Surface water flow impediments (e.g., rip rap) will be used where needed in ditches to slow water velocity;

- Unstable ditch banks will be protected from erosion by vegetation with an appropriate weed free seed mix, and/or physical erosion protection;

- Excessive slope gradients in ditches and graded surfaces will be avoided;

- Ditches and culverts will be used to control water flow;

- Salvaged soil stockpiles and exposed soil areas will be contoured to avoid excessive slopes and will be re-vegetated or otherwise protected;

- Surface disturbance and exposed soil will be minimized;

- Soil disturbance will not occur under conditions where significant erosion may occur (e.g., high winds); and

- Observed erosion as a result of Project activities will be addressed in a timely manner.

#### 8.6.2.4 Weed Control

Weeds will be managed as per regulatory requirements and industry best practices.

- Restricted and noxious weeds as identified in the *Weed Control Act* (Alberta Agriculture and Food, 2001b) will be eliminated or controlled, respectively.
- Facility areas will be routinely monitored for weeds during all phases of the Project. Pre-disturbance information on weeds in the Project area will be used to monitor for the known weeds. Weed control will be undertaken in a timely manner.
- Equipment arriving onsite will be cleaned of soil, if necessary, to prevent importation of weed seeds.
- Non-chemical control of weeds (mowing, cultivation, hand picking) is preferred where practical; chemical weed control will be used when necessary, and subsequent to appropriate approval.
- Herbicides applied will be appropriate for site conditions and weed type; a licensed industrial pesticide applicator will be contracted to select and apply herbicides. Only pesticides approved by Agriculture Canada and AENV will be applied. All federal and provincial regulations regarding use, transportation and storage of herbicides will be followed.
- Soil sterilants will not be used.
- Herbicides will not be applied under windy conditions that would cause application off the intended treatment area. Areas treated with non-selective herbicide will be monitored to assess any movement offsite.
- Herbicides will not be used where desired species would be harmed; this may require spot spraying or mechanical control.

### 8.6.3 Construction Phase

Construction will include the general Project conservation and mitigation measures and measures that are specific for a biophysical area or specific type of facility. Construction methods will be dependent on site-specific surface conditions.

#### 8.6.3.1 Clearing Timber and Brush

Vegetation clearing will be minimized to the extent practical, and buffer zones from sensitive areas (e.g., watercourse, rare plants) will be maintained. Avoidance of rare plants populations is the primary mitigation tool. If it is not possible to relocate a pad to avoid an identified rare plant, North American will assess the feasibility of transplanting the specimen to an adjacent suitable habitat. Post transplantation monitoring will be used to evaluate the success of the transplantation, and this information will be used for future transplanting considerations. Transplantation consideration will be based on the status of the rare plant (plants ranked higher [S1] will be given higher priority than plants with lower ranking [S2]) and the likelihood of transplantation success.

A Conservation and Reclamation Inspector will be contacted when a land surface disturbance that has not been approved is required. Some areas in the Project lease have been previously cleared for conventional gas well sites and pipelines to those sites.

North American is working with Al-Pac to coordinate integrated land management and removal of any merchantable timber during site development as required. For any land not cleared by Al-Pac, North American will implement the following guidelines:

- Land will be cleared according the to timber management regulations of the *Forest and Prairie Protection Act* regulations (ASRD, 2001b and 2001c) and Al-Pac guidelines as they apply to site clearing, debris disposal and onsite firefighting equipment.
- Adequate firefighting equipment, in accordance with provincial guidelines and relative to degree of fire hazard, will be available on the Project site during construction activities. In the event of a fire, the contractor will immediately implement the approved Fire Contingency Plan, and notify the authorized company representative and required regulatory representative(s).
- Merchantable timber is defined as having a diameter at breast height (DBH) of 15 cm or greater. Any merchantable timber present in the Project area will be salvaged from the site for disposition as per consultation with Al-Pac. Timber salvage deck sites will be located in natural clearings, or previously cleared areas (including seismic line intersections) if practical.
- Non-merchantable timber (woody debris - e.g., burnt timber, small-diameter stems, grubbed stumps, standing dead wood or deadfall) will be cleared with a bulldozer equipped with a cutter blade or similar equipment, as appropriate, to maintain ground surface integrity, particularly in areas where grading is not required. Woody debris will be disposed of by burning (with appropriate approvals obtained) or mulching (used for surface protection/erosion control), or will be used as rollback or as directed by the Conservation and Reclamation Inspector. Excess mulched material on the surface can inhibit re-vegetation; this will be avoided.

#### 8.6.3.2 Wildlife Protection

Management strategies to limit habitat loss and fragmentation from construction, infrastructure and production facilities will be implemented (e.g., minimize areas of surface disturbance). Wildlife crossings will be constructed where required for aboveground pipelines.

Tree and brush clearing will be conducted between August 30 and April 1 to protect birds and their nests, and to ensure compliance with Alberta's *Wildlife Act* (ASRD, 2000), and the federal *Migratory Birds Convention Act* (Government of Canada, 1994). If clearing is required within the restricted time period, the area will be surveyed by a biologist to determine presence of nesting birds, including raptors and owls.

The presence of woodland caribou is a potential concern due to its “at risk” status (ASRD, 2000). North American has a caribou protection plan for the area in good standing, which will be updated annually, or as required. The plan includes drilling and construction plans and proposed mitigation measures. Examples of mitigation measures include the combination of several linear facilities within a ROW to decrease the number of corridors, use of existing cut lines to minimize the number of corridors, orientation for field personnel regarding caribou issues, and a public access management plan.

### 8.6.3.3 Area/Facility Construction Mitigative Measures

Construction of facility areas will include berms, ditches, culverts, grading, and clay/synthetic lined collection areas/ponds needed to manage offsite and onsite surface water as indicated in section 8.6.2.2.

If artifacts of cultural or historical significance are encountered, work will be suspended in the area, Alberta Community Development will be contacted and a permit holder will investigate the site.

#### *Construction in Upland Areas*

Construction of well sites, access roads, and CPFs on upland areas generally involves clearing/timber salvage (coordinated with Al-Pac), grubbing/mulching, soil salvage, grading (including cut and fill at some locations) and gravelling. A plan view schematic of a typical well pad construction is presented in Figure 8.6-1. Where fill is required, the subgrade is compacted and the fill laid down in layers that are compacted.

#### *Construction in Peatland Areas*

Construction on peatland will depend on site-specific conditions.

Where peat depth is approximately 40 cm or less, the peat material will be salvaged down to the mineral material below. Peat may be stripped deeper at sites where stripping slightly more peat will reach the mineral layer below. These sites are most likely to occur in peaty Gleysols, shallower Organic soils (Hartley, Mikkwa, Mariana), and boundary areas between upland and deeper Organic soils. The salvaged peat will be preferably stored as surface replacement material for reclamation at the location of origin. After excavation of the peat, deep fill will be laid down in layers and compacted. A mineral soil cap will be placed above the compacted layers, graded and gravelled. A conceptual schematic for construction on shallow peat is provided on Figure 8.6-3.

In deeper peat areas, which are most likely to occur in McLelland and Muskeg soils, a floating pad will be constructed. However, approximately 40 cm of peat will also be salvaged at these sites and stored on the pad. At these sites, geotextile will be laid on the peat surface followed by fill material (till) laid down in layers and compacted (typically to a metre or two above original surface). The cap will then be graded and gravelled. A conceptual schematic for construction on deep peat is provided on Figure 8.6-4.

Well pad construction in wetland areas may include buried rock drains (nominally constructed with filter fabric and drain rock) through the pad if required to prevent impacts from impedance of wetland (fen) water flow.

#### *Pipelines*

The AENV codes of practice for water course crossings (AENV, 2000a) and pipelines and telecommunications lines crossing waterbodies (AENV, 2000c), and applicable DFO Operational Statements will be followed.

For underground pipelines, the ROW will be cleared with timber salvage where required; surface soil will be salvaged on the trench width and replaced at the end of construction. Slash and rollback will also be replaced along the ROW. Re-vegetation will occur by natural regeneration. If natural ingress is slow or the area is prone to erosion, selected areas will be planted with native species and/or re-vegetated with an ASRD-approved seed mix.

Aboveground pipelines ROWs will require clearing and timber salvage. However; little surface disturbance occurs where the support rack piles are driven into the ground. Wildlife crossings will be constructed, as required, over aboveground pipelines.

#### *Borrow/Aggregate Excavations*

Potential borrow excavations will be preferentially located on drier till soils to minimize peatland disturbance. Where feasible, adjustments to proposed locations will be revised according to site specific conditions to avoid local deep peat or surface water drainage. Sites will be preferentially located on topographic crest locations to minimize creation of pits and lessen the need for re-contouring in reclamation to integrate post reclamation topography and drainage with adjacent terrain in reclamation. Rare plant locations will be avoided.

At these sites, general construction measures for upland areas will apply, including topsoil and upper subsoil salvage and storage for use in reclamation at the borrow site. Where practical, borrow material will be recovered for re-use from well pad and roadways as they are abandoned.

The initial aggregate supply will be from third party sources.

#### *Ponds*

The sludge ponds on the CPFs will be constructed with dual synthetic liners and interstitial leak monitoring. The storm water retention pond will be constructed with a single synthetic liner; a ditch/berm system and grading will control onsite surface water.

### 8.6.3.4 Soil Salvage

Surface disturbance will occur mainly at the following locations: CPF areas (including temporary laydown and construction camps), well pads (including production, observation, and source water and disposal wells), access roads, borrow excavations and underground pipelines.

#### *Soil Salvage on Upland Areas*

Soil salvage plans take into account the distribution and characteristics of the mapped soils to optimally retain surface soil quality and quantity. Upland surface soils generally consist of duff (LFH), Ae and B horizons, with shallow peat layers commonly occurring on the wetter mineral (Gleysolic) soils that may not have an A horizon. A summary of soil characteristics related to soil salvage recommendations is presented in Table 8.6-1.

**Table 8.6-1 Mineral Soil Characteristics Related to Soil Salvage**

| Soil Series | Comments |
|---|---|
| Algar | Gleysolic glaciolacustrine soils generally with shallow peat (thickness: 20 cm to 40 cm) with A horizons uncommon. |
| Dover | Luvisolic glaciolacustrine soils generally with shallow peat (thickness: 0 cm to 20 cm), generally with a shallow A horizon (thickness: 6 cm to 15 cm; average 9 cm). |
| Steepbank | Gleysolic till soil with shallow peat (thickness: 14 cm to 55 cm; average 30 cm) surface layer, and presence of A horizon (thickness: 0 cm to 35 cm; average 10 cm) is slightly more common than absence. |
| Firebag | Brunisolic glaciofluvial soil with surface LFH thickness in the range of 1 cm to 10 cm and observed A horizon depth thicknesses of 13 cm to 18 cm. |

| Soil Series | Comments |
|---|---|
| Fort | Luvisolic glaciofluvial soils that may have surface LFH (thickness: 0 cm to 6 cm) or shallow peat horizon (thickness: 0 cm to 15 cm). An A horizon is generally present (thickness: 3 cm to 18 cm; average 10 cm). |
| Kinosis | Luvisolic till soil with both surface LFH (thickness: 0 cm to 19 cm) and shallow peat (thickness: 0 cm to 40 cm) horizons common. A horizons are dominantly from 0 cm to 45 cm (average 15 cm) thick. |
| Livock | Luvisolic glaciofluvial over till soil with both surface LFH (thickness: 0 cm to 25 cm) and shallow peat (thickness: 0 cm to 40 cm) common. A horizons 5 cm to 50 cm thick were observed (average 18 cm). |
| Mildred | Brunisolic glaciofluvial soil with variable LFH surface horizons (thickness: 0 cm to 10 cm) more common than shallow surface peat (thickness: 0 cm to 22 cm). A horizons observed vary from 0 to 22 cm thick with an average of approximately 11 cm. |
| Surmont | Luvisolic till (colluviated) soil with both surface LFH (thickness: 8 cm to 10 cm) and A horizons generally present. A horizons observed were 17 cm to 31 cm thick. |

A horizons are generally eluviated A (Ae) horizons or gleyed variants.

Surface textures are generally:

- **Till** – silt loam or sandy loam to clay loam
- **Glaciolacustrine** – silt loam to silty clay loam
- **Glaciofluvial** – sandy loam or silt loam to loamy sand (Firebag is coarser with stony loamy sand to sand textures)

Subsoil textures are generally:

- **Till** – clay loam to silty clay loam or sandy clay loam
- **Glaciolacustrine** – clay loam or silty clay loam to clay
- **Glaciofluvial** – sandy loam to loamy sand or sandy clay loam (Firebag is coarser with stony loamy sand to sand textures.)

General upland topsoil soil salvage guidelines are provided in Table 8.6-2; however, PDAs will be completed to obtain site-specific soil data (including surface soil depths) on finalized facility locations.

### Table 8.6-2 Upland (Mineral Soil) Topsoil Salvage Guidelines

| Soil Series | Recommended Topsoil Salvage | Comments |
|---|---|---|
| Firebag<br>Fort<br>Kinosis<br>Livock<br>Mildred<br>Surmont | LFH and/or shallow peat plus 15 cm topsoil (or to bottom of topsoil if deeper) | Colour change from greyish Ae to brownish Bt or Bm can often be used as an additional on-site guide to topsoil depth.<br>The finer textured till and glaciolacustrine subsoils will be susceptible to compaction, especially when moist. |

| Soil Series | Recommended Topsoil Salvage | Comments |
|---|---|---|
| Algar Lake<br>Dover<br>Steepbank | Peat plus up to 10 cm of mineral soil | These soils will be very susceptible to compaction and rutting.<br>Water table may be near the surface. |

Up to 30 cm of suitable subsoil as defined in the *Soil Quality Criteria Relative to Disturbance and Reclamation* (Alberta Agriculture, 1987) will also be salvaged from mineral sites. No subsoil will be salvaged from wet (i.e., Organic or Gleysolic) soils. This soil will be preferentially stored at the location of origin. Access roads on mineral soils will have surface duff/peat and surface mineral soil salvaged only.

### *Soil Salvage on Peatland (Organic Soil) Sites*

A summary of peat thickness for the various soil series and associated map units is presented in Table 8.6-3.

**Table 8.6-3 Peat Thickness on Organic Soil Series**

| Soil Series | Comments[1] |
|---|---|
| Hartley | Most commonly Terric Fibrisol. Peat thickness 40 cm to 175 cm (commonly 50 cm to 100 cm); average 93 cm. |
| Mariana | Mostly commonly Terric Fibrisols. Peat thickness 40 cm to 220 cm (commonly 50 cm to 110 cm); average 90 cm. |
| McLelland Muskeg | Most commonly Typic Fibrisols. Peat thickness 40 cm to >220 cm commonly 160 cm to 220 cm or more); dominantly >200 cm |
| Mikkwa | Organic Cryosols. Peat thickness from 60 cm to 120 cm (commonly 70 cm to 100 cm); average 83 cm. |

1. A horizons may occur under the peat, but are uncommon and thin when present.

Soil salvage recommendations for peat areas are described in section 8.6.3.3.

### *Soil Handling Conservation Measures*

As surface soils are important determinants of land capability, the following conservation measures for soil salvage will be taken to conserve soil quantity and quality.

- A soil specialist will ensure that soil salvage will minimize admixture of the LFH/peat and topsoil with the subsoil and preserve salvaged soil quality; colour change from Ae to B horizons can be used as a guide to the maximum topsoil depth at a particular location in most of the dominantly occurring Luvisol soils.

- Volumes and locations of stored salvaged soil will be recorded for future reference.

- Unless otherwise authorized in writing by a Conservation and Reclamation Inspector, topsoil and subsoil salvage will be suspended if wet or frozen conditions will result in degradation of topsoil or subsoil quality.

- Unless otherwise authorized in writing by a Conservation and Reclamation Inspector, topsoil and subsoil salvage will be suspended if high wind velocities will result in degradation of topsoil or subsoil soil quality.
- Salvaged soil will be stored out of the way of surface water flow and operational activities.
- Where practicable saturated peat on organic soils will be salvaged under frozen conditions.

### 8.6.3.5 Soil Stockpiles

Topsoil, peat and subsoil salvaged for reclamation will generally be stockpiled on the site of origin where feasible. Stockpiles will be located along the edge of the facility (Figures 8.6-1 and 8.6-2) or along the access ROW. Locations will be documented and a record will be maintained in the site file. Stockpiles will be located such that they are:

- Outside all areas of potential disturbance so that they do not interfere with onsite activities;
- Outside treed areas and with breaks for intersecting water flow, where required, along access roads;
- Accessible and retrievable for reclamation; and
- On a stable surface where surface runoff from surrounding areas does not impinge on the base of the stockpiles.

A separation of two or more metres will be maintained between separately salvaged stockpiles of different materials to ensure no soil mixing occurs. To minimize erosion, the stockpiles will be contoured to a stable slope gradient and erosion mitigation measures undertaken as needed (e.g., seeded with a certified weed-free ASRD-approved seed mix, use of tackifier or erosion matting). Weed control measures will be undertaken as required for the soil stockpiles.

## 8.6.4 Operational Phase

### 8.6.4.1 Waste Management

North American is committed to minimizing waste production and will reduce, reuse and recycle where practical. Regulatory provincial and federal waste handling requirements will be met. Some examples of these requirements include EUB Directive 050 (EUB, 1996a), EUB Directive 051 (EUB, 1994), EUB Directive 058 (EUB, 1996b), Directive 055 (EUB, 1995), EPEA Waste Control Regulation (AR 192/1996) and AENV Approval conditions.

A water-based drilling fluid will be used in pad drilling, equipped with a central mud collection system. To reduce volumes, drilling fluids will be re-used whenever practical. Drilling fluids will be directed to remote sump locations based on suitable soil condition. Locations will be chosen based on soil sampling indicating the sump base will meet regulatory requirements. Drilling wastes will be monitored and analyzed and disposed of in compliance with EUB Directive 050 (EUB, 1996a). Special attention will be paid to hydrocarbon levels in drilling waste to minimize drilling mud contamination and drilling waste disposal. North American will separate drilling muds contacting oil bearing formations. Materials that comply with Alberta Tier I soil and water quality guidelines for hydrocarbons (AENV, 1994) will be disposed of using the mix-bury-cover method.

Waste not meeting Directive 050 requirements for hydrocarbons levels will be disposed of at an approved waste disposal facility or treated to the guideline levels.

Sour gas will be treated at the Leismer, Thornbury and Corner development areas. Discussions have been undertaken with a sulphur marketing firm for to purchase recovered molten sulphur of saleable quality. The product will be trucked offsite for sale. Approximately 15 days of molten sulphur storage will be provided onsite. Thus, environmental problems associated with long-term storage of sulphur are not anticipated.

When a sludge pond is full it will be drained and the sludge dewatered and trucked offsite to a suitable, licensed landfill.

Additional information on the waste management plan is presented in Volume 1, Section 4.

#### 8.6.4.2 Spill Prevention and Contingency Plans

North American is implementing a comprehensive Corporate Health, Safety and Environmental (HS&E) Management System reflects the high priority that North American places on minimizing the impact of the Project. This ensures that the health and safety of all individuals and communities affected are safeguarded, and the environment is protected. Under the umbrella of the HS&E Management Plan is a Facility Emergency Response Plan, which will include fire control management, environmental monitoring and spill response information and procedures.

Examples of spill procedures and mitigation measures include:

- Surface water management measures (e.g., berms, grading) that will also contain spills onsite;
- Compliance with regulatory secondary containment requirements, use of drip trays and leak detection (e.g., tank farm, sludge ponds) where required;
- Consideration of long-term well bore integrity in the design of and materials used in casing, liners and tubulars, including the implementation of a casing failure monitoring program to identify and track failures;
- Proper storage and tracking of chemicals and waste products; and
- Procedures for incident regulatory reporting (including regular review of procedures) and incident investigation.

Additional information on spill response is presented in Volume 1, Section 5.3.

#### 8.6.4.3 Reclamation and Remediation during Operations

Contaminant releases will be reported and managed as required in a timely manner and assisted by ongoing environmental monitoring. Contaminant monitoring and management will be carried out in accordance with applicable regulations including the AENV Approval for the Project.

Reclamation of well pads, core hole sites, access roads and seismic lines will be carried out on an ongoing basis as required. Interim reclamation for facilities during the operational phase will include re-contouring or other reclamation measures if needed to achieve drainage compatible with the surrounding land, avoid erosion and protect any nearby sensitive areas (e.g., water features). Salvaged soil may be replaced at the edges of some operating facilities after construction to decrease the footprint and promote natural re-vegetation over the operational life of the well. Surface soils salvaged for any underground pipelines will be replaced at the completion of pipeline construction, and natural regeneration of vegetation will be monitored for progress of vegetation establishment, and remedial measures will be carried out for any problem areas.

Brush control on pipeline ROWs will be carried out as required allowing for access should any pipeline repair be needed, and to prevent vegetation growth that could interfere with the pipeline.

#### 8.6.4.4 Final Decommissioning and Abandonment

Individual facilities for the Project will be decommissioned and reclaimed when it is determined a particular facility will no longer be required. At the end of the Project, all remaining Project facilities will be decommissioned and reclaimed. Six months prior to the plant ceasing operation, North American will apply for an amendment of the AENV Approval to Operate to reclaim the facility by submitting a decommissioning and final land reclamation plan to AENV. This plan will contain details as specified by the AENV Approval. This plan will be prepared with input from stakeholders and provincial regulators.

Prior to the removal of any facilities, existing information will be reviewed from environmental reports completed during facility operation, and additional site assessments will be conducted if required to determine the presence and extent of any contamination. Removal of facilities will occur in a manner that prevents release of contaminants. If required, remediation will be conducted during, or after, operations. After decommissioning and abandonment has been completed, any contamination remaining will be addressed. Confirmatory sampling will be carried out to indicate compliance with the remediation objectives of the day.

A plan for controlling erosion will be developed for each of the facility areas prior to decommissioning. Production and monitoring wells will be abandoned according to EUB and AENV standards. The sludge ponds will be decommissioned and surface reclamation completed. All watercourse crossings, culverts and berms will be removed and reclaimed pending consultation with stakeholders and government regulatory agencies.

### 8.6.5 Closure Phase Reclamation

Closure reclamation of the disturbed sites will commence after decommissioning. Reclamation for the disturbed sites includes a plan to return the sites to equivalent or better land capability for forest ecosystems. This plan will also assist in attaining self-sustaining ecosystems able to support a similar range of end land uses compared to baseline conditions.

#### 8.6.5.1 Reclamation for Upland Forested Sites

The plan aims to reclaim sites in upland forested areas to ecosite phases and land uses that will be the same as, or similar to, the pre-disturbance conditions. The goal of this is to promote compatibility with the surrounding vegetation, and similar levels of biodiversity. To achieve this, the reclamation objectives for upland areas include achieving soils, landforms/drainage, vegetation and habitat that are similar to pre-disturbance conditions and compatible with the surrounding undisturbed areas.

*General Reclamation Measures in Upland Areas*

The general approach to reclamation of upland access, well sites (production, source water, disposal, observation), CPFs and other surface disturbances includes:

- Consultation with the local reclamation inspector to discuss the target land use and reclamation objectives;
- Removal of surface gravel, and its reuse elsewhere as appropriate;
- Re-contouring subsoil for compatibility with surrounding land and drainage (including removal of berms and ditches) and leaving a stable surface;
- Alleviation of compaction on operational surfaces, as needed;
- Replacement of salvaged soil;
- Preparation of replaced soil for re-vegetation;
- Addition of amendments (e.g., peat) if required;
- Re-vegetation in consultation with stakeholders (e.g., ASRD); and
- Following re-vegetation, monitoring to assess reclamation success and implementing remedial measures (e.g., weed control, amelioration of drainage or erosion problems) as required.

*Soil Replacement on Upland Mineral Soils*

Salvaged surface LFH/topsoil, upper subsoil, and peat will generally be stored along the edges of the disturbed facility area/ROW. After preparation of the operational surface as outlined in section 8.6.5.1, salvaged soil stored at a particular site will be replaced. Upper subsoil, where salvaged, will be replaced and prepared as necessary for the replacement of salvaged surface soil. Salvaged surface soil stored at the site will then be replaced and prepared for re-vegetation. The surface replacement soil will be placed to create small ridges and hollows that promote diverse microsites and moisture retention.

For upland well sites and access roads, the salvaged soil will be stored and replaced on individual facility sites with the soil handling conservation measures outlined in section 8.6.3.4; the replaced soil depth at these sites is expected to be similar to, or slightly less than, pre-disturbance conditions. Replacement of salvaged soil will enhance re-vegetation on these areas due to native seeds and root fragments in the salvaged surface soil.

### 8.6.5.2 Reclamation for Sites on Peatland

The central areas of well pads on peatland will be reclaimed to upland areas while the outer portions of the pads will be reclaimed to a surface peat area which is transitional to the undisturbed peatland (Figures 8.6-3 and 8.6-4). This transition zone would be a poorly to very poorly drained area with peat surface material, and a target ecosite phase called ‘transitional g1’; further described in Section 8.6.5.7.

The initial reclamation goal would be for the outer portions of well pads on pre-disturbance peat to be reclaimed to the transition zone. This goal may be adjusted for site-specific conditions at well sites and other sites where abandoned wells are not a constraint. Experience gained through the initial pad reclamations as well as through reclamation monitoring, will be used in an adaptive management strategy to revise the procedures as required. As experience is gained, the proportion of land reclaimed to a transition zone vs. upland will be increased where feasible, and reclamation procedures modified to increase similarity between transition zone characteristics and adjacent peatlands.

### *Reclamation Measures on Peatland*

After gravel salvage and initial de-compaction (e.g., ripping) of the operational surface, reclamation would involve excavation of the pad material from the target transition zone onto the areas to be reclaimed as upland. The edges of the upland area will be re-contoured to a stable slope with less than a 30% gradient, which minimizes concentrated surface water flow in order to prevent water erosion. Salvaged peat will be replaced in the transition zone to form a poorly drained shallow replaced 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.

The upland part of the reclaimed well site on pre-disturbance peatland areas will be contoured to a hummocky to undulating surface for increased retention of precipitation on the site in the depressional areas. Peat salvaged at the site will be mixed into the surface mineral material resulting in a surface mineral/peat layer. Soil drainage is anticipated to be imperfectly to poorly drained in the low areas between hummocks and poorly to very poorly drained on the lower slopes of the pad adjacent to the transitional zone. Higher crest areas are anticipated to be moderately well to imperfectly drained.

The g1 ecosite phase has the following site characteristics in the Boreal Highlands, according to the Beckingham and Archibald (1996).

- Dominantly imperfect drainage with moderately well to very poorly drained sites also occurring;
- Typical soil subgroups are dominantly Gleyed Gray Luvisols with Orthic Grey Luvisols and Orthic Gleysols also occurring; and
- Dominant organic thickness of 0 cm to 5 cm, with a ‘mor’ humus form.

Thus the g1 ecosite phase is anticipated to be appropriate for the expected conditions on the reclaimed site in the upland part of the site. Additional information on ecosite phases is presented in Table 8.6-4 and the Vegetation Baseline (Volume 4, Section 10).

Erosion prevention measures will be undertaken where necessary to prevent erosion before a vegetation cover is established. Weed control measures will be undertaken to control weeds as required by the Alberta *Weed Control Act* (AAFRD, 2001).

## 8.6.5.3 Reclamation for Sites Partly on Upland and Partly on Peatland

For sites where part of the area was upland and part peatland before disturbance, the general upland reclamation measures would apply to the pre-disturbance upland part of the site that is to be reclaimed back to upland. The reclamation procedures as described above will apply to the part of the site located on peatland.

## 8.6.5.4 Borrow Excavation Areas and Gravel Pits

Reclamation of borrow sites will involve re-contouring to blend surface topography and drainage with the surrounding area. If a deeper pit has been created, excess clean fill recovered from cut areas or from fill areas being decommissioned will be used as needed. Re-contoured slopes will be stabilized to minimize concentrated surface water flow and prevent water erosion or unintended ponding. The pit bottom will be decompacted as required, and the upper subsoil and topsoil that were salvaged from the site will be replaced. The post reclamation target ecosite phase for borrow sites will be the same as the pre-disturbance ecosite phase, depending on site-specific moisture conditions. For larger sites, re-vegetation will include planting or seeding (weed free) appropriate species for the target ecosite. Natural regeneration will be preferred on small borrow excavation sites, and will be considered as an alternative to seeding/planting where conditions are appropriate (e.g., lower potential for erosion). If natural re-vegetation establishment is slow or the area is prone to erosion, the affected area will be planted with native species and/or re-vegetated with an ASRD-approved seed mix.

Any gravel pit exploration, excavation, operations and reclamation done by North American will follow the appropriate regulatory guidelines including a guide to surface material resource extraction on public land (ASRD, 2001d). In final reclamation, these areas would be re-contoured to be compatible with the surrounding land, and the general upland reclamation procedures would be applied (including subsoil and surface soil replacement and re-vegetation).

#### 8.6.5.5 Pipelines, Utilities and Seismic Lines

For reclamation of aboveground pipeline ROWs, pipe racks will be removed and any reclamation required at those locations will be carried out. Power supply lines and poles will also be removed, and any reclamation necessary at those locations will be carried out. Natural regeneration is planned for these small areas.

For any underground pipelines, salvaged surface soil will be replaced at the completion of pipeline construction subsequent to alleviation of compaction. Areas with erosion potential will be protected (e.g., seeding ASRD-approved seed mix, erosion matting, silt fencing). Re-vegetation will be done in consultation with ASRD. Natural regeneration is preferred for re-vegetation of these narrow disturbances.

Seismic lines are expected to re-vegetate naturally over time since seismic activity does not generally disturb surface soils to a significant depth. Any problem areas will be reclaimed as needed.

#### 8.6.5.6 Access

All roads that are not required for ongoing activities will be closed to vehicular traffic and reclaimed and re-vegetated to native species. The general upland reclamation procedures will occur on roads.

Access roads in peatland areas will largely be reclaimed in place. Gravel will be removed and the access road decompacted. All culverts and mineral soil surrounding the culverts will be removed with the edges of the excavation re-contoured to avoid steep slopes; these areas will be open for water flow, which is especially important in fens. Removal of mineral material over the peat will also occur periodically along the access road. The excavated mineral material will be placed along the parts of the access to be reclaimed as upland, to form an undulating to hummocky surface. Peat salvaged before construction will be replaced and mixed into the mineral surface, and replaced in the excavated areas. Slash and rollback will be replaced along the ROW. Access to the reclaimed road will be blocked by rocks or woody debris.

#### 8.6.5.7 Re-vegetation and Weed Control

Re-vegetation plans will be specific for each development area based on pre-disturbance vegetation, surrounding vegetation, target landform and ecosite phase, and in consultation with regulators and stakeholders (e.g., Al-Pac).

Re-vegetation to appropriate forest species will generally be undertaken for upland areas. For the facilities developed on upland areas, the target ecosite phases will be the same as the pre-development ecosite phases for each site. This may be adjusted on a site-specific basis.

As described in Section 8.6.5.2, at peatland sites the target ecosite phase for the reclaimed upland area is g1, while the reclaimed transitional zone ecosite phase is ‘transitional g1’. The ‘transitional g1’ ecosite phase will have similar target species as the upland g1 (black spruce, bog cranberry, bunchberry, blueberry and Labrador tea), but with decreased tree species density and increased shrub species density. This vegetation is considered to be best suited for the moisture and drainage conditions after reclamation of the transition zone, and will also most closely resemble adjacent existing wetland vegetation.

Wetland ecosite phases (with examples of dominant vegetation) in the Boreal Highlands to be reclaimed in part to a ‘transitional g1’ zone include:

- h1, treed bog with Labrador tea and Black spruce;
- h2, shrubby bog with Labrador tea and stunted Black spruce;
- i1, treed poor fen with Tamarack and Black spruce;
- i2, shrubby poor fen with Tamarack, Black spruce and Bog Birch;
- j1, treed rich fen with Tamarack;
- j2, shrubby rich fen with Tamarack; and
- j3 graminoid rich fen with low percent cover of shrubs; dominated by graminoids with a high cover of sedges.

Figures illustrating the post reclamation Ecological Land Classification units are provided in Volume 4, Section 10. Planting recommendations for the Boreal Highlands Ecological Area are listed in Table 8.6-4. The species listed are the prime species considered for each ecosite phase, though the species may be adjusted on a site-specific basis depending on site and surrounding conditions.

### Table 8.6-4 Planting Prescriptions for Target Ecosite Types

| Reclamation Target Ecosite Phase | Tree Species | Shrub Species |
|---|---|---|
| a1 bearberry Pj | Jack Pine | Blueberry, Bearberry, Bog Cranberry |
| b1 blueberry Pj-Aw(Bw) | Jack Pine, Aspen, White Birch | Blueberry, Labrador Tea, Bog Cranberry, Willow |
| b2 blueberry Aw | Aspen, White Spruce, Jack Pine | Blueberry, Labrador Tea, Bog Cranberry |
| b3 blueberry Sw-Pj | White Spruce, Jack Pine | Blueberry, Labrador Tea, Bog Cranberry |
| c1 Labrador tea-mesic Pj-Sb | Jack Pine, Black Spruce | Labrador Tea, Bog Cranberry, Blueberry |
| d1 low-bush cranberry Aw | Aspen, Balsam Poplar | Low-Bush Cranberry, Green Alder, Rose |
| d2 low-bush cranberry Aw- | Aspen, White Spruce, Balsam | Low-Bush Cranberry, Green Alder, |

| Reclamation Target Ecosite Phase | Tree Species | Shrub Species |
|---|---|---|
| Sw-Sb | Poplar, Black Spruce | Rose |
| d3 low-bush cranberry Sw | White Spruce, Aspen, Balsam Fir | Low-Bush Cranberry, Green Alder, Rose |
| e1 fern Sw | Aspen, White Spruce, White Birch, Balsam Fir | Low-Bush Cranberry, Raspberry, Rose, Currant |
| f1 horsetail Sw | White Spruce, Balsam Fir | Rose, Green Alder, Low-Bush Cranberry, Bog Cranberry, Currant |
| g1 Labrador tea-hygric Sb-Pj | Black Spruce, Jack Pine | Labrador Tea, Bog Cranberry, Blueberry |

Natural regeneration will be preferred on small and/or narrow sites such as access roads, and will be considered as an alternative to seeding/planting where conditions are appropriate (e.g., lower potential for erosion). If natural re-vegetation establishment is slow or the area is prone to erosion, selected areas will be planted with native species and/or re-vegetated with an ASRD-approved seed mix. The use of plants (e.g., grass) that out-compete trees will be avoided where practical. Higher proportions of short-lived species will be used in any seed mixes where colonization by offsite native species onto the disturbed areas is desired.

Annual fertilizer applications will not be applied in order to prevent excessive growth of an overly competitive herbaceous cover that could out-compete tree and shrub species. Where vegetation growth is poor, or indications of nutrient deficiency appear, the need for additional fertilization will be determined by soil analytical fertility tests and the nutrient status of the offsite control soils.

In addition to the weed control measures discussed in Section 8.6.2.4, specific weed control on reclaimed areas will include:

- Avoiding use of straw bales for erosion control unless certified as weed free, with a Certificate of Inspection;
- Not using invasive/persistent agronomic forage species;
- Obtaining a Certificate of Seed Analysis for each native seed lot used for reclamation to ensure these seed mixes are free of problem weed and invasive, agronomic species;
- Conducting ongoing weed monitoring and treating weed infestations in a timely manner; and,
- Only using cereal cover crops (e.g., barley) to control erosion where it is determined that this is more appropriate than other methods for a specific site, and seeding at less than a full agronomic rate.

### 8.6.5.8 Wildlife

The reclamation goal is to achieve a variety of species and plant sizes making up a diverse forest community. To the extent practical, this includes a mixture of both woody and herbaceous species that will support a return to similar biodiversity and habitat to pre-disturbance conditions.

Vegetation along roadsides will be managed to discourage roadside foraging by wildlife and prevent visual obstruction along roadsides. If natural regeneration is not occurring, cutlines and seismic lines no longer in use will be re-vegetated to reduce fragmentation on the landscape. This will reduce both anthropogenic edge and the total amount of linear features.

### 8.6.5.9 Reclamation Constraints and Alternatives

- North American will continually focus on creative technologies and alternatives to diminish overall environmental impacts.
- The goal of reclaiming a portion of the sites located on peatland to the transition zone is to create conditions that closely resemble the adjacent, undisturbed peatland. Experience gained through the initial pad reclamations, as well as through reclamation monitoring will be used in an adaptive management approach to revise the procedures as needed. As experience is gained, the proportion of land reclaimed to a transition zone versus upland will be increased if feasible, and reclamation procedures modified to increase similarity between transition zone characteristics and adjacent wetlands.
- Some constraints and difficulties involved in construction/reclamation of peatlands include:
    - Water management in excavations when constructing well pads in deep peat (especially fens);
    - Geotechnical issues in constructing a stable fill pad where some surface peat has been excavated in deep peat areas;
    - Compression of peat under padded sites resulting in a lower surface elevation of the peat surface under the pad;
    - Excavation of deep peat leading to large excavations, and large volumes of peat;
    - Difficulties in abandonment of wells if the pad is to be totally removed; this would require large excavations through the pad and peat below to cut and cap wells one metre below the final grade (as required by the EUB) before removal of pad; and
    - Removal of geotextile where the pad is removed may be difficult.
- The fine-textured subsoils (Dover, Algar Lake) are more susceptible to compaction. This can be minimized by avoiding soil stripping and handling in wet periods, and adequate decompaction of the subsoils before or after soil replacement.
- Mildred soils are more susceptible to wind erosion when the protective vegetation cover has been removed. Erosion control measures will be applied.
- The presence of long slopes can lead to rill/gulley erosion from concentrated flow. This can be minimized by contouring to avoid concentrated flow down long slopes, or providing protected (e.g., vegetated) drainage ways.

### 8.6.5.10 Return of Land Capability for Forest Ecosystems

#### *Landforms*

For upland well pads and roads, overall landforms will not change significantly as the surface disturbance will generally be relatively surficial (grading, soil salvage and contouring for drainage control). Reclamation will return these sites to pre-disturbance landform conditions compatible with the surrounding landscape. On upland sites where significant cut and fill are required, the site will be re-contoured to blend with the landform surface on which the site is located.

The main changes to landforms will be the reclamation of the sites on peatland partially to upland and partially to a transition zone of lower elevation, poorly drained, surface peat as discussed previously and in the following section.

### *Land Capability for Forestry*

#### Upland Areas

With the conservation and reclamation measures outlined in the C&R plan, it is anticipated that post reclamation soil quality/quantity and terrain on upland mineral soils will be similar to pre-disturbance conditions. It is anticipated that with salvage of the pre-disturbance upland topsoil and subsoil and proper replacement along with the general upland reclamation practices, that the closure soil profiles and soil properties on the reclaimed upland area will be similar to pre-disturbance conditions with a mixed LFH/Ae layer underlain by the salvaged upper subsoil. A return to the same land capability class for forest ecosystems, as well as similar forest productivity and potential commercial forest use is anticipated. For example, the Kinosis soils which are rated Class 3 at pre-disturbance conditions will be returned to a Class 3 post-reclamation capability.

#### Reclaimed Padded Sites in Peatland Areas

The dominant target for the reclaimed transition zone will be Land Capability for Forest Ecosystems Class 5 (non-productive) based on a targeted soil moisture regime of subhydric with a “wet” limitation due to seepage or permanent water table at about 30 cm or less of the surface. In areas where the water table in the transition zone is generally greater than 30 cm (most likely to occur at the boundary of the transition zone and the reclaimed upland), the Forest Ecosystem Land Capability Class 4 (conditionally productive) may occur.

The dominant Forest Ecosystem Land Capability Class target for the remaining part of the reclaimed pad area located on pre-disturbance peatland will be Land Capability for Forest Ecosystems Class 3 (low capability); Class 4 (conditionally productive) may also occur. The estimated changes to land capability for forestry from surface disturbance in the LSA are listed in Table 8.6-5, based on the soil mapping and the C&R plan. Post Reclamation land capability classes are illustrated in Figure 8.6-5.

**Table 8.6-5 Summary of Changes to Land Capability Classification for Forest Ecosystems in the LSA**

| Forest Capability Class[1] | Baseline | | Post Reclamation | |
|---|---|---|---|---|
| | ha | % of LSA | ha | % of LSA |
| Class 1 High Capability | 0 | 0 | 0 | 0 |
| Class 2 Moderate Capability | 1,162 | 1 | 1,162 | 1 |
| Class 3 Low Capability | 31,673 | 28.6 | 31,916 | 28.8 |
| Class 3/5 (Low Capability/Non-Productive) Complex | 0 | 0 | 608 | 0.5 |
| Class 4 Conditionally Productive | 4,126 | 3.7 | 4,134 | 3.7 |
| Class 5 Non-Productive | 62,898 | 56.7 | 62,219 | 56.1 |

| Forest Capability Class[1] | Baseline | | Post Reclamation | |
|---|---|---|---|---|
| | ha | % of LSA | ha | % of LSA |
| Unclassified (Lakes, Rough Broken, Stream Channel, Disturbed soil map units) | 11,079 | 9.9 | 10,899 | 9.8 |
| Total | 110,938 | 100 | 110,938 | 100 |

1. Table 6.4-5 provides class descriptions.

The Class 3/5 Complex corresponds to the reclamation of padded site areas on peatland in part to upland, and in part to the transitional peat surface area; the proportion of upland to transitional area in the Class 3/5 Complex areas will be very site specific. Access roads on peatland will largely be reclaimed to Class 3, which shows an increased post reclamation area. However, this post reclamation Class 3 area will actually be slightly less as portions of the roads on peatland (culvert removal and additional areas) will be removed resulting in wetter areas of Class 5. Slight increases in some of the mineral soils land capability are due to final reclamation of existing disturbances on the proposed footprint. The table data indicate that after reclamation there will be a small net improvement in land capability for forest ecosystems.

#### *Forest Resource Use*

As upland sites will be reclaimed to ecosite phases similar to pre-disturbance conditions with similar land capability, it is expected the potential for commercial forestry will be equivalent after reclamation.

On Organic soils that were reclaimed to ecosite phase g1, the anticipated land capability for forest ecosystems is dominantly Class 3, and native tree species appropriate for the ecosite phase will be planted. On undisturbed g1 sites, timber productivity ratings are dominantly productive (fair, moderate, or good), and dominantly non-merchantable. Timber productivity ratings are expected to be similar for reclaimed g1 ecosite phases. For the reclaimed target ‘transitional g1’ ecosite phase, an unproductive timber productivity rating is anticipated due to the wet moisture regime.

Information on pre-disturbance and post reclamation distribution of forested communities can be found in Volume 4, Section 10 (Vegetation).

### 8.6.5.11 Biodiversity

There is predicted to be no environmental impact on habitat richness in the RSA or LSA as a result of the Project. The magnitude of the impact on habitat fragmentation is anticipated to be low as the change in area for most ecosite phases and other habitats is expected to be less than one percent after reclamation and closure (Volume 4, Section 12; Biodiversity).

### 8.6.5.12 Fisheries

A detailed description of fisheries resources and aquatic habitat in the Project area is provided in Volume 3, Section 8 (Fish and Fish Habitat). Work will be conducted according to the appropriate DFO Operational Statements and AENV regulations and guidelines. Progressive reclamation will limit impacts to water quality and aquatic habitat during Project operations. Areas no longer in use will become stabilized and re-vegetated.

### 8.6.5.13 Hydrology

Potential changes to the surface water hydrology in the LSA from the Project will be highly localized and mitigated with a series of measures to minimize these changes. Additional information on hydrology can be found in Volume 3, Section 6 (Hydrology).

### 8.6.5.14 Monitoring, Research and Reporting

Development of the Project will occur in a phased manner, allowing for sequential development and on-going reclamation of well pads and other sites as they are abandoned. Environmental monitoring will be carried out to determine the progress and success of reclamation. The objectives of reclamation monitoring include assessing:

- Soil and terrain, to ensure that equivalent land capability is achieved for reclamation certification;
- Vegetation, to ensure that it is re-established for the target ecosite phase and meets reclamation requirements; and
- Reclamation issues that need remedial measures, such as erosion, weed infestation, drainage problems, or industrial debris, are assessed and addressed.

Experience gained in reclamation and reclamation monitoring of the initial pads abandoned will contribute to adaptive management and potential improvements in construction and reclamation techniques throughout the Project life. On-going reclamation activities and procedures will be documented. Documentation will include a description of the type of development which was present, and a description of the date and reclamation activity carried out for a specific site.

Environmental monitoring will include a number of programs, for example:

- Soil, air and groundwater monitoring will be carried out in accordance with the AENV Approval.
- North American is currently undertaking a wildlife study using scat detection dogs for caribou, moose and wolf. The program as it is currently designed is scientifically based and is focused on moose (based on First Nations concerns), caribou (based on endangered species concerns) and wolf (based on the predator prey relationship between them).
- PDAs will be undertaken prior to facility construction, and assessment of reclamation needs for each site will be conducted to guide reclamation procedures.
- Environmental monitors will be onsite during the construction phase of the Project to ensure the environmental protection measures are followed.
- Reclamation monitoring will be ongoing as sites are abandoned and reclaimed.
- Results of environmental monitoring will be reported to AENV as directed.
- A final post-reclamation assessment will be conducted at completion of reclamation to document soil, terrain and vegetation conditions and will be included in the application for reclamation certificate.

## *Reclamation Monitoring*

In general, reclamation monitoring will include assessment of surface soil (quantity and visual assessment for quality problems, and profile restrictions) and landscape characteristics (e.g., drainage, erosion, surface stability, rocks, over-accumulation of woody debris in an area, and industrial debris). Where practical, the soil and landscape assessment would preferentially occur before re-vegetation. Soil assessments would not be carried out where there was no disturbance or apparent impact. Vegetation will be assessed for achieving the re-vegetation objective including species (woody and herbaceous), woody and tree growth, ground cover and health.

The reclamation monitoring program will evaluate the success of reclamation over time to ensure reclamation is addressing the following:

- Acceptable landscape characteristics (drainage, erosion, slope stability, gravel and rocks, and debris).
- Soil quality (e.g., texture, structure/compaction) and quantity (e.g., depth of surface replacement soil). Soils will be sampled and analyzed where needed to confirm any potential soil quality issues. Soil analytical parameters may include texture, structure, compaction, pH, electrical conductivity, sodium adsorption ratio and macronutrient levels.
- Adequate re-vegetation of disturbed areas and weed control.
- Adequate progress towards re-establishment of wildlife habitat.
- Fish and fish habitat post-construction monitoring (e.g., road/bridge stream crossings) where required by DFO and AENV regulations.
- Reclamation is progressing in a manner that is adequate for meeting the reclamation certification criteria of the day. The current reclamation criteria include the *Reclamation Criteria for Wellsites and Associated Facilities* – 1995 Update (AENV, 1995), *Guide To: Reclamation Criteria for Wellsites and Associated Facilities 2007* – Forested Lands in the Green Area Update (ASRD, 2007), as well as any conditions to be contained in the AENV Approval to Operate. Sampling design for the reclamation assessments will utilize the suggested procedures in these documents in conjunction with observance of reclamation problem areas, and there will be sufficient inspection locations to be representative of the reclaimed site.

## *Reclamation Monitoring Schedule*

Monitoring programs on reclaimed areas will be conducted to assess reclamation success. Reclaimed areas will be routinely monitored for terrain, drainage, erosion, re-vegetation or weeds.

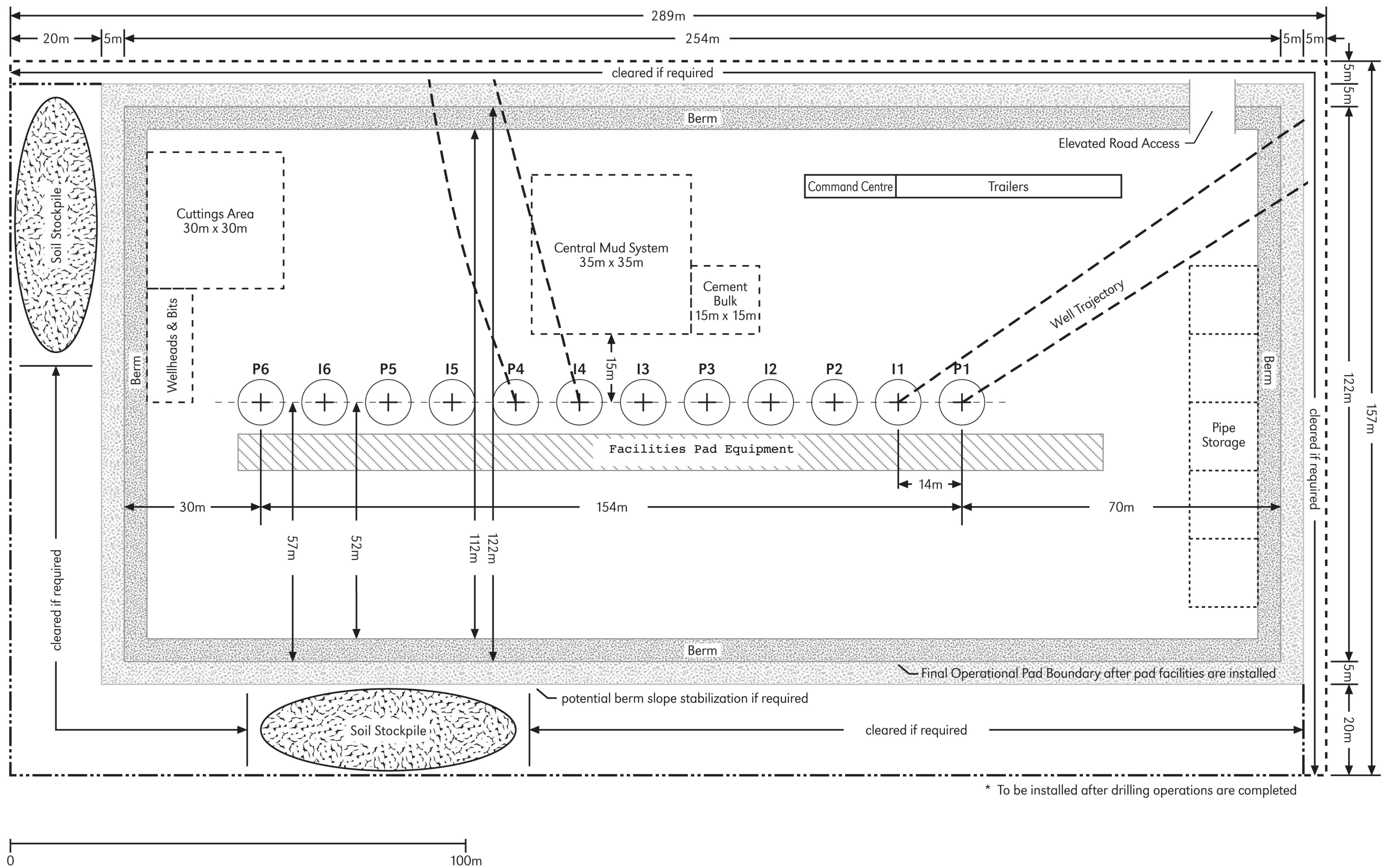
Reclaimed areas will be inspected after the first growing season following reclamation. Initial establishment of the vegetation will be assessed. Any reclamation problems will be assessed and reclamation remedial measures undertaken as needed. Once vegetation is established, progress toward re-establishing the target ecosite phase will be monitored over time. The pre-development biophysical information collected will provide a reference with which to assess reclamation success.

A final post-reclamation assessment will be conducted at completion of reclamation to document soil, terrain and vegetation conditions and will be included in the application for reclamation certificate.

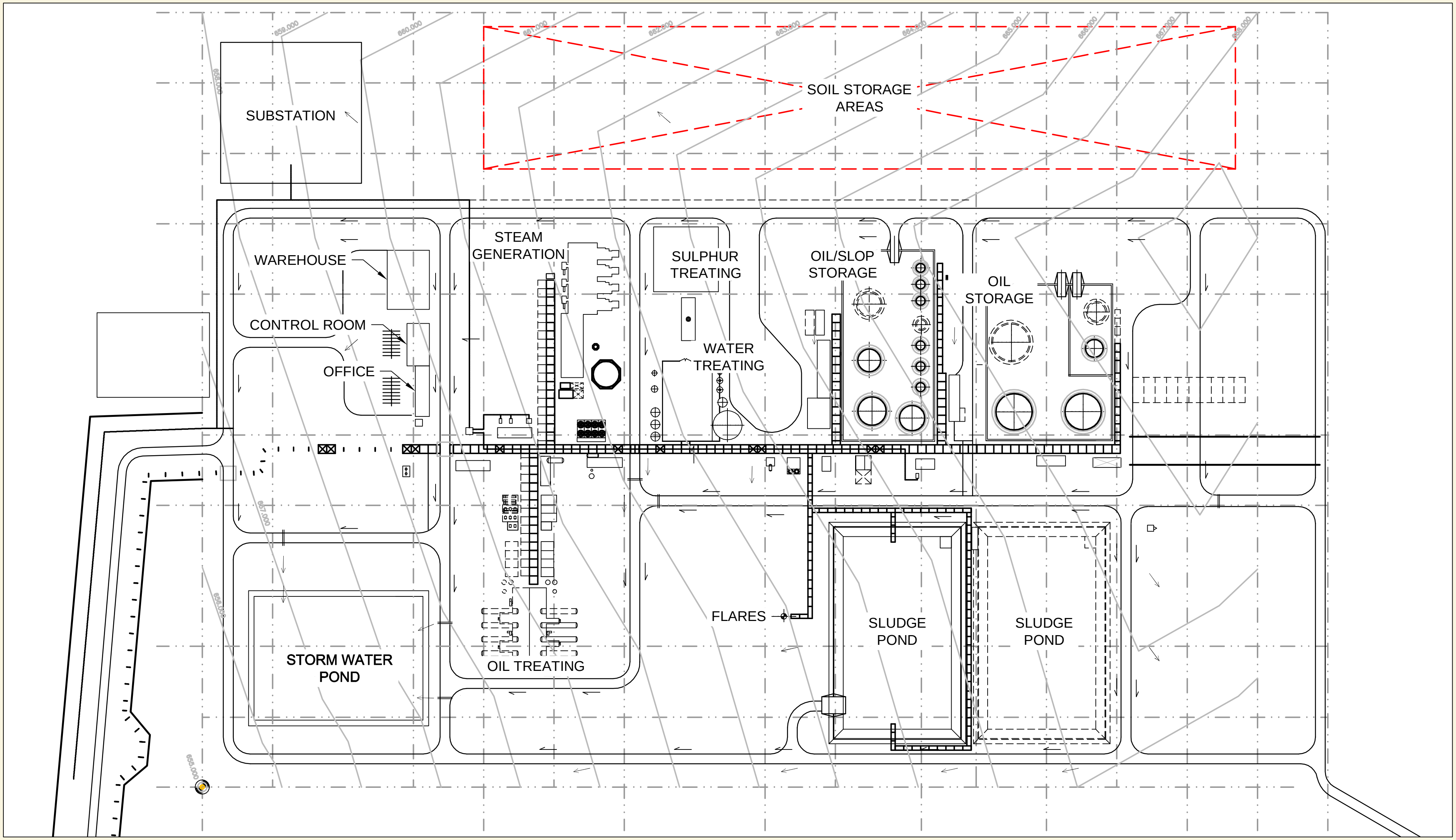
# Kai Kos Dehseh Project

## Typical Well Pad Layout During Drilling Operations

**FIGURE 8.6-1**




Typical Well Pad Drill & Fac AEUB 220K REV1 070126



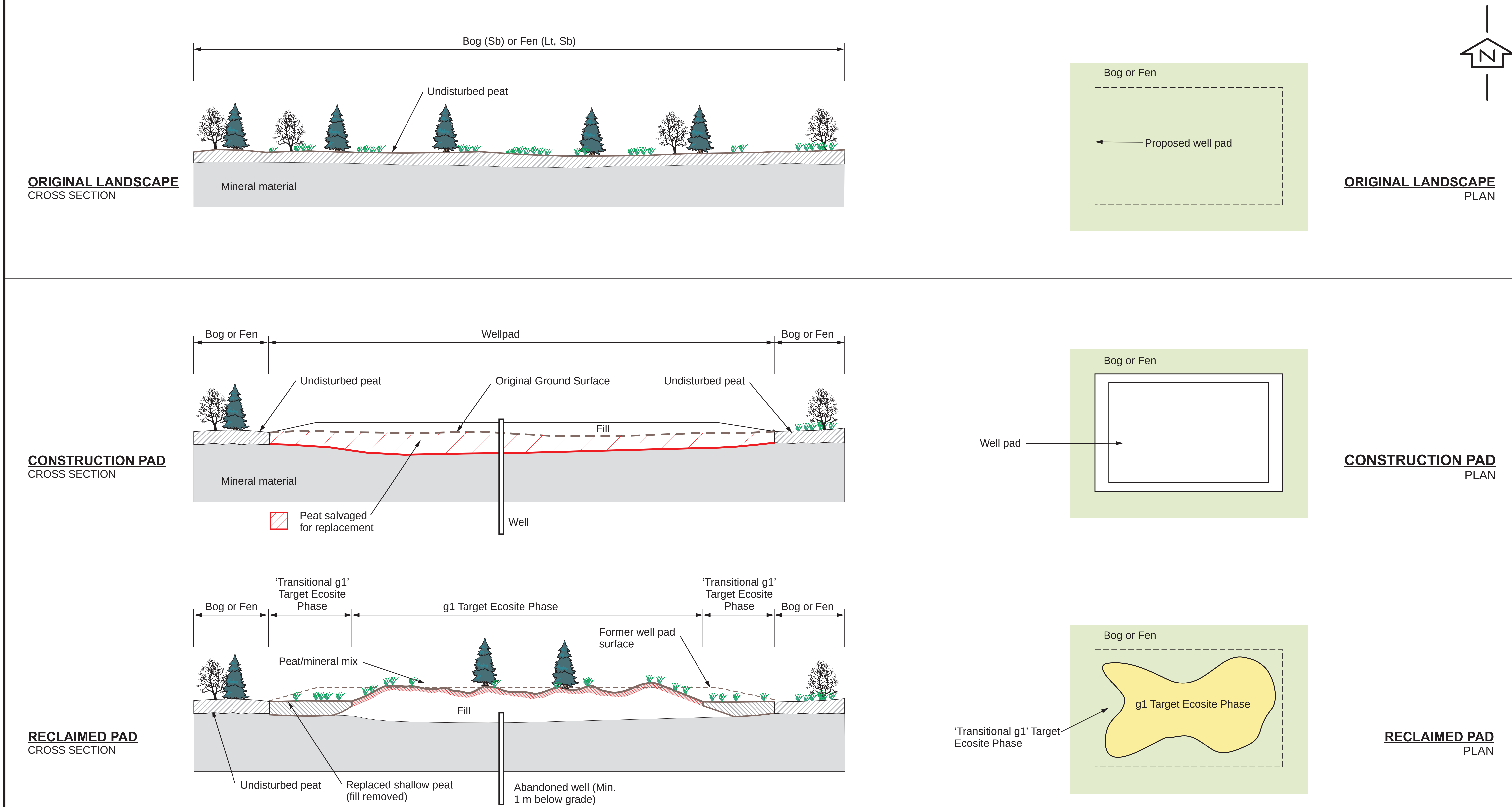

SCALE 1:4000 metres

40 0 40 80

Title:

**REPRESENTATIVE CENTRAL PROCESSING FACILITY PLOT PLAN**

| Approved: LP | Revision Date: 07/05/07 | |
|---|---|---|
| File: 4455-PROCESS-07.DWG | | |
| Drawn by: ADF | Checked: BW | Fig. No.: **8.6-2** |




Legend

Bog:
- Sb (Black spruce)

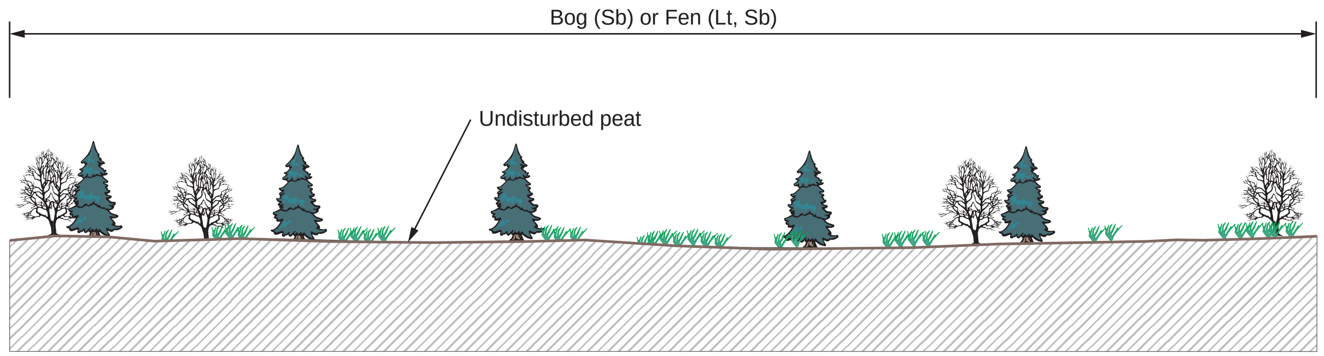
Treed Fen:
- Sb (Black spruce)
- Lt (Tamarack)

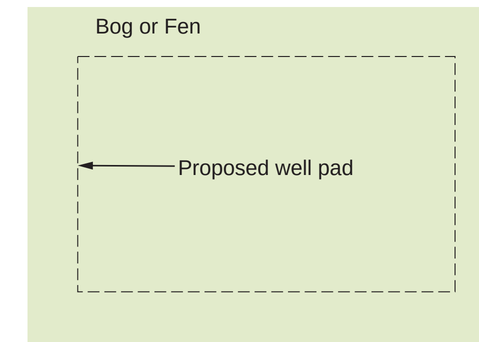
'Transitional g1'
- Sb (Black spruce)

g1
- Sb (Black spruce)

| Title: KAI KOS DEHSEH CONCEPTUAL RECLAMATION OF WELLPAD ON SHALLOW PEAT | | | |
|---|---|---|---|
| Approved: | | Revision Date: 07/04/19 | |
| File: 4455-RECLAMATION C +R.cdr | | | |
| Drawn by: BSW | Checked: SC | Fig. No.: 8.6-3 | |

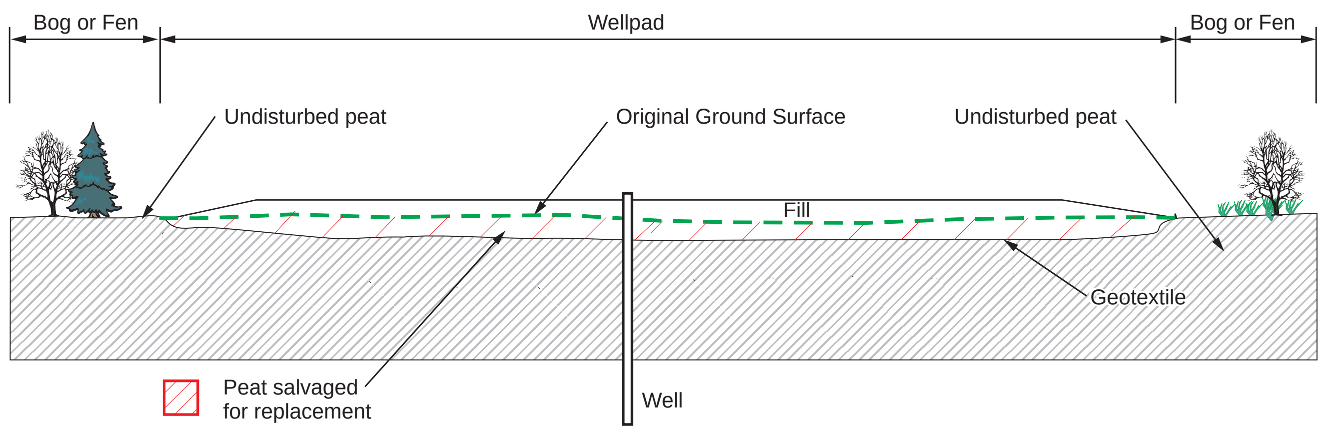
**ORIGINAL LANDSCAPE**
CROSS SECTION

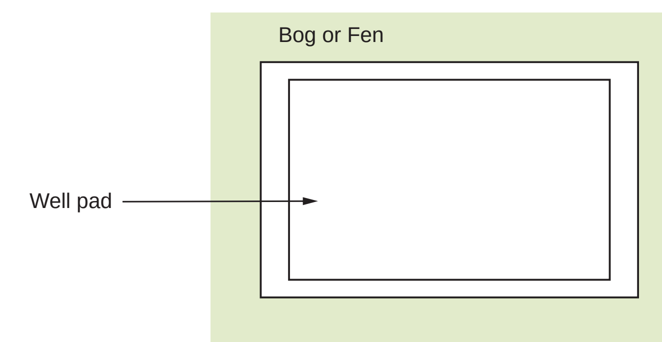



**ORIGINAL LANDSCAPE**
PLAN

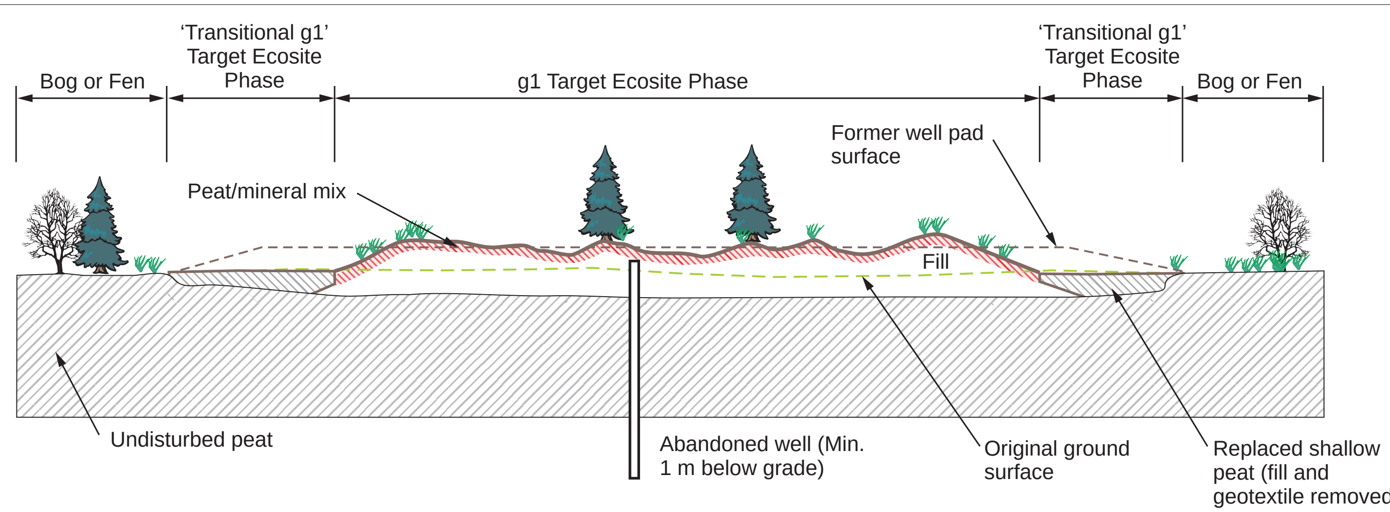
**CONSTRUCTION PAD**
CROSS SECTION

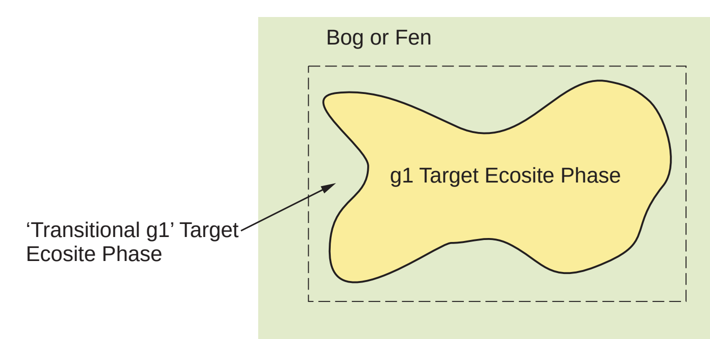



**CONSTRUCTION PAD**
PLAN

**RECLAIMED PAD**
CROSS SECTION




**RECLAIMED PAD**
PLAN

Legend

Bog:
- Sb (Black spruce)

Treed Fen:
- Sb (Black spruce)
- Lt (Tamarack)

'Transitional g1'
- Sb (Black spruce)

g1
- Sb (Black spruce)

Title:

KAI KOS DEHSEH
CONCEPTUAL RECLAMATION OF
WELLPAD ON DEEP PEAT

| | |
|---|---|
| Approved: | Revision Date: 07/04/19 |
| File: 4455-RECLAMATION C +R DEEP.cdr | |

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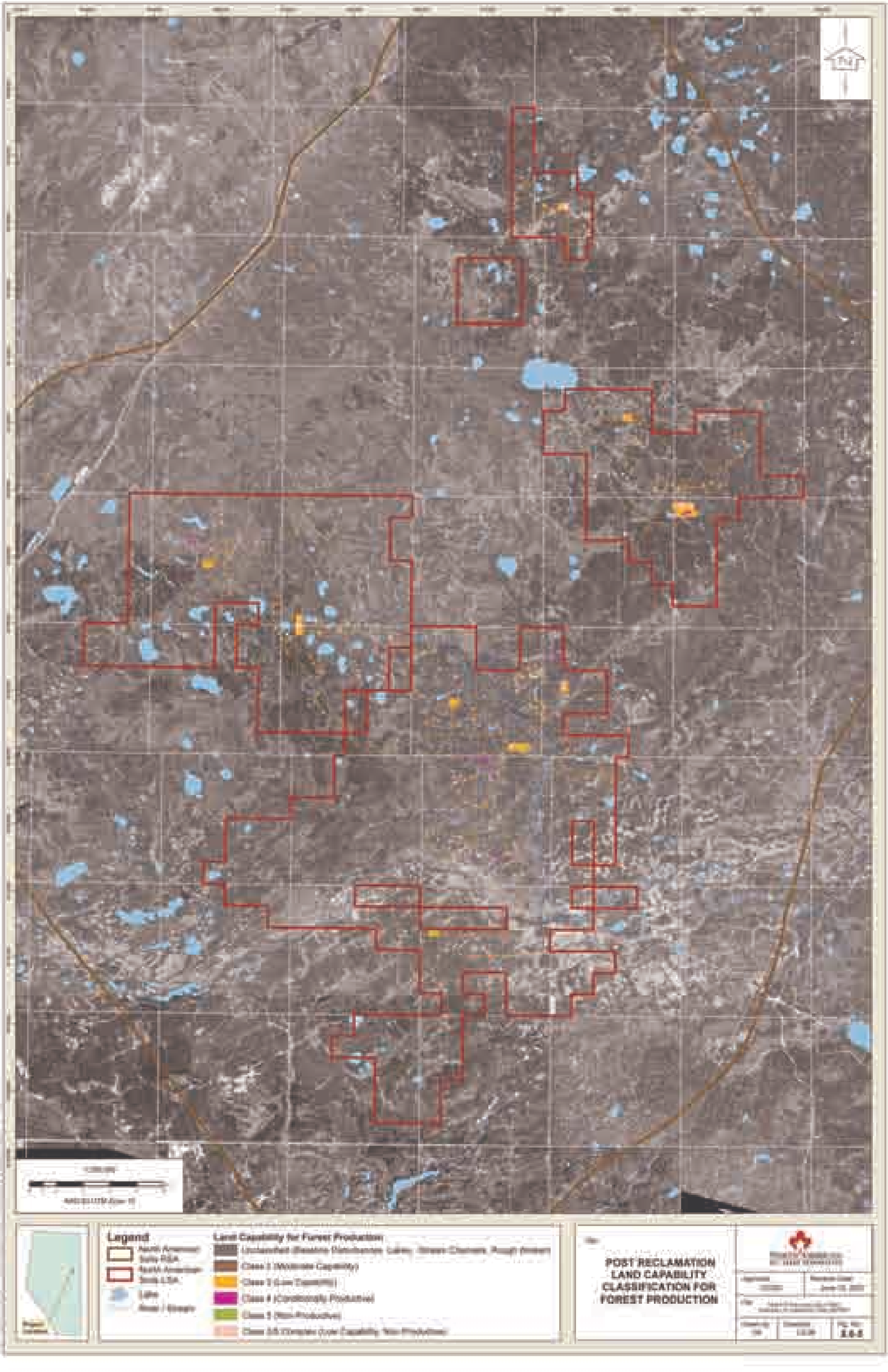
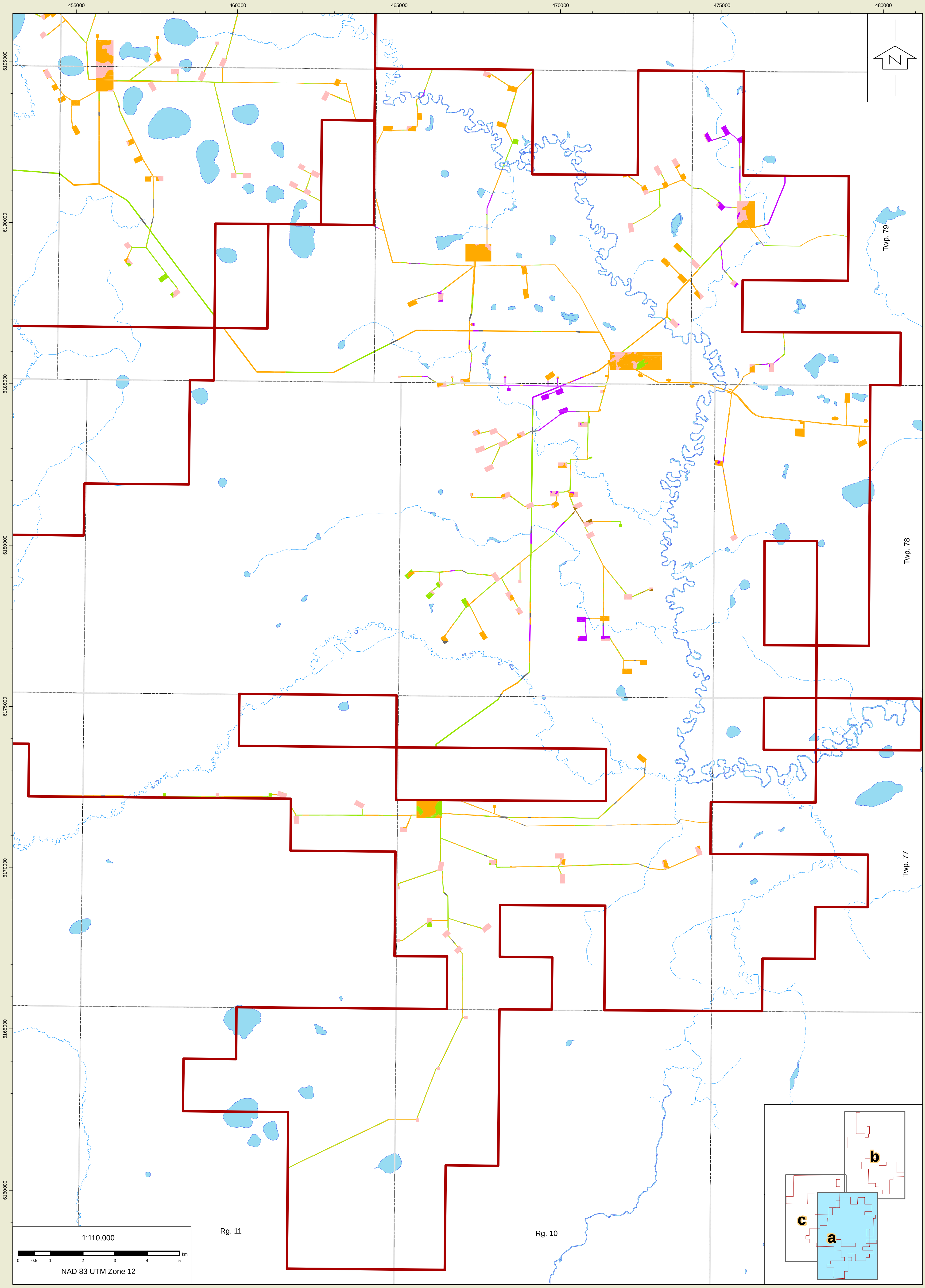
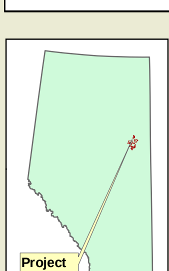

Legend
Land Capability for Forest Production
Class 2 (Moderate Capability)
Class 3 (Low Capability)
Class 4 (Conditionally Productive)
Class 5 (Non-Productive)
Lake
POST RECLAMATION
LAND CAPABILITY
CLASSIFICATION FOR
FOREST PRODUCTION




## 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

NORTH AMERICAN OIL SANDS CORPORATION

| Approved: | Revision Date: | |
|---|---|---|
| CG/SC | June 13, 2007 | |
| File: Fig 8.6-5a_Post_Land_Cap_Forest_Production_in_Application_Case_20070611 | | |
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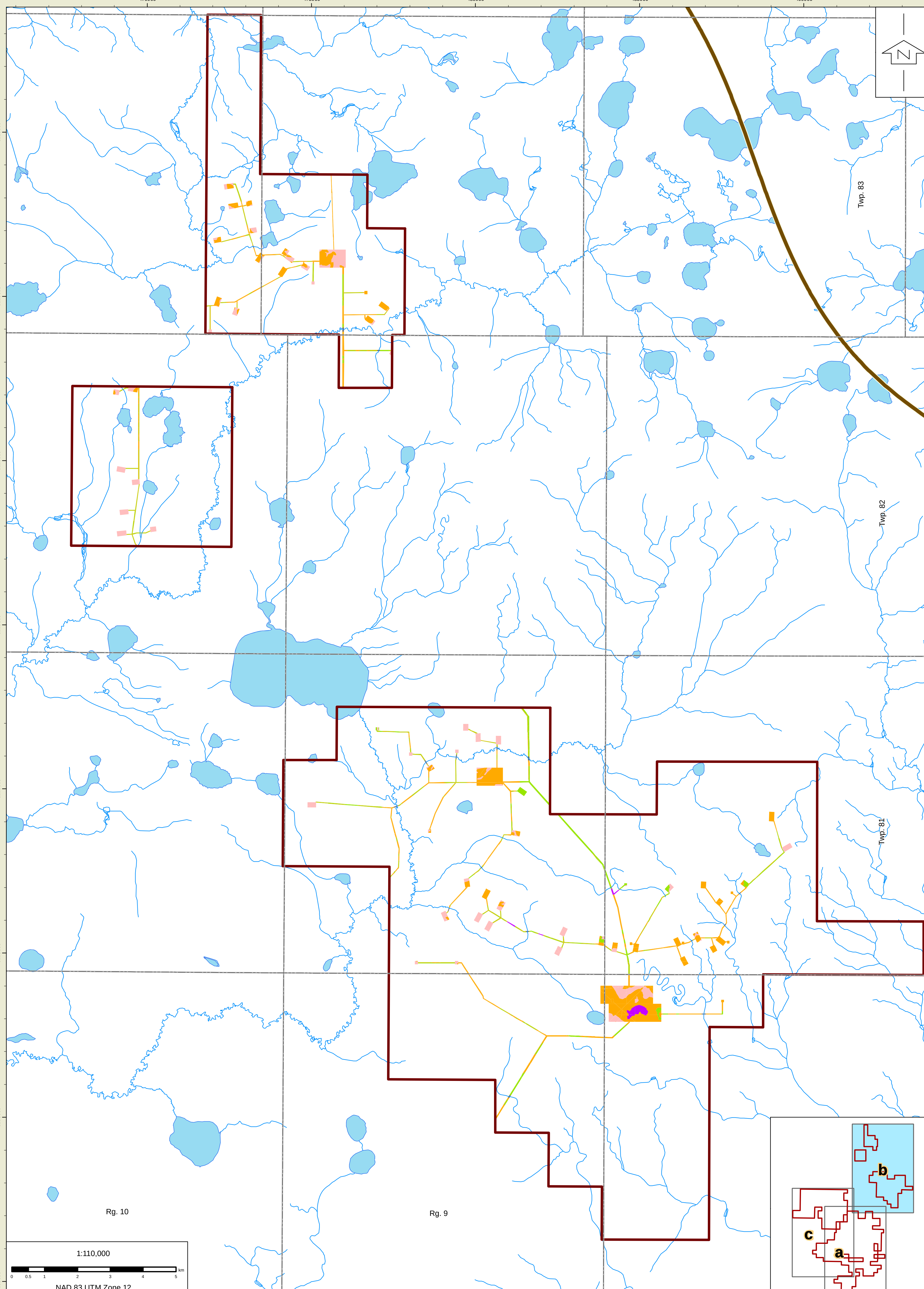


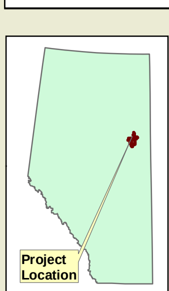


## Legend

- 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**

NORTH AMERICAN OIL SANDS CORPORATION

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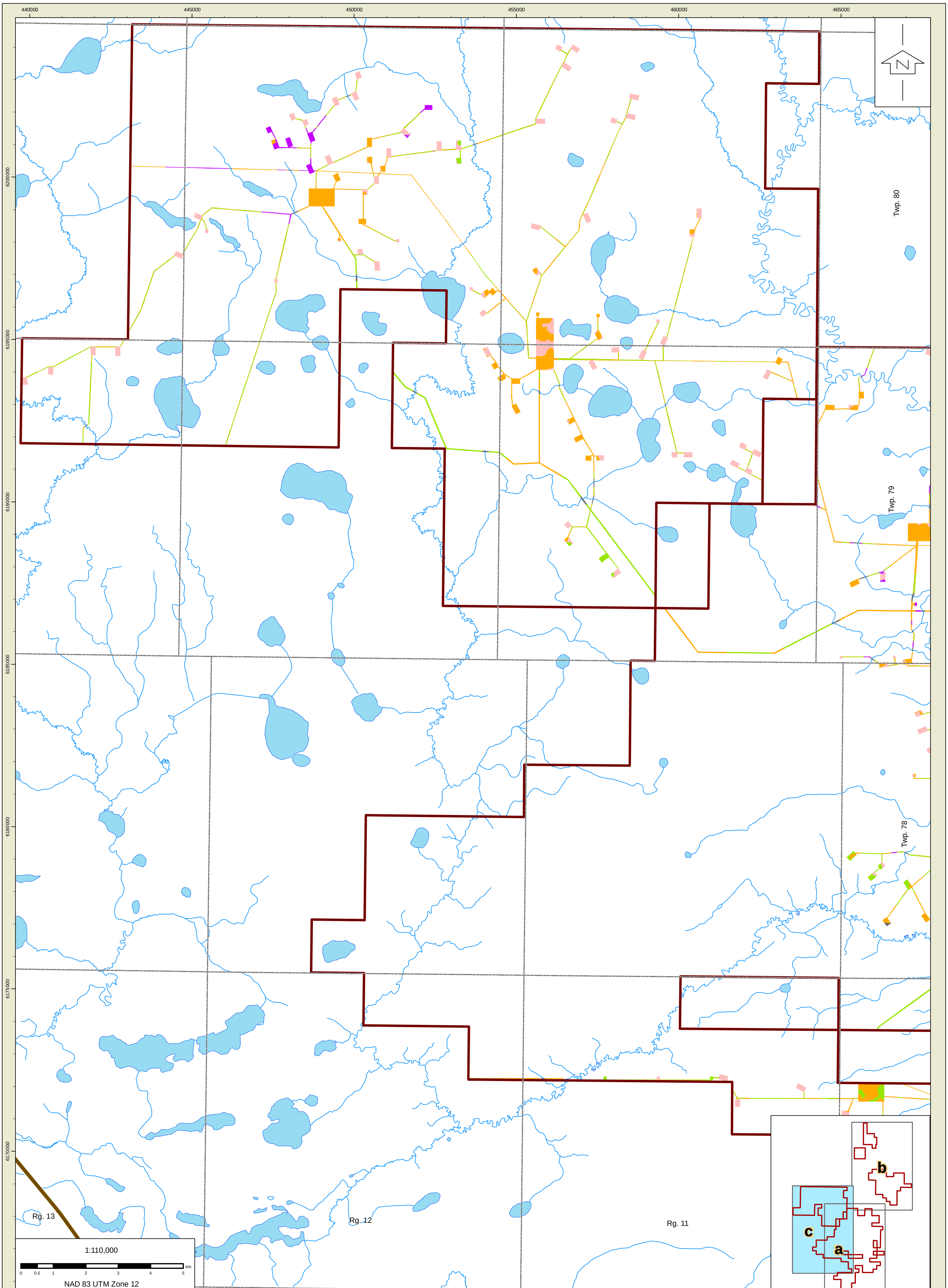


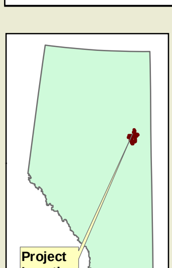


## Legend

- 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**

NORTH AMERICAN OIL SANDS CORPORATION

| Approved: CG/SC | Revision Date: May 10, 2007 | |
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# Appendix A

# APPLICATION FOR APPROVAL OF THE LEISMER COMMERCIAL HUB OF THE KAI KOS DEHSEH PROJECT

SUBMITTED TO

ALBERTA ENERGY AND UTILITIES BOARD

AND

ALBERTA ENVIRONMENT

SUBMITTED BY

NORTH AMERICAN OIL SANDS CORPORATION

August 2007

# Table of Contents

## TABLES



## FIGURES

# A1 INTRODUCTION

The North American oil sands leases are located in Townships 76 to 83, Ranges 8 to 13 West of the 4th Meridian. The oil sands leases are not contiguous and fall within the Rural Municipality of Wood Buffalo and Lakeland County.

North American is continuing to interpret and evaluate seismic and corehole data in its major project areas. This document provides the geological and reservoir information necessary for the Alberta Energy Utilities Board (EUB) to review the “Application for Approval of the Leismer Commercial Hub”. This Application targets those North American lands located between the southeast portion of Section 6-78-9 W4M to the northwest portion of Section 4-79-10 W4M. This Application takes the original 1,590 $m^3$/d (10,000 bpd) Leismer Demonstration Hub and proposes to double the production to approximately 3,180 $m^3$/d (20,000 bpd) utilizing the original well pairs with no additional horizontal well drilling.

North American recently gained approval for the Leismer Demonstration Hub (Approval No. 10935) which will have an initial bitumen production capacity of 1,590 $m^3$/d (10,000 bpd). The increase in production for the Leismer Commercial Hub will not require any additional well pads, CPF area or steam generating equipment (Figure A1.1-1). The production and treating processes, as well as the water treatment equipment, are the same as for the approved Leismer Demonstration Hub, with the exception of an additional treater, saline water source wells, a saline water tank, pumps, a heat exchanger and associated piping.

The Leismer Demonstration Hub Approval provides for the drilling of 22 SAGD well pairs within the approved development area. A portion of the approved wells will be required to produce at the approved bitumen production rate of 1,590 $m^3$/d (10,000 bpd). The exact number of well pairs required to achieve the approved production rate will be determined by reservoir and production well performance. The purpose of the amendment requested in this Appendix A to the “Application for Approval of the Kai Kos Dehseh Project” is to initiate production from any or all of the 22 well pairs within the approved development area in order to achieve a bitumen production rate of up to 3,180 $m^3$/d (20,000 bpd). No additional well pairs are proposed for approval, hence the details of the well pad and well completion designs for this expanded production approval are as presented in North American’s previous application and supplemental information, as follows:

- “Application for Approval of the Leismer Demonstration Project”, May, 2006, primarily Section 4.3.1, SAGD – Production Pads and Horizontal Wells.
- “Application for Approval of the Leismer Demonstration Project, Geology and Reservoir”, June, 2006, Section 4 Resource Recovery
- “Application for Approval of the Leismer Demonstration Project, Supplemental Information”, October, 2006, various areas such as Response 8, Figures 5-1 and 8-1.
- “Application for Approval of the Leismer Demonstration, Supplemental Information - Project Errata”, November, 2006, various sections, including Figures 1 to 5, Tables 1 to 3.
- “Application for Approval of the Leismer Demonstration Project, Supplemental Information”, February, 2007, various responses including 2 (b), 2 (c), 2 (d), 3 (a), 3 (b), 3 (c), 4(a), 4 (b), 4 (c), 4 (d).

Additional drilling in Q1, 2007 was carried out in the Leismer area. Maps in Section 4 of this Appendix include an update of 2007 drilling, but results do not materially change the original horizontal well placement as detailed in the Leismer Demonstration Application. This Appendix should not be construed as a request for an amendment to the Leismer Demonstration Hub approval.

The currently approved 22 well pairs and the associated well pads will be utilized to attain bitumen production rates up to the requested approval rate of 3,180 $m^3$/d (20,000 bpd). Details regarding incremental well pairs and pads to maintain production will be provided in future development and amendment submissions.

The Leismer Commercial Hub is part of the larger Kai Kos Dehseh Project, which is the topic of the main body of this volume. Section 7.0 of the main body presents a summary of the Environmental Impact Assessment for the Kai Kos Dehseh Project, which includes the Leismer Commercial Hub. Volumes 2-5 present the Environmental Impact Assessment in its entirety.

Table A1-1 presents the capacity and first steam dates for the Leismer Commercial Hub and the previously approved hub.

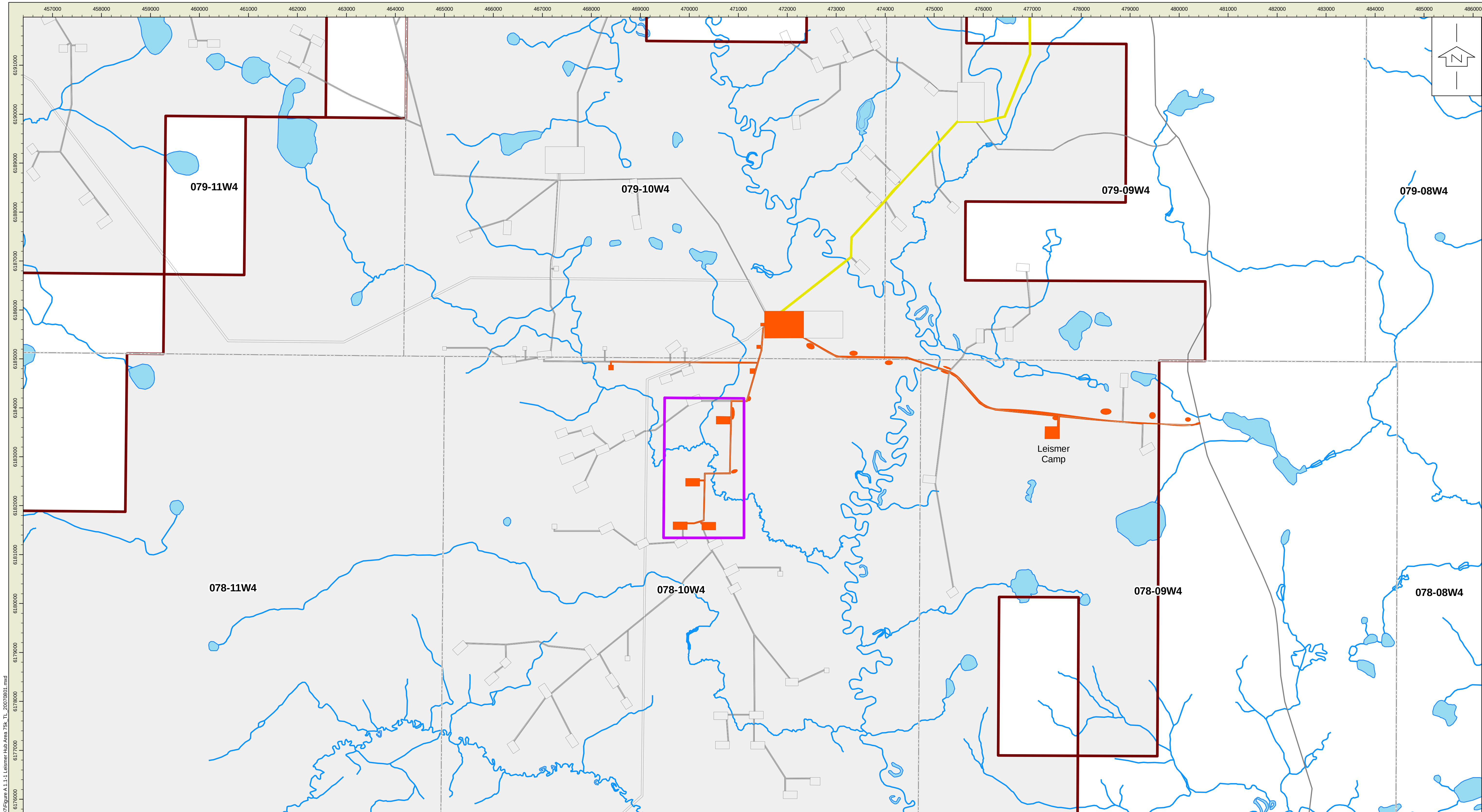
**Table A1-1 Leismer Commercial Project Development Area and Hub**

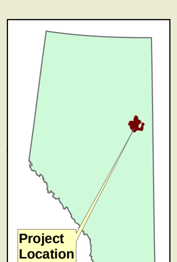
| Project | Development Area | Hubs | Capacity ($m^{3/}d$) | Capacity (bpd) | First Steam Date |
|---|---|---|---|---|---|
| Kai Kos Dehseh | Leismer | Leismer Demonstration | 1,590 | 10,000 | 2009 |
| | | Leismer Commercial | 1,590 | 10,000 | 2010 |

## A1.1 Land and Mineral Rights

SAGD bitumen production, natural gas production and forestry are the predominant industries in the area surrounding the Leismer Commercial Hub. It is important that, where appropriate, operators coordinate their activities so the total value is increased. North American is participating with the integrated land management activities of the Chamber of Resources, Alberta-Pacific Forest Industries inc. (Al-Pac) and other oil and gas operators in the region.

North American is the operating partner of the oil sands leases contained within the Leismer Commercial Hub area. Figure 2.3-1, in the main body of the Application, shows oil sands leases in the area of application. All oil sands leases within the Leismer Regional Geological Study Area (RGSA) are owned by North American. Figure A1.1-2 shows details of the P&NG rights in the area.




## Legend

- North American Lease Boundary
- ATS Township / Range
- Roads
- Lake
- Stream
- Future Footprint
- Leismer Demonstration / Commercial Hub
- Leismer Expansion Hub
- Sales and Diluent Pipeline
- Leismer Demonstration Approved Development Area

1:75,000

NAD 83 UTM Zone 12

Title:

**LEISMER COMMERCIAL HUB**

NORTH AMERICAN OIL SANDS CORPORATION

| Approved: | Revision Date: | |
|---|---|---|
| SC/DH/LZ | August 1, 2007 | |
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I:\4455-514_NAOSC\NAOSC_Maps\Maps_Volume_1\FINAL_MAY_2007\Figure A 1.1-1 Leismer Hub Area 75k_TL_20070801.mxd

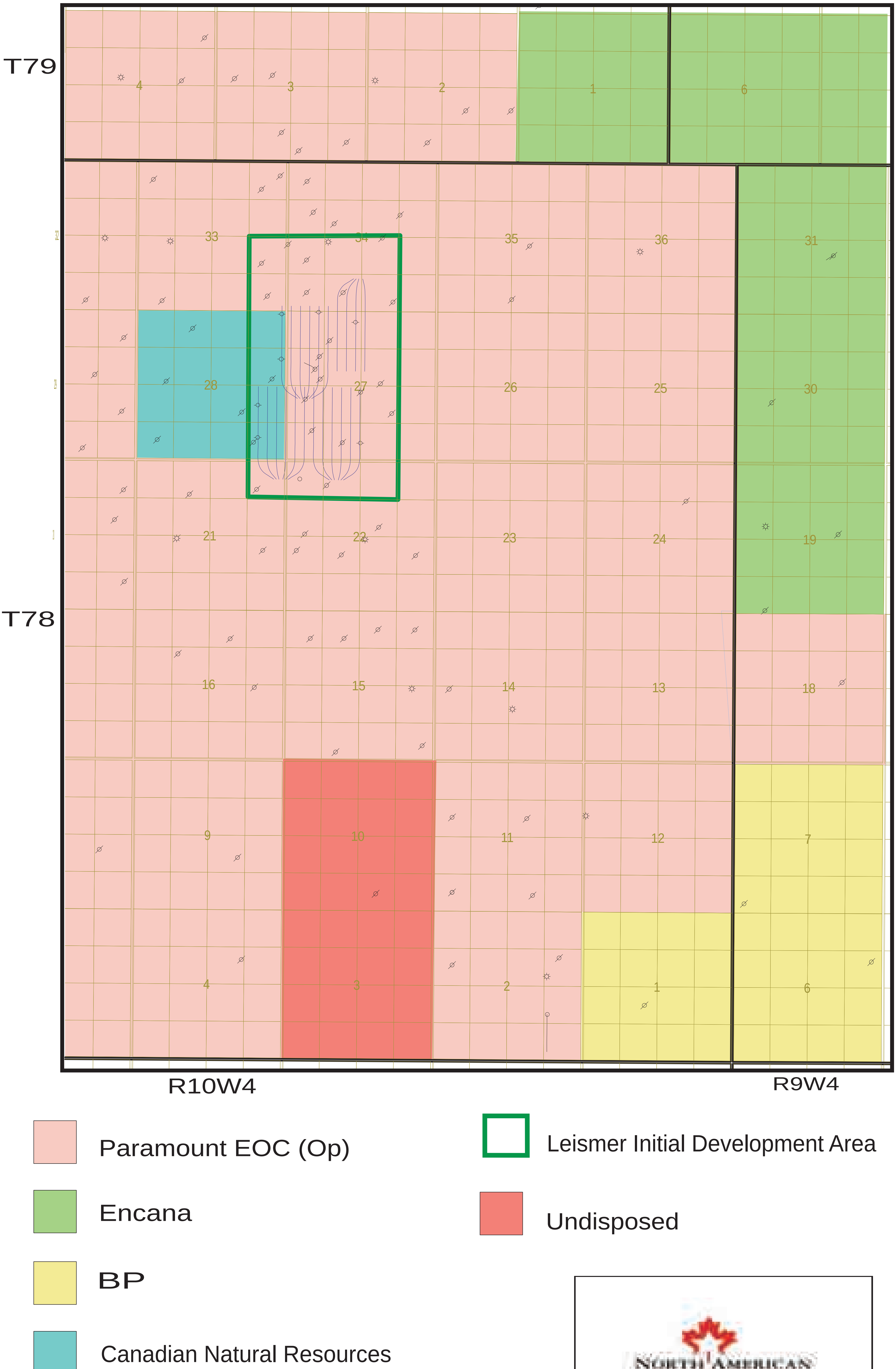



Figure A1.1-2 Leismer Area P&NG Lease Holders

Leismer Area P&NG Lease Holders

| | | |
|---|---|---|
| Author: K. Kerr | Scale: 1:40,000 | Date: 15 June, 2007 |

## A1.2 Production Capacity

Bitumen production capacity will be increased to approximately 3,180 $m^3$/d (20,000 bpd) by accelerating the production of the 22 well pairs that will be drilled and completed by July 2009 for the Leismer Demonstration Hub.

## A1.3 Schedule

The Leismer Demonstration Hub will initially come on stream in late 2009 and utilize the necessary wells from the 22 well pairs in the approved development area to achieve a sustained 1,590 $m^3$/d (10,000 bpd) production rate.

The Leismer Commercial Hub involves initiating steam and production operations on the remainder of the 22 wells approved for the Leismer Demonstration Hub. The Leismer Commercial Hub will initially produce up to approximately 3,180 $m^3$/d (20,000 bpd) on an annual average calendar day basis from the 22 approved well pairs. This Appendix requests approval for the Leismer Commercial Hub production and presents process, reservoir and production information for the Leismer Commercial Hub.

Assuming regulatory approval, installation of equipment and facility additions to upgrade the Leismer Demonstration Hub will begin in 2009. Steam injection is planned to commence in the first or second quarter of 2010, and initial production is expected in the second or third quarter of 2010.

Table A1.3-1 shows a detailed project schedule for the Leismer Commercial Hub.

**Table A1.3-1: Schedule for Leismer Commercial Hub**

| Quarter | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2007 | 2007 | 2007 | 2007 | 2008 | 2008 | 2008 | 2008 | 2009 | 2009 | 2009 | 2009 | 2010 | 2010 | 2010 | 2010 | 2011 | 2011 | 2011 | 2011 | 2012 | 2012 | 2012 | 2012 | 2013 | 2013 | 2013 | 2013 | 2014 | 2014 | 2014 | 2014 | 2015 | 2015 | 2015 | 2015 | 2016 | 2016 | 2016 | 2016 | 2017 | 2017 | 2017 | 2017 | 2018 | 2018 | 2018 | 2018 |
| **Leismer Demonstration Hub** | | | Approved | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Engineering and Construction/Drilling | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Production/injection operations | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Leismer Commercial Hub** | | | Appendix A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Engineering and Construction/Drilling | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Production/injection operations | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

# A2 LEISMER COMMERCIAL HUB DESCRIPTION

## A2.1 Overview

North American is committed to effective resource recovery for the Leismer Commercial Hub. The Leismer Commercial Hub will utilize SAGD in-situ technology to recover approximately 3,180 $m^3$/d (20,000 bpd) of bitumen on an annual average calendar day basis. The 3,180 $m^3$/d (20,000 bpd) of bitumen includes the original 1,590 $m^3$/d (10,000 bpd) of bitumen from the Leismer Demonstration Hub.

North American has been conducting seismic and oil sands exploratory (OSE) drilling programs in the Leismer area. In the first quarter of 2006, North American acquired 10.2 sections of high resolution 3D seismic and drilled 50 wells. In the first quarter of 2007, North American acquired an additional 12.3 sections of high resolution 3D seismic and drilled 46 wells. Well density is currently at 16.2 ha (40 acres) spacing in the Leismer Commercial Hub development area with surrounding areas effectively at 32.4 ha (80 acres) spacing. Fifty cored wells are available in the area. The drilling and seismic programs confirm the existence of a significant bitumen resource.

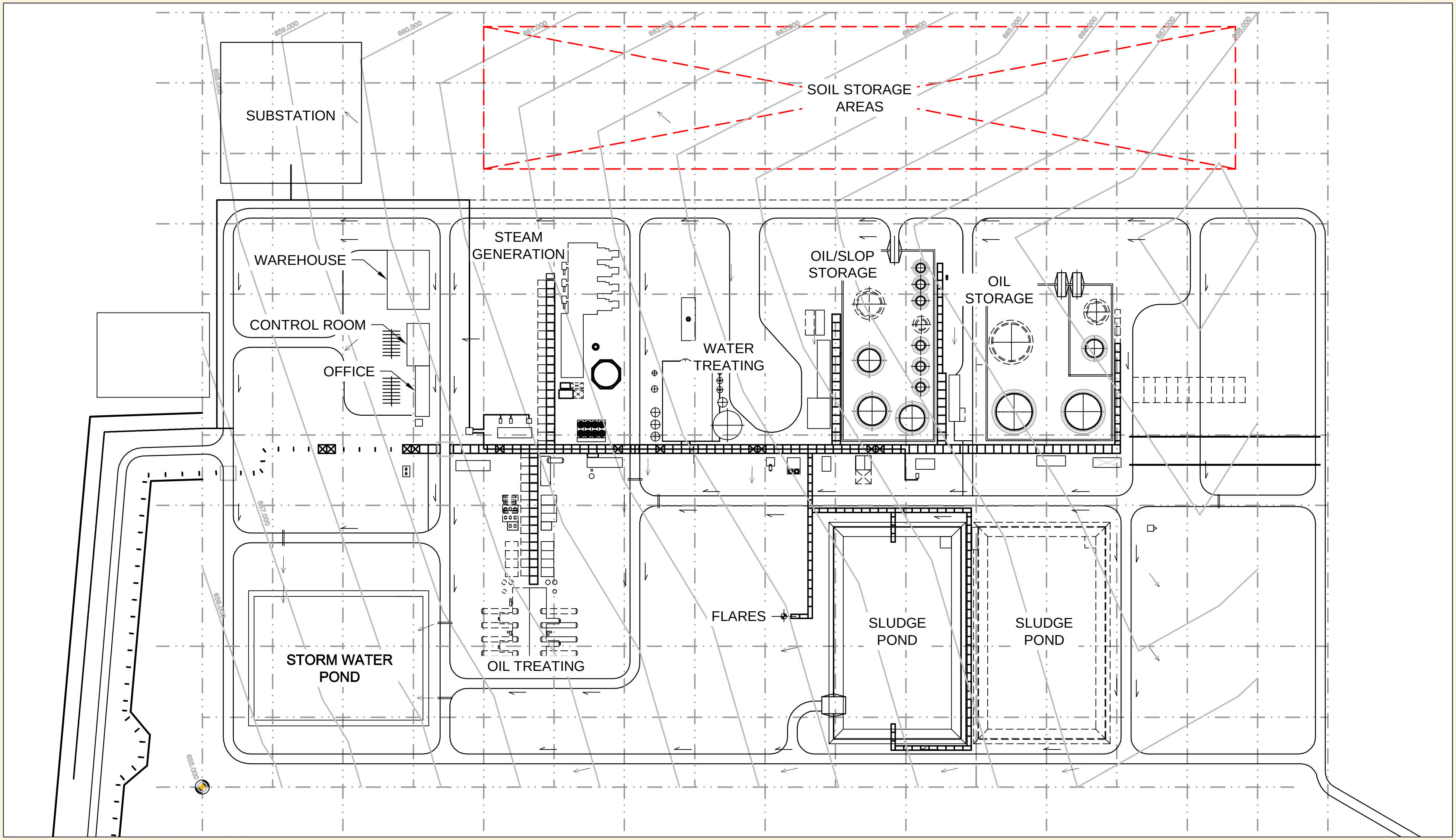
The increase in production for the Leismer Commercial Hub will not require any additional well pads, CPF area or steam generating equipment. The production and treating processes, as well as the water treatment equipment, are the same as for the approved Leismer Demonstration Hub, with the exception of an additional treater, saline water source wells, a saline water tank, pumps, a heat exchanger and associated piping which are detailed in Section A2.2.

## A2.2 CPF and Services

The process and equipment and services (water source and disposal wells, and related pipelines) as detailed in the Leismer Demonstration Project Application will be modified to accommodate the following additional equipment and wells:

- A treater vessel
- Two or more Basal McMurray Source wells (saline water) and related underground pipelines
- One saline water tank
- One saline water heat exchanger
- Pumps and associated piping to tie in the additional equipment

Figure A2.2-1 presents refinements of the Leismer Demonstration plot plan to reflect the Leismer Commercial Plot Plan. Figures A2.2-2 through A2.2-4 present the material, water and energy balances for the increased production at the Leismer Commercial Hub.



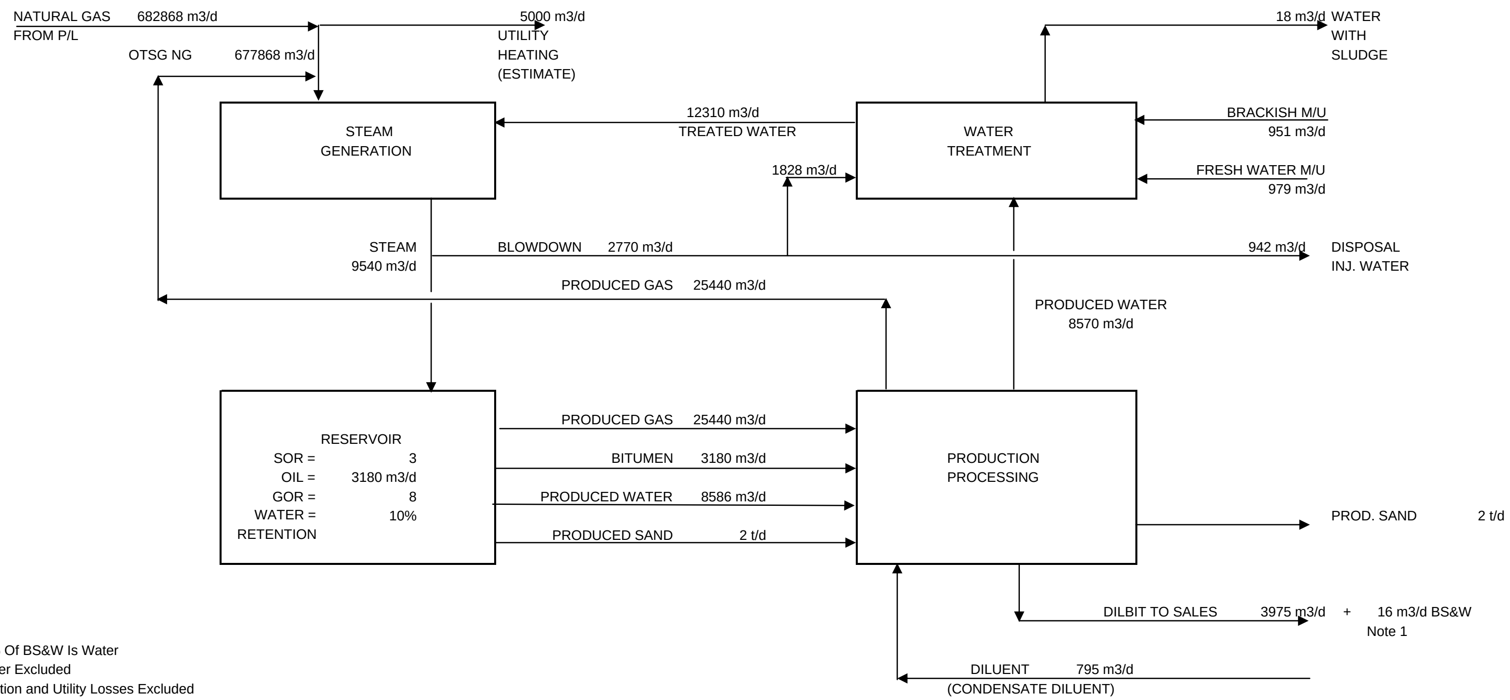

SCALE 1:4000 metres

40 0 40 80

Title:

**LEISMER COMMERCIAL HUB**
**CPF PLOT PLAN**

| | | |
|---|---|---|
| Approved: LP | Revision Date: 07/05/07 | |
| File: 4455-PROCESS-07.DWG | | |
| Drawn by: ADF | Checked: BW | Fig. No.: **A2.2-1** |



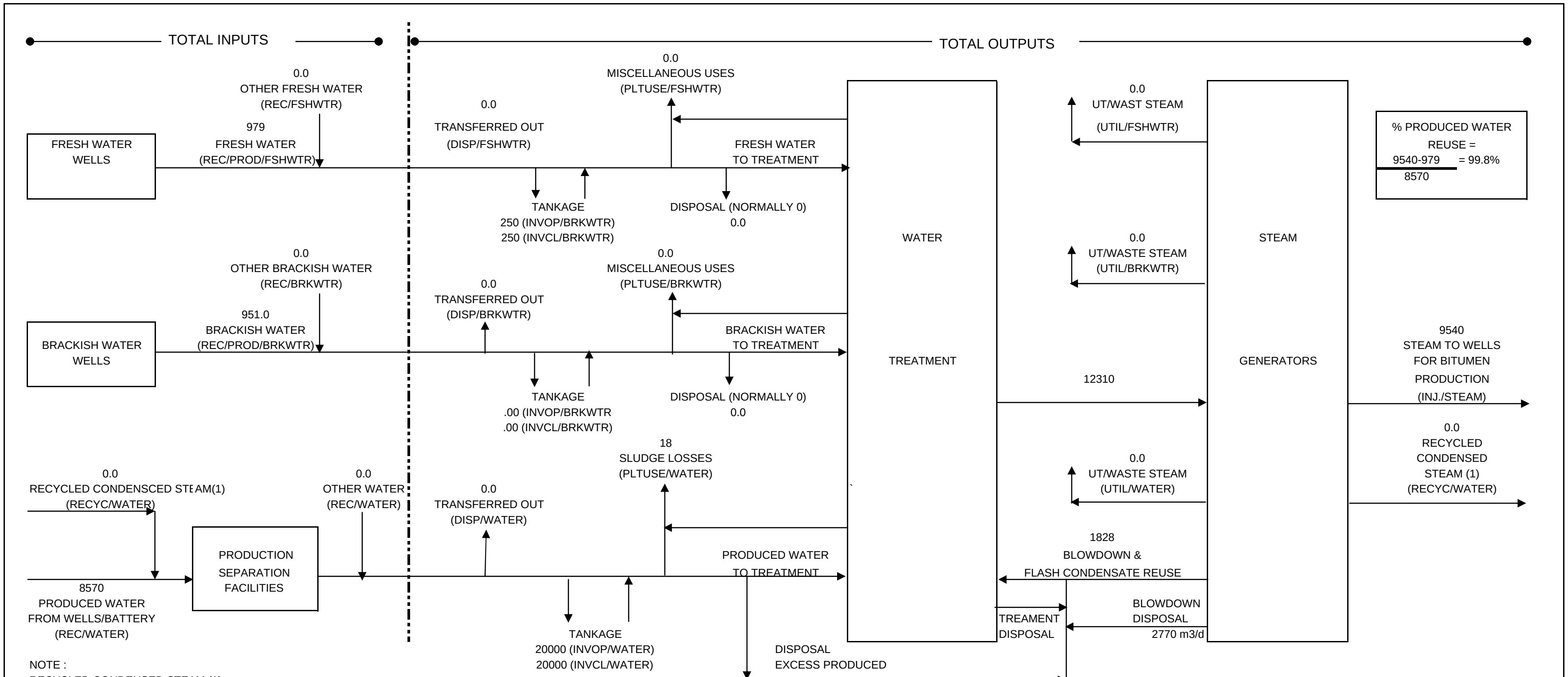

Notes:
1.) Assumes 50% Of BS&W Is Water
2.) Domestic Water Excluded
3.) Pond Evaporation and Utility Losses Excluded

Approximate Stream Rates

NOTE: CALENDAR DAY

Values shown are rounded in Table A2.3-1

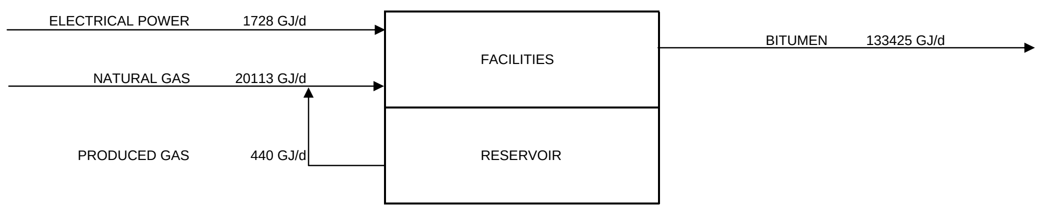
| | | | |
|---|---|---|---|
| MATERIAL BALANCE<br>BITUMEN PRODUCTION 3,180 $m^3$/d (20,000 bpd)<br>SOR = 3, RR = 10% | | | |
| SCALE | SIZE | DRAWING NUMBER | REV |
| NONE | B | FIGURE A2.2-2 | A |




NOTE :
RECYCLED CONDENSED STEAM (1)
(RECY/WATER) RECYCLED CONDENSED UTILITY STEAM THAT ENTERS THE PROCUCED WATER STREAM COMING BACK INTO THE FACILITY
DISPOSAL (2)
(INJ/WATER ) DISPOSAL OF FRESH+BRACKISH+PRODUCED WATER
DISPOSAL FRESH PORTION IS CALCULATED FROM TOTAL FRESH IN - OTHER FRESH WATER USES +/- TANKAGE - FRESH WATER INJECTED. NORMALLY 0
DISPOSAL BRACKISH PORTION IS CALCULATED FROM TOTAL BRACKISH IN - OTHER BRACKISH WATER USES +/- TANKAGE - BRACKISH WATER INJECTED NORMALLY
DISPOSAL PRODUCED PORTION IS CALCULATED FROM TOTAL DISPOSAL - DISPOSAL PRESH - DISPOSAL BRACKISH

SIMPLIFIED WATER BALANCE
BITUMEN PRODUCTION 3,180 $m^3$/d (20,000 bpd)
- CONTINUOUS PLANT OPERATIONS
AFTER STARTUP (RECYCLE OPERATING)

| SCALE | SIZE | DRAWING NUMBER | REV |
|---|---|---|---|
| NONE | B | FIGURE A2.2-3 | A |




ENERGY BALANCE
BITUMEN PRODUCTION 3,180 $m^3$/d (20,000 bpd)
SOR = 3, RR = 10%

| SCALE | SIZE | DRAWING NUMBER | REV |
|---|---|---|---|
| NONE | B | FIGURE A2.2-4 | A |

# A2.3 Water

## A2.3.1 Camp for Construction and Operations

The construction and operations camp for the Leismer Commercial Hub will be the same camp used to house the construction and operations workforce for the Leismer Demonstration Hub. The camp is an integrated facility located in S1/2 32-78-9 W4 with a total of 450 rooms which accommodates the planned workforce.

The construction side of the camp is sized for 300 people while the operations side is sized to 150 people. When on shift, the construction personnel will have an occupancy rate of close to 100%. When off-shift, the construction camp occupancy will likely drop to about 10%. The operations staff will normally have an occupancy level of 60% to 70% but could reach 100% during start-up, turn-around and shut-down events. The average occupancy for the 450 man camp is estimated at 305 men per day, with a variation from lows of 80 people to highs of 450 people. The camp water requirement is estimated at 225 L per person per camp day. At 225 L per man, water demand at the camp will range between 18 $m^3$/d (minimum) to 101 $m^3$/d (maximum) with an average daily usage of 68 $m^3$.

The construction/operations camp will utilize groundwater from a local quaternary well. The water will be treated and tested to meet the Potable Water Regulation. The wastewater stream from the water treatment plant will be de-chlorinated, settled and discharged to the environment in an approved manner.

## A2.3.2 Domestic Wastewater Treatment for the Construction and Operations Camp

The domestic wastewater from the construction and operations camp is collected and treated in a mechanical wastewater treatment system. The type of biological process equipment is a membrane bioreactor process (MBR). The plant is designed and operated in accordance with the latest edition of “Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems”. The treated effluent from the wastewater treatment plant is discharged to the environment down-gradient of the water well in a safe manner. The sampling frequency and effluent from the wastewater plant meets Domestic Wastewater Management Guidelines for Industrial Operations.

The excess sludge generated from the treatment plant is disposed at a wastewater treatment facility approved under the Environmental Protection and Enhancement Act.

## A2.3.3 Domestic Wastewater Treatment for the Central Processing Facility

The domestic wastewater treatment system designed for the Leismer Demonstration Hub is adequate for the Leismer Commercial Hub.

## A2.3.4 Produced Water and Water Reuse Process

The produced water and water reuse process designed for the Leismer Demonstration Hub is adequate for the Leismer Commercial Hub.

Balanced withdrawal and injection into the Basal McMurray will be incorporated in the Leismer Commercial Hub. The balanced approach will require the addition of saline water source wells, a saline water tank, heat exchanger and associated pumps and pipelines.

## A2.3.5 Water Balance and Contingency Operating Conditions

The following discussion includes the water management plan for the Leismer Demonstration as well as the Leismer Commercial Hub. The estimated water makeup and disposal requirements are summarized in Table A2.3-1.

### Table A2.3-1 Estimated Leismer Commercial Hub Water Demands

| Water Demand | 10% Reservoir Retention Long-Term Push-Pull ($m^3$/ calendar day) | 7% Reservoir Retention Long-Term Push-Pull ($m^3$/ calendar day) |
|---|---|---|
| Initial Make-up (Lower Grand Rapids Aquifer) | 3,850[1] | 3,850[1] |
| Normal Disposal (Basal McMurray Aquifer) | 950[3] | 892 |
| Maximum Disposal (Basal McMurray Aquifer | 2,100[2] | 1,950[2] |
| Normal Make-up (Lower Grand Rapids Aquifer) | 980[3] | 646 |
| Maximum Make-up (Lower Grand Rapids Aquifer) | 1950 | 1365 |
| Normal Make-Up (Basal McMurray) | 950[3] | 889 |

Notes:

1 Water for one OTSG without produced water returns

2 Short-term – if blowdown recycle to warm lime softening is not functioning

3 Values are shown rounded from Table A2.3-2 and Figure A2.2-2

The most common upset condition expected in the Leismer Commercial Hub is short-term increased reservoir retention. Reservoir retention is the most significant variable affecting the water make-up required to sustain the SAGD process. Reservoir retention is the produced water or condensed steam which does not return from the producing zone.

The consequence of increasing reservoir retention is increased make-up as shown in Table A2.3-2.

In Leismer with bottom and top water in the reservoir, some production of reservoir water, in addition to the condensed steam is expected. The exact amount is going to depend on both the detailed geology and the strategies developed and optimized during actual operations. North American plans to operate the SAGD to minimize reservoir retention since it has the negative impact of increasing operating cost and increased water make-up.

Extensive modeling has been done for the Leismer Commercial Hub to understand the effects of changing SORs and reservoir retention on the water balance as the Leismer Commercial Hub develops and strives to meet the water recycle rates. The attached Table A2.3-2 summarizes key balance parameters based on a produced water total dissolved solids (TDS of 3,500 mg/L). The actual produced water may vary and is expected to be less saline, however the trends and expected recycle rates are achievable within a plus 10% range on the produced water and easier to achieve with lower TDS concentrations. In order to achieve the 90% recycle rate, a portion of the blowdown must be recycled. The remainder of the blowdown is sent to disposal to purge the TDS from the system, and keep the boiler feedwater TDS below a normal maximum of 8,000 mg/L.

The Table A2.3-2 represents the best estimate of how the reservoir is expected to respond based on evaluation of the geology and experience from other operations. The water reuse plant and the overall project are designed with significant flexibility and are capable and expected to meet or exceed 90% recycle within one year of operation. The following is a discussion of Table A2.3-2:

- The Leismer Demonstration Hub as approved is assumed to be operating at 1590 $m^3$/d oil production rate utilizing a portion of the 22 approved well pairs. The plan for the additional wells is to initiate steam in the circulation mode on both the injector and producer for approximately 3 months, followed by conversion of the well pairs to SAGD mode (steam in the injector and production from the producer) and gradual SAGD production. Key aspects of this period are possibly high reservoir retention and high SORs as the steam chamber develops and the best operating pressure and steaming strategy is developed. Produced water reuse will be ongoing with the operation of the Leismer demonstration plant. Saline water from the Basal McMurray is planned to supplement the Grand Rapids make-up.

- From 6 to 18 months the conversion of all the well pairs to SAGD is planned and the production rate should gradually increase. Key aspects of this period are decreasing reservoir retention and decreasing SOR as experience is gained with this reservoir and the steam chamber development continues. Produced water recycle will be at or above plan some days but the average is expected to be slightly below the 90% level.

- The stream day operation from 18 to 36 months is expected to have a service factor of about 90%, and reservoir retention and SOR are expected to continue to improve. Water recycle should meet or exceed the 90% level and production should be fairly stable at the 3,180 $m^3$/d level. Greater than 90% water recycle rate is expected to be met on a yearly basis. Push-Pull into and out of the Basal McMurray will be practiced.

- The stream day operation for the long-term is expected to have a service factor in the range of 92%, and the reservoir retention in the range of 0 to 7%, with SOR in the range of 2.8 to 3.0. Produced water recycle is planned to exceed the 90% recycle rate with partial saline water makeup. The performance of Push-Pull from and to the Basal McMurray should be known. If it is successful, then it will be continued. If it causes resource recovery and operational issues it will be modified or discontinued.

**Table A2.3-2 North American Water Management Plan for Combined Leismer Demonstration Hub of 1,590 $m^3$/d and 1,590 $m^3$/d Leismer Commercial Hub**

| | | Stream Day | | | | Calendar Day | |
|---|---|---|---|---|---|---|---|
| | | **Start Up** | | | **Long Term Operations** | Maximum Reservoir Retention | Average Reservoir Retention |
| | | **0 to 6 months** | **6 to 18 months** | **18 to 36 months** | **Long-term High Recycle** | **Long –Term Push-Pull** | **Long –Term Push-Pull** |
| | | | | Stream Day Factor 90% | Stream Day Factor 92% | **Push - Pull** | **Push - Pull** |
| Oil Production Rate | $m^3$/d | 795 | 1990 | 3537 | 3459 | 3181 | 3181 |
| Reservoir Retention | % | 25% | 15% | 10% | 7% | 10% | 7% |

| | | Stream Day | | | | Calendar Day | |
|---|---|---|---|---|---|---|---|
| | | **Start Up** | | | **Long Term Operations** | Maximum Reservoir Retention | Average Reservoir Retention |
| | | **0 to 6 months** | **6 to 18 months** | **18 to 36 months** | **Long-term High Recycle** | **Long –Term Push-Pull** | **Long –Term Push-Pull** |
| | | | | Stream Day Factor 90% | Stream Day Factor 92% | **Push - Pull** | **Push - Pull** |
| Reservoir Retention | $m^3/d$ | 1093 | 1194 | 1132 | 678 | 954 | 623 |
| SOR | | 5.5 | 4.0 | 3.2 | 2.8 | 3.0 | 2.8 |
| WOR | | 4.125 | 3.400 | 2.880 | 2.604 | 2.700 | 2.604 |
| Steam (Note 1) | $m^3/d$ | 4373 | 7961 | 11317 | 9684 | 9542 | 8905 |
| BFW Flow | $m^3/d$ | 5643 | 10273 | 14603 | 12495 | 12312 | 11491 |
| BFW TDS | mg/L | 5594 | 5903 | 7435 | 7523 | 7432 | 7521 |
| PW Reuse as per EUB | % | 87% | 89% | 99% | 99% | 99% | 99% |
| BD Recycle | % | 69% | 69% | 66% | 66% | 66% | 66% |
| Source Grand Rapids | $m^3/d$ | 1490 | 1919 | 1158 | 701 | 979[4] | 646 |
| Source Grand Rapids TDS | mg/L | 1837 | 1837 | 1837 | 1837 | 1837 | 1837 |
| Basal McMurray | $m^3/d$ | 0 | 0 | 1130 | 968 | 951[4] | 889 |
| Source TDS | mg/L | 14061 | 14061 | 14061 | 14061 | 14061 | 14061 |
| PW Flow to Reuse | $m^3/d$ | 3280 | 6767 | 10185 | 9006 | 8587 | 8282 |
| PW TDS | mg/L | 3519 | 3515 | 3517 | 3519 | 3519 | 3520 |
| Water lost to BS&W ( Note 2) | $m^3/d$ | 2 | 5 | 9 | 9 | 8 | 8 |
| Disposal Flow | $m^3/d$ | 390 | 711 | 1134 | 970 | 956[4] | 892 |
| Disposal TDS | mg/L | 34469 | 36454 | 46027 | 46595 | 46012 | 46583 |
| Water lost to Sludge | $m^3/d$ | 6 | 11 | 17 | 14 | 14 | 13 |
| Fuel Gas to Steam Plant (Note 3) | sm3/d | 312049 | 568075 | 807523 | 690996 | 680833 | 635445 |

1 Cold water equivalent

2 Assumes 50% of BS&W is water.

3 Calculated at 32.7 $MJ/m^3$, 90% firing efficiency. Produced gas at 17.3 $MJ/m^3$ also included at same efficiency. GOR 8.0 $^3/m^3$ fuel for utilities not included.

4 These values are shown rounded in Table A2.3-1.

## A2.3.6 Push-Pull to/from the Basal McMurray

The Basal McMurray water sands in the Leismer Commercial Hub development area in general is a relatively thin zone except for the localized thick water sands in the area of a Devonian Low (as discussed on Page 2 Sections 2.2.1 and 2.2.2 of the Leismer Demonstration Project Geology Submission, June, 2006) and potentially isolated from the main wet Basal McMurray 30 to 40 km to the east. This isolation or limited recharge could limit the quantities of Basal McMurray source water available in the long-term from the zone. For this reason, the balanced Push-Pull disposal and source water production from the Basal McMurray is planned.

Future drilling programs will target ongoing evaluation of the Devonian low. The drilling results coupled with reservoir modeling results will be used to assess the potential impacts of McMurray source water withdrawals on the SAGD process areas. It will also provide further understanding of the viability of a balanced McMurray disposal and source water withdrawals process (Push-Pull disposal/partial make-up water scenario from the Basal McMurray).

### A2.3.7 Disposal Water Quality

The only planned disposal stream is flashed OTSG blowdown. The TDS of the boiler blowdown will be approximately four to six times the TDS of the boiler feedwater (BFW). The boiler blowdown is planned to be recycled to a BFW TDS limit of 8,000 mg/L, and the boiler blowdown will then be in the range of 32,000 to 48,000 mg/L. The hardness and silica concentrations of the blowdown are estimated at 2 to 6 mg/L and 200 to 300 mg/L respectively. North American expects the disposal stream to be compatible with the Basal McMurray waters which are expected to be in the 11,000 to 20,000 mg/L TDS range.

### A2.3.8 Hydrogeologic Evaluation

The hydrogeologic assessment, including well testing and numerical groundwater modelling provided in Volume 3 Section 5.6 Impact Assessment, concludes that sufficient water is available to meet the water demands of the Leismer Commercial Hub. To summarize, the water demands and supporting aquifers for the Leismer Commercial Hub are 980 $m^3$/d from the Lower Grand Rapids Aquifer and 950 $m^3$/d from the Basal McMurray Aquifer. The Leismer Commercial Hub will also dispose of 950 $m^3$/d into the Basal McMurray Aquifer.

## A2.4 Chemical Consumption

A variety of chemicals, lubricating oils and domestic and office supplies are required for operations at the CPF. Storage and tracking of the supplies and disposal of waste products includes provisions for secondary containment, leak detection and inventory reconciliation as necessary and as required by Regulation. The largest chemical consumption streams include hydrated lime, magnesium oxide (dry), hydrochloric acid (HCl) and sodium hydroxide (NaOH). Storage capacity for chemicals is generally based on ten to fourteen days supply plus one bulk truckload. Smaller amounts of secondary chemicals such as filtration coagulants, demulsifiers, dispersants, and water treatment aids are also consumed. Chemical consumption estimates for these secondary chemicals are provided as part of the detailed design of the CPF. Table A2.6-1 presents the estimated chemicals that will be consumed during operation of the Leismer Commercial Hub at the aggregate rate of 3,180 $m^3$/d (inclusive of the Leismer Demonstration Hub requirements).

**Table A2.4-1 Chemical Consumption**

| Chemical | Consumption for 3,180 $m^3$/d Bitumen Production (t/d) |
|---|---|
| Hydrated Lime | 7.36 |
| Magox | 3.79 |
| Soda Ash | 1.65 |
| HCl (32%) | 4.74 |
| Caustic (50%) | 3.44 |
| Demulsifier | 0.48 |
| Reverse Demulsifier | 1.12 |
| Flocculant | 0.02 |
| Hypochlorite | 0.15 |
| Coagulant | 0.20 |

| Chemical | Consumption for 3,180 $m^3$/d Bitumen Production (t/d) |
|---|---|
| Polymer | 0.25 |
| $O_2$ scavenger | 0.14 |
| After filter aid | 0.01 |
| Chelant | 0.05 |
| Filming amine | 0.05 |

# A3 APPLICATION FOR APPROVAL

## A3.1 Existing Approvals

North American has received EUB approval for the Leismer Demonstration Hub, which is included within the Kai Kos Dehseh Project area.

## A3.2 Request for Approval

North American hereby applies for regulatory approval to amend, construct, operate and reclaim the proposed Leismer Commercial Hub on a portion of the oil sands leases located in Townships 76 to 83, Ranges 8 to 13 West of the 4$^{th}$ Meridian. The CPF for the Leismer Commercial Hub will be located in the SE ¼ of 2 in 79-10 W4M. Additional surface disturbance will not be required for the Leismer Commercial Hub.

The Leismer Commercial Hub will use SAGD to increase bitumen production at the Leismer Demonstration Hub from 1,590 $m^3$/day (10,000 barrels per day (bpd)) to a rate of 3,180 $m^3$/d (20,000 bpd) on an annual average calendar day basis. North American will seek approval for additional phases of the Leismer Hub under future amendments.

This appendix (Application for Approval of the Leismer Commercial Hub of the Kai Kos Dehseh Project) comprises the Application for Approval of the Leismer Commercial Hub and serves to meet requirements under the Alberta Oil Sands Conservation Act (AOSCA), the Alberta Environmental Protection and Enhancement Act (AEPEA) and the Water Act. The document is provided as an integrated application to the EUB and AENV as outlined in the EUB/AENV Memorandum of Understanding on the Regulation of Oil Sands Developments (IL 96-07).

With this Application, North American is seeking approval from:

1. The EUB for:

   Approval to amend a bitumen recovery scheme, under Section 13 of the Oil Sands Conservation Act, from the Athabasca Oil Sands Deposit in the McMurray Formation, at Oil Sands Leases located between Sections 27, 28, 33 and 34-78-10 W4M owned by North American Oil Sands Corporation; and

2. AENV for:

   Amendment to Leismer Demonstration Hub bitumen treating capacity, under Division 2 of Part 2 and Section 63 of the AEPEA.

*Original Signed by*

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# A4 LEISMER COMMERCIAL HUB GEOLOGY AND RESERVOIR

## A4.1 Geological Description of Leismer Commercial Hub Development Area

Additional drilling in Q1, 2007 was carried out in the Leismer area. Maps in Section 4 of this Appendix include an update of 2007 drilling, but results do not materially change the original horizontal well placement as detailed in the Leismer Demonstration Application. This Appendix should not be construed as a request for an amendment to the Leismer Demonstration Hub approval.

### A4.1.1 Geological Database

North American evaluated the regional geology in a Leismer Regional Geological Study Area (RGSA) defined by the southeast of Section 6-78-9 W4M and the northwest of Section 4-79-10 W4M. The Leismer Commercial Hub is located in the central part of the Leismer RGSA. Map boundaries were selected to include the proposed plant site (LSD's 7 and 8-2-79-10 W4M) and proposed source and disposal well areas.

North American has conducted extensive geological and geophysical investigations throughout the Leismer RGSA including 2D and 3D seismic and extensive exploratory and delineation drilling combined with selective coring. Summary maps of Geological and Geophysical Control for the Leismer RGSA illustrate the distribution of wells (Figure A4.1-1A) and cores and high resolution micro imager logs (Figure A4.1-1B). Drilling density over the Leismer Commercial Hub development area is approximately one well per LSD. Of the 38 wells in the Leismer Commercial Hub development area, 34 have been cored. The well and core counts include an additional 11 wells (cored 9) in the Leismer Commercial Hub development area and an additional 35 wells (7 cored) in the Leismer RGSA drilled by North American in 2007.

One hundred and twelve wells have been drilled in the Leismer RGSA and most have been wireline logged. Four wells did not penetrate the full McMurray and do not provide full information on the SAGD potential (6-1-78-10 W4M, 1-2-78-10 W4M, 7-9-78-10 W4M and 3-2-79-10 W4M). In addition, 75 high resolution micro imager logs (HMI), of which 38 are in the immediate Leismer Commercial Hub development area.

The Leismer Commercial Hub development area is mostly covered by a 25.6 $km^2$ 3D seismic survey acquired by North American in Q1, 2006. An additional 22 $km^2$ 3D seismic survey was added to the existing survey in Q1, 2007 but the new data does not impact the Commercial Hub development area. Other parts of the Leismer RGSA are less well defined but will be the subject of additional exploration in future years.

The standard log suite for North American wells includes gamma, neutron, density, PE, SP, resistivity, HMI and sonic. Shear dipole sonic logs are available on selected wells.

All seismic data were interpreted in the Seisware geophysical software. Simandoux shaly sand analysis was carried out by petrophysicists at Weatherford Canada. All log data and seismic surfaces used were integrated in the Geographix Discovery geological software.

Additional drilling will continue in areas outside of the Leismer Commercial Hub development area in future years and will be the subject of future commercial applications

### A4.1.2 Regional and Leismer Commercial Hub Development Area Geology and Geophysics

The regional geological picture is for the overall Leismer RGSA. This evaluation is closely aligned with the EUB's review of geological data in the area presented in Report 2003-A (EUB-Athabasca Wabiskaw – McMurray Geological Study). Some of the North American formation tops have undergone minor revision (less than 2 m) due to re-interpretation and KB correction.

### A4.1.3 Regional Stratigraphy

The bitumen resource is in the McMurray Formation, which is the basal unit of the Lower Cretaceous Mannville Group. In northeastern Alberta, the Mannville Group is composed primarily of unconsolidated clastic sedimentary rocks that are divided into three Formations. From oldest to youngest, these formations are the McMurray Formation, the Clearwater Formation and the Grand Rapids Formation. Figure A4.1-2 illustrates the regional stratigraphy in the Leismer Commercial Hub RGSA.

The McMurray Formation rests unconformably on the carbonates of the Devonian Beaverhill Lake Group. The unconformity at the base of the McMurray Formation was formed during a lengthy period of sub aerial exposure and erosion and resulted in deeply incised valleys that influenced the deposition of the lower McMurray bitumen sand reservoirs. The lower sands are fluvial in nature while the upper sediments are deposited in estuarine and interdistributary bay environments. The basic regional sequence in the Leismer Commercial Hub development area consists of stacked progradational parasequences designated, from top down, A1, A2, B1, B2 considered to have been deposited in interdistributary bay settings. C channel deposits underlie the parasequences. McMurray estuarine channels originate at many stratigraphic levels within the stratigraphic section. If a McMurray channel is contained within two of the regional muds, it is named after the sequence it is in (a B1 channel is bound by the A2 mud and underlying B1 mud). Any channels that have cut through the B2 muds or are stacked without preserved regional muds are termed "McMurray channels".

The Mannville Group is overlain by the shales and minor sands of the Colorado Group which are truncated in areas by pre-Quaternary erosion. The Colorado Group is overlain by Tertiary aged sand and gravel and by Quaternary glacial deposits.

### A4.1.4 Devonian

The relationship between McMurray thickness and paleotopographical relief on the unconformity surface was previously discussed in Section A4.1.3. The Devonian in the Leismer Commercial Hub development area consists of dolomitized fossiliferous limestones and argillaceous limey mudstones of the Beaverhill Lake Group. Figure A4.1-3 shows the Wabiskaw to Sub-Cretaceous Unconformity isopach. This map integrates well control with a depth converted Wabiskaw to Devonian isochron. Most of the isopach displays little relief and generally is between 59 m (well 10-4-78-10 W4M) and 67 m (well 4-7-78-9 W4M) thick. A rather pronounced thickness on the isopach is evident on the 3D seismic and has been penetrated by several well bores along the western edge of the Development area. The isopach attains thicknesses of 75 m in a series of wells along the eastern side of Sections 28 and 33-78-10 W4M and attains a maximum thickness of 80 m in the recently drilled well AB/5-34-78-10 W4M. Figure A4.1-4 illustrates two seismic plan views of the feature. A gradient edge map illustrates the low feature on the Devonian surface and a timeslice shows the McMurray sediment infilling the low. All of the relief features were infilled in early McMurray time and are not evident in younger strata.

Figure A4.1-5 shows the present day structure on the Sub-Cretaceous Unconformity. This map was prepared by integrating geological well control with the 3D depth converted structure on the Devonian surface. Similar to the Wabiskaw- Devonian isopach (Figure A4.1-3), structural relief is subdued except for a pronounced north trending low on the west edge of the Leismer Commercial Hub development area. Direct evidence for the abruptness of the low on the Devonian surface can be seen in 40 acre offset wells at 1- 3-79-10 W4M and 2-3-79-10 W4M (17 m difference) and AB/12-27-78-10 W4M and 9-28-78- 10 W4M (14 m difference).

### A4.1.4.1 McMurray Formation

General stratigraphy in the Leismer RGSA follows that established by the EUB and has been previously discussed (Section 4.1.3). The regional sequences consist of basal mudstones grading up to sandier wave rippled to bioturbated sandier facies. The relatively uniform isopach thickness of the regional parasequences (<10m) precludes development of a thick enough sandstone reservoir to be economically exploited with today's SAGD technology. Sedimentary structures and trace fossils indicate deposition in a restricted marine interdistributary bay fill setting. The thicker, exploitable reservoirs occur in the sandstone dominant portions of fluvial and estuarine deposits.

The McMurray Formation ranges from 36.8 m (well 100/31-78-9 W4M) to 69.6 m (well AB 5-34-78-10 W4M) in thickness in the Leismer RGSA, as shown in Figure A4.1-6, the McMurray to Sub-Cretaceous Unconformity isopach. Again, the pronounced north trending thickening in the Development area is evident. This map is similar to the Wabiskaw to sub- Cretaceous Unconformity isopach since the Wabiskaw is of relatively uniform thickness. It should be noted that the McMurray isopach presented in Figure A4.1-6 has not included information from the 3D since the Wabiskaw is a more consistent seismic top than the McMurray. 2007 drilling added additional detail on the isopach but did not materially change the overall picture.

Structure on the top of the McMurray is illustrated in Figure A4.1-7. Present day relief on the top of the McMurray tilts to the SW with a few closures present.

### A4.1.4.2 Wabiskaw Member of the Clearwater Formation

The Wabiskaw Member sharply overlies the McMurray Formation. The Wabiskaw consists of transgressive marine glauconitic silty sandstones. The Wabiskaw is approximately 10 m thick in the Leismer RGSA and ranges from 9 m to 13 m.

Structure on the top of the Wabiskaw is shown in Figure A4.1-8. Since the Wabiskaw is a more consistent seismic pick than the top of the McMurray, the map of Figure A4.1-8 was selected for integration with 3D depth converted isochron data to produce the Structure map on the sub-Cretaceous Unconformity (Figure A4.1-5). The Wabiskaw tilts to the southwest in the Leismer RGSA at about 4 m per 1,600 m with a lows of 254.0 m and 254.8 m (wells 10-4 and 11-16-78-10 W4M, respectively) and highs of +271.9 m and 271.8 m at wells 12-19-79-9 W4M and 6-36-78-10 W4M, respectively. The 2007 drilling confirmed pre-existing mapping.

### A4.1.4.3 Clearwater Formation

The Clearwater Formation in the Leismer Commercial Hub development area consists of a basal marine shale (5 to 10 m thick), the Clearwater B sandstone and an upper Clearwater shale. The upper Clearwater A sandstone is not developed in the Leismer RGSA.

*Clearwater B Sandstone*

The Clearwater B sandstone is up to 40 m thick in the southern portion of the Leismer Commercial RGSA. Net porous sandstone maps are presented and discussed in Section A4.3.5. The unit is a fine to medium grained glauconitic marine sandstone.

*Upper Clearwater Shale*

The Clearwater sandstone in the Leismer Commercial Hub development area is sharply overlain by a marine shale about 50 m thick.

*Grand Rapids Formation*

In the Leismer RGSA, the Grand Rapids Formation consists of an Upper and Lower member. The Lower Member is a blocky, clean sandstone and a thin coal (<2 m) is commonly present towards the top. Net porous sandstone maps are presented and discussed in Section A4.3.4.

The Upper Grand Rapids is 40 m to 60 m thick and consists of stacked progradational parasequences with basal marine shales grading up into clean porous sandstones. Gas over water may be locally present in these upper sandstones.

*Joli Fou Formation*

Tight marine shales of the Joli Fou Formation directly overlie the Upper Grand Rapids Formation. The Joli Fou is truncated by the Quaternary unconformity and is overlain by unconsolidated glacial sediments. In the Leismer Commercial Hub development area, the Viking formation is commonly preserved and locally, Cretaceous sediment as high up as the base of Fish Scales may be present.

*Quaternary*

The Mannville Group is overlain by the shales and minor sands of the Colorado Group which are truncated in areas by pre-Quaternary erosion. The Colorado Group is overlain by Tertiary aged sand and gravel and by Quaternary glacial deposits.

## A4.1.5 Leismer Commercial Site Geology

### A4.1.5.1 Type Log of the McMurray Formation for the Leismer Commercial Hub Development Area

Figure A4.1-9 illustrates well AB/3-34-78-10W4M/00, which was selected as the type log for the Leismer Commercial Hub development area.

*Log and Core Comparison*

The Leismer Commercial RGSA has a total of 112 wells with 49 cores in the McMurray. The Leismer Commercial Hub development area has a total of 31 wells (25 were drilled by North American in the last three years) and 26 cores. Weatherford Canada was retained to carry out Simandoux shaly sand analyses on the cored wells in the vicinity of the Leismer Commercial Hub development area. Core and log data compared favourably and an example is illustrated in Figure A4.1-10 for the type log AB/03-34-78-10 W4M. Log parameters and a Pickett plot, used to determine Rw, as determined by Weatherford, are shown in Figure A4.1-11

Several things can be noted from the core to log comparison of Figure A4.1-10. Saturations match most closely in the cleaner reservoir intervals. The largest discrepancy can be seen in highly interbedded sections where core sampling tends to high-grade the cleaner sandstone beds and where logs tend to average their response across the interbedded sands and shales. Net SAGD pay maps for the Leismer Commercial Hub development area were prepared by using 6 weight percent bitumen cutoffs as determined by Simandoux analysis and consistent with Report 2003-A.

Of particular interest, the Rw as determined from the Pickett plot (Figure A4.1-11) and core-log calibrations is quite consistent at a value of 0.55. Rw variations in the McMurray can be quite significant, particularly in areas close to surface or outcrop, and may result in a need for frequent coring to determine oil saturations. North American believes there is already enough core control in the area to verify that Rw is consistent and no additional coring is required in the Leismer Commercial Hub development area to address that specific issue.

Table A4.1-1 summarizes the McMurray reservoir characteristics from the all cores taken in the Kai Kos Dehseh Project area.

**Table A4.1-1 Reservoir Characteristics from All Cores in the Project Area**

| Parameter | Core Range |
|---|---|
| Porosity | 27-41% |
| Permeability | 2-10 Darcies |
| Bitumen Saturation | 50-90% |

### *Seismic Characterization of the McMurray Formation*

North American conducted 3D seismic utilizing a mini-vibrator source in the Leismer area, a portion of which covered the Leismer Commercial Hub development area, in Q1 of 2006. Innovative grid design achieved high resolution sampling, while limiting environmental impact to 10 ha. North American imaged and mapped the Middle McMurray channel sequences and oil sand prone porosity zones, achieving 5 m bed resolution. Coherency and signal to noise of the mini-vibe seismic, spatial sampling and, prestack time migration processing have combined to produce highly interpretable seismic with excellent agreement to the wireline log data. Identification of channel facies from seismic will help refine infill drilling programs and reduce the need for high density drilling patterns to delineate the McMurray channels.

Seismic parameters are as follows:

- 112 m source line interval, 140 m receiver line interval (Reverse acquisition geometry)
- Source: Single Mini-vibe 12,000 lbs. units, non-linear sweep 8-180 Hz.
- Infill dynamite around lakes and impassable areas (about 0.5% of source points)
- 1 millisecond sample rate, ARAM 24 bit recorder
- Processed by Paradigm, March/April, 2006

- Imaged 7 m x 7 m bins (10 fold), 10 m x 20 m bins (20 fold) and 14 m x 14 m bins (40 fold) binning options- the best 7 m x 7 m having the highest migration fold
- Bandwidth in migrated stack 10-165 Hz., after NMO stretch
- Dominant frequency of 100 Hz., at 2400 m/s- resolving 6 m beds
- Detection of hard shales within these sands down to 3 m, with gas zones down to 2 m

Channel fairway interpretation successfully separates the regional wells from the channels with added insight to stacked sequences in "McMurray channels" in certain wells. For example, Shallow B1 channels have been interpreted in AB/3-2-79-10 W4M, AB/5-34, AB/4-27, AA/14-21 and AA/6-21-78-10 W4M, A over C channels (1-33-78-10 W4M), and C channel below regional parasequences (11-34-78-10 W4M).

3D seismic with high resolution parameters can help map channel fairways and sand prone facies. Integrating the 3D seismic with logs has effectively allowed North American to define the bounding reservoir limits, and combined with oil/water contact information from logs, and effectively place horizontal wells to optimize recovery.

An additional 12.3 sections of 3D was added to the 2006 survey in Q1, 2007. The data is being interpreted but does not immediately impact the Leismer Commercial Hub development area.

### A4.1.5.2 Reservoir Characteristics

The integrated geology and geophysics was presented in the June, 2006 Reservoir and Geology submission to the EUB. As this application deals with an increase of production from the original horizontal wells of the 2006 Demonstration application, the following descriptions focus on updating with information resulting from 2007 drilling. Eleven wells were drilled within the Leismer Commercial Hub development area and an additional 35 were drilled in the remaining Leismer RGSA in Q1, 2007. The Leismer Commercial Hub development area can be described as a continuous reservoir bounded to the northeast by a main channel edge, to the northwest by a McMurray B1 channel (formerly considered an A2 channel, but the presence of the A2 mudstone has been confirmed in new cores and in a detailed review of earlier core), and at the base by a tilted oil/water contact. As will later be demonstrated, the initial development area will be contained within the bounding features. Figures A4.1-12 and A4.1-13 are east-west and north-south cross sections, respectively, through the Leismer Commercial Hub development area. Figures A4.1-14 and A4.1-15 are east-west and north-south geological cross sections, respectively.

The Net 6 Weight % SAGD pay map (Figure A4.1-16) illustrates the main bounding surfaces. New (2007) drilling has further refined the bounding features as discussed below.

1. The eastern channel edge was previously defined largely by 3D seismic. The 2007 AC/6-27-78-10 W4M well encountered 10.0 m of SAGD pay as a result of the presence of a 12 m thick basal shale. The eastern edge of the SAGD project area was further defined by AB/14-27-78-10 W4M which encountered a shale plug with only 7.5 m of pay.

2. The northeast trending B1 channel with its subordinate southeast trending arm was identified by seismic and the 2-3-79-10 W4M well. Wells were drilled in 2007 to further test what pay thickness, if any might, be preserved under the B1 channel and to further test the associated gas thickness. Associated gas thickness is discussed below. Additional drilling and seismic interpretation indicate the channel no longer cuts as deeply into the reservoir as previously thought.

3. New drilling has provided further information on the oil/water contact. Previous large discrepancies were caused by systematic ground elevation errors which were resurveyed and corrected by North American and were discussed in the Leismer Demonstration Project November 2006 Errata submitted to the EUB. New drilling is consistent with the corrected mapping and is discussed in detail in Section A4.3, Hydrogeology.

Figure A4.1-16 indicates the presence of additional bitumen resource in the main trend to the west and southeast of the main Leismer Commercial development area and with additional exploitable SAGD pay elsewhere in the Leismer RGSA. These deposits will be further delineated in the future and will be the subject of future applications as part of the overall Kai Kos Dehseh Project.

### Table A4.1-2 Cut offs Used to Estimate Bitumen Resource

| Parameter | Value |
|---|---|
| Bitumen Saturation (core) | 6 Wt. % |
| Bitumen Saturation (logs) | RT ≥ 20 ohms at 27% phi |
| Sand porosity (density log) | 27% |
| Gamma ray (log) | 75 API |

Figure A4.1-17 is the isopach of the B2 Mudstone. The mudstone is only present to the east of the main channel target in the Leismer Commercial Hub development area and will not form a caprock for the SAGD development but may help constrain vertical leakage lateral to thermal operations. Figure A4.1-18 is the isopach of the B1 Regional parasequence. The unit forms a caprock over most of the Leismer Commercial Project area with the exception of the down-cutting B1 channel complex. The A2 regional parasequence with the basal A2 mudstone barrier is present throughout the Leismer Commercial Hub development area and forms the main caprock for the SAGD operation. The basal mudstone isopach (Figure A4.1-19) shows the mudstone ranges from 0.4 m thick (well 16-28-78-10 W4M) to 2.1 m thick (well AB/14-27-78-10 W4M).

Structure maps on the Top and Base of the SAGD Gross Pay (at a 40 ohm cutoff) are shown in Figures A4.1-20 and A4.1-21, respectively. The base of the 6 weight percent bitumen is very close to the oil/water contact and, at 50 percent bitumen saturation (6 weight percent), is in the lower transition zone. North American wishes to avoid placing wells in the transition zone and proposes to use a 40 ohm cutoff to determine lower well positioning. In areas <4 m of bottom water, the wells will be placed 1 m above the 40 ohm cutoff. In areas of ≥4 m bottom water, the well will be placed 4 m above the 40 ohm cutoff. North American feels the additional standoff is required for the thicker bottom water areas. The transition from water to 6 weight percent to 40 ohms is fairly abrupt in the Leismer Commercial Hub development area and is usually less than 2 m.

Figure A4.1-20 shows the structure on the top of the gross SAGD pay.

Figure A4.1-21 shows the structure on the base of the 40 ohm SAGD pay. New drilling is consistent with earlier results. Well AB/5-34-78-10 W4M came in with a base of SAGD pay of 198.4 m, at least 6 m lower than offsets.

Table 4-3 includes volumetrics, by pad, for bitumen in place above the producing wells to the top of the 6 weight percent pay and volumetrics for stranded oil in place from the producing wells to the base of 6 weight percent bitumen. These volumes were calculated in Geographix for the pad areas by using grid operations top and base of net >6 weight percent bitumen surfaces and a third surface determined by the selected elevations for the horizontal wells with a final gross to net reduction.

## Table A4.1-3 SAGD Pad Volumes

| Pad | Volume Classification | Drainage Area | No. of Well Pairs | Average Pay Thickness | Average Bitumen Saturation | Average Porosity | Original Bitumen in Place (6 wt%) | Average OBIP per Well Pair | Estimated Recovery Factor | Estimated Pad Recoverable Reserves | Rec. per Well Pair |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (ha) | | (m) | (fraction) | (fraction) | ($e^6m^3$) | ($e^6m^3$) | (fraction) | ($e^6m^3$) | ($e^6m^3$) |
| 1 | Above Producer Level | 48.4 | 6 | 21.3 | 0.82 | 0.32 | 2.71 | 0.45 | 0.53 | | |
| | Below Producer Level | | 6 | 2.3 | 0.79 | 0.32 | 0.28 | 0.05 | | | |
| | Total | | 6 | 23.6 | 0.81 | 0.32 | 2.99 | 0.50 | 0.48 | 1.44 | 0.24 |
| 2 | Above roducer Level | 47.6 | 6 | 22.9 | 0.82 | 0.32 | 2.87 | 0.48 | 0.57 | | |
| | Below Producer Level | | 6 | 3.9 | 0.79 | 0.32 | 0.46 | 0.08 | | | |
| | Total | | 6 | 26.8 | 0.81 | 0.32 | 3.33 | 0.56 | 0.49 | 1.63 | 0.27 |
| 3 | Above Producer Level | 52.3 | 6 | 23.8 | 0.82 | 0.32 | 3.28 | 0.55 | 0.62 | | |
| | Below Producer Level | | 6 | 3.3 | 0.79 | 0.32 | 0.43 | 0.07 | | | |
| | Total | | 6 | 27.1 | 0.81 | 0.32 | 3.71 | 0.62 | 0.55 | 2.10 | 0.35 |
| 4 | Above Producer Level | 35.0 | 4 | 27.8 | 0.82 | 0.32 | 2.56 | 0.64 | 0.56 | | |
| | Below Producer Level | | 4 | 3.7 | 0.79 | 0.32 | 0.32 | 0.08 | | | |
| | Total | | 4 | 31.5 | 0.81 | 0.32 | 2.88 | 0.72 | 0.50 | 1.64 | 0.41 |

* Table originally submitted as Table 2-3 in Leismer Demonstration Project November 2006 Errata

Figure A4.1-22 shows well pair and pad locations for the Leismer Commercial Hub development area. Figure A4.1-23 shows the pad and horizontal well locations in conjunction with the structure map on the base of the SAGD pay. Table A4.1-4 lists the producer horizontal wells and the structural elevations used in the calculations for Table A4.1-3. Individual plots of each horizontal producer well in the Leismer Commercial hub development area with a depth converted 3D seismic profile and key horizons are included at the back of this Appendix.

## Table A4.1-4 Elevations of Horizontal Producing Wells

| Well Pair Name | Well (productive) length (m) | Elevation of horizontal well (TVDSS m) - | Drilling Direction |
|---|---|---|---|
| 01-L01-P6 | 700 | 211 | N |
| 02-L01-P5 | 700 | 211 | N |
| 03-L01-P4 | 700 | 211 | N |
| 04-L01-P3 | 700 | 208 | N |
| 05-L01-P2 | 700 | 208 | N |
| 06-L01-P1 | 700 | 208 | N |
| 07-L02-P6 | 700 | 208 | N |
| 08-L02-P5 | 700 | 206 | N |
| 09-L02-P4 | 700 | 208 | N |

| Well Pair Name | Well (productive) length (m) | Elevation of horizontal well (TVDSS m) - | Drilling Direction |
|---|---|---|---|
| 10-L02-P3 | 700 | 208 | N |
| 11-L02-P2 | 700 | 210 | N |
| 12-L02-P1 | 700 | 210 | N |
| 13-L03-P6 | 700 | 208 | N |
| 14-L03-P5 | 700 | 208 | N |
| 15-L03-P4 | 700 | 208 | N |
| 16-L03-P3 | 700 | 206 | N |
| 17-L03-P2 | 700 | 206 | N |
| 18-L03-P1 | 700 | 206 | N |
| 19-L04-P4 | 700 | 213 | S |
| 20-L04-P3 | 700 | 213 | S |
| 21-L04-P2 | 700 | 212 | S |
| 22-L04-P1 | 700 | 212 | S |

An upper associated top thief zone, generally in continuity with SAGD pay, is locally present in channel complex. Figure A4.1-24 is an isopach of the McMurray associated net gas. This associated gas exclusively occurs in a sandstone found at the top of the B1 cross cutting channel filled occurs in several discrete areas and can be up to 9.7 m thick in the Leismer Commercial Hub development area. Two 2007 wells, AB/5-34-78-10 W4M and 14-27-78-10 W4M targeted the B1 channel and yielded 10.7 m and 2.8 m of gas, respectively.

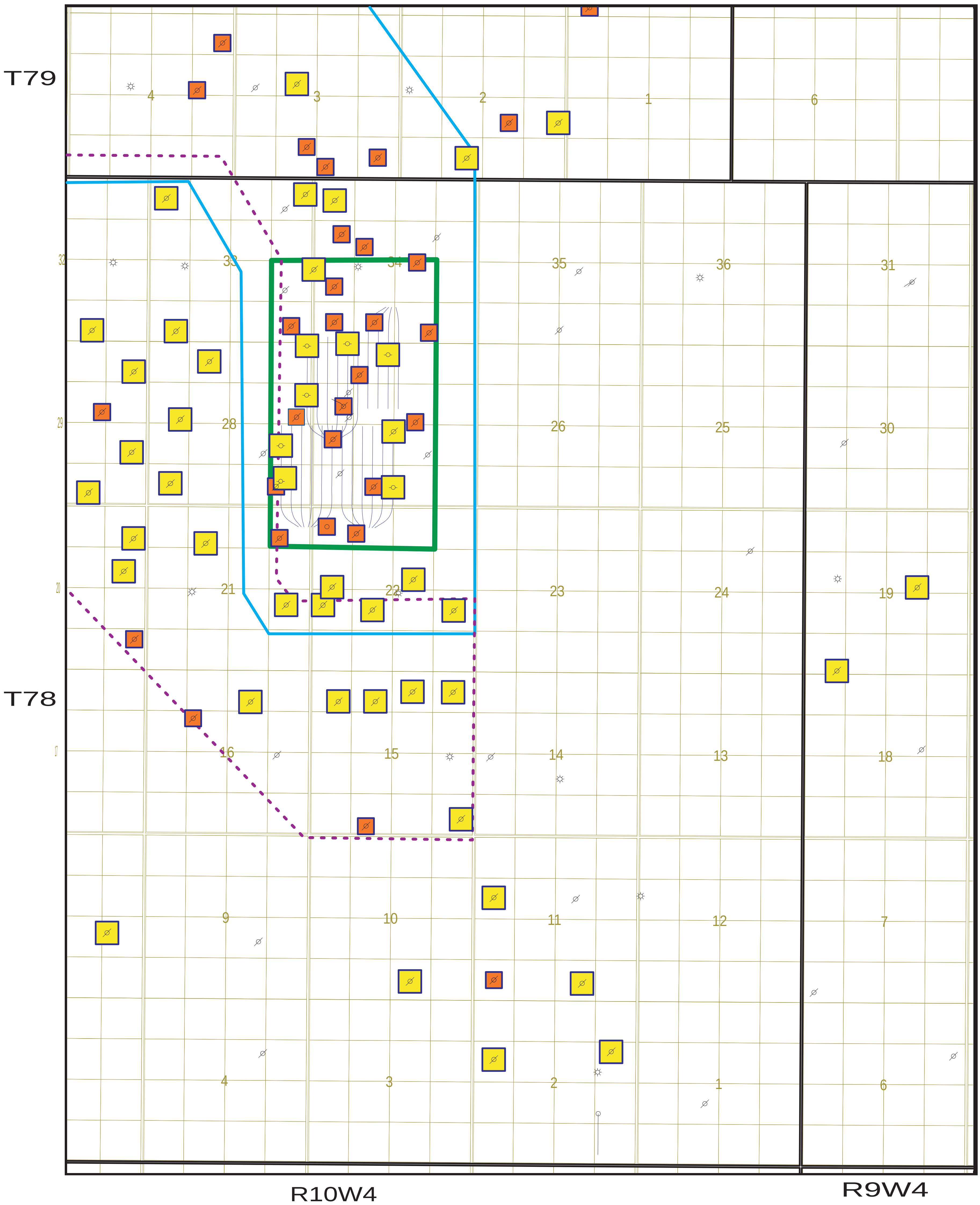
Figure A4.1-25 is a McMurray associated net top lean and top water isopach. The combined Zone is from 0.5 m (8-28-78-10W4M) to 13.6 m thick (100/16-33-78-10 W4M). The zone is typically interbedded with shale and a series of SFT pressure tests in the development area confirm no depletion has occurred in the associated gas or lean or top water zone. No associated gas is producing in the development area.

Non-associated gas (Figure A4.1-26) and non-associated bitumen (Figure A4.1-27) are present in the regional sequences (typically A or B1). Thin bitumen legs occur with the non-associated gas and can be up to 8 m thick but are typically around 3 m. Table A4.1-5 is a listing of all the gas wells, status and owners in the vicinity of the Leismer Commercial Hub development area. No associated McMurray gas is producing in the area.

### Table A4.1-5 Gas Wells in the Vicinity of the Project Area

| Well | Gas Zone | Status as of May 2007 | Owner | Associated or Non Associated | In Hub Area? |
|---|---|---|---|---|---|
| 00/9-6-78-9 W4M | McMurray A2, B1 seq | Flowing | BP Canada | N | N |
| 00/12-19-78-9 W4M | McMurray A2, B1 seq | Flowing | EnCana Corp | N | N |
| 00/6-1-78-10 W4M | McMurray A2 seq | Flowing | Paramount Energy | N | N |
| 00/9-2-78-10 W4M | McMurray A2 seq | Flowing | Paramount Energy | N | N |
| 00/4-11-78-10 W4M | | Flowing | Paramount Energy | | N |
| 00/12-12-78-10 W4M | McMurray A2, | Flowing | Paramount Energy | N | N |

| Well | Gas Zone | Status as of May 2007 | Owner | Associated or Non Associated | In Hub Area? |
|---|---|---|---|---|---|
| | B1 seq | | | | |
| 00/7-14-78-10 W4M | | Flowing | Paramount Energy | | N |
| 00/8-15-78-10 W4M | McMurray A2 seq | Flowing | Paramount Energy | N | N |
| 00/6-21-78-10 W4M | McMurray A1 seq | Suspended | Paramount Energy | A | N |
| 00/7-22-78-10 W4M | Grand Rapids | Flowing | Paramount Energy | N | N |
| 00/5-33-78-10 W4M | McMurray A1,A2, B1 Regional | Flowing | Paramount Energy (65%), Primewest Energy (35%) | N | N |
| 00/6-34-78-10 W4M | McMurray A1, B1 Regional | Flowing | Paramount Energy (65%), Primewest Energy (35%) | N | Y |
| 00/6-36-78-10 W4M | McMurray A2, B1, B2 seq B2 Channel | Flowing | Paramount Energy | N | N |
| 00/12-2-79-10 W4M | McMurray A1 Regional | Flowing | Paramount Energy (65%), Primewest Energy (35%) | N | N |




Leismer Initial Development Area

3D Seismic Survey 2007

3D Seismic Survey 2006

NAOSC Drilled 2007

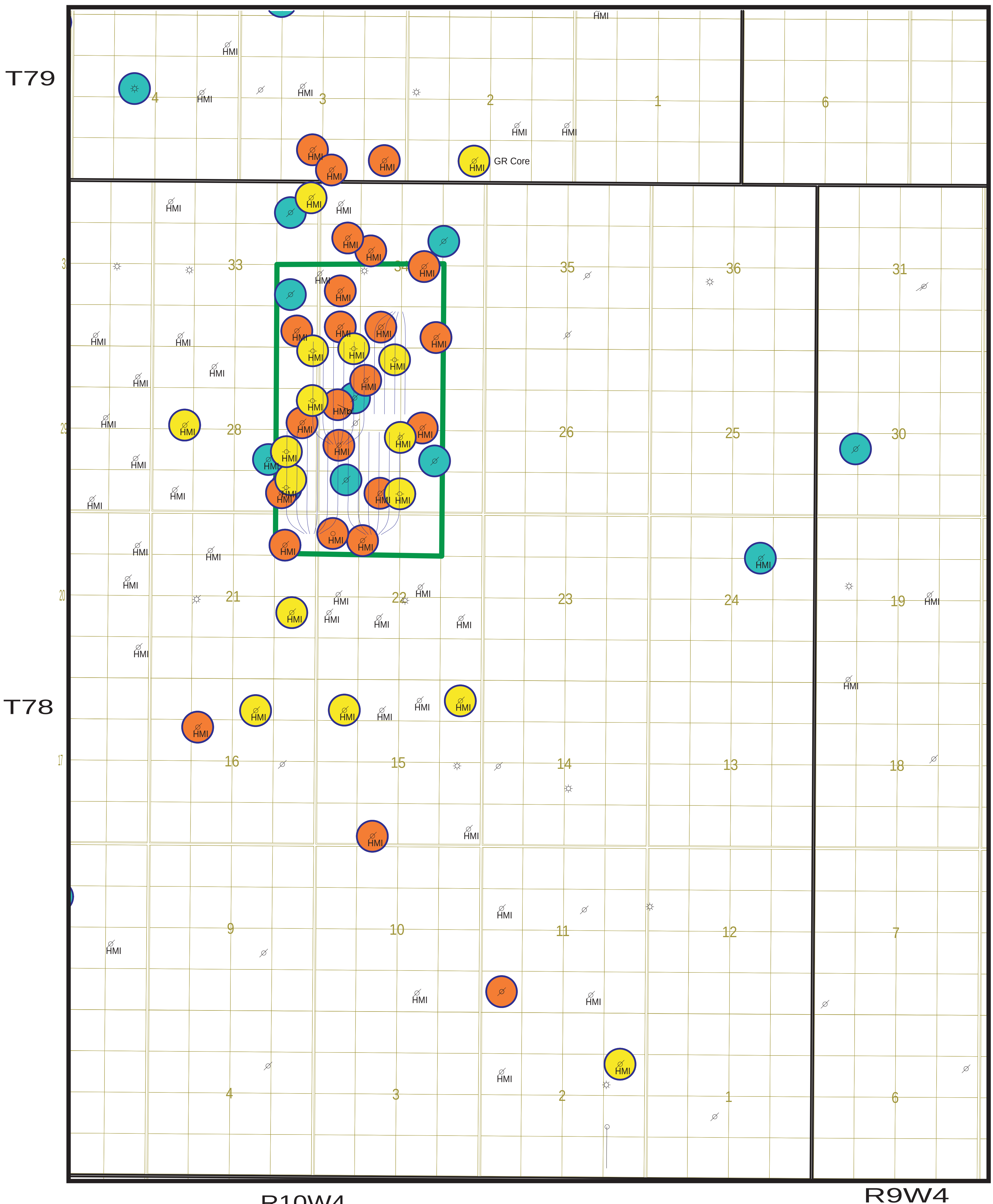
NAOSC Drilled 2005 & 2006

# Figure A4.1-1A
# Well Control & 3D Seismic

North American

Leismer
Well Control & 3D Seismic Surveys

| Author: J. Lobsinger, P. GEOL. | CUTOFF: | Date: 9 May, 2007 |
|---|---|---|
| | Scale: 1:40,000 | |




Leismer Initial Development Area

NAOSC Cored 2007

NAOSC Cored 2005 & 2006

Pre 2005 Legacy Core

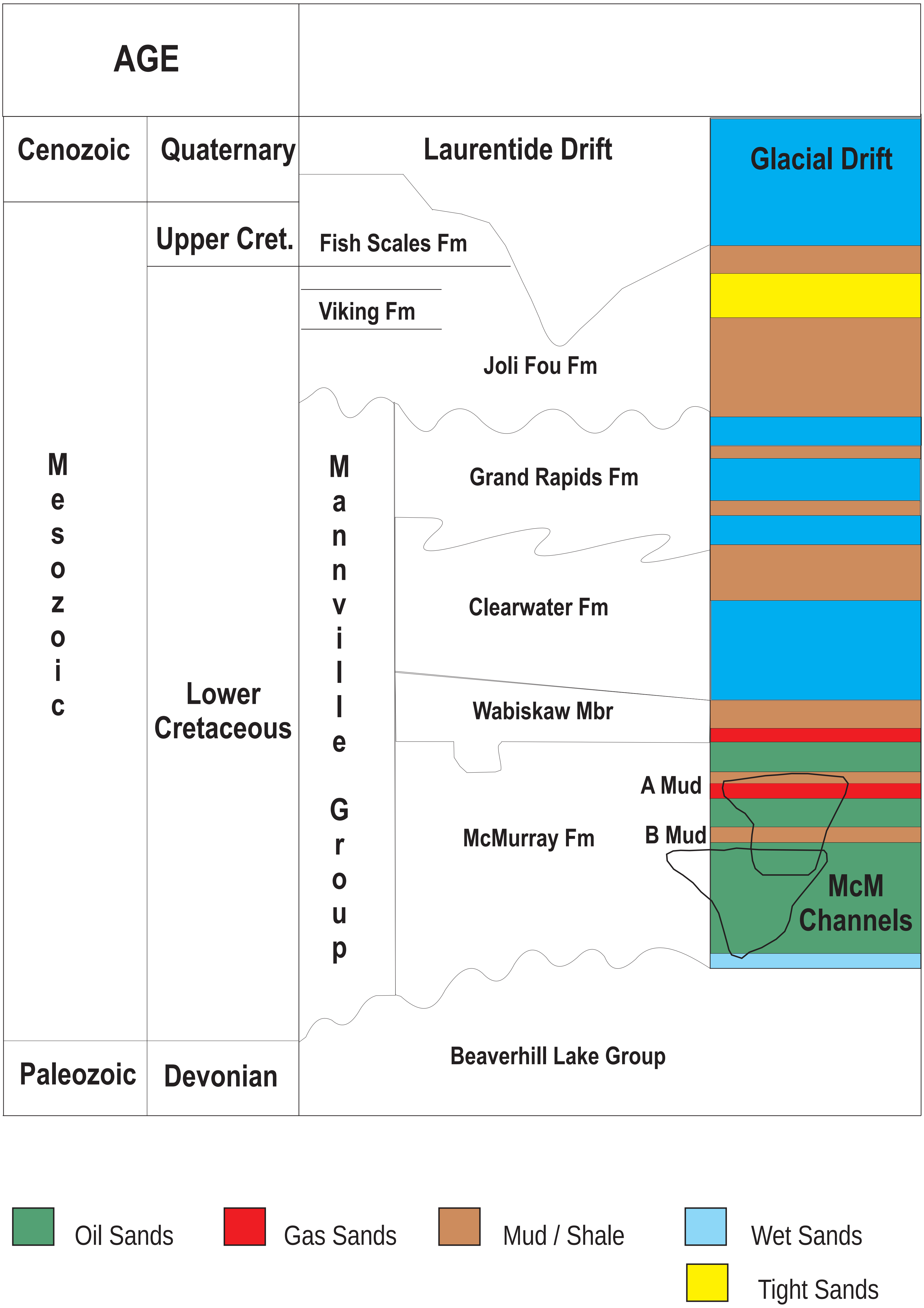
HMI NAOSC HMI Logs

# Figure A4.1-1B
# Cored Wells, HMI Logs

NORTH AMERICAN

Leismer
All Cored Wells and HMI Wells

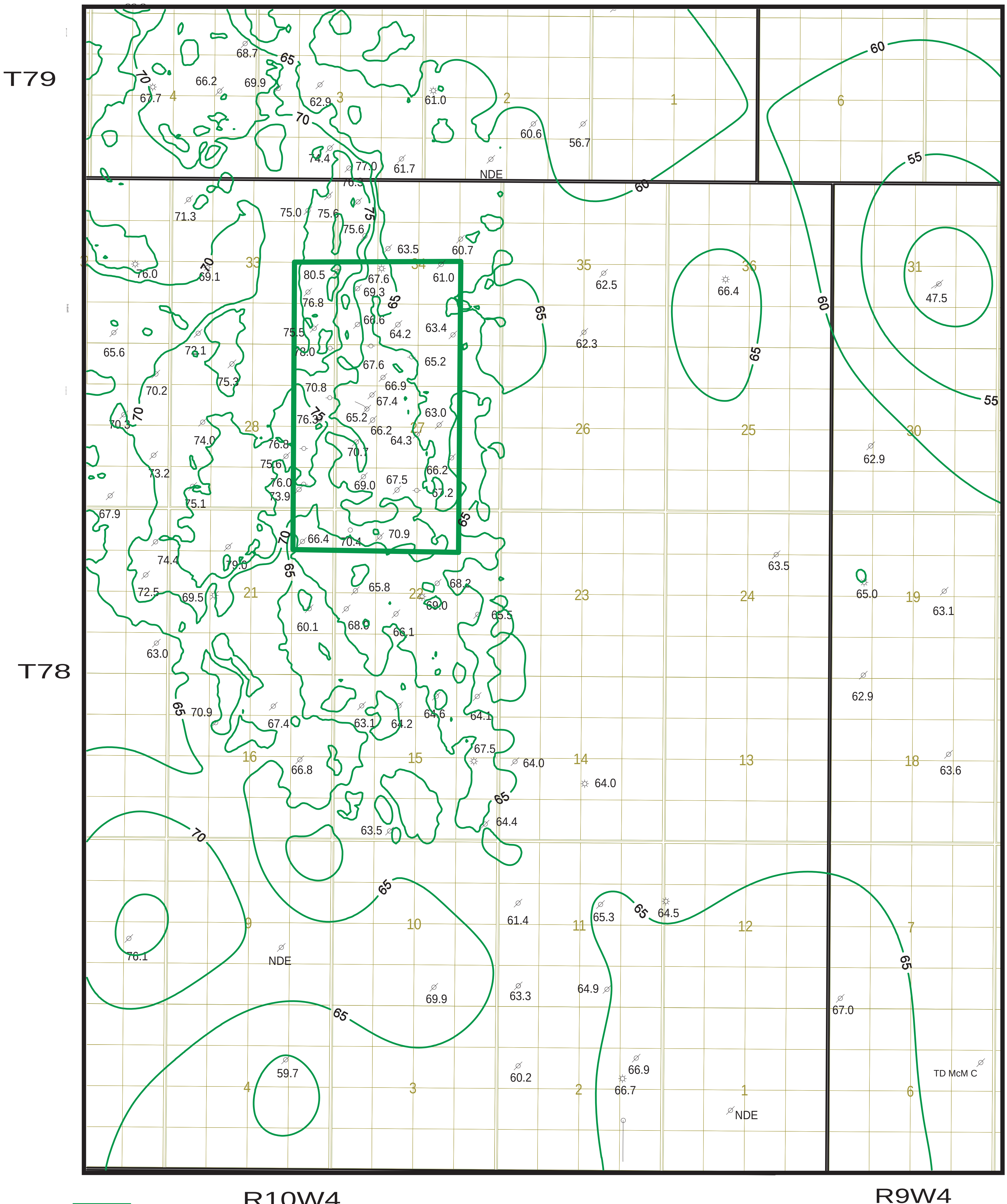
| | | |
|---|---|---|
| Author: J. Lobsinger, P. GEOL. | CUTOFF: | Date: 4 May, 2007 |
| | Scale: 1:40,000 | |




**General Stratigraphy in the Regional Study Area**

NORTH AMERICAN OIL SANDS CORPORATION

**Figure A 4.1-2**




Leismer Initial Development Area

64.5 Wabiskaw to Sub-Cretaceous Unconformity Posted Isopach

TD McM C Total Depth McMurray Channel

NDE Not Deep Enough

Figure A4.1-3 Wabiskaw to Sub-Cretaceous Unconformity Isopach Modified with 3D Seismic

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
Wabiskaw to Sub-Cretaceous Unconformity
Isopach Modified with 3D Seismic

| | | |
|---|---|---|
| Author: J. Lobsinger, P. GEOL. | CUTOFF: | Date: 13 June, 2007 |
| C.I.=5 m | Scale: 1:40,000 | |

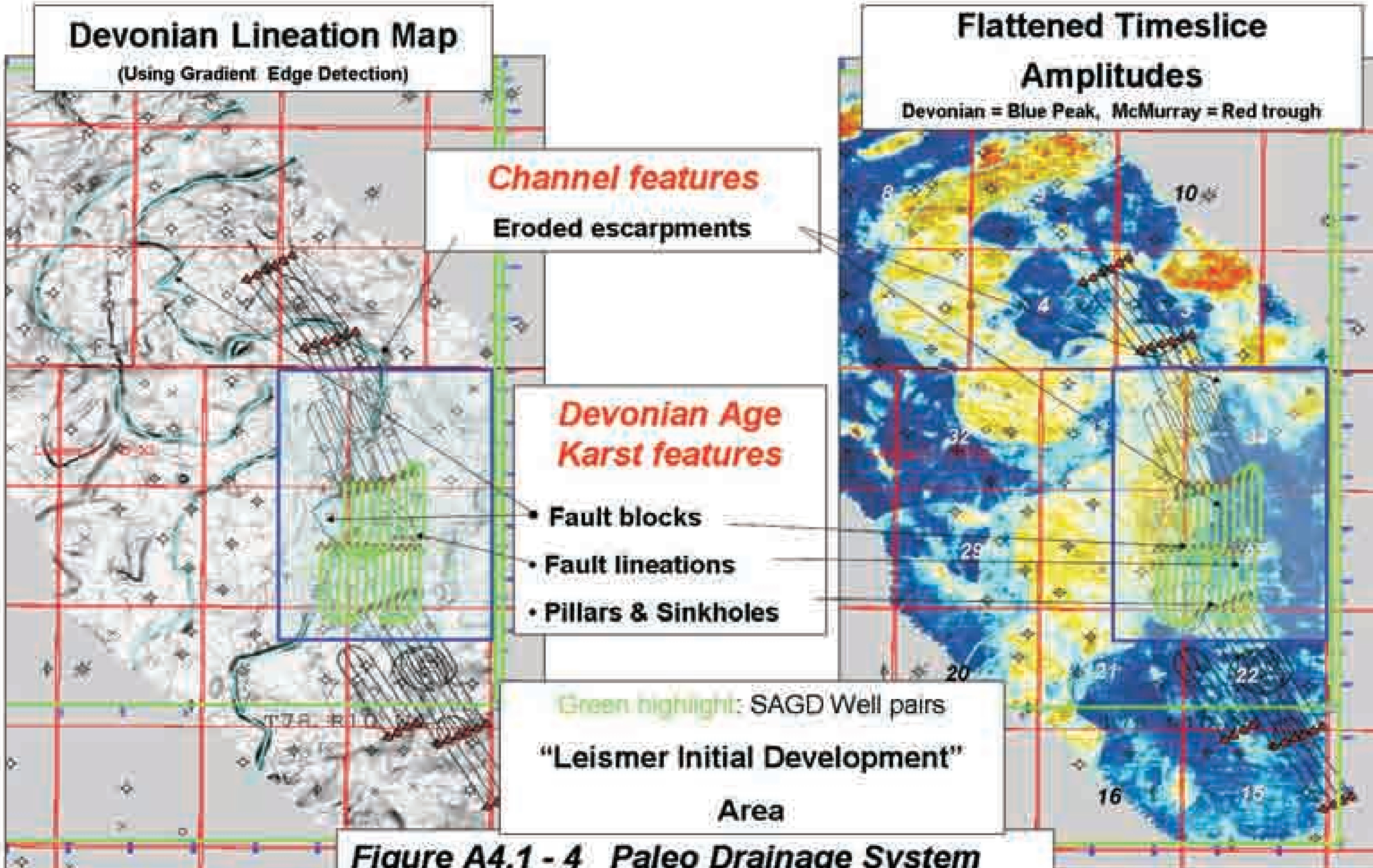
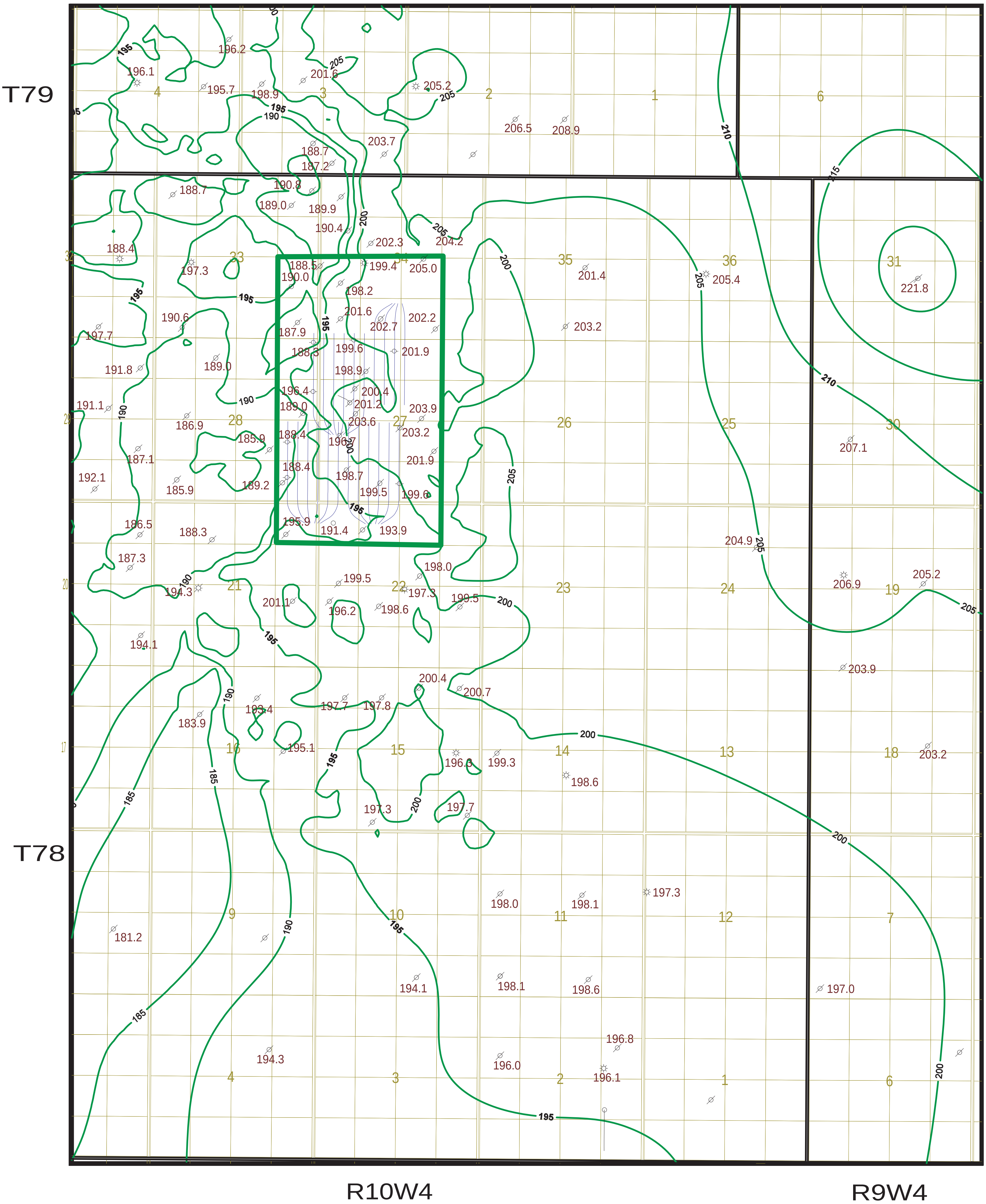



*Figure A4.1 - 4 Paleo Drainage System*




Leismer Initial Development Area

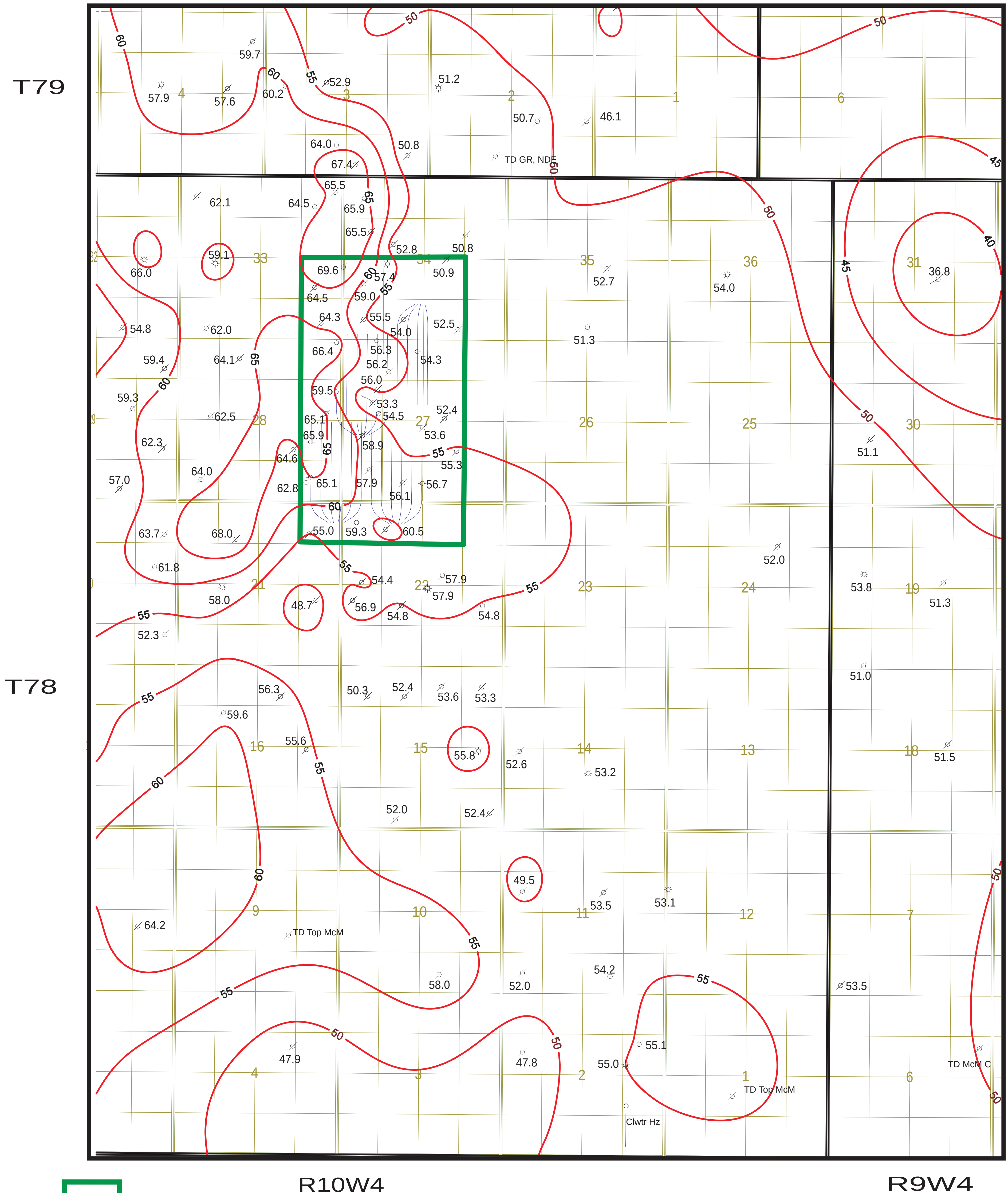
198.1 Sub-Cretaceous Unconformity Posted Value

# Figure A4.1-5
# Sub-Cretaceous Unconformity Structure Modified with Seismic

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
Sub-Cretaceous Unconformity Structure Modified with Seismic

| Author: J. Lobsinger, P. GEOL. | CUTOFF: | Date: 18 May, 2007 |
|---|---|---|
| C.I.=4m | Scale: 1:40,000 | |




Leismer Initial Development Area

55.8 McMurray to Sub-Cretaceous Unconformity Poster Isopach

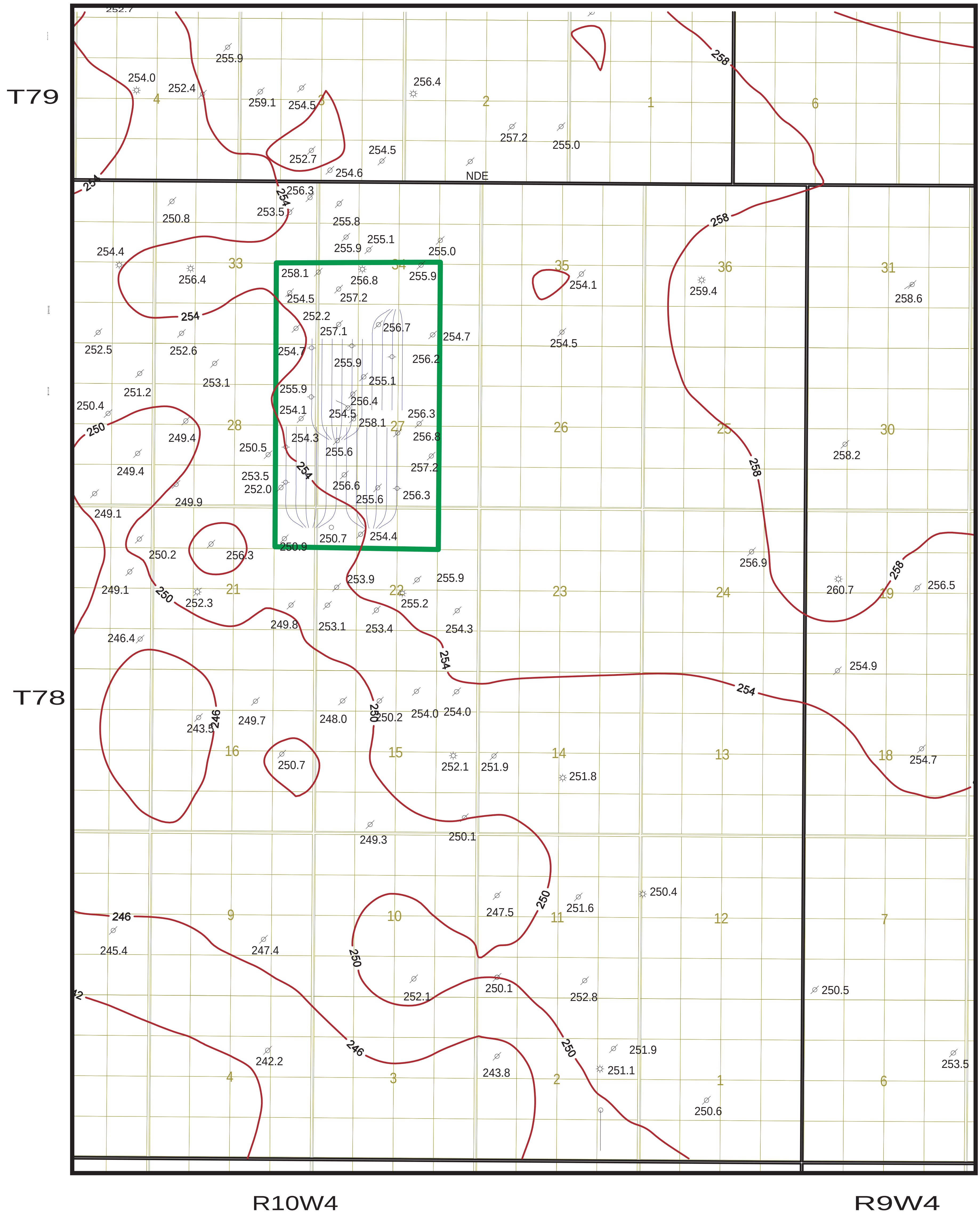
TD McM C Total Depth McMurray Channel

Clwtr HZ Clearwater Horizontal

# Figure A4.1-6 McMurray to SubCretaceous Unconformity Isopach

Leismer
McMurray to SubCretaceous Unconformity

| Author: J. Lobsinger, P.GEOL. | CUTOFF: | Date: 16 June, 2007 |
|---|---|---|
| C.I.=5m | Scale: 1:40,000 | |




Leismer Initial Development Area

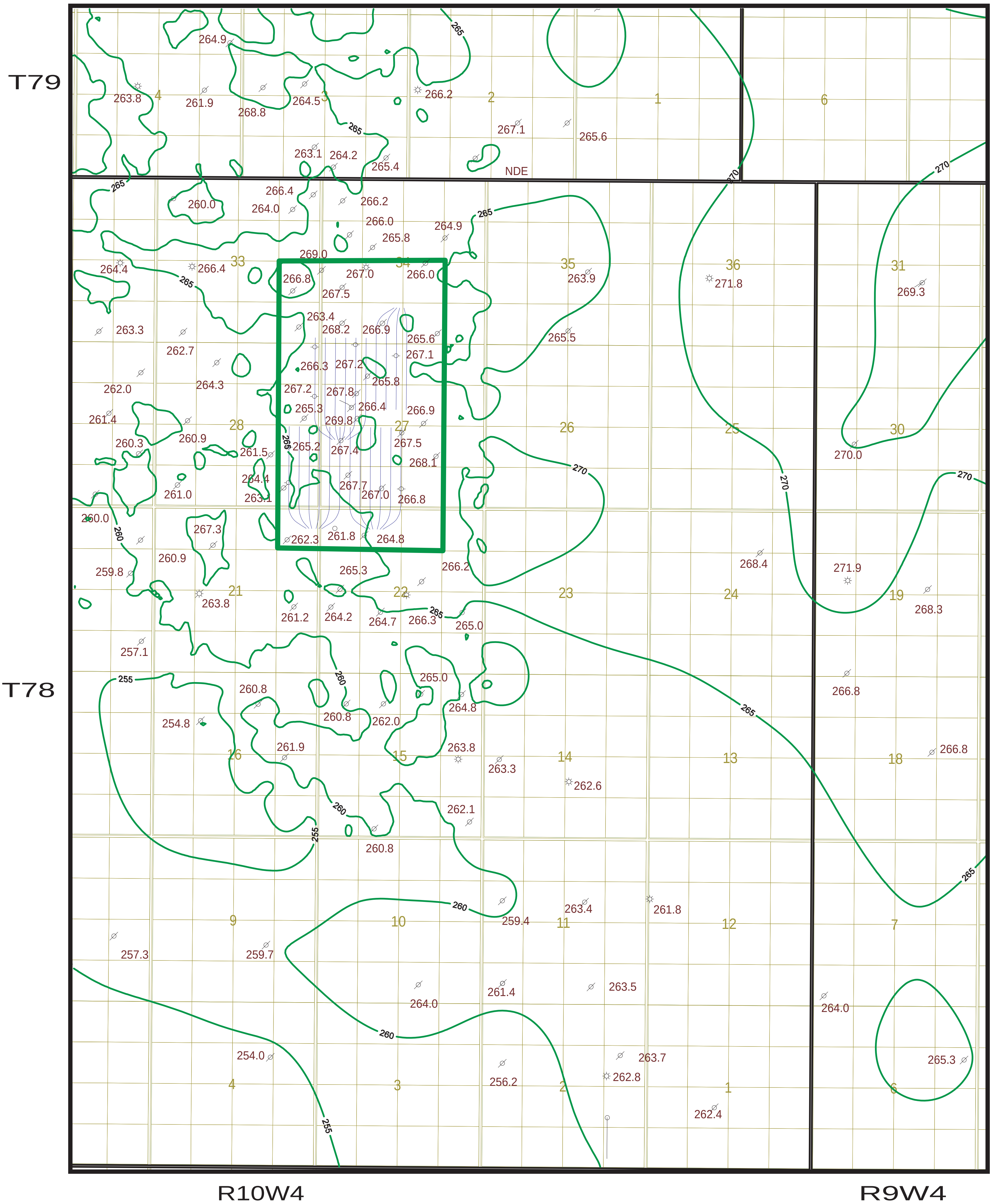
251.6 McMurray Structure Posted Value

# Figure A4.1-7
# McMurray Structure

NORTH AMERICAN OIL SANDS CORPORATION

Leisme
McMurray Structure

| Author: J.Lobsinger, P. GEOL. | CUTOFF: | Date: 13 June, 2007 |
| --- | --- | --- |
| CI=4m | Scale:1:40,000 | |




Leismer Initial Development Area

269.4 Wabiskaw Structure Posted Value

# Figure A4.1-8 Wabiskaw Structure Modified with 3D Seismic

Leismer
Wabiskaw Structure Modified with 3D Seismic

| | | |
|---|---|---|
| Author: J. Lobsinger, P. GEOL. | CUTOFF: | Date: 13 June, 2007 |
| C.I.=5m | Scale: 1:40,000 | |

AB/03-34-078-10W400

NORTH AMERICAN OIL S
NAOSC / PARA LEISMER 3-34-78-10
TWP. 78 - Range: 10 - Sec. 34

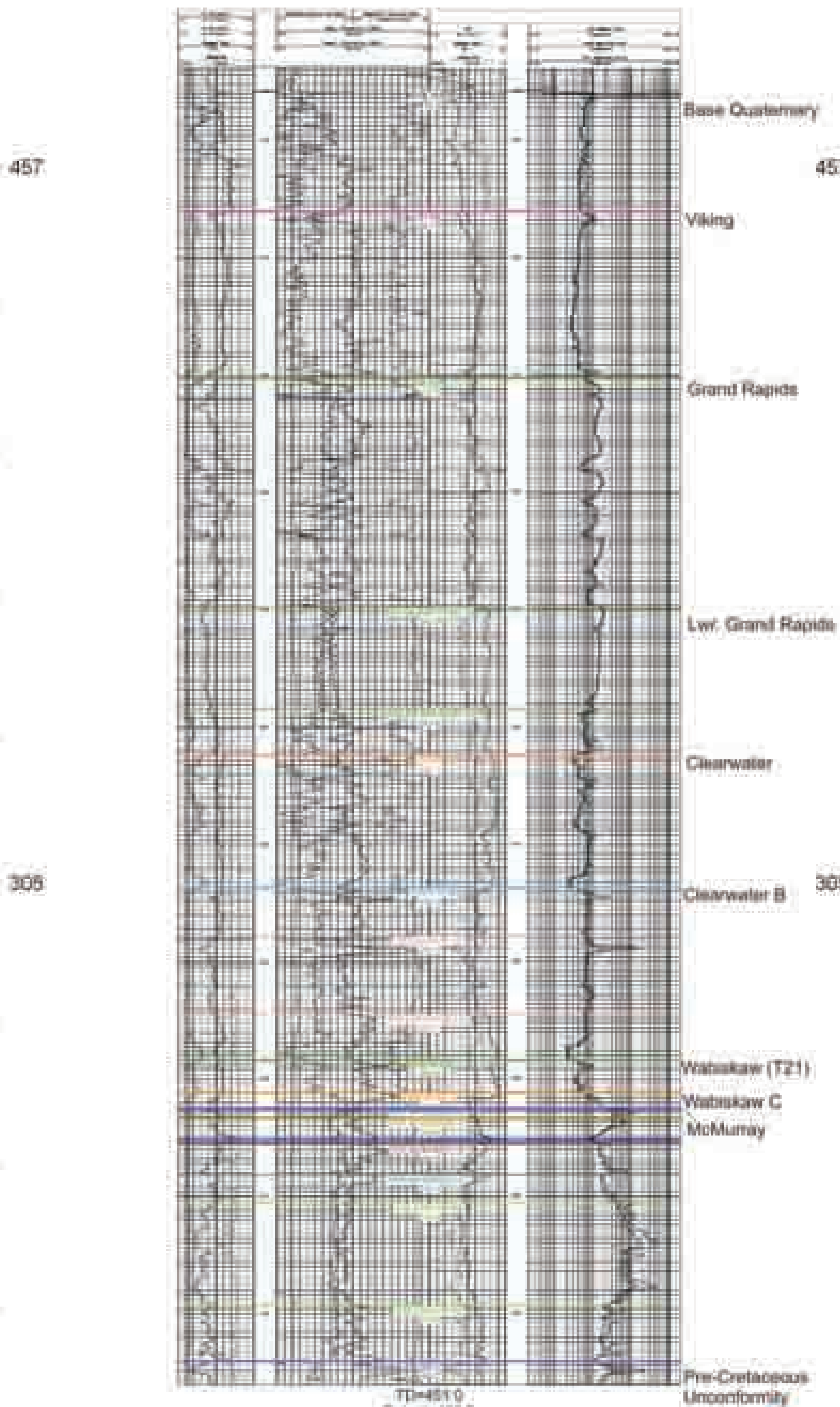



Figure A4.1-9

Type Log
AB/03-34-078-10W4

NORTH AMERICAN OIL SANDS CORPORATION

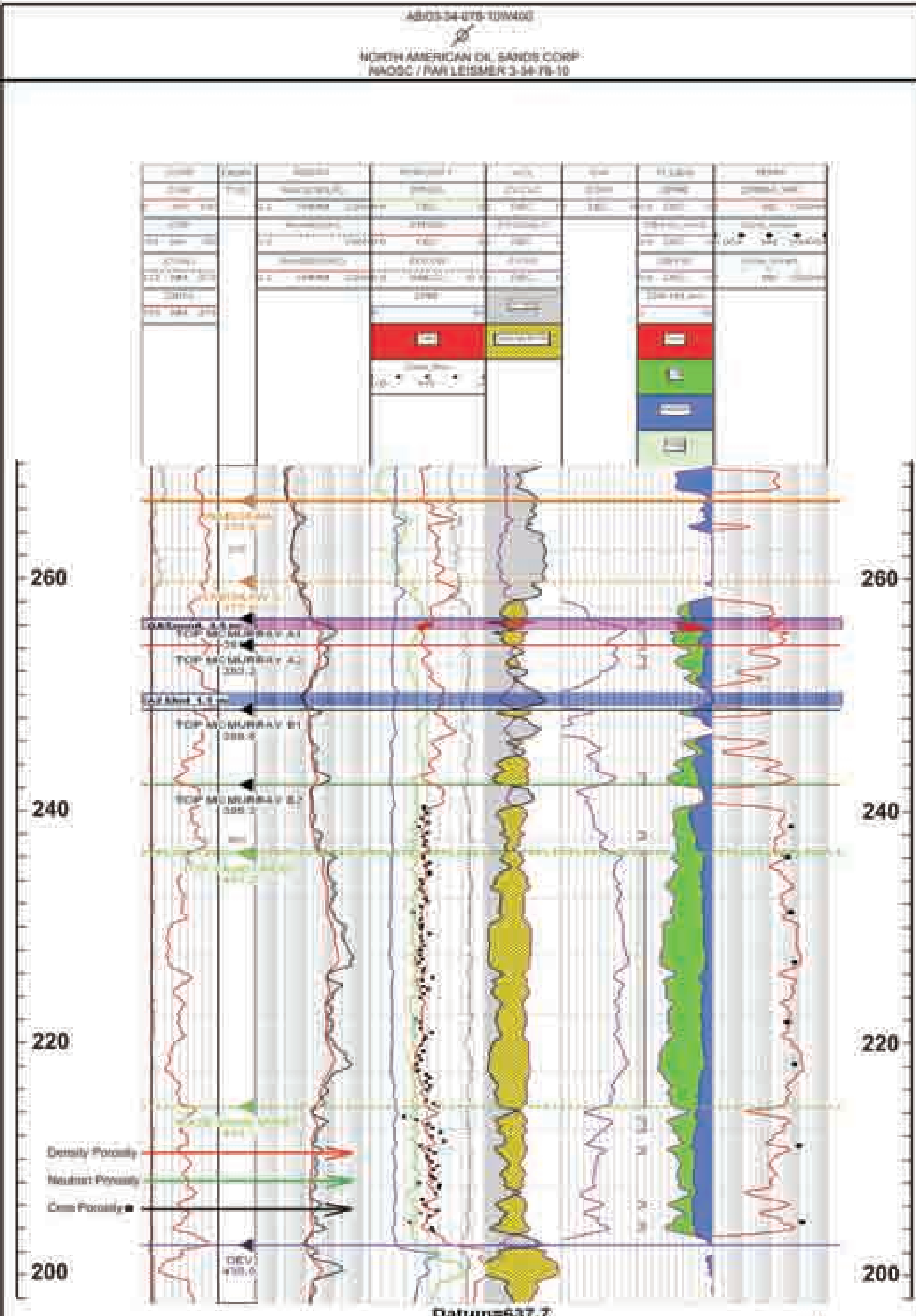
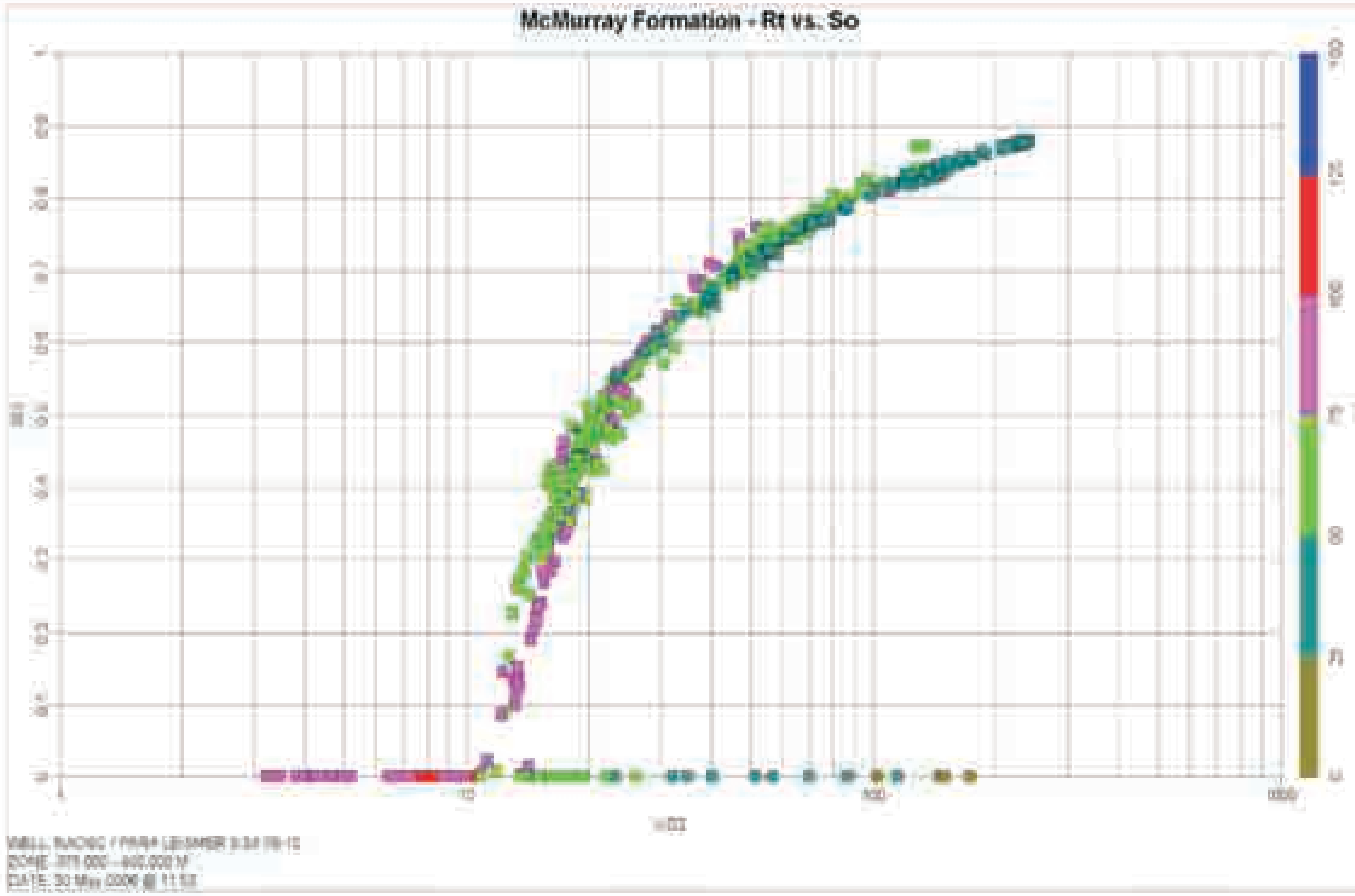



**Figure A4.1-10 Core to Log Comparison AB/03-34-078-10W4 Shaly Sand Analysis**

NORTH AMERICAN OIL SANDS CORPORATION




## ARCHIE'S WATER SATURATION:

$$(SW)^N = \frac{A}{(PHI)^M} \cdot \frac{RW}{RT}$$

Rw= 0.55, a=1, m=1.8, n=2

Rt@ 20ohms = 50% So ~ 6%wt

Rt@ 40ohms = 70% So ~ 11%wt

NORTH AMERICAN OIL SANDS CORPORATION

Figure A4.1-11 Rt vs So Pickett Plot of 3-34-78-10W4

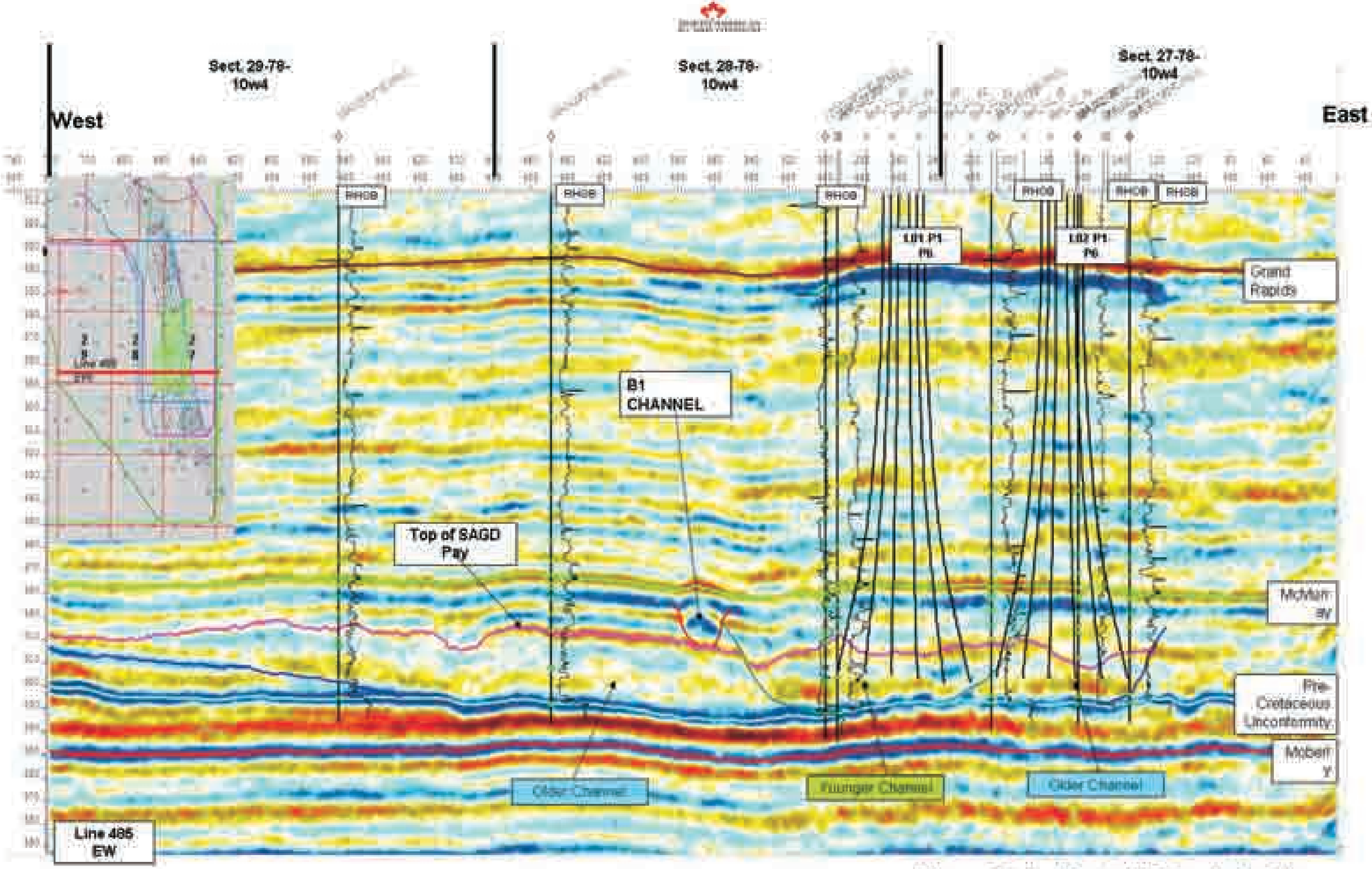



Figure A4.1 – 12 EW Seismic Profile

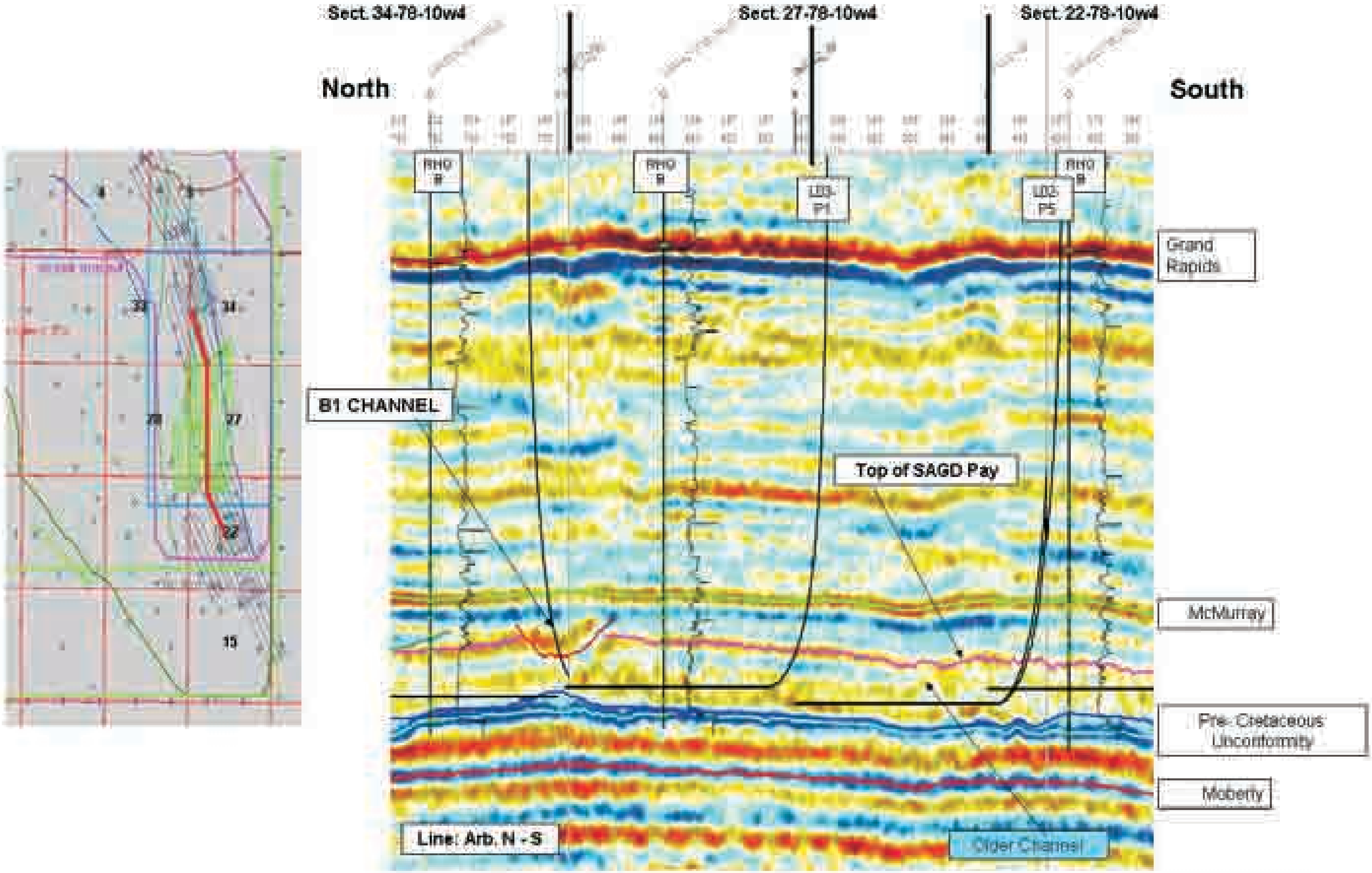



**Figure A4.1 - 13 NS Seismic Profile**

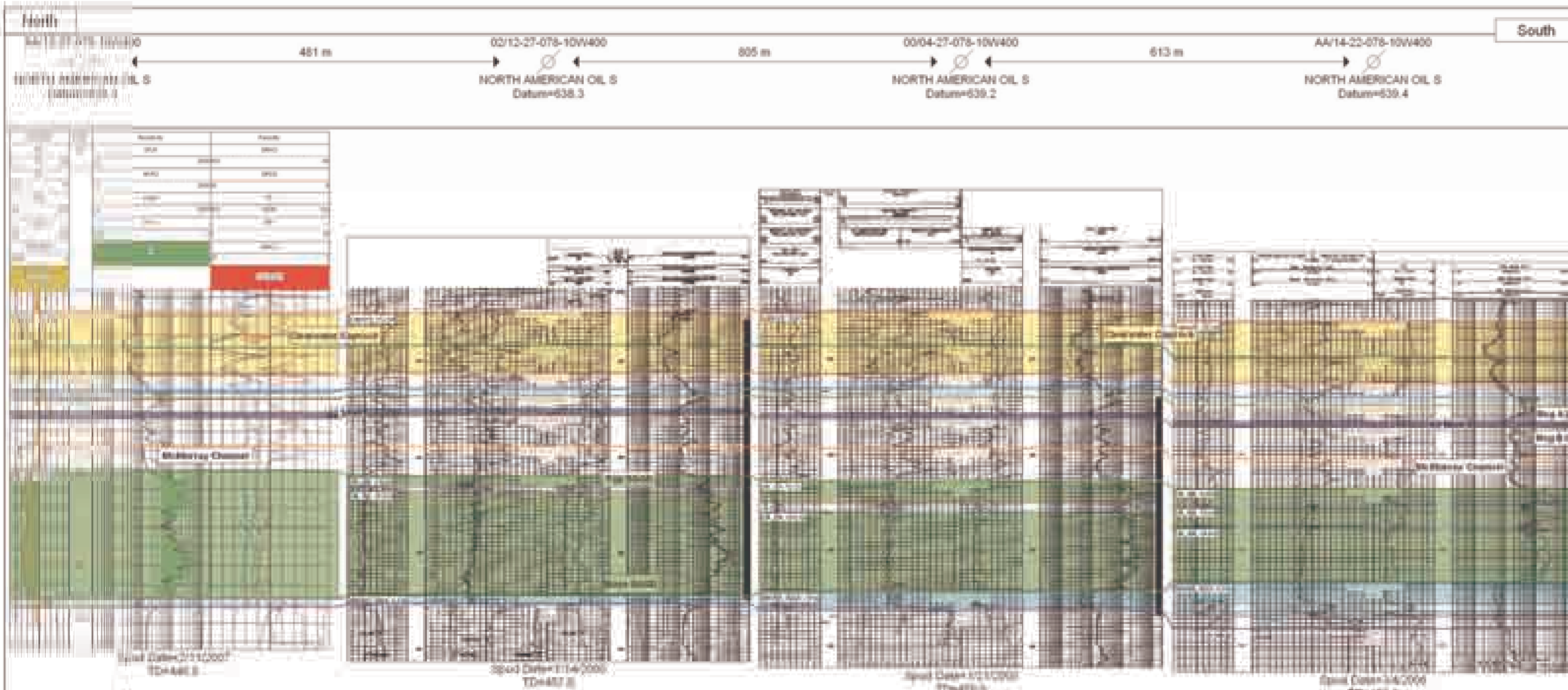



**Figure A4.1-14 Leismer Initial Development Area North to South Cross Section (Across Pad 2 & 3) Structural**

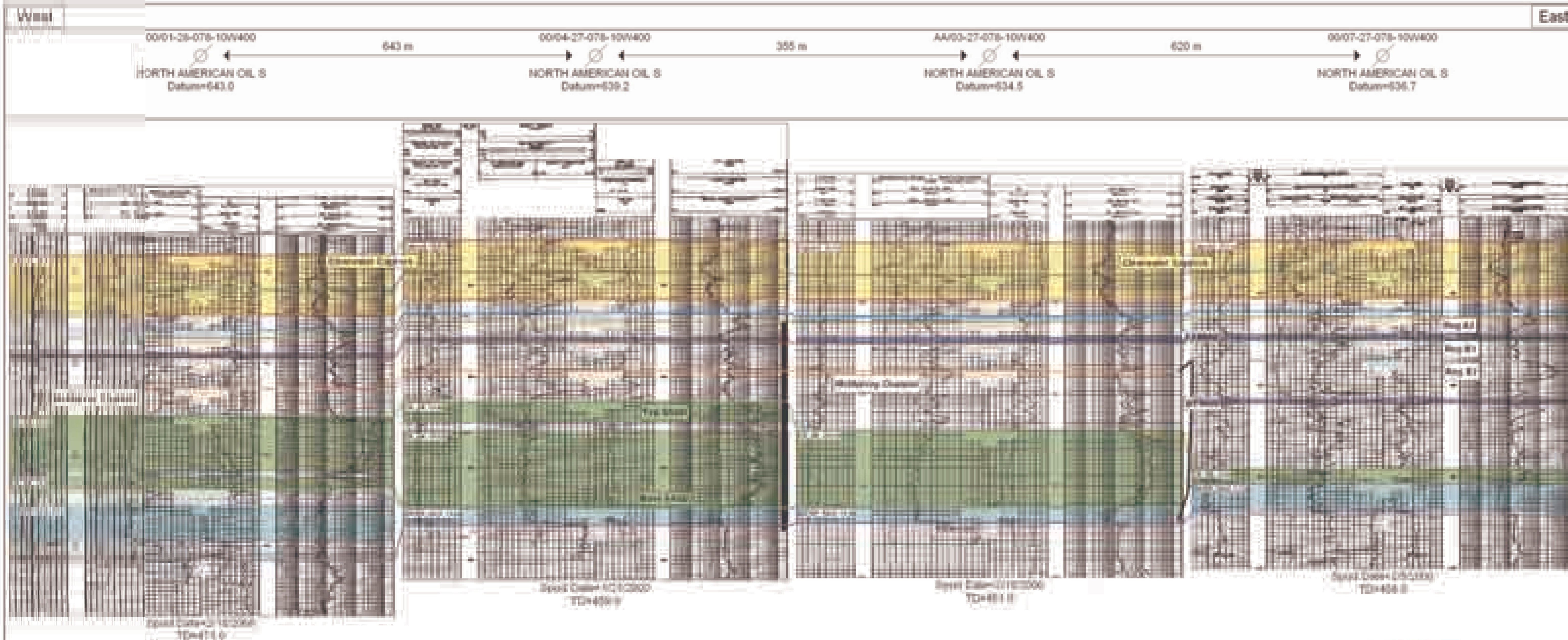
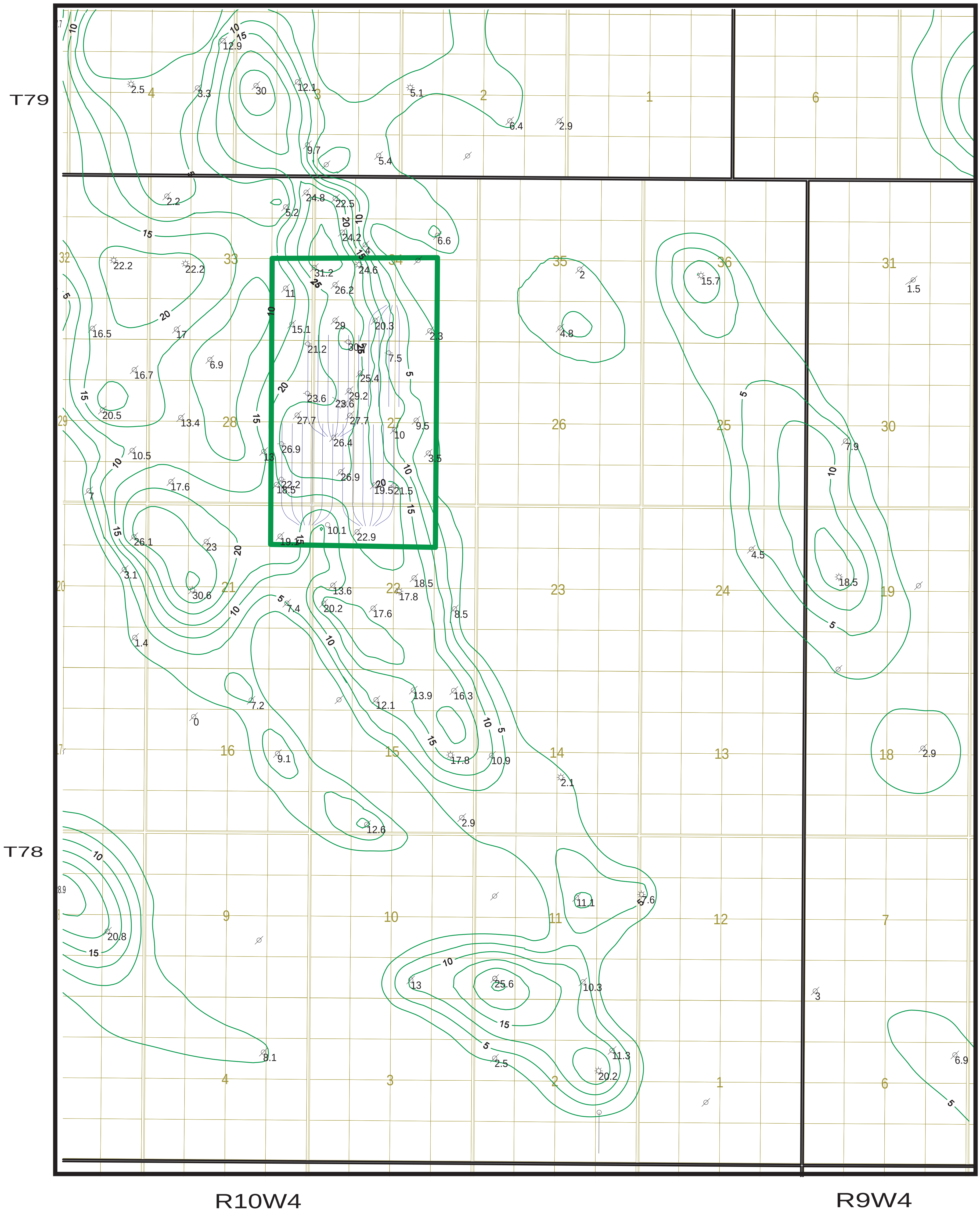



**Figure A4.1-15 Leismer Initial Development Area West to East Cross-Section (Across Pad 1 & 2) Structural**



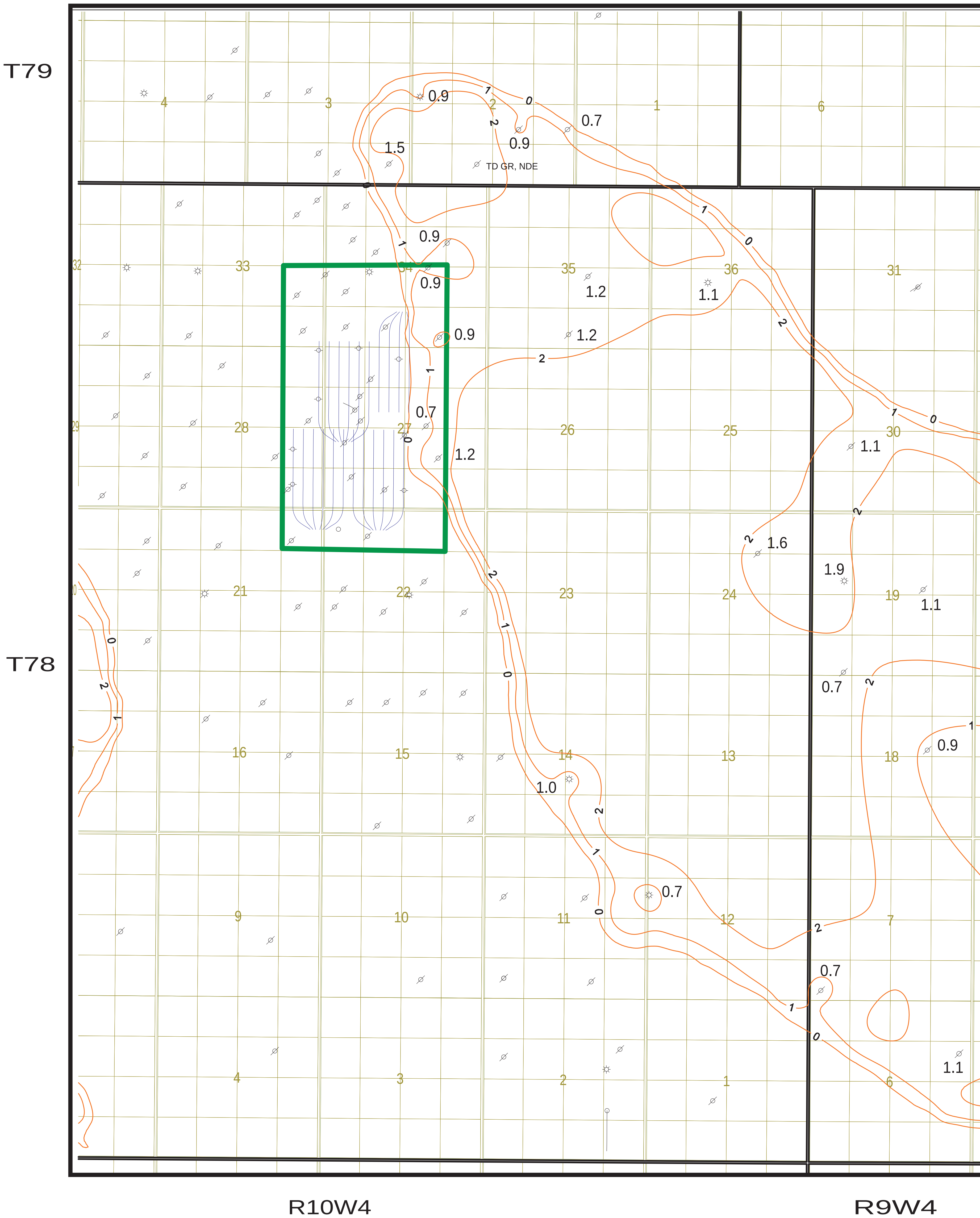

Leismer Initial Development Area

2.2 Net SAGD Pay Posted Isopach Value

Figure A4.1-16 McMurray Net Pay Bitumen (6 Wt% Cutoff)

NORTH AMERICAN OIL SANDS CORPORATION

| Leismer McMurray Net SAGD Bitumen Pay (6 wt% Cutoff) | | |
|---|---|---|
| Author: J. Lobsinger, P. GEOL. | CUTOFF: 27% Porosity, 40 ohms Resistivity, 2m vertical mud facies | Date: 4 July, 2007 |
| | Scale: 1:40,000 | |




Leismer Initial Development Area

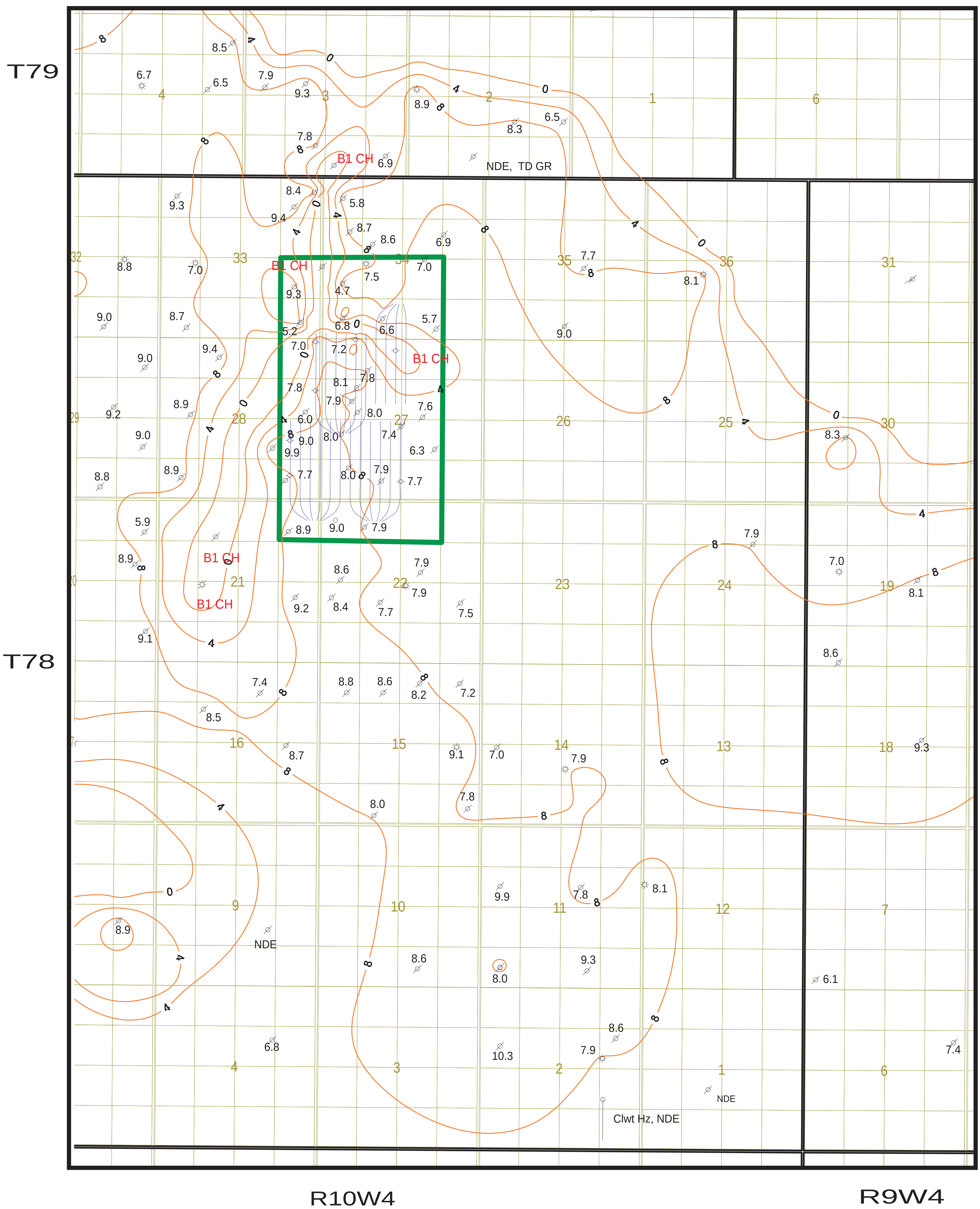
0.7 B2 Mud Posted Isopach Value

# Figure A4.1-17 McMurray Channel Cap Rock Isopach (McMurray B2 Mud)

North American Oil Sands Corporation

Leismer
McMurray B2 Mud Distribution
(.5m thickness cutoff)

| | | |
|---|---|---|
| Author: J. Lobsinger, P. GEOL. | CUTOFF: 10 ohms Resistivity, CNL/FDC divergence | Date: 14 June, 2007 |
| CI: 1m | Scale: 1:40,000 | |



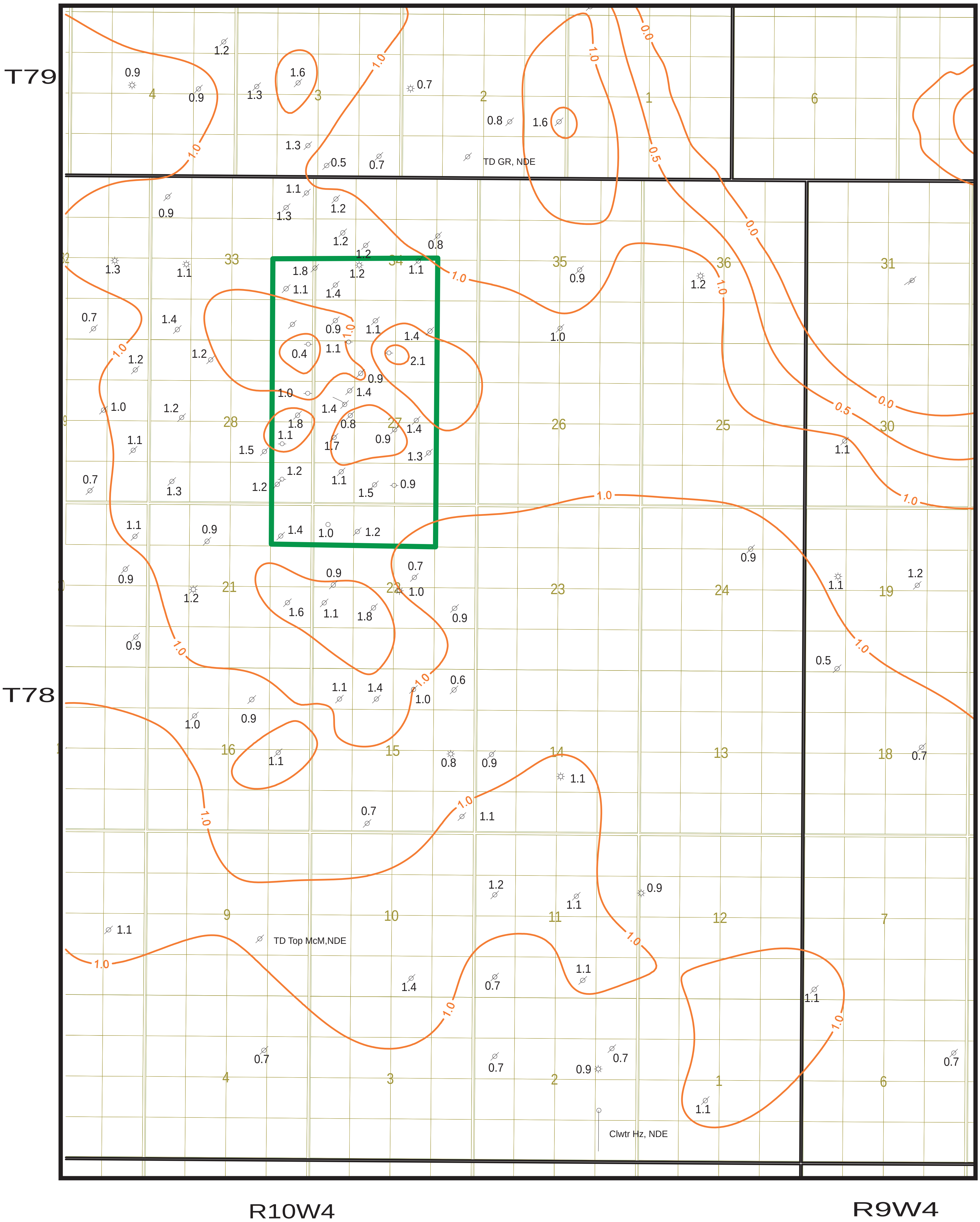

Leismer Initial Development Area

1.1 McMurray B1 Parasequence Isopach Contour

# Figure A4.1-18 McMurray B1 Parasequence Isopach

Leismer
B1 Parasequence Isopach

| Author: J. Lobsinger, P. GEOL. | CUTOFF: | Date: 14 June, 2007 |
|---|---|---|
| C.I.=4m | Scale: 1:40,000 | |




Leismer Initial Development Area

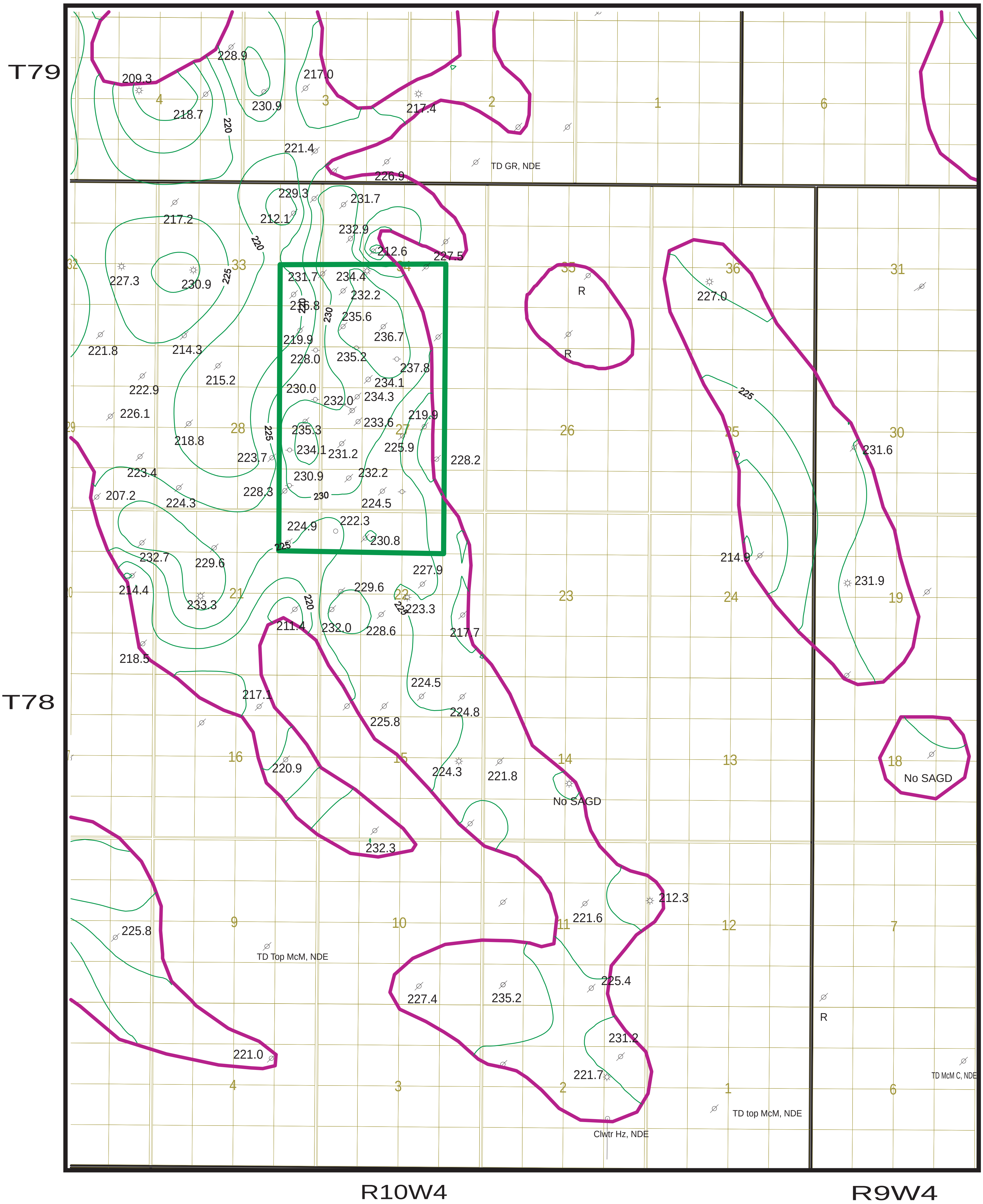
2.2 A2 Mud Posted Isopach Value

# Figure A4.1-19 McMurray Channel Cap Rock Isopach (McMurray A2 Mud)

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
McMurray A2 Mud Distribution
(.5m thickness cutoff)

| Author: J. Lobsinger, P. GEOL. | CUTOFF: 10 ohms Resistivity, CNL/FDC divergence | Date: 14 June, 2007 |
|---|---|---|
| CI: 0.5m | Scale: 1:40,000 | |




Zero Edge SAGD

Leismer Initial Development Area

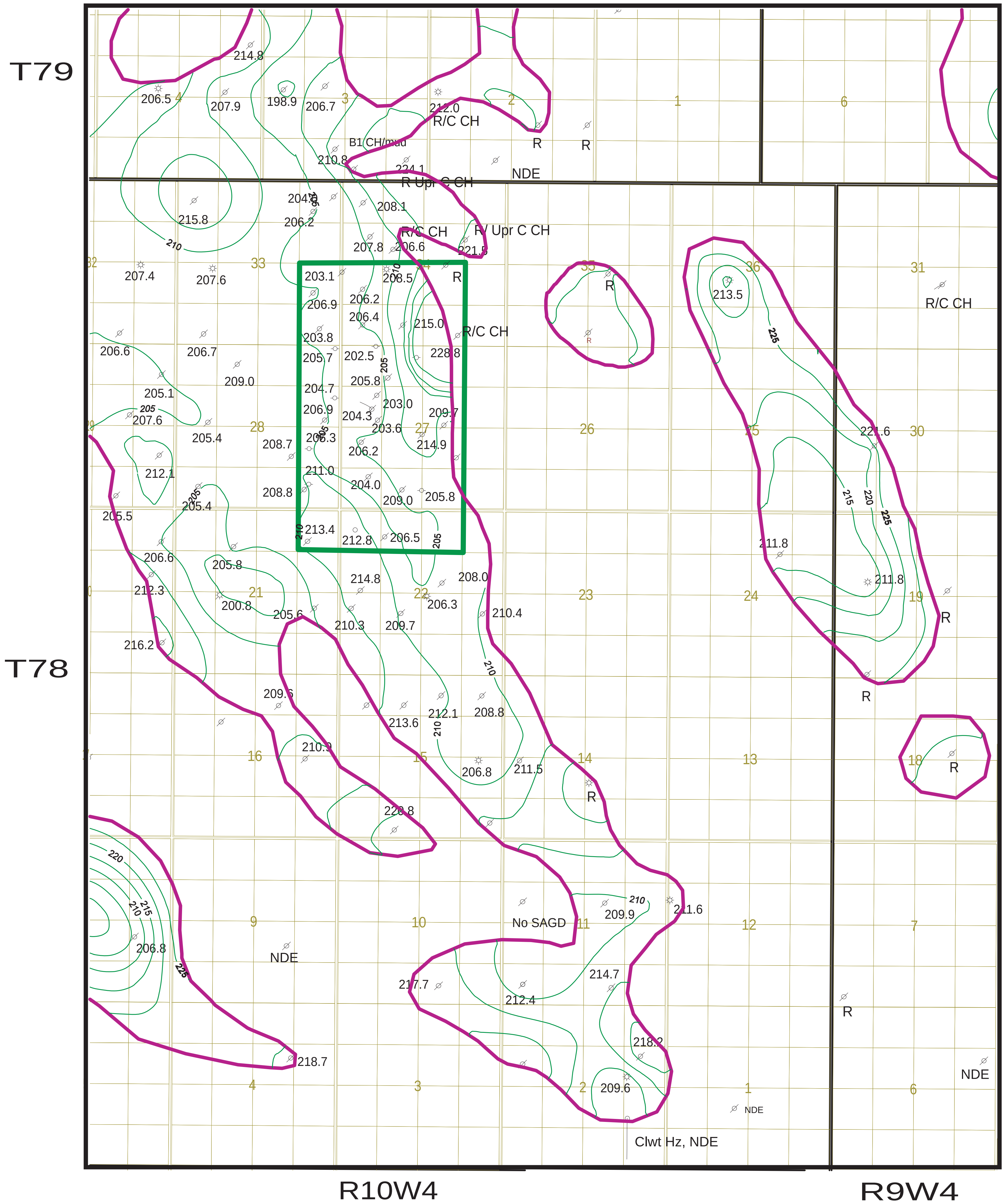
224.3 Top SAGD Posted Structural Value

# Figure A4.1-20 Top SAGD Structure

North American Oil Sands Corporation

Leismer
Top SAGD Structure

| | | |
|---|---|---|
| Author: J. Lobsinger, P. GEOL. | CUTOFF: 27% Porosity, 40 ohms Resistivity, 2m vertical mud facies | Date: 19 July, 2007 |
| CI: 5m | Scale: 1:40,000 | |




Zero Edge SAGD

Leismer Initial Development Area

NDE Not Deep Enough

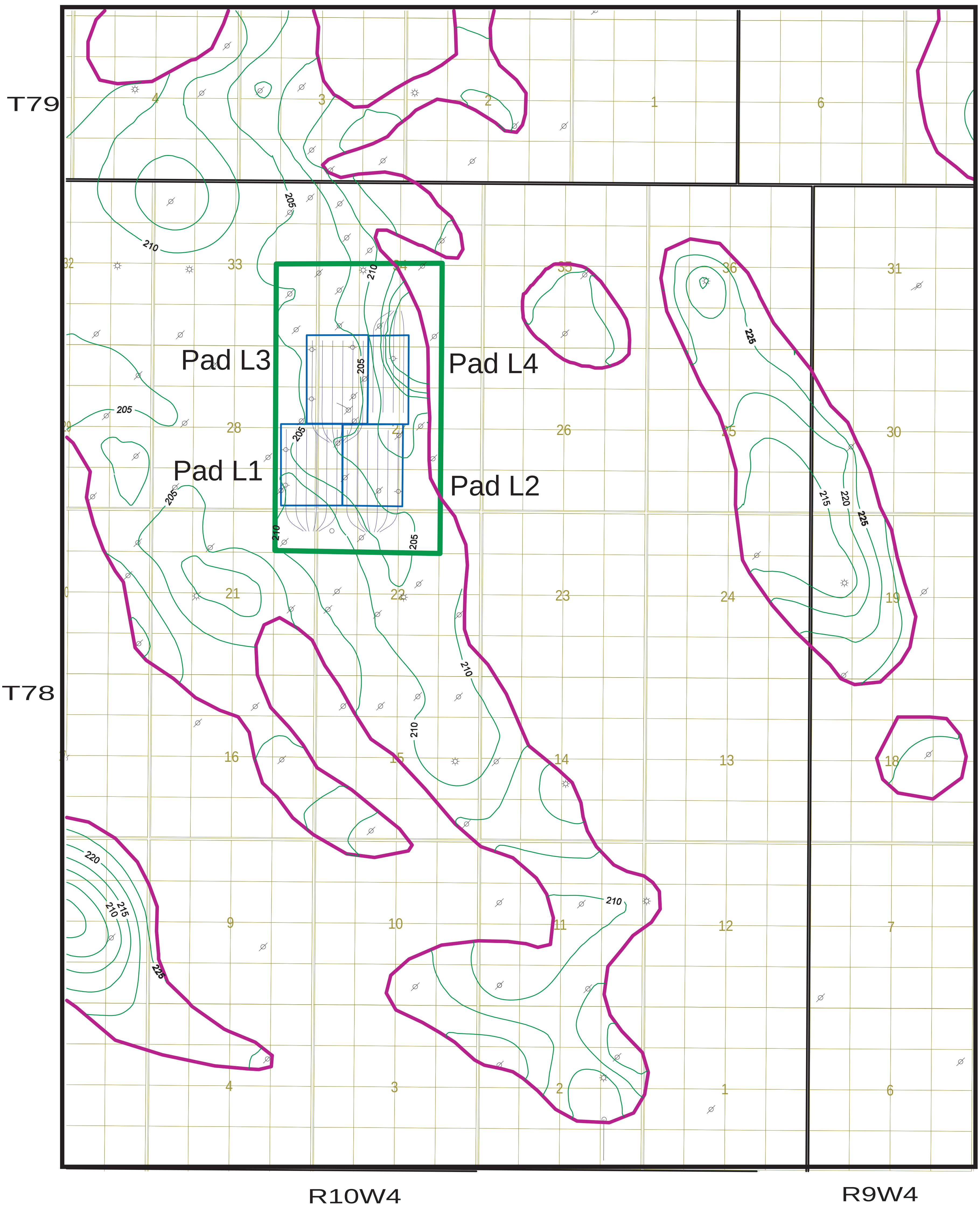
R Regional

210.5 Base SAGD Posted Structure Value

# Figure A4.1-21 Base SAGD Structure

NORTH AMERICAN OIL SANDS CORPORATION

| Leismer Base SAGD Structure (0m pay cutoff) | | |
|---|---|---|
| Author: J. Lobsinger, P. GEOL. | CUTOFF: 27% Porosity, 40 ohms Resistivity, 2m vertical mud facies | Date: 25 May, 2007 |
| | Scale: 1:40,000 | |




Zero Edge SAGD

Leismer Initial Development Area

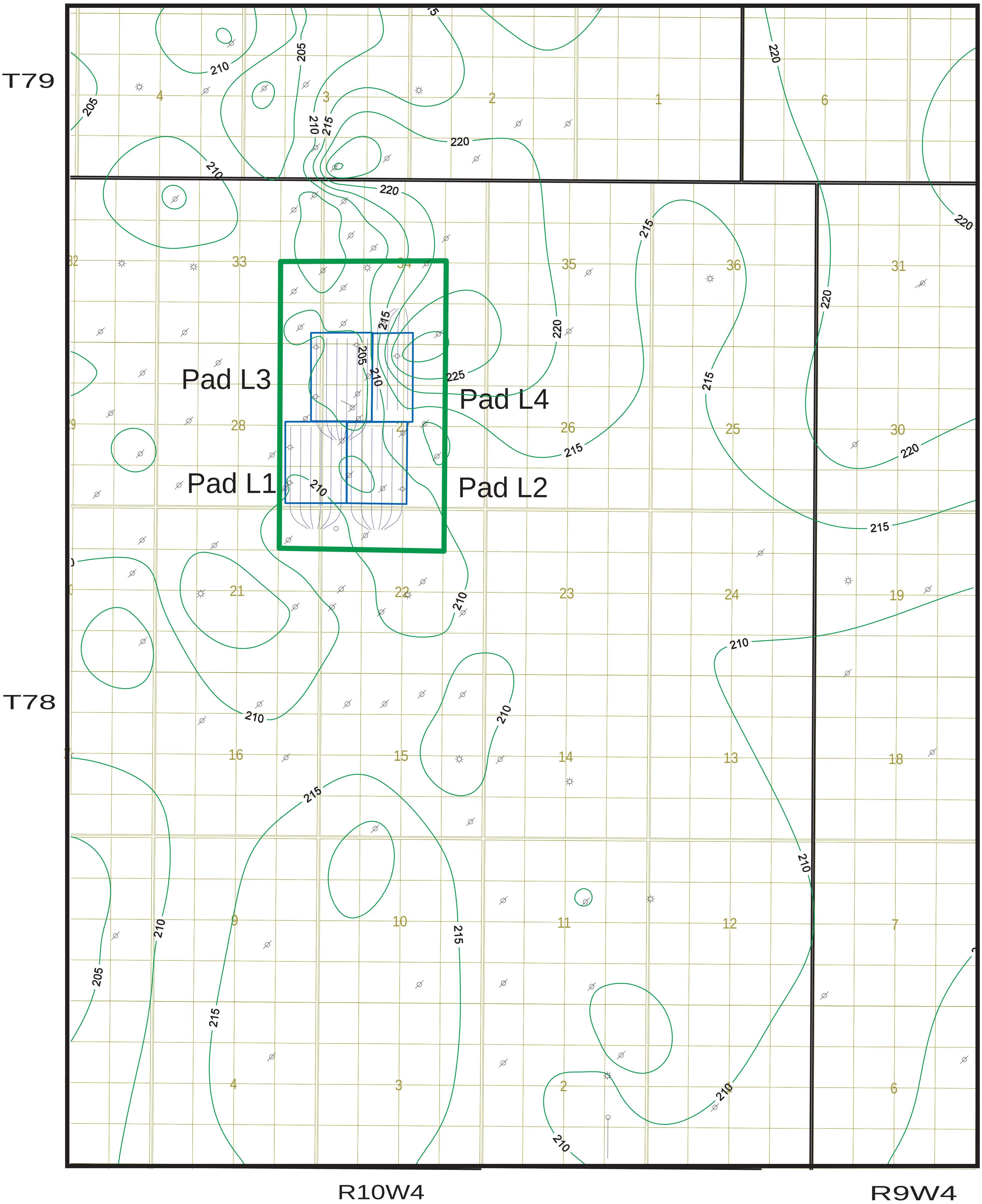
Well Pad Drainage Areas

Figure A4.1-22 Location of Drainage Pads and Horizontal Wells

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
Location of Drainage Pads and Horizontal Wells

| Author: J. Lobsinger, P. GEOL. | CUTOFF: | Date: 24 May, 2007 |
| --- | --- | --- |
| | Scale: 1:40,000 | |



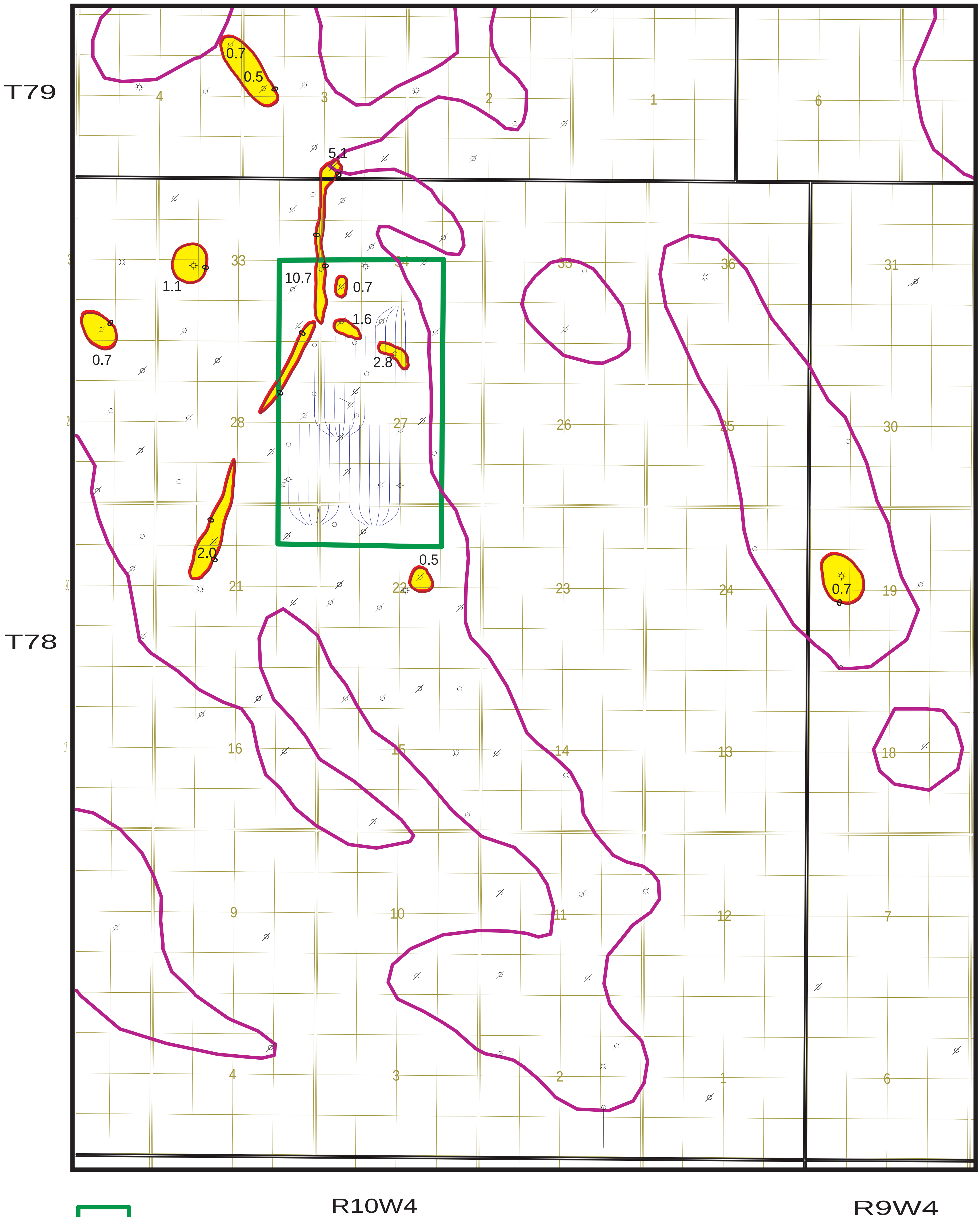

Leismer Initial Development Area

Well Pad Drainage Areas

# Figure A4.1-23 Drainage Pads and Horizontal Well Pairs with Base SAGD Structure

Leismer
Drainage Pads and Horizontal Wells with Base SAGD Structure

| | | |
|---|---|---|
| Author: J. Lobsinger, P. GEOL. | | Date: 14 June, 2007 |
| CI: 5m | Scale: 1:40,000 | |




Leismer Initial Development Area

SAGD Bitumen Zero Edge

Associated Gas

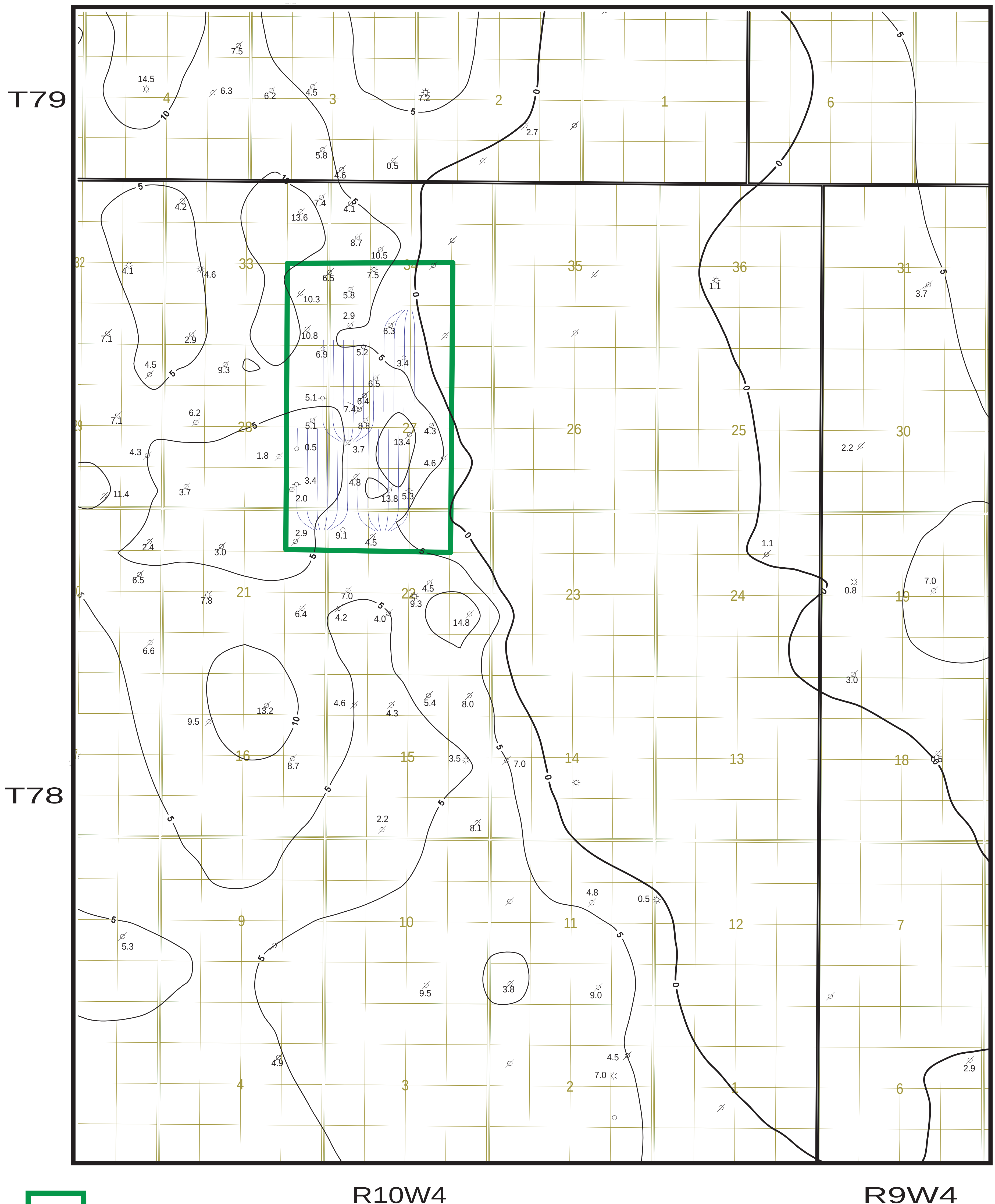
2.2 Associated Gas Posted Value

# Figure A4.1-24 McMurray Associated Net Gas Pay (Thief Zone Gas)

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
McMurray Associated Net Gas Pay Isopach

| Author: J. Lobsinger, P.GEOL. | CUTOFF: | Date: 9 May, 2007 |
|---|---|---|
| | Scale: 1:40,000 | |




Leismer Initial Development Area

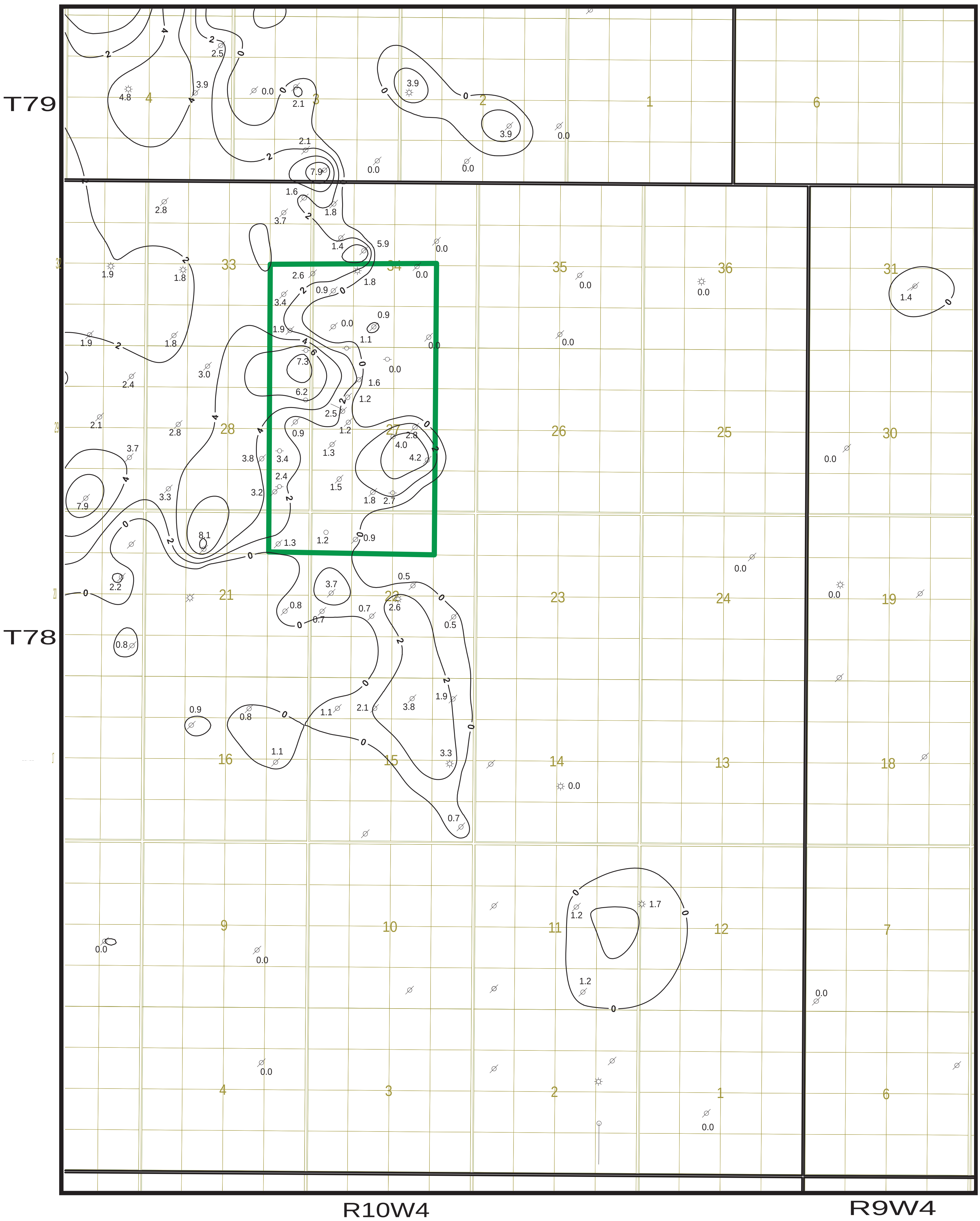
4.4 Net Top Lean & Top Water Posted Value (Thief Zone)

Figure A4.1-25 Net Top Lean & Net Top Water Isopach (Thief Zone)

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
Net Top Lean & Top Water Isopach
(Thief Zone)

| Author: J.Lobsinger, P. GEOL. | CUTOFF: 0 to 40ohms, includes top water, 27% Porosity | Date: 14 June, 2007 |
|---|---|---|
| CI=5m | Scale: 1:40000 | |




Leismer Initial Development Area

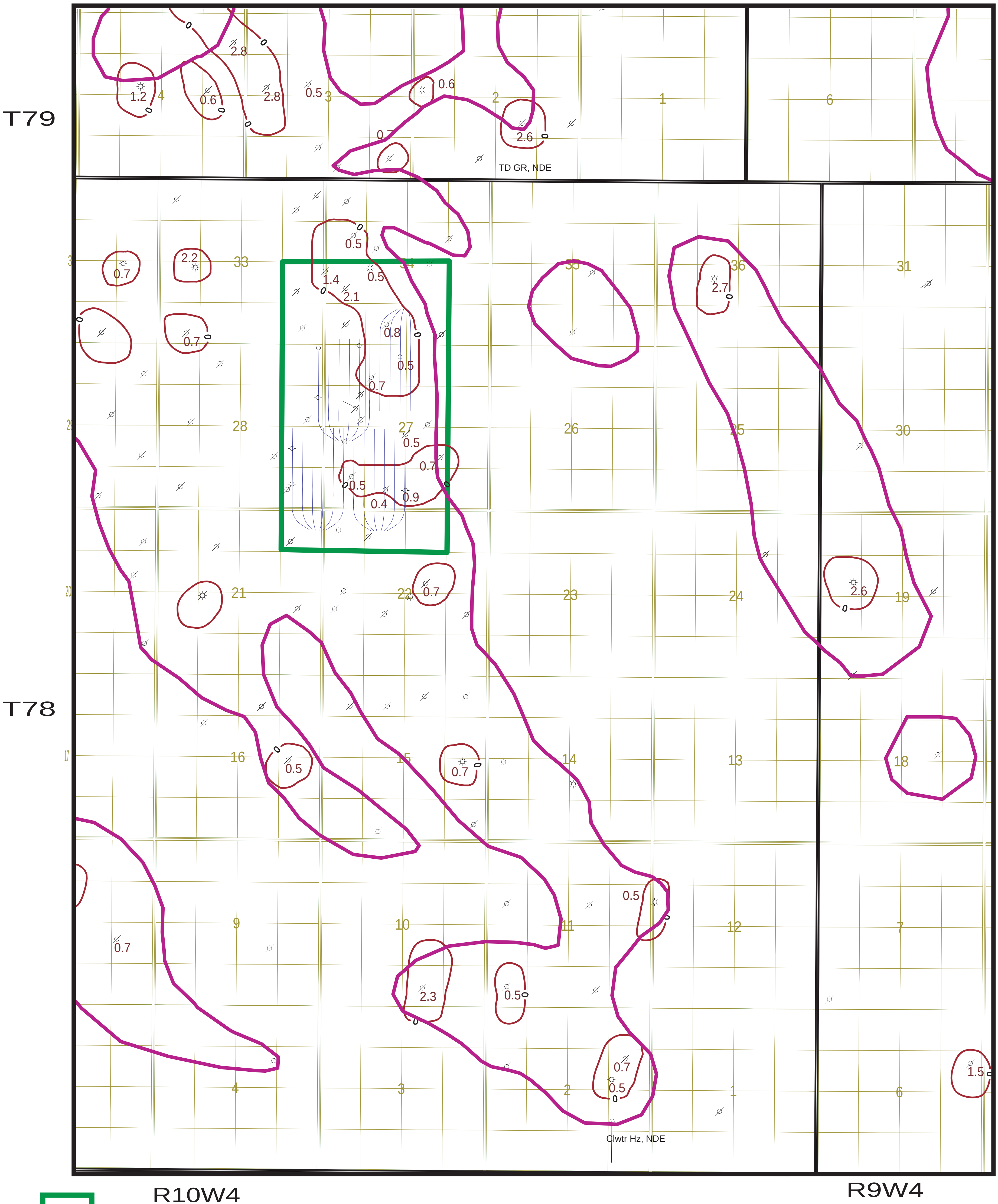
1.3 Associated Net Bitumen Isopach Posted Value (Thief Zone)

# Figure A4.1-25A
# Associated Net Bitumen Isopach (Thief Zone)

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
Associated Net Bitumen Isopach
(Thief Zone)

| | | |
|---|---|---|
| Author: J.Lobsinger, P. GEOL. | CUTOFF: 40ohms, 27% Porosity | Date: 14 June, 2007 |
| CI=2m | Scale: 1:40000 | |




Leismer Initial Development Area

SAGD Bitumen Zero Edge

Non-Associated Gas Net Gas Pay

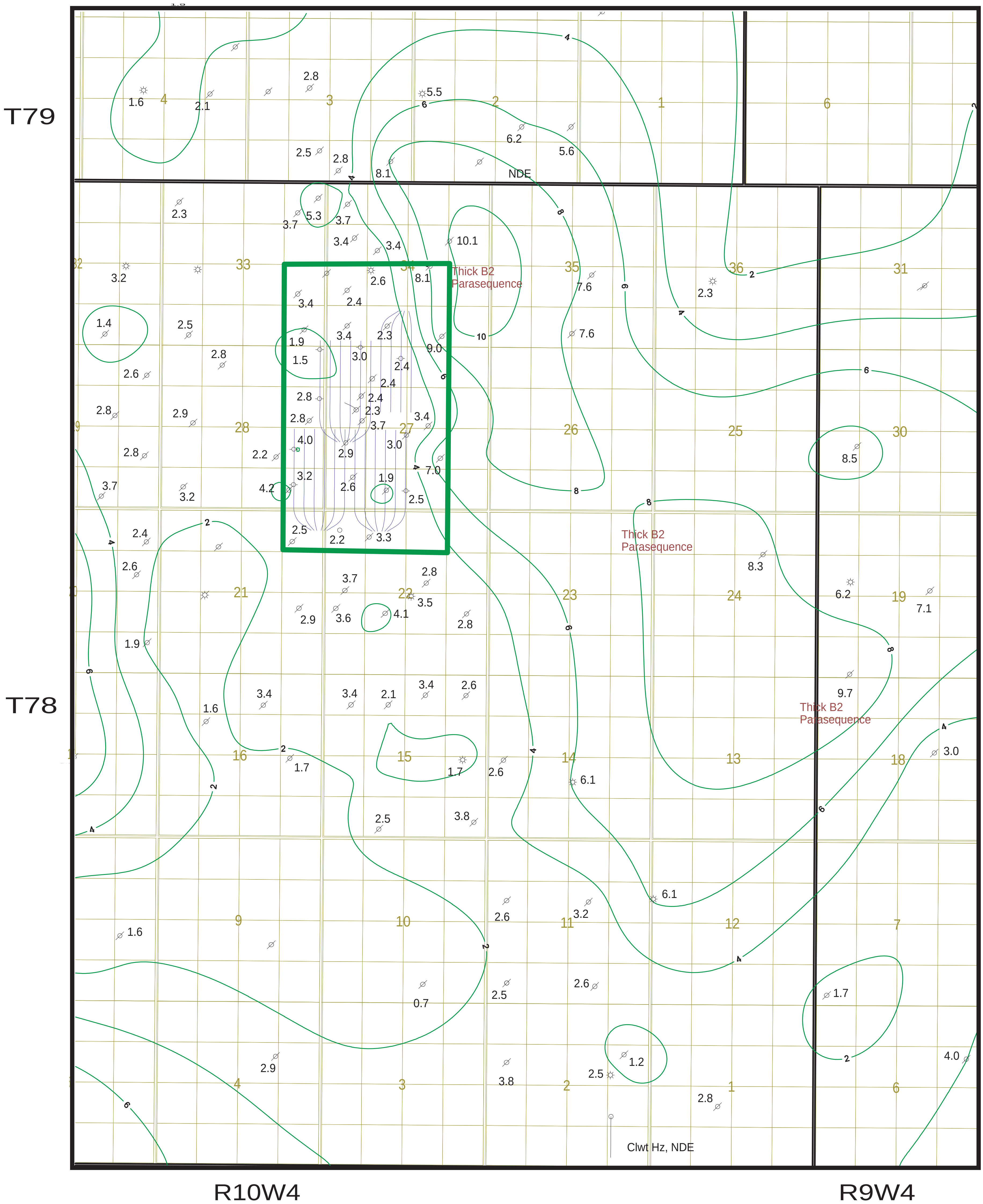
2.2 Non-Associated Gas Posted Isopach

# Figure A4.1-26 McMurray Non-Associated Net Gas Pay Isopach

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
McMurray Non-Associated Gas

| Author: J. Lobsinger, P. GEOL. | CUTOFF: | Date: 4 April, 2007 |
|---|---|---|
| | Scale: 1:40,000 | |




Leismer Initial Development Area

2.1 Non-Associated Bitumen Value

# Figure A4.1-27
# Non-Associated Net Bitumen Isopach

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
Non-Associated Bitumen Isopach

| | | |
|---|---|---|
| Author: J. Lobsinger, P.GEOL. | CUTOFF: 27% Porosity, 40 ohms Resistivity, 2m vertical mud facies | Date: 14 June, 2007 |
| CI: 2m | Scale: 1:40,000 | |

## A4.2 Reservoir Recovery Process

North American will employ SAGD to recover bitumen from the McMurray Formation. The recovery process for the Leismer Commercial Hub is the same as outlined approved for the Leismer Demonstration Hub.

In order to monitor SAGD well performance, selected oil sands exploration wells, drilled in 2007 for the Leismer Demonstration Hub were outfitted as temperature and pressure observation wells (Figure A4.2-1). The following seven wells were drilled and cased specifically for reservoir observation purposes:

1AB/03-27-078-10 W4M

1AA/13-27-078-10 W4M

1AB/14-27-078-10 W4M

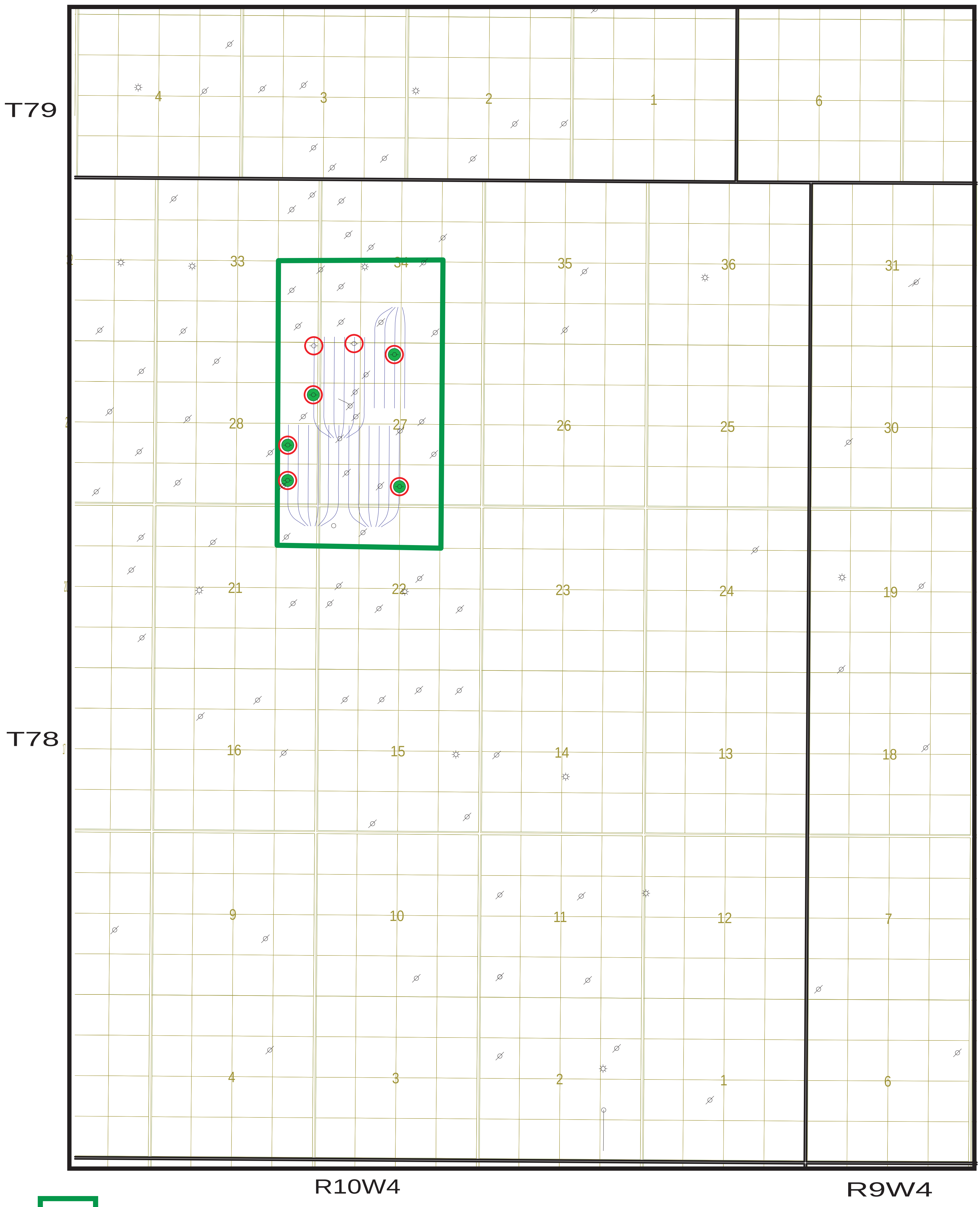
1AA/01-28-078-10 W4M

1AA/08-28-078-10 W4M

1AB/09-28-078-10 W4M

1AA/16-28-078-10 W4M

All seven of the observation wells may be used for temperature surveys. Additionally, five of the wells were also completed with pressure recording instruments (piezometers) on the casing exterior (1AB/03-27, 1AB/14-27, 1AA/01-28, 1AA/08-28 and 1AA/16-28). Piezometer installations were situated to provide pressures from top gas, bitumen and bottom water intervals. Pressure monitoring operations are slated to begin in 2008 and will provide baseline pressure and temperature data.




Leismer Initial Development Area

Cased for Temperature Monitoring (7 wells)

Equipped with Piezometers for Pressure Monitoring (5 wells)

# Figure A4.2-1
# Observation Wells

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
Pressure and Temperature Observation Wells

| Author: J. Lobsinger, P. GEOL. | CUTOFF: | Date: 4 June, 2007 |
| --- | --- | --- |
| | Scale: 1:40,000 | |

# A4.3 Hydrogeology

## A4.3.1 Hydrostratigraphy

Hydrostratigraphy provides a classification of the geological units according to hydrogeological characteristics. The geological column for the region, shown on the left hand side of Figure A4.3-1, has been arranged into a series of aquifers and aquitards, based on the relative hydraulic characteristics of each unit or adjacent units. Six aquifers have been identified in the region as being feasible for providing the Kai Kos Dehseh Project with some or all of its groundwater demand and meeting some or all of its disposal requirements. These aquifers are listed below (with increasing depth) and are discussed in Sections 4.3.3 to 4.3.7 (Volume 1).

i. Empress Terrace Aquifer

ii. Empress Channel Aquifer

iii. Lower Grand Rapids Aquifer

iv. Clearwater A Aquifer

v. Clearwater B Aquifer

vi. Basal McMurray Aquifer

## A4.3.2 Methodology

North American has updated its geology since the Application for the Leismer Demonstration Project. Updated geology focussed on the Mannville Group (including the Grand Rapids, Clearwater and McMurray Formations) from Township 75, Range 6 to Township 83, Range 14.

All well logs available within North American leases were reviewed. Outside of North American leases, all well logs with geology documented down to the Devonian deposits were reviewed. In all, over 1,600 well logs in the Kai Kos Dehseh Project area were used to update geological mapping of the Mannville Group.

The geology review process paid particular attention to the Lower Grand Rapids, Clearwater A, Clearwater B and Basal McMurray Aquifers. The determination of these aquifers was based on the following criteria;

- less than 60 API gamma response;
- greater than 30% density porosity;
- resistivity less than 10 Ω (Basal McMurray Aquifer only); and
- good spontaneous potential response.

## A4.3.3 Empress Formation Aquifers

The Empress Formation is defined as all stratified sediments that rest on bedrock and are covered by the first occurrence of glacial till in the area (Andriashek, 2003). These drift sediments consist of Tertiary age "stratified gravel, sand, silt and clay of fluvial, lacustrine, and colluvial origin" (Whitaker and Christiansen, 1972) and exist within bedrock channels (channel aquifer) and on bedrock terraces or interfluve benches (Terrace Aquifer).

The Empress Channel and Empress Terrace Aquifers are important regional aquifers beneath the Project area. Isopach maps of the Empress Channel and Terrace Aquifers are provided as Figures 4.3-2 and 4.3-3 (Section 4.3, Volume 1). .

Groundwater in the Empress Aquifers is considered to be non-saline with total dissolved solids (TDS) concentrations expected to be less than 1,000 mg/L. Testing of the North American 11-14-78-9 W4M camp water supply well identified TDS concentrations of 748 mg/L and 816 mg/L.

## A4.3.4 Lower Grand Rapids Aquifer

The Grand Rapids Formation of the upper Mannville Group represents a regional regression event (Bachu et al., 1993). The lower portion of the Grand Rapids Formation consists primarily of thick sandstone bounded at the top and bottom by shale (Bachu et al., 1993). This sandstone is regionally extensive in the Kai Kos Dehseh Project area with thicknesses ranging from 15 m to 45 m (Figure 4.3-7). A net water isopach of the Lower Grand Rapids sandstone (Figure A4.3-2) has been updated for the Leismer RGSA. It shows the Lower Grand Rapids being laterally continuous in the Leismer RGSA with a maximum thickness of 26.6m (16-4-79-10 W4M). The Groundwater in the Lower Grand Rapids Aquifer is considered to be non-saline with expected total dissolved solids concentrations ranging from 1,000 to 3,500 mg/L (Figure 4.3-5, Volume 1). Tests conducted by North American, during the winter of 2007, identified TDS concentrations in the Lower Grand Rapids Aquifer ranging from 1,340 mg/L to 1,520 mg/L.

## A4.3.5 Clearwater A and B Aquifers

The Clearwater Formation is composed of several thick, coarsening-upwards, sand successions each separated by thin shale layers (Hitcheon et. al., 1989). Beneath the Kai Kos Dehseh Project area, there are two substantial sand bodies in the Clearwater Formation known as the Clearwater A and B Aquifers (Maher, 1989). The Clearwater B Aquifer is restricted to beneath the southern portion and the Clearwater A Aquifer is limited to beneath the far northern portion of the Kai Kos Dehseh leases. Clearwater A and B isopachs are provided on Figures 4.3-6 and 4.3-7 (Section 4.3, Volume 1). The Clearwater A Aquifer is not present in the Leismer RGSA. The Clearwater B Aquifer is best developed in the southern portion of the Leismer RGSA and the net water isopach is shown in Figure A4.3-3.

Groundwater in the Clearwater Aquifers is considered to be transitional between non-saline and saline with expected TDS concentrations ranging from 2,500 mg/L to 8,000 mg/L. Salinity maps for the Clearwater A and B are shown in Figures 4.3-8 and 4.3-9 (Section 4.3, Volume 1). Tests conducted by North American, during the winter of 2007, identified TDS concentrations in the Clearwater B Aquifer ranging from 6,340 mg/L to 7,610 mg/L.

## A4.3.6 Basal McMurray Aquifer

The McMurray Formation consists predominantly of fluvial and estuarine sediments deposited in the valleys of the sub-Cretaceous Unconformity surface (Hitcheon et al., 1989). The lower sands of the McMurray Formation are fluvial in nature. Fluvial sands that are water saturated are referred to as the Basal McMurray Aquifer. An isopach map of the Basal McMurray Aquifer is provided as Figure A4.3-4. As noted in the original Leismer Demonstration application of 2006, thickest bottom water is associated with the erosional feature on the pre Cretaceous Unconformity surface along the western edge of the Leismer Commercial Hub where bottom water can be up to 18.9 m thick (100/7-28-78-10 W4M). Recent drilling did not significantly deviate from existing mapping. Two wells in the Leismer Commercial Hub development area, 00/12-27-78-10 W4M and 3-34-78-10 W4M do not have bottom water as they are sitting on localized paleotopographical highs.

Figure A4.3-5 is the Net McMurray Bottom Water isopach and displays similar trends to the gross bottom water.

Figure A4.3-6 is the Structure on the McMurray Oil/Water Contact. Large variations previously seen in the oil/water contact were a result of ground elevation survey areas and corrections were made by North American and were the subject of the December, 2006 Errata submitted to the EUB. 2007 infill drilling has confirmed the corrected mapping and significant deviations were not noted.

Groundwater in the Basal McMurray Aquifer is considered to be saline with TDS concentrations ranging from 10,000 mg/L to 15,000 mg/L. Figure 4.3-11 (Section 4.3, Volume 1) illustrates Basal McMurray Aquifer salinity. Tests conducted by North American, during the winter of 2007, identified TDS concentrations in the Lower Grand Rapids Aquifer ranging from 10,700 mg/L to 13,500 mg/L.

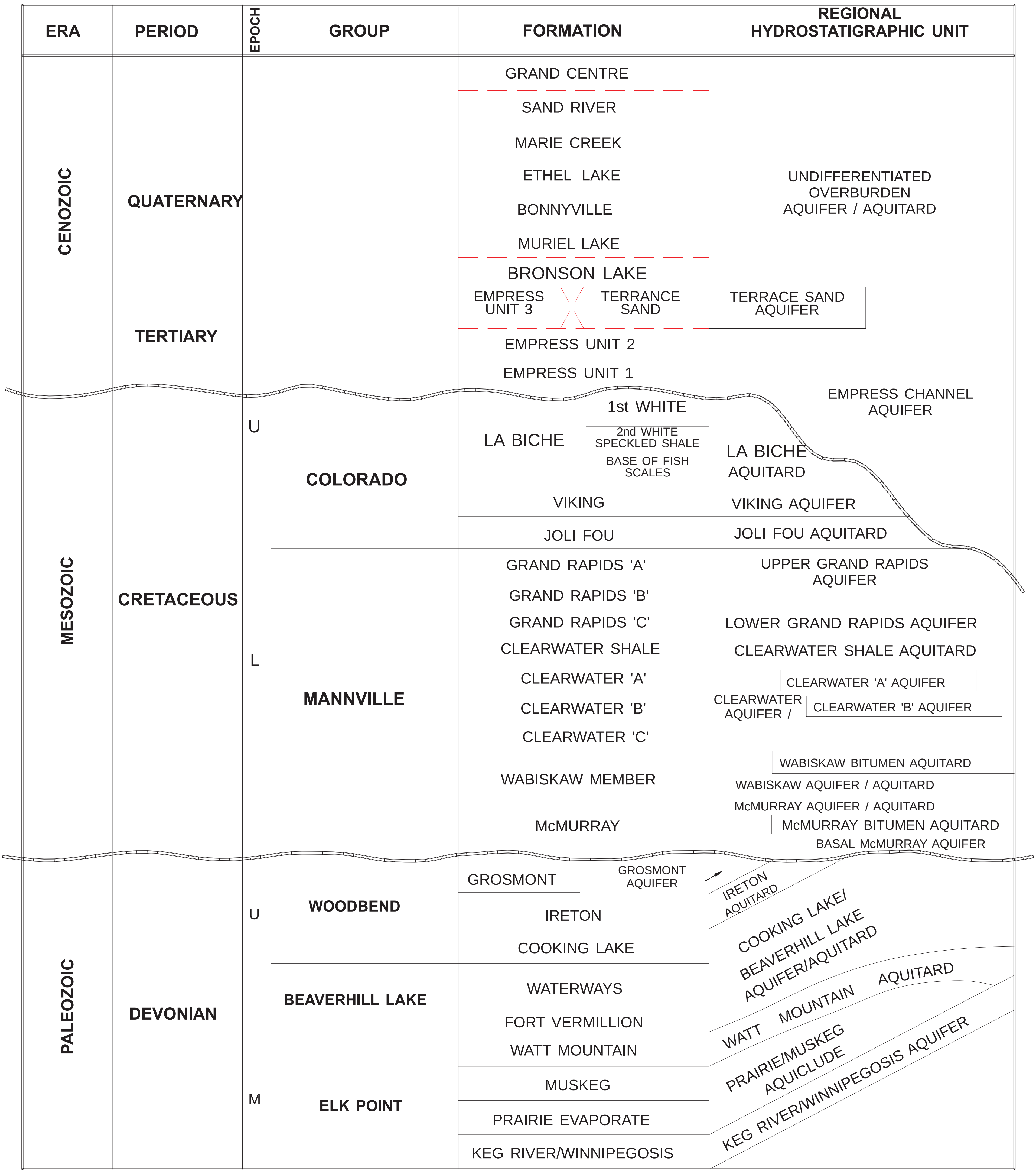
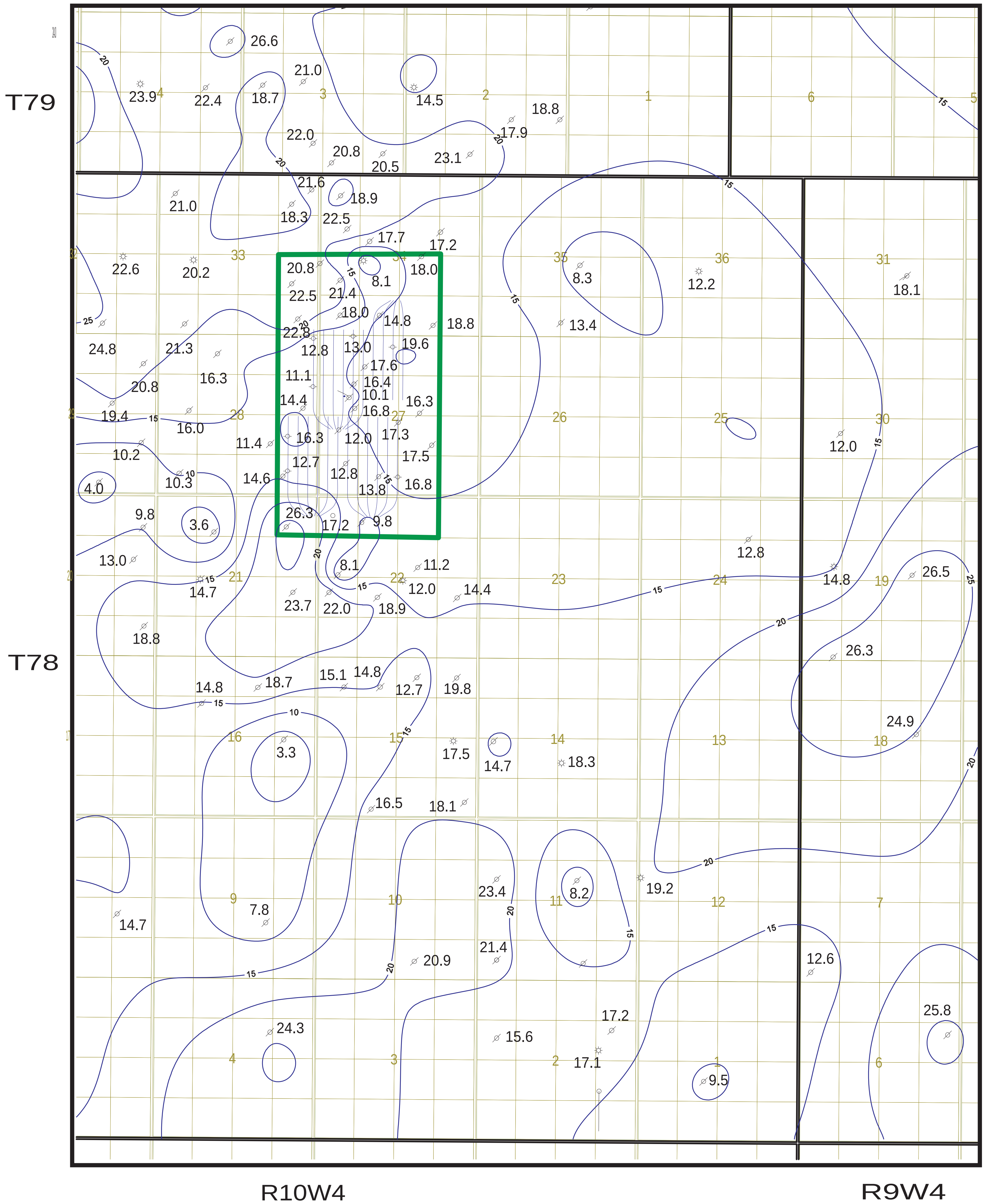



Figure A4.3-1
Geological Column



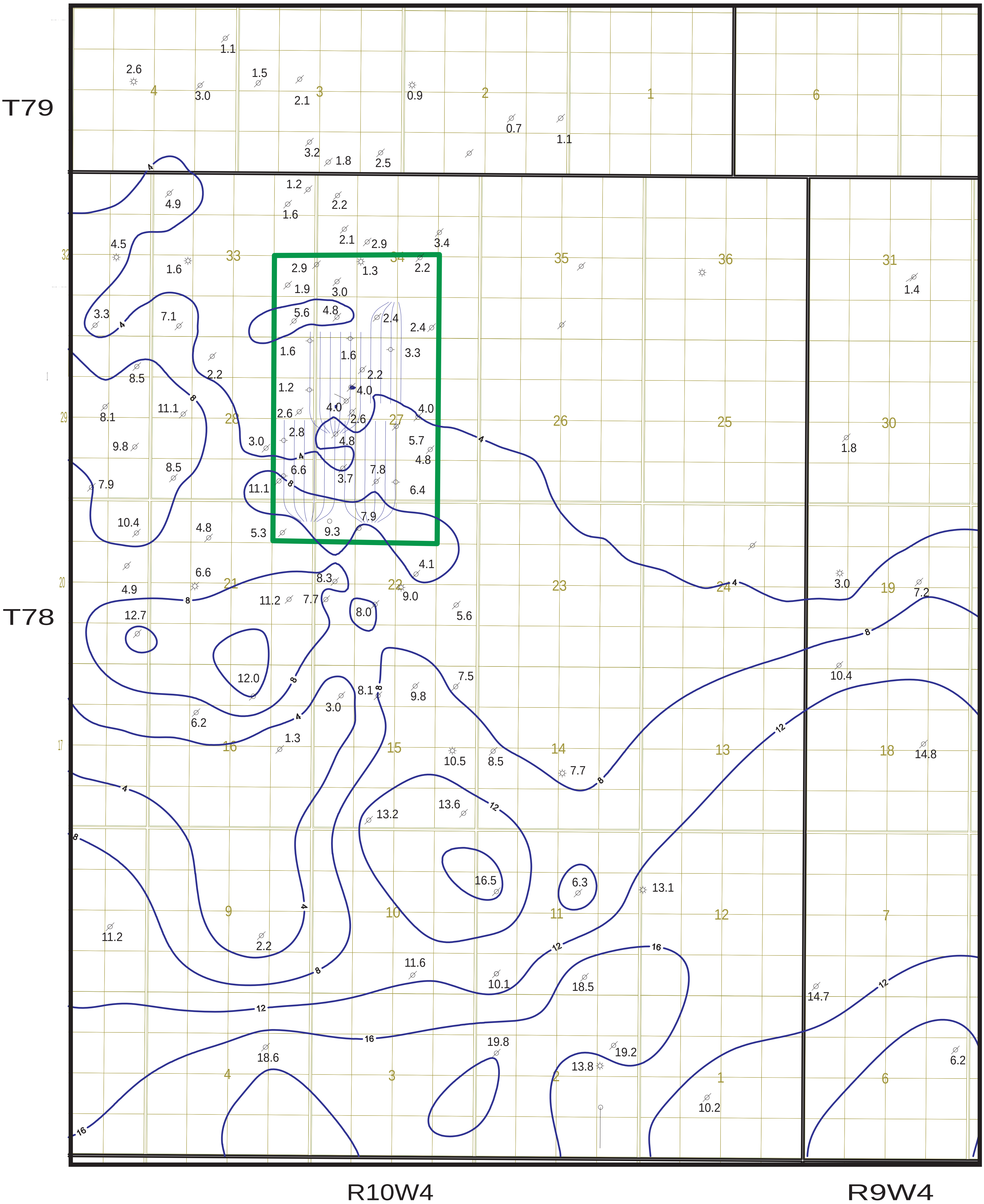

Leismer Initial Development Area

21.7 Lower Grand Rapids Net Water Posted Isopach

# Figure A4.3-2 Lower Grand Rapids Net Water Isopach

NORTH AMERICAN OIL SANDS CORPORATION

| Leismer Lower Grand Rapids Net Water Isopach | | |
|---|---|---|
| Author: J. Lobsinger, P. GEOL. | CUTOFF: 60api or app 36% density porosity | Date: 14 June, 2007 |
| C.I.=5m | Scale: 1:40,000 | |




Leismer Initial Development Area

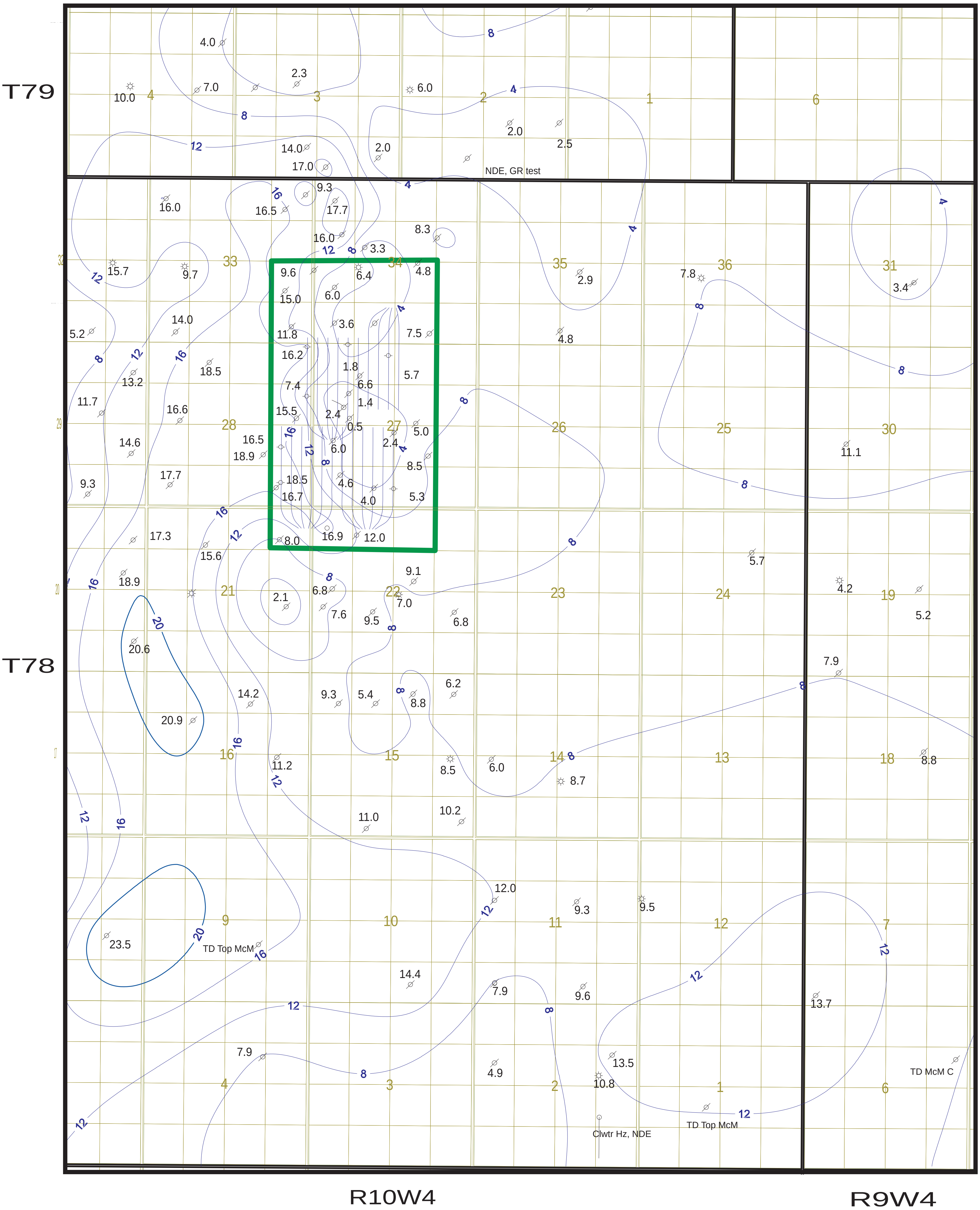
19.8 Clearwater B Net Water Posted Isopach

# Figure A4.3-3 Clearwater B Net Water Isopach

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
Clearwater B Net Water Isopach

| | | |
|---|---|---|
| Author: J. Lobsinger, P. GEOL. | CUTOFF 36% density porosity or approx 60api GR | Date: 18 May, 2007 |
| C.I.=4m | Scale: 1:40,000 | |




Leismer Initial Development Area

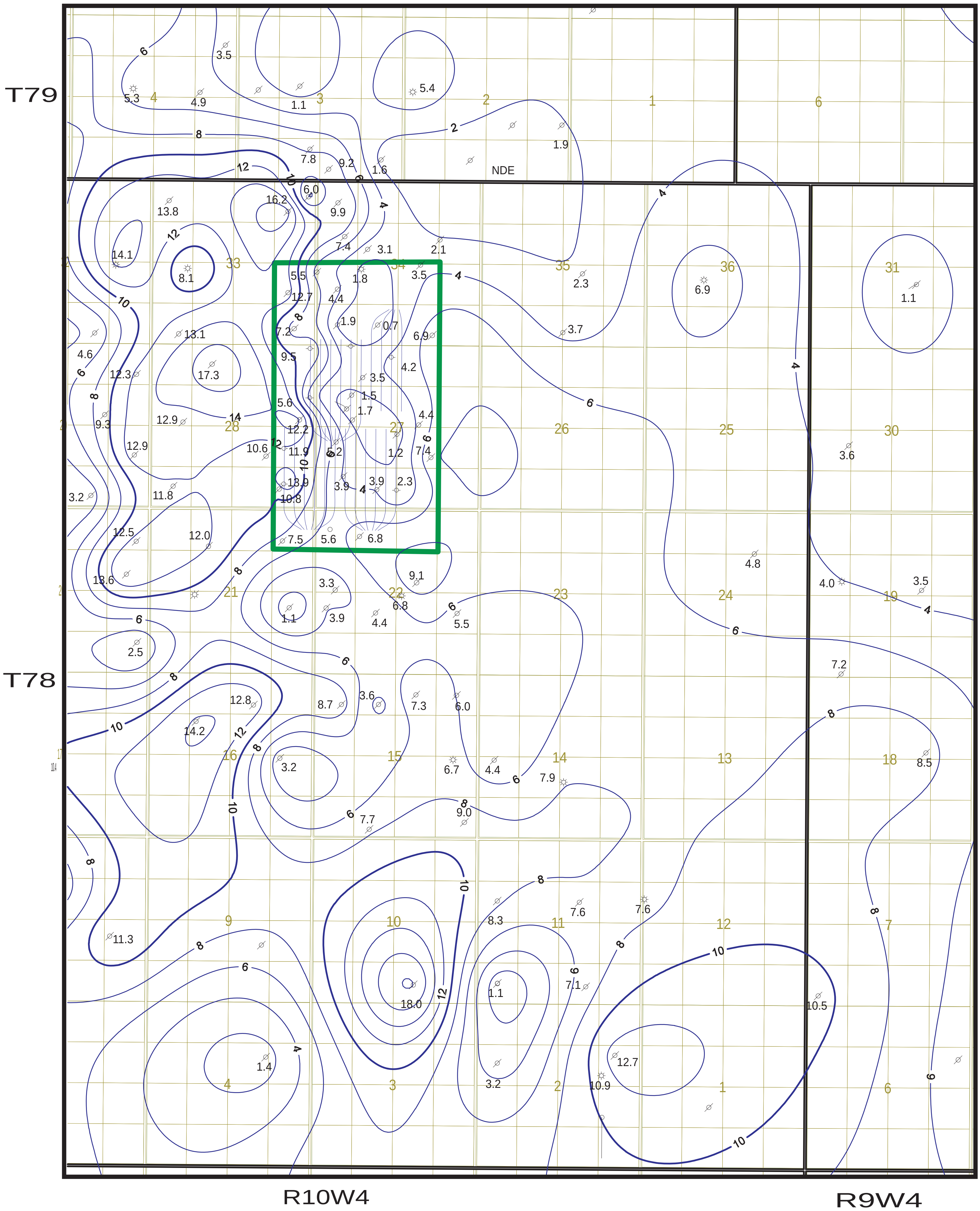
14.4 Gross Bottom Water Isopach Posted Value

# Figure A4.3-4 McMurray Gross Bottom Water Isopach

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
McMurray Gross Bottom Water Isopach

| | | |
|---|---|---|
| Author: J.Lobsinger, P. GEOL. | CUTOFF: 10ohms, 27% Porosity | Date: 9 May, 2007 |
| CI=4m | Scale: 1:40000 | |




Leismer Initial Development Area

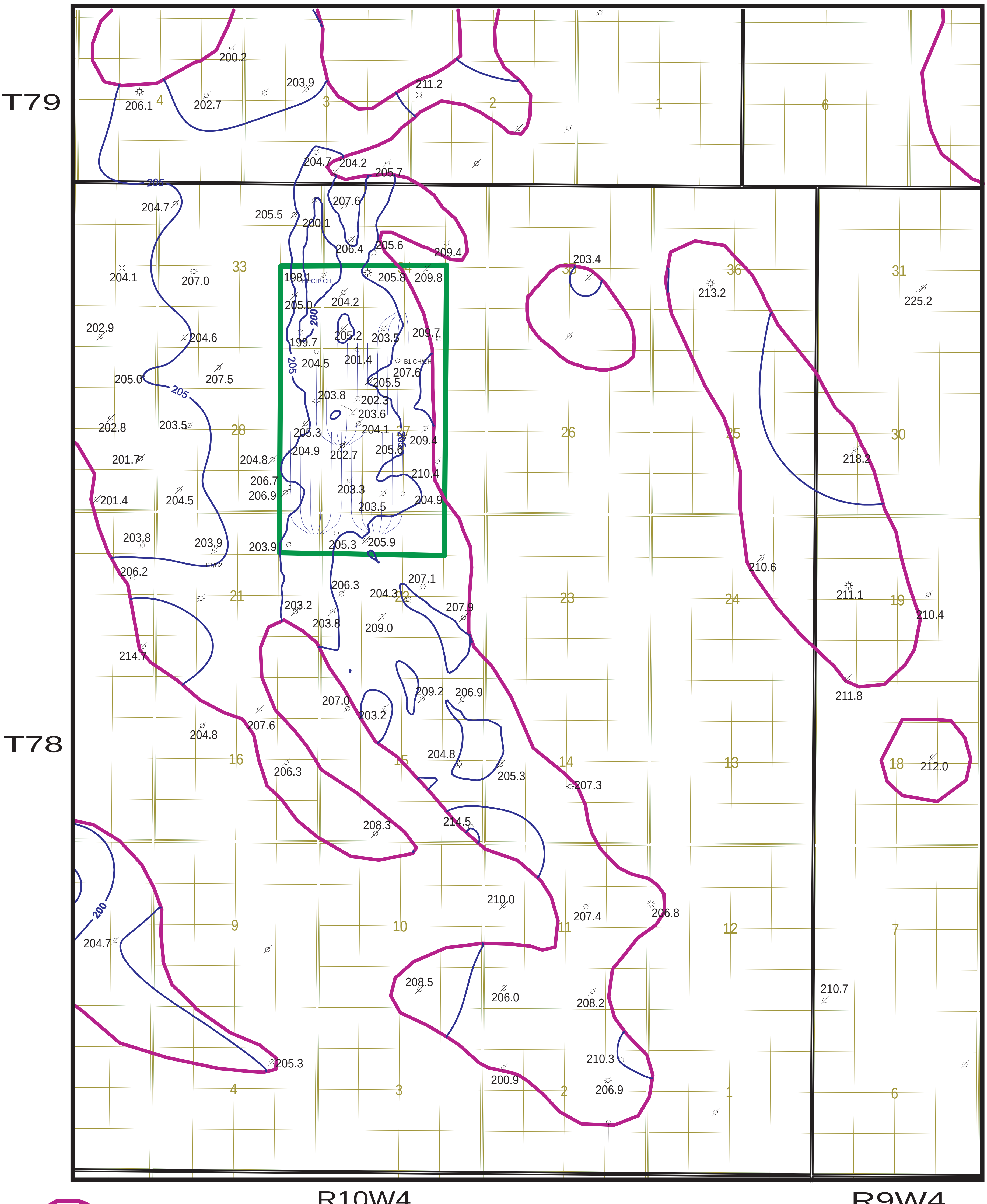
2.2 Net Bottom Water Isopach Posted Value

# Figure A4.3-5 McMurray Net Bottom Water Isopach

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
McMurray Net Bottom Water Isopach

| | | |
|---|---|---|
| Author: J.Lobsinger, P. GEOL. | CUTOFF: 10ohms, 27% Porosity | Date: 9 May, 2007 |
| CI=4m | Scale: 1:40000 | |




Zero Edge SAGD

Leismer Initial Development Area

207.5 Bitumen/Water Contact Structure Posted Value

# Figure A4.3-6
# McMurray Bitumen/Water Contact Structure

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
McMurray Bitumen/Water Contact Structure

| Author: J.Lobsinger, P. GEOL. | CUTOFF: 10ohms, 27% Porosity | Date: 15 June, 2007 |
| --- | --- | --- |
| CI=5m | Scale: 1:40000 | |

# A5 LEISMER COMMERCIAL HUB CONSERVATION & RECLAMATION PLAN

## A5.1 Introduction

This section provides site-specific conservation and reclamation (C&R) practices and mitigation activities for the Leismer Commercial Hub. General C&R measures (e.g. re-contouring, decompaction, weed/erosion control, surface water management, etc.) applicable to all the Kai Kos Dehseh development areas are presented in the conceptual C&R plan (Volume 1, Section 8).

Preceding application for approval of the Kai Kos Dehseh Project, North American had applied for regulatory approval of its Leismer Demonstration Project. The content of this section was originally submitted as the C&R Plan with the Leismer Demonstration Application and revised as part of the Leismer Demonstration supplemental information requests. The data from these two submissions have been compiled into this section for ease of reference and convenience. No changes have been made since the final Leismer Demonstration supplemental information request process. As part of the regulatory review, revisions to the original Leismer Demonstration Project C&R plan were made. Specifically, North American has made the following commitments:

- Corduroy will not be used in the construction of pads developed on deep (>40 cm) peats;
- A minimum of 40 cm of peat will be salvaged from areas developed in deep peats; and
- Borrow areas will be developed in upland areas only.

The commitments have been incorporated into the conceptual C&R plan presented in Volume 1, Section 8 and in to this detailed C&R plan.

## A5.2 Leismer Commercial Hub Facilities

Facility areas associated with the Leismer Commercial Hub are the same as the Leismer Demonstration Project, and include the Leismer Commercial Hub CPF, four production pads (Pads L1 – L4) and associated facilities (access road, above and below ground pipelines, power lines, camps and borrow areas). There is an Al-Pac right-of-way for accessing the CPF from the east. Table A5.2-1 lists the facility areas on the Leismer Commercial Hub footprint. Table A5.2-2 presents the soils on the Leismer Commercial Hub footprint and Figure A5.2-1 illustrates the mapped soil units on the Leismer Commercial Hub footprint.

**Table A5.2-1 Leismer Commercial Hub Facilities – Area Extent**

| Leismer Commercial Hub Facilities | Area on Footprint (ha) |
|---|---|
| Central Plant Facility (CPF) | 44.0 |
| Production Well Sites (4) | 18.3 |
| Roads and facility ROWs | 26.4 |
| North American borrow areas (3) | 16.2 |
| Al-Pac ROW | 31.1 |
| Al-Pac borrow areas | 9.5 |

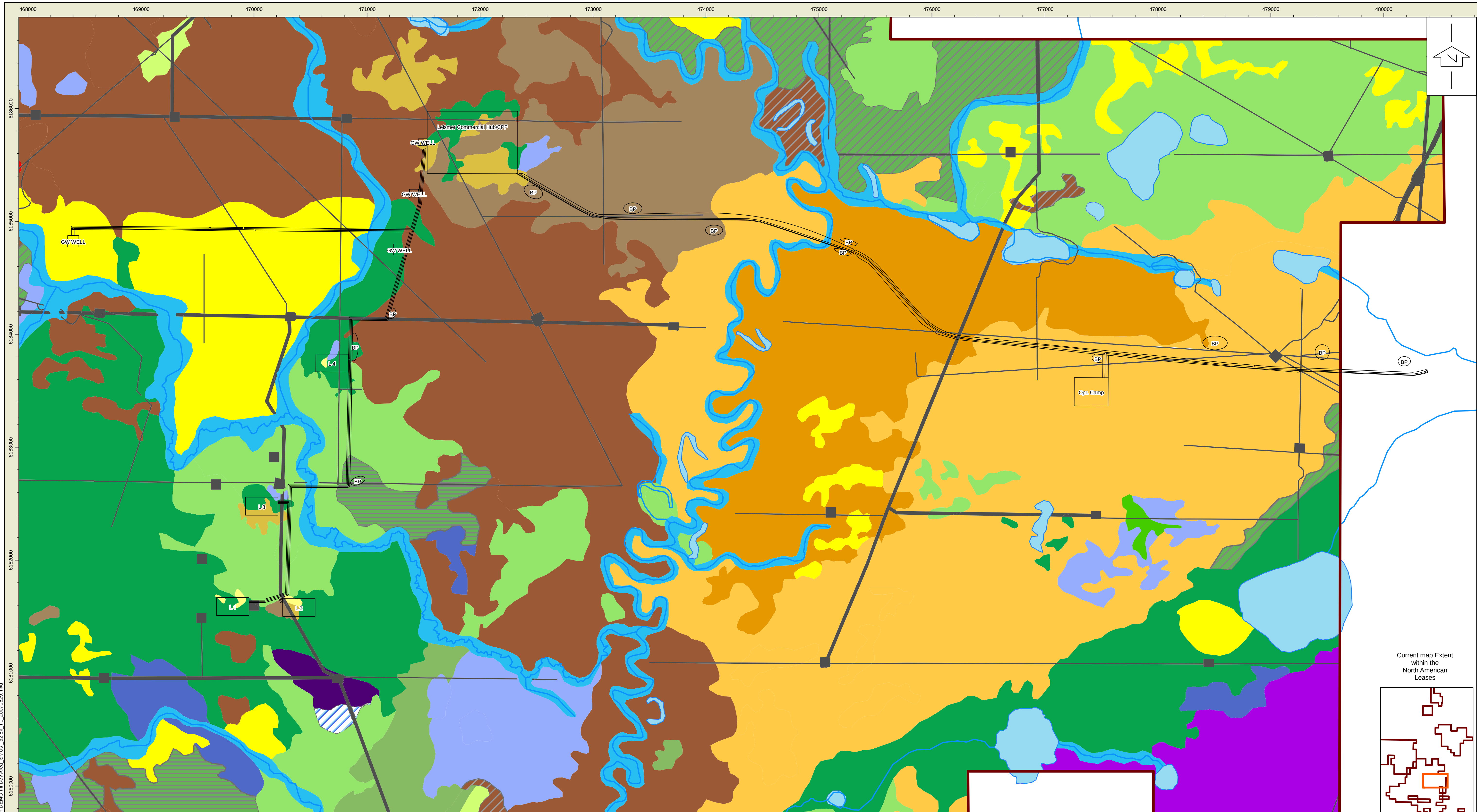
| Leismer Commercial Hub Facilities | Area on Footprint (ha) |
|---|---|
| Operations Camp | 8.5 |
| Water source and disposal wells | 2.9 |
| **Total** | **156.9** |

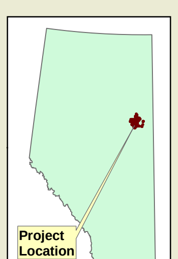
## Table A5.2-2 Leismer Commercial Hub – Soil Types and Area Extent

| Soil Map Units | CPF | Pad L1** | Pad L2 | Pad L3 | Pad L4 | Roads / Connectors / ROW | NEW North American borrow areas (conceptual) | Al-Pac ROW | Al-Pac borrow pits (conceptual) | Operations Camp | Water source and disposal wells | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hartley (HLY) | | | | | | 6.5 | | | | | | **6.5** |
| Kinosis (KNS) | 18.1 | | 0.4 | | | 3.8 | 12.9 | 5.8 | 3.8 | | 0.8 | **45.6** |
| Livock (LVK)* | 11.1 | | 0.8 | | | 0.6 | | 0.3 | | | 0.3 | **13.1** |
| McLelland (MLD) | 12.2 | 3.7 | 1.9 | 1.3 | 3.8 | 4.0 | 0.7 | | | | 0.8 | **28.4** |
| Mildred (MIL) | | 0.8 | 0.8 | 2.5 | 0.3 | 7.7 | | | | | 1.0 | **13.1** |
| Mariana (MRN) | | | | | | 1.3 | 1.8 | | | | | **3.1** |
| Steepbank (STP) | | | | | 0.4 | 0.1 | | | | | | **0.5** |
| Surmont (SRT) | | | | | | | | 23.5 | 5.7 | 8.5 | | **37.7** |
| Existing Disturbance | 2.6 | 0.1 | 0.7 | 0.8 | | 1.7 | 0.8 | 1.3 | | 0.0 | | **8.0** |
| River/Lake/Stream Channel | | | | | | 0.7 | | 0.2 | | | | **0.9** |
| **Total** | **44.0** | **4.6** | **4.6** | **4.6** | **4.5** | **26.4** | **16.2** | **31.1** | **9.5** | **8.5** | **2.9** | **156.9** |

* Winefred (WIN) had been used on previous Leismer Demonstration Project regulatory submissions. Winefred has now been correlated to Livock (LVK).

** Refer to Figure A5.2-1 for pad locations.




## Legend

- North American Soils LSA
- Lake
- River / Stream

L1-L4: Leismer Commercial Hub Well Site

CPF: Central Plant Facility
GW Well: Groundwater Well Site
BP: Borrow Pit

### Soil Map Units

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

1:32,500

0 0.25 0.5 1 1.5 2 km

NAD 83 UTM Zone 12

Title:

# SOIL MAP UNITS ON LEISMER COMMERCIAL HUB FOOTPRINT

NORTH AMERICAN OIL SANDS CORPORATION

| Approved: | Revision Date: |
|---|---|
| **SC/DH/LZ** | **May 10, 2007** |

File: Figure. A 1.2-1 Leismer DEMO Ini Dev Area_SMUs _32.5k_TL_20070629.mxd

| Drawn by: | Checked: | Fig. No.: |
|---|---|---|
| **TR/JC/LZ** | **LZ/SC** | **A 5.2-1** |

14455-514_NAOSC\NAOSC_Maps\Maps_C&R\Figure. A 1.2-1 Leismer DEMO Ini Dev Area_SMUs _32.5k_TL_20070629.mxd

# A5.3 Land Capability for Forest Ecosystems Classification

Figures A5.3-1 and A5.3-2 illustrate the pre-disturbance and target post reclamation Land Capability Classification for Forest Ecosystems for the Leismer Commercial Hub footprint.

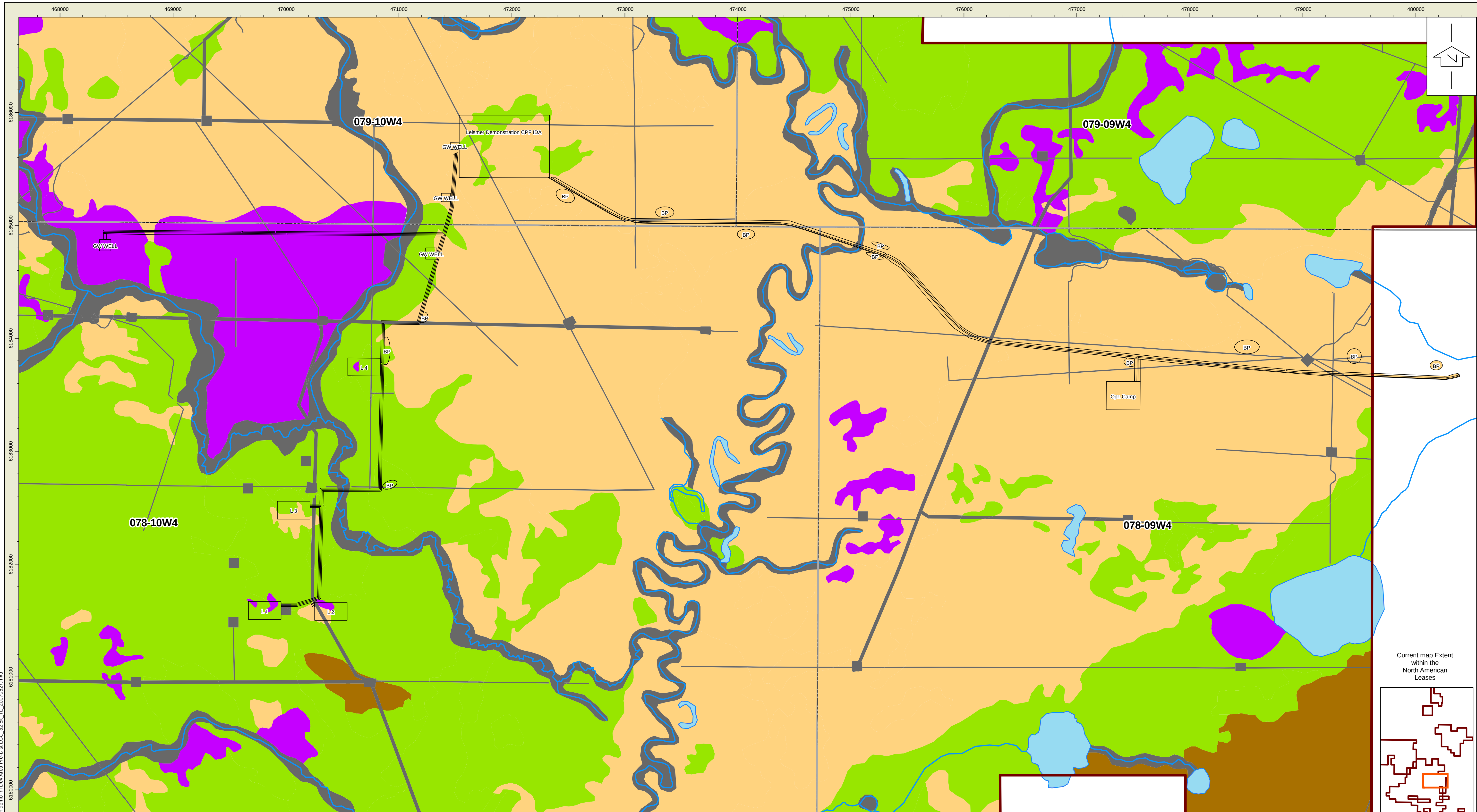
Table A5.3-1 compares the pre-disturbance and post reclamation Land Capability for Forest Ecosystem classes.

**Table A5.3-1 Pre-disturbance and Post Reclamation Land Capability for Forest Ecosystem Classes for the Leismer Commercial Hub Footprint**

| Forest Capability Class | Baseline | | Post Reclamation | |
|---|---|---|---|---|
| | Area (ha) | % of Footprint | Area (ha) | % of Footprint |
| Class 1 High Capability | 0 | 0 | 0 | 0 |
| Class 2 Moderate Capability | 0 | 0 | 0 | 0 |
| Class 3 Low Capability | 98.7 | 62.9 | 102.5 | 65.3 |
| Class 3/5 (Low Capability/Non-Productive) Complex | 0 | 0 | 26.8 | 17.1 |
| Class 4 Conditionally Productive | 10.6 | 6.8 | 10.7 | 6.8 |
| Class 5 Non-Productive | 37.9 | 24.1 | 15.7 | 10 |
| Unclassified (Lakes, Rough Broken, Stream Channel, Disturbed soil map units) | 9.8 | 6.2 | 1.3 | 0.8 |
| **Total** | **156.9** | **100** | **156.9** | **100** |

The Class 3/5 complex represents the reclamation approach for padded sites developed on areas of deep peat (Class 5), where a portion will be reclaimed to an upland ecosite phase (dominantly Class 3), and the edges to the ‘transitional g1’ ecosite phase (dominantly Class 5). The areas of padded well sites, CPFs, access roads and camps developed on peatland that will be reclaimed to the ‘transitional g1’ ecosite phase represent the greatest change to land capability from the baseline conditions (see Figures 8.6-3 and 8.6-4 in Volume 1, Section 8).

The siting of well sites, CPFs, access roads and camps on deep peats will result in a reduction of some peatland area; however, reclamation to the ‘transitional g1’ area is an initial step in mitigation of this loss. As experience is gained in reclamation of wetland areas, the area of peatland reclaimed to areas with similar characteristics can be expanded over time.




## Legend

- North American Soils LSA
- Lake
- River / Stream

L1-L4: Leismer Commercial Hub Well Site
CPF: Central Plant Facility
GW Well: Groundwater Well Site
BP: Borrow Pit

**Land Capability for Forest Ecosystems**

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

1:32,500

0 0.25 0.5 1 1.5 2 km

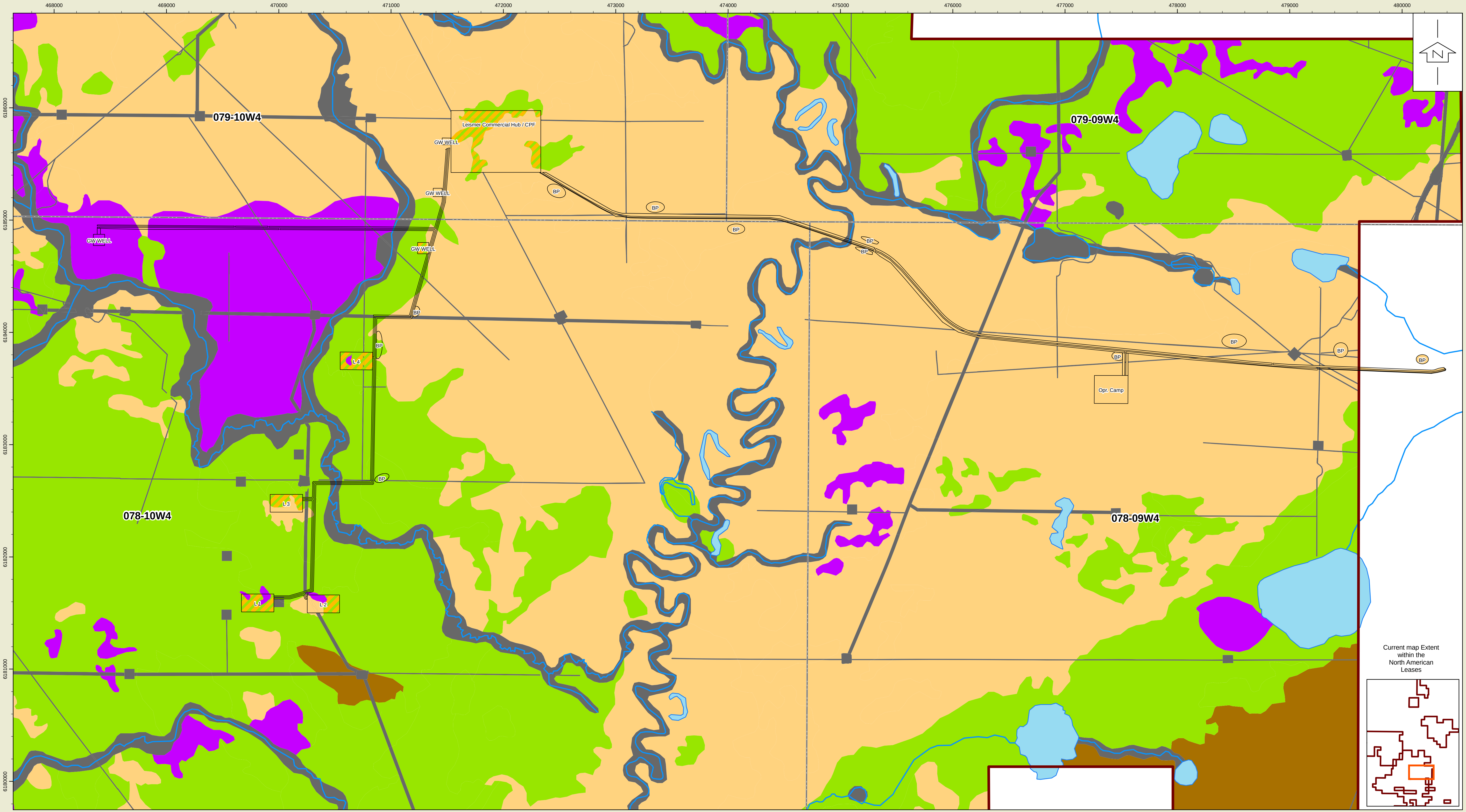
NAD 83 UTM Zone 12

Title:

**PRE-DISTURBANCE LAND CAPABILITY FOR FOREST ECOSYSTEMS ON LEISMER COMMERCIAL HUB FOOTPRINT**

NORTH AMERICAN OIL SANDS CORPORATION

| Approved: | Revision Date: | |
|---|---|---|
| SC/DH/LZ | May 10, 2007 | |
| File: Figure. Figure. A 5.3-1 Leismer demo Ini Dev Area Pre-Dist LCC_32.5k_TL_20070627.mxd | | |
| Drawn by: TR/JC/LZ | Checked: LZ/SC | Fig. No.: A 5.3-1 |




## Legend

North American Soils LSA

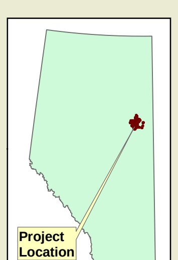
Lake

River / Stream

L1-L4: Leismer Commercial Hub Well Site
CPF: Central Plant Facility
GW Well: Groundwater Well Site
BP: Borrow Pit

**Land Capability for Forest Ecosystems**

- 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)




1:32,500

0 0.25 0.5 1 1.5 2 km

NAD 83 UTM Zone 12

Title:

# POST-RECLAMATION LAND CAPABILITY FOR FOREST ECOSYSTEMS ON LEISMER COMMERCIAL HUB FOOTPRINT

NORTH AMERICAN OIL SANDS CORPORATION

| Approved: | Revision Date: | |
|---|---|---|
| SC/DH/LZ | May 10, 2007 | |
| File: | Figure. A 5.3-2 Leismer DEMO Ini Dev Area Post-Recl LCC_Forest_32.5k_TL_20070627.mxd | |
| Drawn by: TR/JC/LZ | Checked: LZ/SC | Fig. No.: A 5.3-2 |

14455-514_NAOSC\NAOSC_Maps\Maps_C&R\Figure A 5.3-2 Leismer DEMO Ini Dev Area Post-Recl LCC_Forest_32.5k_TL_20070627.mxd

## A5.4 Hydrology

Access between Pads L3 and L4 will require crossing an unnamed tributary, a Class C watercourse, to the Christina River. In this reach, the defined channel is approximately 4 m wide, and assuming a clear-span bridge, an assessment is not technically required. North American is continuing to work on the design of the crossing, and in the event that bank disturbance is required, North American plans to conduct a fish and fish habitat assessment. Notification for any crossing, under the Code of Practice, will satisfy the requirements of the Water Act. Should an aquatic assessment be required, it will be conducted on the crossing in Q2 2007. Results and conclusions from this assessment along with a detailed crossing design will be submitted to AENV, Fisheries and Oceans Canada (DFO) and Navigable Waters later in 2007.

Culverts will be used along access roads to maintain surface and shallow subsurface flows in fen systems. Water flow is anticipated to go around Pads L2 to L4. The use of rock drains may also be considered to maintain flow in fen complexes.

During operation, North American's construction and operation personnel will conduct visual assessments to ensure water flow is maintained up and down gradient of roads and to ensure that open culverts are maintained. In addition, piezometers, water gauges or manholes will be installed on the upstream side of Pad L1 to monitor water levels. Measurements will be conducted each spring and fall for the life of the facility.

Additional mitigation measures to prevent impacts on surface water are presented in the conceptual C&R (Volume 1 Section 8.6.2.2) and Hydrology (Volume 3 Section 6), and Fish and Fish Habitat (Volume 3 Section 8) sections of the EIA.

## A5.5 Soils Handling Plan

The objective of soil salvage and management is to provide valuable topsoil for reclamation purposes by stripping and storing topsoil in a manner that will minimize loss until it is required for future replacement and reclamation. Through proper handling and conservation, the degradation of topsoil by erosion, compaction, rutting, loss of viable plant material and soil mixing is reduced. For the purposes of salvaging, stockpiling, and replacing soil during reclamation, soil-handling activities have been recommended for the dominant soil series encountered.

Table A5.2-2 provides the distribution of soil series encountered on the Leismer Commercial Hub CPF and well pads. Two disturbed areas (wellsites) occur on the CPF. The well sites are North American/Paramount Leismer 7-2-79-10 W4M (drilled and abandoned) and North American/Paramount Leismer 8-2-79-10 W4M. The disturbed areas on the pads are also abandoned evaluation wells owned by North American/Paramount and are located at 14-22-78-10 W4M (Pad L2) and 5-27-78-10 W4M (Pad L3).

Prior to construction, the disturbed areas will be assessed for contamination through visual inspections. Any noted contamination will be remediated as appropriate. All clean topsoil and up to 30 cm of suitable subsoil will be salvaged, under the direction of a professional soil scientist.

One rare plant was observed on the Leismer Demonstration Project footprint. Ground-fir (Diphasiastrum sitchense) was identified on Pad L2, in the c1 ecosite phase. While avoidance of rare plant populations is a primary vegetation mitigation tool, from a resource perspective, Pad L2 cannot be moved enough to avoid the Ground-fir. Ground-fir is ranked as S2 and as it is considered to have poor transplantability, North American does not propose any mitigation for this specimen.

### A5.5.1 Topsoil and Subsoil Salvage

A professional soil scientist will direct, monitor and document all soil salvage activities according to all applicable regulatory guidelines. All areas of surface disturbance on the Leismer Commercial Hub footprint will have surface soils salvaged as detailed in Table A5.5-1 (based on average topsoil depths for soil series). Where present, colour change from A to B horizons can also be used to guide topsoil stripping. North American will document the volumes and locations of all salvaged topsoils at the time of salvage.

**Table A5.5-1 Recommended Topsoil Salvage Depths by Soil Series**

| Soil Series | Recommended Soil Salvage Depth (cm) |
|---|---|
| Firebag<br>Fort<br>Kinosis<br>Mildred | LFH and/or shallow peat plus 15 cm topsoil (or to bottom of topsoil if deeper) |
| Livock<br>Surmont | LFH and/or shallow peat plus 18 cm topsoil (or to bottom of topsoil if deeper) |
| Algar Lake<br>Dover<br>Steepbank | peat plus 10 cm of underlying mineral soil |
| McLelland<br>Hartley<br>Mariana | Minimum 40 cm of peat |

Where topsoil is being stripped, activities will be suspended immediately if soils become excessively wet, or if any other field conditions or operations occur that will result in the degradation of topsoil quality, e.g., rutting, high winds. Where the development area occurs within wet terrain, stripping will occur during frozen conditions.

Up to 30 cm of suitable subsoil (i.e., subsoil rated as good, fair or poor for reclamation suitability according to the Soil Quality Criteria Relative to Disturbance and Reclamation (Revised) Alberta Agriculture (1987)) will also be salvaged from mineral soil sites. No subsoil will be salvaged from wet (i.e., Organic or Gleysolic) soils. Access roads on mineral soils will have surface duff/peat and surface mineral soil (topsoil) salvaged only.

Salvage and stockpile information will be presented in the Annual Conservation and Reclamation Report.

### A5.5.2 Stockpile Management

The mineral topsoil, peat from the Organic soils, and the subsoil will be stored in separate, stable stockpiles on site. Stockpiles will be located such that they will not interfere with on site activities. They will be accessible and retrievable for reclamation. North American has included sufficient stockpile area on the CPF and each pad to accommodate the material volume. The proposed stockpile locations for the CPF and four pads are presented in Table A5.5-2.

**Table A5.5-2 Proposed stockpile locations for the Leismer Commercial CPF and Pads L1-L4**

| Facility | Mineral Topsoil | Organic Topsoil | Subsoil |
|---|---|---|---|
| CPF | northern lease boundary | northern lease boundary | northern lease boundary |
| Pad L1 | northern lease boundary | southern lease boundary | northern lease boundary |
| Pad L2 | northern or southern lease boundary | eastern lease boundary | northern or southern lease boundary |
| Pad L3 | northern lease boundary | southern lease boundary | northern lease boundary |
| Pad L4 | northern lease boundary | eastern lease boundary | northern lease boundary |

Stockpile sites will be documented in the Annual Conservation and Reclamation Report submitted to AENV and staked or marked in the field.

The stockpiles locations will have stable foundations and will also be stabilized to control water and wind erosion. The requirement for immediate erosion control measures, such as erosion control matting or tackifiers will be determined on a stockpile-specific basis. An ASRD-approved seed mix suitable for the Central Mixedwood Subregion will be used to provide a protective vegetation cover where required. Soil stockpiles will be monitored and additional erosion control measures adopted, as necessary, where seed germination or plant growth have been poor.

# A5.6 Reclamation

## A5.6.1 End Land Use Objectives

As discussed in Volume 1, Section 8, the disturbed upland mineral soil areas will be reclaimed to an ecosite phase and land capability equivalent to the pre-disturbance conditions. The central areas of the well pads developed on peatland areas will be reclaimed to a target g1 Labrador tea - subhygric Black spruce-Jack pine ecosite phase with a land capability for forest ecosystems of Class 3 (to 4). The edges of the pads will be reclaimed to a wetter peat surface area providing a transition between the reclaimed upland area and the existing wetland area. The transition area will have a target ‘transitional g1’ ecosite phase, with an anticipated land capability for forest ecosystems of Class 5 (to 4) as described in Volume 1, Section 8 and illustrated in Figures 8.6-3 and 8.6-4.

The ‘transitional g1’ ecosite phase will have similar target species as the g1 Labrador tea - subhygric Black spruce-Jack pine ecosite phase (black spruce, bog cranberry, bunchberry, blueberry and Labrador tea); however, there will be a decrease in tree species density and an increase in shrub species density. The prescribed vegetation for reclamation is considered to be best suited for the moisture and drainage conditions that will occur in the transition zone, and which will also most closely resemble adjacent existing wetland vegetation.

## A5.6.2 Site Reclamation

Reclamation for all the Leismer Commercial Hub facilities will be carried out as discussed in the conceptual C&R plan (Volume 1 Section 8) and section A5.6.1; the Central Plant Facility and well pads are further discussed below. Site preparation for soil replacement will follow the guidelines presented in the conceptual C&R (Volume 1, Section 8.6.5).

Pre-Development Assessments (PDAs) for the Leismer Demonstration Project areas were also submitted for regulatory review, and revised in the review process. As mentioned, Facility areas associated with the Leismer Commercial Hub are the same as the Leismer Demonstration Project.

Commercial Hub Well Pads

Well Pad L1 is dominantly on McLelland organic soil with portions on Mildred soil. Inspected peat depths on the Organic soil varied from 75 to greater than 200 cm.

Well Pad L2 is dominantly mineral soil (Kinosis, Mildred and Livock) on the west part of the pad with McLelland Organic soil on the east portion. Peat depths encountered range from about 9 cm on the toe of the mineral unit to 220 cm in the McLelland soil at the east boundary.

Well Pad L3 has McLelland Organic soil on the north part of the pad and mineral Livock soils on the south with a very small area of Steepbank soil in the northeast corner.

Well Pad L4 is dominantly on McLelland Organic soil with mineral soils (Mildred and Steepbank) extending into the pad from the north.

Surface soils (LFH/shallow peat/topsoil) and subsoil will be salvaged as discussed in the conceptual C&R plan for the upland areas, and a minimum of 40 cm of peat will be salvaged on the deeper peat areas with Organic soil. The mineral topsoil, peat from the Organic soils, and the subsoil will be stored separately. North American has included sufficient stockpile area on each pad to accommodate the material volume (refer to Table A5.5-2).

For the production pads, the central pad areas that are located on pre-disturbance peatland will be reclaimed to upland with a target ecosite phase of g1 and a land capability for forest ecosystems of Class 3 (to 4). The outer portions of the well pads located on pre-disturbance peatland areas will be reclaimed to the wetter, transitional peat surface area with a target ecosite phase 'transitional g1' with a land capability for forest ecosystems of Class 5 (to 4). The reclamation target for upland mineral soil areas is to return those areas to similar conditions to pre-disturbance conditions.

Reclamation on well pads will be carried out as discussed in the conceptual C&R plan to create the surface peat transitional areas to integrate with the adjacent undisturbed peatland, and re-integrate the remaining pad area (e.g., drainage and topography) with the adjacent undisturbed mineral soil areas.

Commercial Hub Central Plant Facility

The Central Plant Facility is dominantly on the mineral Kinosis and Livock soils. Organic (McLelland) soils are found mainly in the northwest part of the CPF and a small area along the southeast border of the CPF.

Reclamation of the CPF will be similar to the well pads; however, without the restrictions of abandoned wells, the reclamation target will be to reclaim a dominant portion of the padded area on Organic soil to a surface peat transitional area, which would be a transitional zone from the upland portions of the reclaimed area to the undisturbed peatlands around the site. The remainder of the site would remain as an upland landform. Target ecosite phases are d1/d2 for the pre-disturbance upland portions of the site, and g1/'transitional g1' for the deep peat areas.

Reclamation would involve excavation of the pad material from the target transitional zone and placement onto the areas to remain as upland (after gravel salvage and de-compaction by deep ripping of those upland areas). The edges of the upland area would be sloped towards the poorly drained transitional zone with a slope gradient less than 30%. The upland surface would be contoured to an undulating to rolling surface form with 0.5 to 9 % slope gradients that restores natural drainage patterns that integrate with the surrounding topography. Additional de-compaction will be done on the re-contoured upland surface soil if necessary. Previously salvaged topsoil and subsoil from the pre-disturbance upland area would be replaced on the area to be reclaimed to upland, and revegetation will commence. Erosion prevention measures will be undertaken where required to prevent erosion before a vegetation cover is established.

In the target transition zone, after excavation of the pad material, peat that was salvaged from the pre-disturbance peat areas on the site and stored on the CPF will be replaced in the transition zone to form a shallow peat surface over mineral material similar to the adjacent undisturbed peatland area (though the peat in this zone may be less thick). It is anticipated this area will be reclaimed to a Land Capability for Forest Ecosystems Class 5 (to 4).

It is anticipated that with salvage of the pre-disturbance upland topsoil and subsoil and proper replacement along with standard best practice reclamation practices common for upland areas, that closure soil profile and properties on the target upland area will be similar to pre-disturbance conditions with a mixed duff/Ae layer replaced as a surface layer underlain by the salvaged upper subsoil. Reclaimed upland surface soil textures are anticipated to be dominantly silt loam to fine sandy loam with a clay loam to sandy clay loam upper subsoil, and a clay loam lower subsoil. Soil internal drainage on the reclaimed upland is anticipated to be dominantly moderately well drained with imperfectly to poorly drained areas in depressional and lower slope positions. It is anticipated that the Land Capability Class for the upland area will be returned to Land Capability for Forest Ecosystems Class 3 (to 4).

The objective of the revegetation program is to achieve a healthy self-sustaining, range of plant species that are compatible with site conditions, adjacent vegetation, and includes a mixture of woody and herbaceous species.

Target ecosite phases are d1/d2 for the upland portion (same as pre-disturbance). The Central Processing Facility lies within the Lower Boreal Highlands Natural Subregion and a d1 ecosite phase in this subregion is described as Low-bush cranberry with Aspen. The d2 ecosite phase is described as Low-bush cranberry with Aspen, White spruce and Black spruce. The ‘transitional g1’ ecosite phase will have similar target species as g1 (black spruce, bog cranberry, bunchberry, blueberry and Labrador tea), but there will be a decrease in tree species density and an increase in shrub species density.

It is anticipated that the successional trajectories for the targeted ecosite phases will be set in place and vegetation will establish in the first growing season, however, to achieve the targeted ecosite phases will take a longer period of time to develop.

### A5.6.3 Material Balance

Table A5.6-1 presents the material balance volumes for the topsoil (including shallow peat and LFH), deep peat, and subsoil material available for salvage and replacement for the Leismer Commercial Hub. All salvaged soil will be replaced on the site of origin wherever possible; therefore, the target replacement value is shown equivalent to the soil available for salvage. The actual replacement values may be slightly less than the target due to soil loss that may occur during salvage activities. Access roads developed on mineral soils will have surface LFH/peat and surface mineral soil salvaged only.

**Table A5.6-1 Surface Soil and Subsoil Available for Salvage and Replacement**

| Topsoil Volume Available ($m^3$) | Topsoil Volume Replacement Target ($m^3$) | Peat Volume Available ($m^3$) | Peat Volume Replacement Target ($m^3$) | Subsoil Volume Available ($m^3$) | Subsoil Volume Replacement Target ($m^3$) |
|---|---|---|---|---|---|
| 220,750 | 220,750 | 122,400 | 122,400 | 306,000 | 306,000 |

Underground pipeline construction has direct replacement of salvaged soil at the end of construction, and powerlines and above-ground pipelines have minimal soil disturbance; therefore these areas are not included in the material balance volumes.

# A6 LITERATURE CITED

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# A7 LEISMER COMMERCIAL HUB HORIZONTAL PRODUCER WELL PLOTS

The Leismer Commercial Hub horizontal producer well plots are the same as those originally submitted for the Leismer Demonstration application and as such they are not presented in this appendix.

# Appendix B

# APPLICATION FOR APPROVAL OF THE LEISMER EXPANSION HUB OF THE KAI KOS DEHSEH PROJECT

SUBMITTED TO

ALBERTA ENERGY AND UTILITIES BOARD

AND

ALBERTA ENVIRONMENT

SUBMITTED BY

NORTH AMERICAN OIL SANDS CORPORATION

August 2007

# Table of Contents

## TABLES



## FIGURES

# B1 INTRODUCTION

The North American oil sands leases are located in Townships 76 to 83, Ranges 8 to 13 West of the 4th Meridian. The oil sands leases are not contiguous and fall within the Rural Municipality of Wood Buffalo and Lakeland County.

North American Oil Sands Corporation (North American) is continuing to interpret and evaluate seismic and core hole data in its major project areas. This document provides the geological, reservoir information and operations overview necessary for the Alberta Energy Utilities Board (EUB) to review the “Application for Approval of the Leismer Expansion Hub of the Kai Kos Dehseh Project”. This Application targets those North American lands located between the southeast portion of Section 6-78-9 W4 to the northwest portion of Section 4-79-10 W4. This Application proposes to add an additional 20,000 bpd of new production adjoining the Leismer Commercial Hub (the Subject of Appendix A).

North American recently gained approval for the Leismer Demonstration Hub which will have an initial bitumen production capacity of 1,590 $m^3$/d (10,000 bpd). Appendix A applied for the Leismer Commercial Hub, which increased bitumen production from the Leismer Demonstration Hub to 3,180 $m^3$/d (20,000 bpd). North American is now applying for the Leismer Expansion Hub, which increases production in the Leismer Development Area to 6,360 $m^3$/d (40,000 bpd). The increase in production will require an expansion of the approved development area to accommodate additional well pairs and well pads, including additional: steam generating equipment, production and water treatment equipment and processing area. The addition of sulphur removal equipment will also be part of the Leismer Expansion Hub development.

This document includes (Section B4) a description of the geology and reservoir for the Leismer Expansion Hub, including detailed information on the geology and the hydrogeology of the area and an evaluation of resources and reserves

The Leismer Expansion Hub will consist of a SAGD hub consisting of centralized facilities (which will include steam generation, water treatment, emulsion gathering and treating, and sulphur removal equipment) and field facilities (well pads, connecting roads and utilities).

The Leismer Expansion Hub incremental production of 3,180 $m^3$/d (20,000 bpd) will consist of 8 pads with 40 well pairs. Future development phases will be applied for when appropriate as identified in the Kai Kos Dehseh Project application and more are anticipated to be defined by future drilling.

Table B1.1-1 presents the capacity and first steam dates for the Leismer Expansion Hub.

**Table B1.1-1 Leismer Expansion Hub**

| Project | Development Areas | Hubs | Capacity ($m^3/d$) | Capacity (bpd) | First Steam Date |
|---|---|---|---|---|---|
| Kai Kos Dehseh | Leismer | Leismer Demonstration (Approved) | 1,590 | 10,000 | 2009 |
| | | Leismer Commercial (Appendix A) | 1,590 | 10,000 | 2010 |
| | | Leismer Expansion Hub (Appendix B) | 3,180 | 20,000 | 2011 |

## B1.1 Leismer Expansion Hub Location

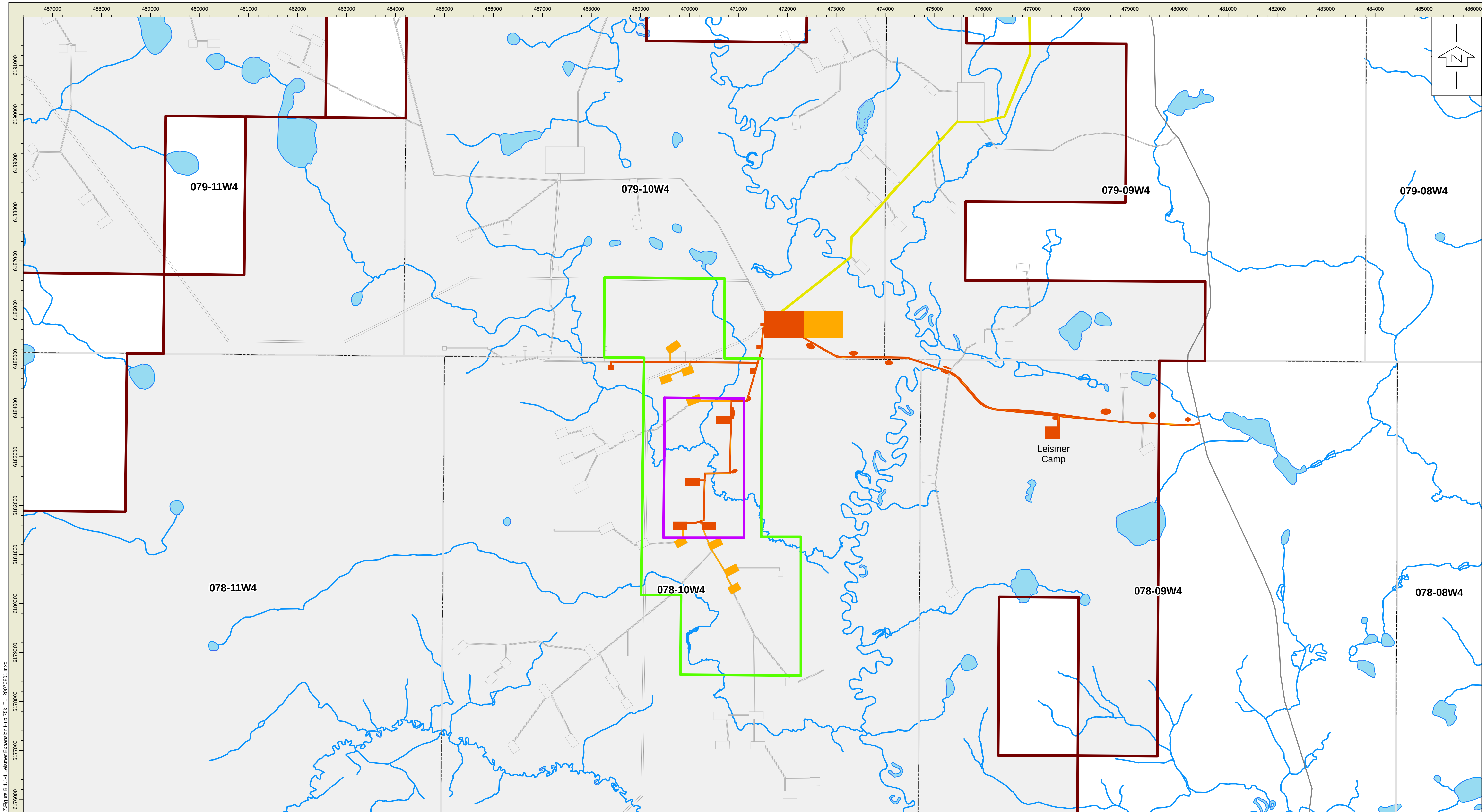
North American is proposing to develop the Leismer Expansion Hub on a portion of the oil sands leases it holds in the Conklin, Alberta Area. The CPF for the Leismer Expansion Hub will be located in LSDs 7 and 8 in 2-79-10 W4, coincident with and/or an expansion of the Leismer Demonstration and Commercial Hubs (Figure B1.1-1), approximately 30 km northwest of Conklin, Alberta and approximately 120 km north of Lac La Biche in the County of Lakeland. The SAGD well pairs will be drilled from eight surface production pads located in Section 21, 22, 33 and 34 78-10 W4 and Section 3 -79-10 W4.

The Leismer Expansion Hub is in a region that has been extensively explored and developed for natural gas and more recently explored for oil sands resources. A number of other thermal recovery projects are under application or operating in the Conklin area, however, most are proposed east of Conklin in the main McMurray channel trend.

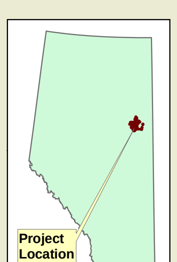
## B1.2 Land and Mineral Rights

SAGD bitumen production, natural gas production and forestry are the predominant industries in the area surrounding the Leismer Expansion Hub. It is important that, where appropriate, operators coordinate their activities so the total value is increased. North American is participating with the integrated land management activities of the Chamber of Resources, Alberta-Pacific Forest Industries inc. (Al-Pac) and other oil and gas operators in the region.

North American is the operating partner of the oil sands leases contained within the Leismer Expansion Hub. Figure 2.3-1, in the main body of the Application, shows oil sands leases in the area of application. All oil sands leases within the Leismer RGSA are owned by North American. Figure B1.2-1 shows the P&NG rights in the area.




14455-514_NAOSC\NAOSC_Maps\Maps_Volume_1\FINAL_MAY_2007\Figure B 1.1-1 Leismer Expansion Hub 75k_TL_20070801.mxd




## Legend

- North American Lease Boundary
- ATS Township / Range
- Roads
- Lake
- Stream
- Future Footprint
- Leismer Demonstration / Commercial Hub
- Leismer Expansion Hub
- Sales and Diluent Pipeline
- Leismer Demonstration Approved Development Area
- Leismer Expansion Initial Development Area

1:75,000

0 0.5 1 2 3 4 5 km

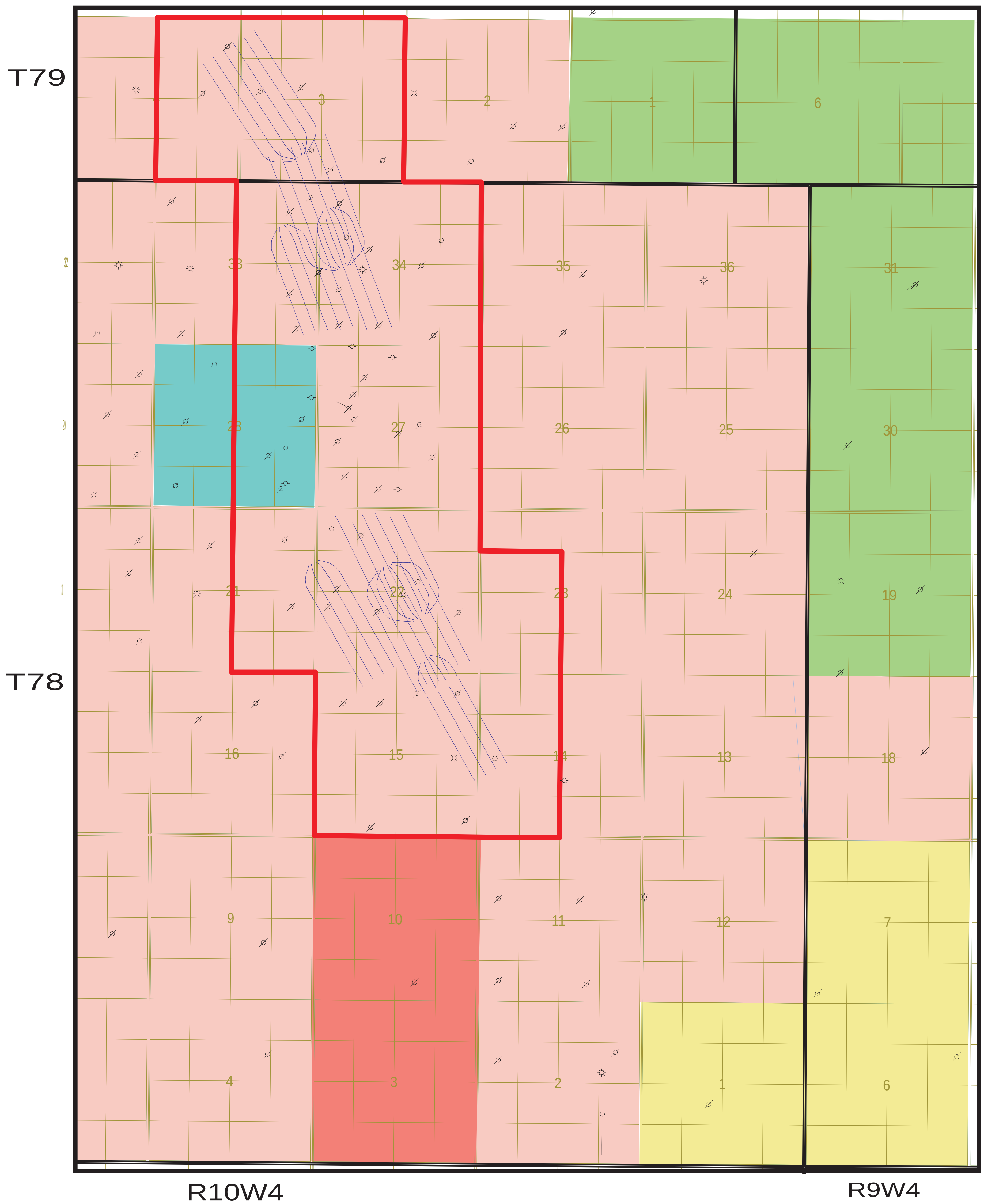
NAD 83 UTM Zone 12

Title:

**LEISMER EXPANSION HUB**

NORTH AMERICAN OIL SANDS CORPORATION

| Approved: SC/DH/LZ | Revision Date: August 1, 2007 | |
|---|---|---|
| File: Figure B 1.1-1 Leismer Expansion Hub 75k_TL_20070801.mxd | | |
| Drawn by: TR/JC/LZ | Checked: LZ/SC | Fig. No.: B 1.1-1 |




Paramount EOC (Op)

Encana

BP

Canadian Natural Resources

Leismer Expansion Area

Undisposed

# Figure B1.2-1 Leismer Area P&NG Lease Holders

| Leismer Area P&NG Lease Holders | | |
|---|---|---|
| Author: K. Kerr | | Date: 15 June, 2007 |
| | Scale: 1:40,000 | |

## B1.3 Production Capacity

North American is requesting an approved production capacity for the Leismer Expansion Hub of 3,180 $m^3$/d (20,000 bpd) on an annual average calendar day basis. Adequate resource recovery for the Leismer expansion development area will be provided by 8 production pads consisting of a total of 40 well pairs.

This increased production will bring the total Leismer production capacity up to 6,360 $m^3$/d (40,000 bpd) on an annual average calendar day basis.

## B1.4 Leismer Expansion Hub Schedule

The Leismer Expansion Hub schedule is shown in Table 1.4-1. The schedule is approximate and subject to modification in response to the receipt of regulatory approvals, business considerations and weather factors. Assuming favourable regulatory approval and market conditions, construction of the Leismer Expansion Hub is scheduled to begin in Q3 2009 with initial production in Q3 2011.

Stakeholders have been consulted since the Fall of 2004 and will continue to be involved throughout the development process. It is North American's intention to continue communication and interaction with the surrounding community throughout the life of the Leismer Expansion Hub.

## Table B1.4-1 Leismer Expansion Hub Schedule

| Quarter | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2007 | 2007 | 2007 | 2007 | 2008 | 2008 | 2008 | 2008 | 2009 | 2009 | 2009 | 2009 | 2010 | 2010 | 2010 | 2010 | 2011 | 2011 | 2011 | 2011 | 2012 | 2012 | 2012 | 2012 | 2013 | 2013 | 2013 | 2013 | 2014 | 2014 | 2014 | 2014 | 2015 | 2015 | 2015 | 2015 | 2016 | 2016 | 2016 | 2016 | 2017 | 2017 | 2017 | 2017 | 2018 | 2018 | 2018 | 2018 |
| **Leismer Expansion Hub** | | | Appendix B | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Engineering and Construction/Drilling | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Production/injection operations | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

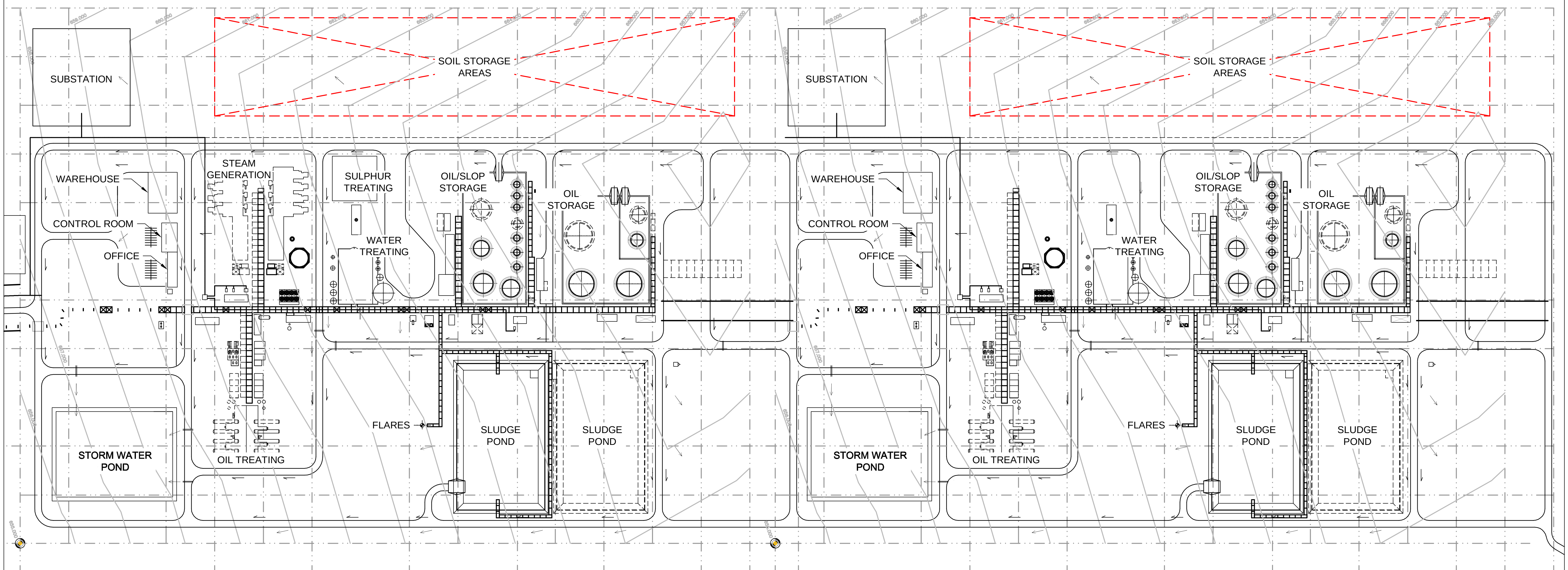
# B2 LEISMER EXPANSION HUB DESCRIPTION

## B2.1 Overview

North American is committed to effective resource recovery for the Leismer Expansion Hub. The Leismer Expansion Hub will utilize SAGD in-situ technology to recover approximately 3,180 $m^3$/d (20,000 bpd) of bitumen on an annual average calendar day basis. The layout of the Leismer Expansion Hub (CPF plot plan) is presented in Figure B2.1-1. Figures B2.1-2 through B2.1-4 present the material, water and energy balances for the Leismer Expansion Hub.

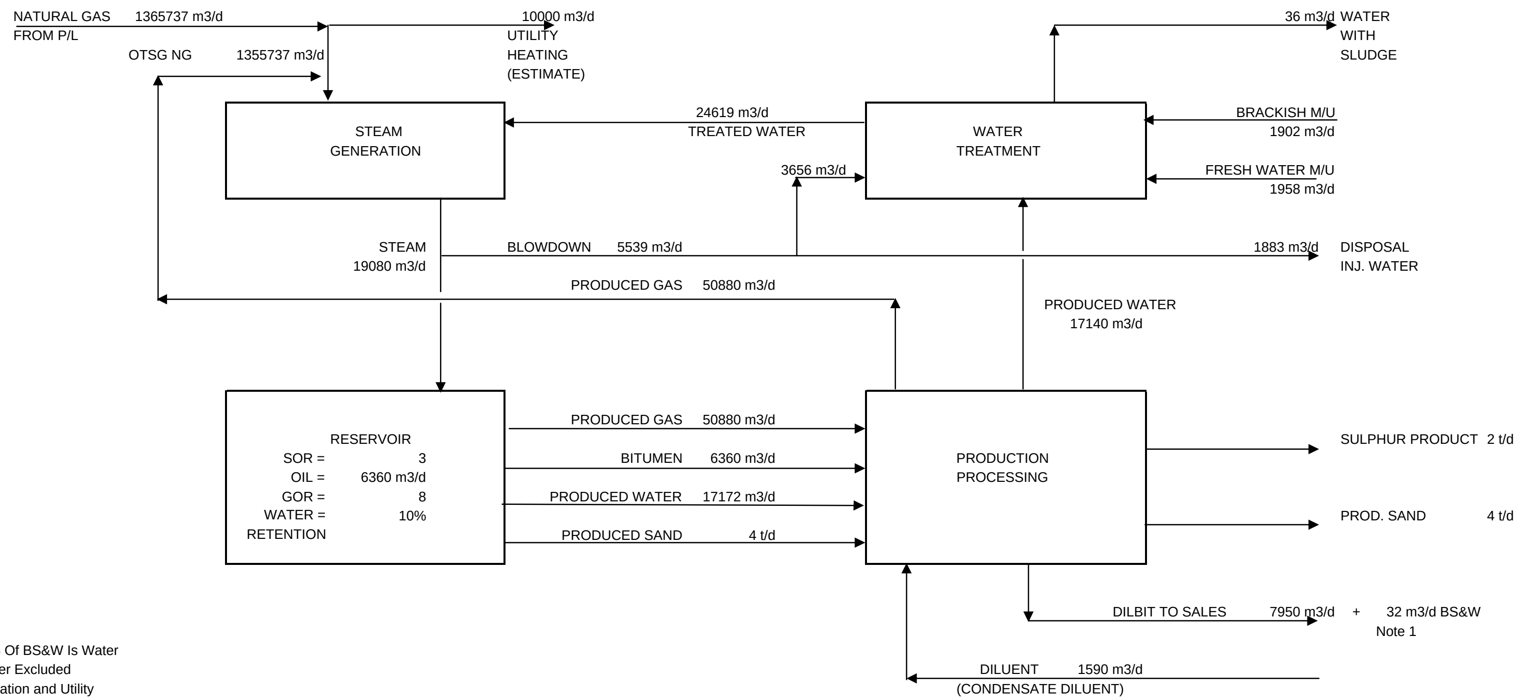
North American has been conducting seismic and oil sands exploratory (OSE) drilling programs in the Leismer Expansion Hub development area. In the first quarter of 2006, North American acquired 10.2 sections of high resolution 3D seismic and drilled 50 wells. In the first quarter of 2007, North American acquired an additional 12.3 sections of high resolution 3D seismic and drilled 46 wells. Well density is currently at 40 acre spacing in the approved Leismer Demonstration development area with surrounding areas, including the Leismer Expansion development area, effectively at 32.4 ha (80 acres) spacing. Fifty wells were cored in the area. The drilling and seismic programs confirmed the existence of a significant bitumen resource.

The components of the Leismer Expansion Hub will be identical to the components of the Leismer Commercial and Demonstration Hubs. The reader is directed to the “Application for Approval of the Leismer Demonstration Project” for details regarding the demonstration facility and to Appendix A for details on the additions for the Leismer Commercial Hub. Upgrades and additions to handle processing of the process streams associated with the increased production, requested herein, are detailed below. North American will incorporate additional components at the CPFs into the existing footprint, which in many cases, has an expansion slot in place for the additional equipment. The additional components required to achieve the requested production capacity are detailed in sections that follow.




SCALE 1:4000 metres
40 0 40 80

| | |
|---|---|
| Title: **LEISMER EXPANSION HUB CPF PLOT PLAN** | |
| Approved: ## | Revision Date: 07/06/22 |
| File: 4455-PROCESS-07.DWG | |
| Drawn by: ADF | Checked: ## |
| Fig. No.: **B2.1-1** | |



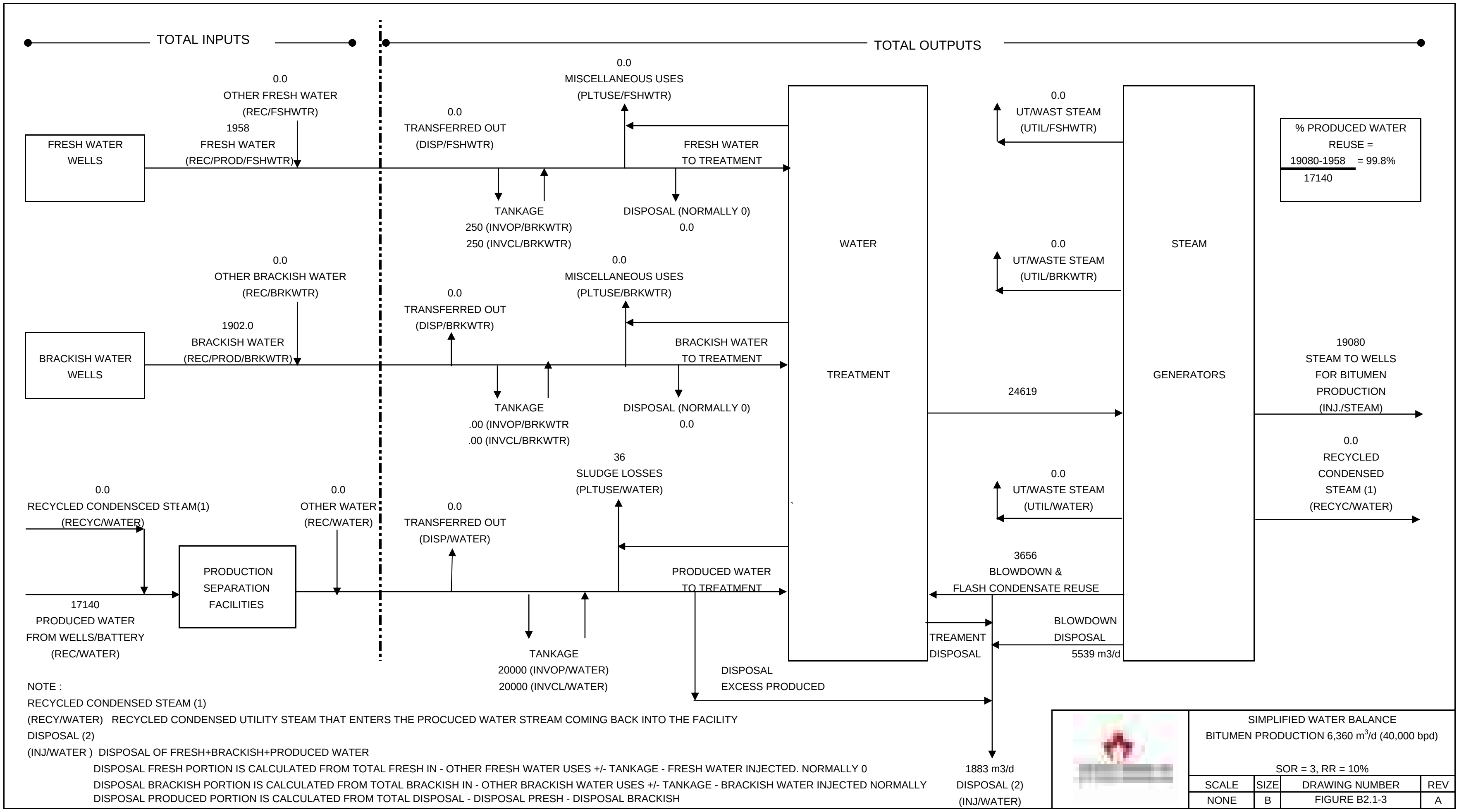

Notes:
1.) Assumes 50% Of BS&W Is Water
2.) Domestic Water Excluded
3.) Pond Evapouration and Utility Losses Excluded

Approximate Stream Rates

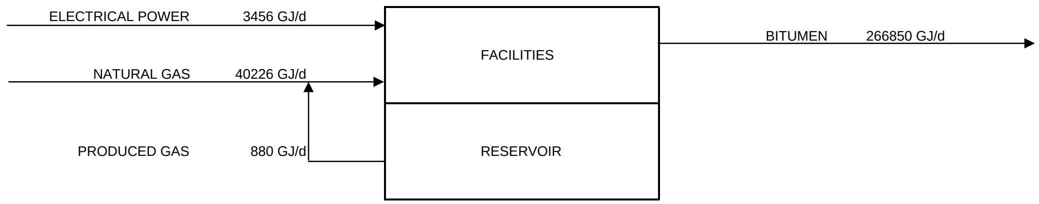
NOTE: CALENDAR DAY

Values shown are rounded in Table B2.4-1

| | | | |
|---|---|---|---|
| MATERIAL BALANCE<br>BITUMEN PRODUCTION 6,360 $m^3$/d (40,000 bpd)<br>SOR = 3, RR = 10% | | | |
| SCALE | SIZE | DRAWING NUMBER | REV |
| NONE | B | FIGURE B2.1-2 | A |



TOTAL INPUTS
TOTAL OUTPUTS
0.0
OTHER FRESH WATER
(REC/FSHWTR)
1958
FRESH WATER
(REC/PROD/FSHWTR)
FRESH WATER
WELLS
0.0
TRANSFERRED OUT
(DISP/FSHWTR)
0.0
MISCELLANEOUS USES
(PLTUSE/FSHWTR)
FRESH WATER
TO TREATMENT
TANKAGE
250 (INVOP/BRKWTR)
250 (INVCL/BRKWTR)
DISPOSAL (NORMALLY 0)
0.0
WATER
TREATMENT
0.0
UT/WAST STEAM
(UTIL/FSHWTR)
STEAM
GENERATORS
% PRODUCED WATER
REUSE =
19080-1958 = 99.8%
17140
0.0
OTHER BRACKISH WATER
(REC/BRKWTR)
1902.0
BRACKISH WATER
(REC/PROD/BRKWTR)
BRACKISH WATER
WELLS
0.0
TRANSFERRED OUT
(DISP/BRKWTR)
0.0
MISCELLANEOUS USES
(PLTUSE/BRKWTR)
BRACKISH WATER
TO TREATMENT
TANKAGE
.00 (INVOP/BRKWTR
.00 (INVCL/BRKWTR)
DISPOSAL (NORMALLY 0)
0.0
0.0
UT/WASTE STEAM
(UTIL/BRKWTR)
24619
19080
STEAM TO WELLS
FOR BITUMEN
PRODUCTION
(INJ./STEAM)
0.0
RECYCLED
CONDENSED
STEAM (1)
(RECYC/WATER)
36
SLUDGE LOSSES
(PLTUSE/WATER)
0.0
UT/WASTE STEAM
(UTIL/WATER)
0.0
RECYCLED CONDENSCED STEAM(1)
(RECYC/WATER)
0.0
OTHER WATER
(REC/WATER)
0.0
TRANSFERRED OUT
(DISP/WATER)
PRODUCTION
SEPARATION
FACILITIES
17140
PRODUCED WATER
FROM WELLS/BATTERY
(REC/WATER)
PRODUCED WATER
TO TREATMENT
3656
BLOWDOWN &
FLASH CONDENSATE REUSE
TREAMENT
DISPOSAL
BLOWDOWN
DISPOSAL
5539 m3/d
TANKAGE
20000 (INVOP/WATER)
20000 (INVCL/WATER)
DISPOSAL
EXCESS PRODUCED
NOTE :
RECYCLED CONDENSED STEAM (1)
(RECY/WATER) RECYCLED CONDENSED UTILITY STEAM THAT ENTERS THE PROCUCED WATER STREAM COMING BACK INTO THE FACILITY
DISPOSAL (2)
(INJ/WATER ) DISPOSAL OF FRESH+BRACKISH+PRODUCED WATER
DISPOSAL FRESH PORTION IS CALCULATED FROM TOTAL FRESH IN - OTHER FRESH WATER USES +/- TANKAGE - FRESH WATER INJECTED. NORMALLY 0
DISPOSAL BRACKISH PORTION IS CALCULATED FROM TOTAL BRACKISH IN - OTHER BRACKISH WATER USES +/- TANKAGE - BRACKISH WATER INJECTED NORMALLY
DISPOSAL PRODUCED PORTION IS CALCULATED FROM TOTAL DISPOSAL - DISPOSAL PRESH - DISPOSAL BRACKISH
1883 m3/d
DISPOSAL (2)
(INJ/WATER)
SIMPLIFIED WATER BALANCE
BITUMEN PRODUCTION 6,360 m3/d (40,000 bpd)
SOR = 3, RR = 10%
SCALE
SIZE
DRAWING NUMBER
REV
NONE
B
FIGURE B2.1-3
A




ENERGY BALANCE
BITUMEN PRODUCTION 6,360 $m^3$/d (40,000 bpd)
SOR = 3, RR = 10%

| SCALE | SIZE | DRAWING NUMBER | REV |
|---|---|---|---|
| NONE | B | FIGURE B2.1-4 | A |